

III INTERNATIONAL CONGRESS ON CONSTRUCTION AND BUILDING RESEARCH (COINVEDI)

Madrid, 14th, 15th and 16th of December 2015

Escuela Técnica Superior de Edificación

Universidad Politécnica de Madrid

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BOOK OF EXTENDED ABSTRACTS

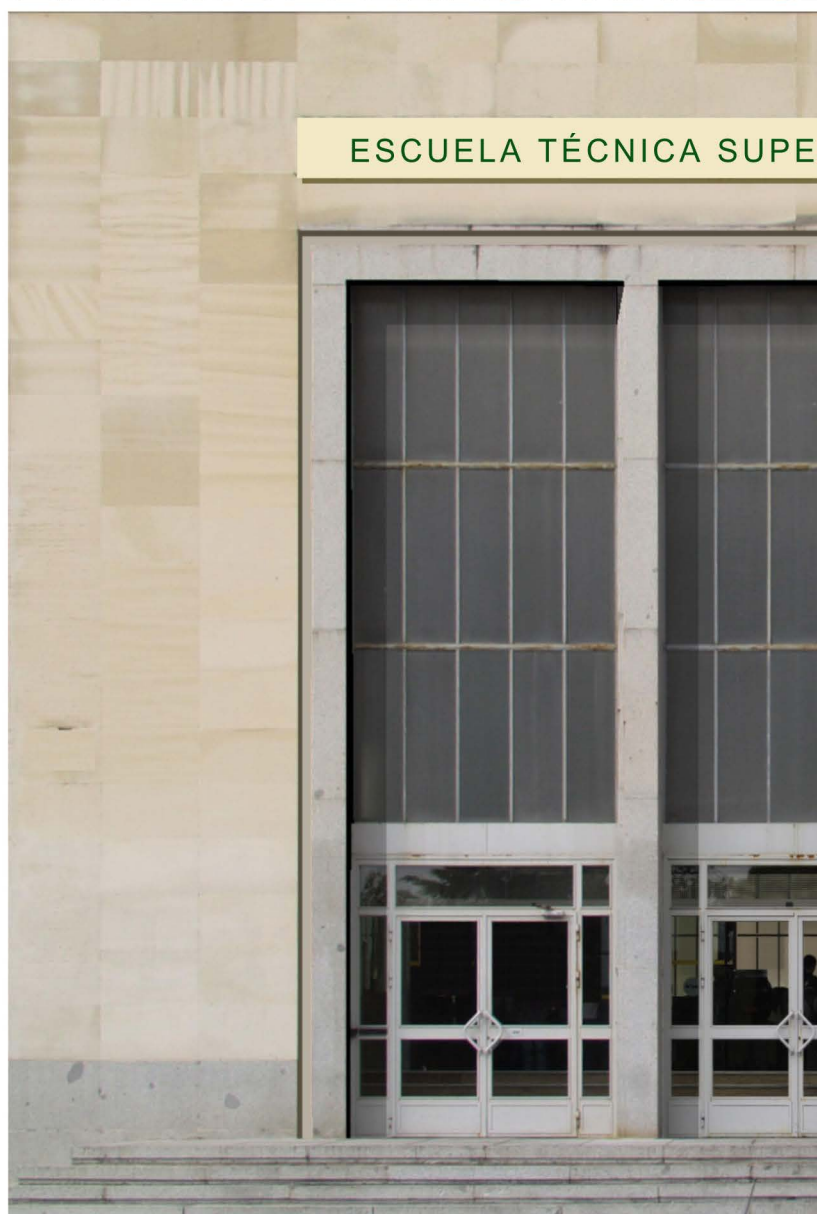
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POLITÉCNICA



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POLITÉCNICA

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Universidad Politécnica de Madrid

ISBN: 978-84-933567-6-7



Materiales de
Construcción

informes
de la construcción

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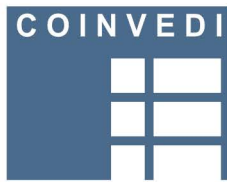


MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD



GYPSUM TO GYPSUM





III International Congress on Construction and Building Research

Escuela Técnica Superior de Edificación
Universidad Politécnica de Madrid
Avda. de Juan de Herrera 6, 28040 Madrid, Spain

14th - 16th of December 2015

PRESENTATION

Given the success of the 2nd International Congress on Construction and Building Research held in Valencia (Spain), the Director's Conference of Building Engineering (CODATIE) has encouraged the organization of the third edition to the School of Building Construction of Madrid (ETSEM) and in particular to the Building Technology and Sustainability Research Group (TEMA Rg).

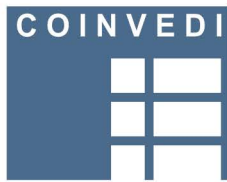
Participants from other countries have been invited in order to advance and improve research in the building sector, so as to achieve more sustainable world through research and innovation. The Congress main goal is to present the latest research advances and innovative applications in the Building sector by getting together research groups, administration and companies which have an interest in the building research, development and innovation. In addition, the Congress will provide the opportunity to serve as a meeting point between the University and the business world creating a frame that will facilitate technology transfer.

More than 130 papers will be presented at the III COINVEDI, of which 34% were accepted for poster presentation and 65% for oral presentation. We hope these presentations offer the possibility to interchange experiences among researchers and fruitful interactions from the different perspectives and approaches.

We kindly invite all members of the scientific community and professionals related to Building Construction to participate in the debates so as to attain conclusions to organize and coordinate activities together in the near future, within the Building Construction area.

Finally, we would like to thank everyone for their participation in the Congress and wish all a pleasant stay in Madrid hoping to see you back in the forthcoming editions of the Congress.

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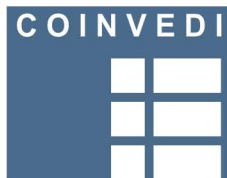
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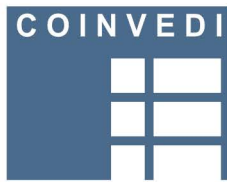
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COINVESTED

PROGRAMME



PROGRAMME*

Monday, 14th December

09:30 - 10:00 Registration

10:00 - 10:30 Opening Ceremony  *Auditorium*

- Mr. Carlos Conde Lázaro. Rector of the Universidad Politécnica de Madrid.
- Ms. María Carmen Vela Olmo. Secretariat of State of Research, Development and Innovation
- Ms. Mercedes del Río Merino. Dean of the School of Building construction of Madrid
- Mr. Jesús Paños Arroyo. President of Colegio Oficial de Aparejadores y Arquitectos Técnicos de Madrid

10:30 - 11:00 Awards ceremony  *Auditorium*

- Ms. Marta Castellote. Director of Instituto de Ciencias de la Construcción Eduardo Torroja
- Ms. Francisca Puertas Maroto. Editor-in-Chief of *Materiales de Construcción*
- Mr. David Revuelta Crespo. Editor-in-Chief of *Informes de la Construcción*

11:00 - 12:00 SESSION 1  *Auditorium*

Chair: **Ms. Francisca Puertas Maroto.** *Instituto de Ciencias de la Construcción Eduardo Torroja*

- 11:00 - 11:15 • Infrared thermography application in energy audits of buildings. *Pablo Palma Sellés, Beatriz Piedecausa-García, Joaquín López-Davó*
- 11:15 - 11:30 • Experimental performance of synthetic waterproofing membranes in the inverted flat roof. *Antonio Pedrosa González and Mercedes del Río Merino*
- 11:30 - 11:45 • Study about hygrothermal parameters in the rehabilitation of cavedwellings. *Luis Jimenez Lopez, Susana Moreno Soriano and Consolación Ana Acha Román*
- 11:45 - 12:00 • Fuel poverty analysis in three Spanish autonomous regions. Some retrofitting policy considerations. *Carmen Sanchez-Guevara, Ana Sanz Fernández, Agustín Hernández Aja and F. Javier Neila González*

12:00 - 12:30 Coffee break - Poster session I - Entrance Lobby

12:30 - 13:15 Keynote speaker  *Auditorium*

Ms. Giuliana Iannaccone. "Integrated strategies for the energy efficient refurbishment of existing building stock: a European perspective" Associate Professor of Architectural Engineering at the Department ABC of the Politecnico di Milano

Chair: **Mr. Mariano González Cortina.** *Universidad Politécnica de Madrid*

13:15 - 14:45 SESSION 2  *Auditorium*

Chair: **Ms. Giuliana Iannaccone**

- 13:15 - 13:30 • Energy demand benchmarking of non-domestic buildings in Scotland. *Julien Chetboul, Julio Bros-Williamson and John Currie*
- 13:30 - 13:45 • Building information modeling (BIM) for existing buildings. *Enrico Dassori and Marco Vassale*
- 13:45 - 14:00 • Assessing cost-effectiveness of energy conservation measures in the

* Simultaneous translation will be provided throughout the Congress for oral presentations (Spanish and English)

- existing social housing building stock: an Italian case study. *Graziano Salvalai, Giuliana Iannaccone and Marta Maria Sesana*
- 14:00 - 14:15 • Building Retrofit through Prefabricated Panels: an Overview on the State of the Art. *Elena Seghezzi and Gabriele Masera*
- 14:15 - 14:30 • GWT - New testing system for "in-situ" measurements of concrete water permeability. *Andrzej Moczko and Marta Moczko*
- 14:30 - 14:45 • Attachable housing modules & structural core facilities building system. *Alejandro Cabello Carretero*

14:45 - 16:00 Lunch - Entrance Lobby

16:00 - 16:30 Keynote speaker  **Auditorium**

Ms. María Josefa Cassinello Plaza. "Eduardo Torroja 1949/ International competition on industrialise housing in post-world war II" *Director of Fundación Eduardo Torroja*
Chair: **Ms. Carmen Rodríguez Liñán**

16:30 - 18:15 SESSION 3  **Auditorium**

Chair A: **Ms. María Josefa Cassinello Plaza.** *Director of Fundación Eduardo Torroja*

- 16:30 - 16:45 • The inspection with non destructive techniques as a tool for sustainable interventions in buildings with wooden structures. *Carmen Rodríguez-Liñán, M^a Jesús Morales-Conde, Paloma Rubio de Hita, Filomena Pérez-Gálvez*
- 16:45 - 17:00 • Review of building environmental assessment methods for residential building envelopes. Application to southern Spain: a case study in Seville. *Julia Garrido-Piñero, M^a del Pilar Mercader-Moyano and Antonio Ramírez de Arellano-Agudo*
- 17:00 - 17:15 • Environmental impact on life cycle of building. *Cristina Rivero Camacho, Antonio Freire Guerrero, Jaime Solís and Madelyn Marrero*

Chair B: **Ms. María del Pilar Mercader Moyano.** *Universidad de Sevilla*

- 17:15 - 17:30 • The adaptive approach to thermal comfort in Seville. *Daniel Sánchez García, Carmen Sánchez-Guevara Sánchez; Carlos Rubio Bellido*
- 17:30 - 17:45 • The influence of glazing over the parametres and energy rating according to the building orientation and the façade opening percentages. *Jorge Ávila Delgado, María Dolores Robador González, Madelyn Marrero Meléndez, José Antonio Barrera Vera*
- 17:45 - 18:00 • Ecological Footprint of manpower in construction in Spain, Chile and Mexico. Food Consumption. *Patricia González-Vallejo, A.Martínez-Rocamora, J.Solís-Guzmán, R.Llácer Pantión, P.Mercader and M.Marrero.*
- 18:00 - 18:15 • Analysis and proposals of energy saving for the building stock of the Valencian community. *Francisco Cubel Arjona, Víctor Calvet Rodríguez, Javier Benlloch Marco, José María Fran Bretones*

18:15 - 18:45 Coffee break - Poster session I (continue) - Entrance Lobby

18:45 - 21:00 SESSION 4  **Auditorium**

Chair A: **Ms. Carmen Llinares Millán.** *Universidad Politécnica de Valencia*

- 18:45 - 19:00 • Luminous and thermal impact of fixed solar shadings devices. *David Moreno Rangel, Paula Esquivias and Manuel Fernández-Expósito*
- 19:00 - 19:15 • Kansei engineering in the lighting design of emotional spaces. *Nuria Castilla Cabanes, Carmen Llinares and Vicente Blanca*
- 19:15 - 19:30 • Residential environment quality and its repercussion on human health. A

- preliminary approach. *Néstor Rouyet Ruiz, Mercedes Del Rio Merino and Carmen Viñas Arrebola*
- 19:30 - 19:45 • Influence of accumulation of service deformation concrete trusses effect of rigid enclosure. *Francisco Gil Carrillo and Antonio José Mas-Guindal*
- 19:45 - 20:00 • Waste to resources. Mercedes del Río Merino, Jaime Santa Cruz Astorqui, Paola Villoria Sáez, Carmen Rodríguez Liñán and Pilar Mercader Moyano
- Chair B: **Mr. Antonio Ros Serrano. Universidad Politécnica de Madrid**
- 20:00 - 20:15 • Planning for building construction management: implementing last planner through business process management. *María Dolores Andújar-Montoya, Virgilio Gilart-Iglesias, Andrés Montoyo and Diego Marcos-Jorquera*
- 20:15 - 20:30 • Planification, control and monitoring of a professional service of engineering building a model of quality management in accordance to ISO 9001. *Eloísa González Ponce, Juan Roldán Ruiz, M^a Concepción Parra Meroño*
- 20:30 - 20:45 • Study of safety and health management in the construction sector of Valencia. *José Luis Fuentes-Bargues, M.C. González-Cruz, C. González-Gaya; N. García-Arambarri and M.P. Díaz de Mera-Sánchez*
- 20:45 - 21:00 • Earned value method applied in management project in Spanish edification. *Raúl Fuente Juridías, Víctor Sardá Martín and Jesús Esteban Gabriel*

Tuesday, 15th December

- 09:30 - 11:30 **SESSION 5 - 1st International Workshop on Construction Recycled Materials**
  Auditorium
 Keynote speaker:
Mr. Luigi Della Sala. "GtoG Life + Project : First steps towards a circular economy for gypsum".
 Chair: **Mr. Justo García Navarro. Universidad Politécnica de Madrid**
- 10:00 - 10:15 • Gypsum best practice indicators. *Ana Jiménez Rivero, Marta Rodríguez-Quijano, Ana de Guzmán-Báez and Justo García-Navarro*
- 10:15 - 10:30 • Gypsum plasterboard deconstruction to recycling economic analysis: three case studies. *Marta Rodríguez-Quijano, Ana Jiménez Rivero, Ana de Guzmán-Báez and Justo García-Navarro*
- 10:30 - 10:45 • Fraction of recycled aggregates from construction and demolition waste CDW in masonry mortar fabrication. *Pablo Saiz Martínez, Mariano González Cortina and Francisco Fernández Martínez*
- 10:45 - 11:00 • Case study: Adaptavate's journey from academia to commercialisation of alternative building materials towards a circular economy. *Tom Robinson and Alberto Fernández Minguela*
- 11:00 - 11:15 • Biocomposites for advanced profiles adapted to building envelope. *Inma Roig, S. Fita, O. Menes and N. Soriano*
- 11:15 - 11:30 • Municipal solid waste incineration fly ash stabilization and immobilization into sulfoaluminate cement mortars matrix: physical/mechanical behaviour. *O. López Zaldívar, R.V. Lozano Díez, A. Verdú Vázquez*
- 11:30 - 12:00 **Coffee break - Poster session II - Entrance Lobby**
- 12:00 - 14:00 **SESSION 6**  Auditorium
- Chair A: **Mr. Julián García Muñoz. Universidad Politécnica de Madrid**
- 12:00 - 12:15 • Integrated Project Delivery (IPD) assisted by BIM for Sustainable Design

- Solutions. *Barry Jones*
- 12:15 - 12:30 • Contemporary methodology for infrastructure project management, dispute avoidance and delay analysis. *Yiannis Vacanas, Kyriacos Themistocleous, Athos Agapiou and Chris Danezis*
- 12:30 - 12:45 • Risk management framework for international construction joint ventures (ICJVs). *Tugce Ercan*
- 12:45 - 13:00 • The impact of social change on construction methods. *Jan Werner*

Chair B: **Mr. Carlos Morón Fernández**  Auditorium

- 13:00 – 13:15 • Packaging impact reduction in product stage: Eco-redesign of cardboard boxes. *Natalia González Pericot, Mercedes Del Río Merino, Oscar Liébana Carrasco and Enrique Martínez Sierra*
- 13:15 - 13:30 • Masonry structures: "old" and "new" approaches to strongly local phenomena. *Fernando Magdalena Layos, Julián García Muñoz, David Mencías Carrizosa*
- 13:30 – 13:45 • STRUCTURA, the self-supporting face brick façade to comply with the new CTE DB HE (Technical Building Code Basic Document for Energy Saving) requirements. *Concepción del Río Vega and Ana Ribas Sangüesa*
- 13:45 – 14:00 • Effect of thermal mass activation on concrete mechanical properties of building structures. *Inmaculada Martínez, Alfonso Cobo, María Isabel Prieto, Luis De Pereda and Sonsoles González*

14:00 - 15:15 Lunch - Entrance Lobby

15:15 - 16:00 **Keynote speaker**  Auditorium

Mr. Pedro Garcés Terradillos "Hormigones Conductores Multifuncionales". Full Professor at the Civil Engineering Department of the Universidad de Alicante
Chair: **Ms. Eva García Alcocel**. Universidad de Alicante

16:00 – 17:30 **SESSION 7 - 1st International Workshop on Construction Recycled Materials**
 Auditorium

Chair: **Mr. Pedro Garcés Terradillos** Universidad de Alicante

- 16:00 – 16:15 • Life cycle assessment of natural and recycled masonry mortars. *Gloria M^a Cuenca-Moyano, Sara Zanni, Alessandra Bonoli and Ignacio Valverde-Palacios*,
- 16:15 – 16:30 • Analysis of the mechanical behaviour of concretes with recycled aggregates and diatomite residual as a cement replacement. *Viviana Letelier, Ester Tarela, Juan Pablo Cardenas and Giacomo Moriconi*
- 16:30 - 16:45 • Reuse of construction and demolition recycled aggregates for the preparation of alkali activated cement mortars. Characterization and mechanical behaviour. *Rocío Santos, M^a Mar Alonso, Mercedes del Río and Francisca Puertas*
- 16:45 - 17:00 • Mechanical reduction of adhered mortar from recycled aggregates and its effect in concrete. *Viviana Letelier, Ester Tarela and Pedro Muñoz*
- 17:00 - 17:15 • Experimental mechanical characterisation of a structural lightweight aggregate concrete according to EC-2. *Fernando Israel Olmedo Zazo, Alfonso Cobo, Borja Díaz and María Ángeles Vidal*
- 17:15 - 17:30 • Study of the acoustic resistance of traditional Canarian mortar with polystyrene additives. *Pedro Yanes González, Mercedes del Río Merino*

17:30 – 18:00 Coffee break - Poster session II (continue) - Entrance Lobby

18:00 - 20:15 **SESSION 8** Auditorium

Chair A: **Mr. José Ángel Pérez Benedicto** *Universidad de Zaragoza*

- 18:00 – 18:15 • Recycling of gypsum plasterboard lightened with polyurethane waste. *S. Gutiérrez-González, V. Calderón, L. Alameda and C. Junco*
- 18:15 - 18:30 • Re-use of glass waste in restoration mortar. *Regina Ochoa, Pablo Luis Campos, Jesús Gadea*
- 18:30 - 18:45 • Dry industrial mortars dosed with slags. *Isabel Santamaría-Vicario, Verónica Calderón, Ángel Rodríguez, Juan García-Cuadrado*
- 18:45 - 19:00 • The thermal resistance of plasterboard made with ladle furnace slag. *Verónica Calderón, Ángel Rodríguez, Sara Gutiérrez-González, Alba Rodrigo*
- 19:00 - 19:15 • Study of the validity of techniques electrochemical in the corrosion of rebars embedded in mortar specimens with slag LFS. *M^a Isabel Prieto Barrio, A. Cobo Escamilla, A. Rodríguez Sáiz and M.N. González García*

Chair B: **Mr. Jesús Gadea Sáinz** *Universidad de Burgos*

- 19:15 – 19:30 • Effect of the use of glass waste on the physical and mechanical properties and durability of mortars made with cement and hydraulic lime. *Alba Rodrigo, Víctor de Domingo, Raquel Quevedo, Jesús Gadea and Pablo Luis Campos*
- 19:30 - 19:45 • Geophysical recognition of reinforced concrete foundation structures applying GPR. *José Ángel Pérez Benedicto, Oscar Pueyo Anchuela and Pedro Luis López Julián*
- 19:45 - 20:00 • Anodization of titanium for the building envelope using different cathodes and their photocatalytic behavior. *Irene González Morán, Maria Vittoria Diamanti, Maria Pia Pedferri, Francisco Fernández Martínez and Mercedes del Río Merino*
- 20:00 – 20:15 • Profiles related of fatal accidents in building sector 2008-2012. *Fundación MUSSAT, Francisco J. Forteza Oliver, Mateo Moyá Borrás and L. Damián Ramos Pereira*
- 20:15 – 20:30 • Plasterboard partitions: a way out to reduce construction waste on site. *Paola Villoria Sáez, Mercedes del Río Merino and César Porras Amores*

Wednesday, 16th December

09:30 - 10:15 **Keynote speaker** Auditorium

Ms. Sara Pavia. "Thermal and hygric properties of insulation materials suitable for historic and traditional fabrics". Professor at the Civil Engineering Department of the Trinity College of Dublin.

Chair: **Ms. Paola Villoria Sáez** *Universidad Politécnica de Madrid*

10:15 - 11:45 **SESSION 9** Auditorium

Chair: **Mr. Sara Pavia** *Trinity College of Dublin*

- 10:15 – 10:30 • Decrease of the drying shrinkage of C3S paste by using crystallized germs manufactured by ball-milling. *Matthieu Horgnies, Lingjie Fei, Raquel Arroyo-Sanz and Verónica Calderón*
- 10:30 – 10:45 • Innovations in the modern built environment - old and new structural fire safety considerations. *Cristian Maluk Zedan*
- 10:45 – 11:00 • Effects of fire positions on the breaking behaviour of point-supported and frame-supported glass facades. *Yu Wang, Qingsong Wang, Jinhua Sun, K.M. Liew and Linghui He*

- 11:00 - 11:15 • Optimum switch temperature for buildings incorporated phase change materials in Mediterranean climates. *El Hadi Bouguerra and Nouredine Retiel*
- 11:15 - 11:30 • Thermal upgrades of hard-to-treat historic buildings Edinburgh's New Town. *Julio Bros-Williamson, Jon Stinson, Alasdair Reid and John Currie*
- 11:30 - 11:45 • A proposal for the infographic computerization of the buildings by ICT tools. *Davide Barbato*

11:45 - 12:15 Coffee Break - Poster session III - Entrance Lobby

12:15 - 14:15 SESSION 10 Auditorium

Chair A: **Ms. Verónica Calderón Carpintero.** *Universidad de Burgos*

- 12:15 – 12:30 • Study workability of self-compacting concrete with fibres. *Alejandro Celaya Naya, Martín Orna Carmona, Ángel Salesa Bordanaba*
- 12:30 - 12:45 • Rheological behaviour of OPC and geopolymer pastes. *Sara Gismera, M^a Mar Alonso, C. Varga and Francisca Puertas*
- 12:45 – 13:00 • Properties of hydrated lime mortars with pozzolans. *Marwa Aly and Sara Pavia*
- 13:00 – 13:15 • Influence of the position of the insulation within the construction in roofing retrofitting in Madrid. *Juan Francisco Alamillo, Beatriz Arranz, Sergio Vega, Mercedes Del Rio*

Chair B: **Ms. M^a del Mar Alonso López.** *Instituto de Ciencias de la Construcción Eduardo Torroja*

- 13:15 - 13:30 • Transparent integration of construction workers through business process management systems and internet of things. *María Dolores Andújar-Montoya, Virgilio Gilart-Iglesias, Andrés Montoyo, Diego Marcos-Jorquera and Encarnación García-González*
- 13:30 - 13:45 • Study and analysis of the duties and responsibilities of the developer regarding safety matters on construction sites in 22 countries. *Iván Martín Pérez and Jesús Esteban Gabriel*
- 13:45 – 14:00 • Health and safety risk assessment methods in building construction: an outstanding problem. *Antonio José Carpio de los Pinos and María de las Nieves González García*
- 14:00 – 14:15 • Q-BIM. Quality and assurance control for construction projects on a BIM environment. An analysis of the strengths and weaknesses of the current software. *Patricia Del Solar Serrano, Silvia Andrés Ortega, Aránzazu De la Peña González, María Dolores Vivas Urías and Diego Quibén de la Rosa*

14:15 - 15:30 Lunch - Entrance Lobby

15:30 – 17:30 SESSION 11 Auditorium

Chair A: **Ms. Carmen Viñas Arrebola.** *Universidad Politécnica de Madrid*

- 15:30 – 15:45 • Mechanical and physical properties of two volcanic tuffs used in traditional canary constructions. *M^a del Mar Barbero-Barrera, Nelson Flores-Medina and Esther Moreno-Fernández*
- 15:45 – 16:00 • General methodology applied to monitoring a building and assess its energy performance. *Rubén Felices Puertolas, Carmen Viñas Arrebola and Juan Carlos Losada González*
- 16:00 – 16:15 • Experimental design, monitoring and analysis of the thermal behavior of the external thermal insulation system (ETICS) in the retrofitting of a residential building *Sheila Varela Luján, Carmen Viñas Arrebola, Antonio Rodríguez Sánchez,*

- 16:15 - 16:30 • Variations of the colour in the wood of inner construction by chemical toasted method. *Francisco Lora Toro, Antonio Rodríguez Rodríguez, Alfonso García Santos*

Chair B: **Mr. Antonio Rodríguez Sánchez.** *Universidad Politécnica de Madrid*

- 16:30 - 16:45 • Re-design of plaster prefabricated elements. *Jaime Santa Cruz Astorqui, Mercedes del Río Merino and Paola Villoria Sáez*
- 16:45 - 17:00 • Analysis measuring transmission loss in concrete samples with a standing wave tube. *David Caballol, Mariano González and Antonio Rodríguez*
- 17:00 - 17:15 • Studying the behaviour of ceramic flooring as heat energy collector, in buildings constructed following bioclimatic criteria. *Carolina Piña Ramírez, Carmen Viñas Arrebola, Mercedes del Río Merino*
- 17:15 - 17:30 • Strategies to drive the generalization of housing states renovation based on the generation of energy surpluses. *Marta Gómez Gil, Belinda López-Mesa, Alejandro del Amo Sancho*

17:30 – 18:00 Coffee break - Poster session III (continue) - Entrance Lobby

18:00 – 20:15 SESSION 12  **Auditorium**

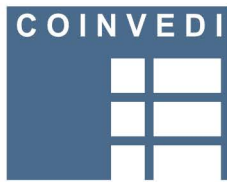
Chair A: **Mr. Jaime Santa Cruz Astorqui.** *Universidad Politécnica de Madrid*

- 18:00 – 18:15 • A study on the pathologies of foundations elements in Andalusia. *Manuel J. Carretero-Ayuso, A. Moreno-Cansado, Eduardo M. Cuerda-Correa*
- 18:15 – 18:30 • A case study of the structural rehabilitation of housing units complying with ten-year insurance policies. *Carmelo Muñoz Ruipérez, Francisco Fiol Olivan*
- 18:30 - 18:45 • Special foundation for a modular educational building next to the arab wall of Guadalajara. *Fernando da Casa Martin, Juan Manuel Vega Ballesteros and Jorge Delgado Garcia*
- 18:45 - 19:00 • "Symbcity" project for solardecathlon 2014. Sustainable refurbishment of buildings and redensification of cities. *Francisco Castilla Pascual, A. Baño Nieva, F. Estirado Oliet, J.L. Serrano Cantó*

Chair B: **Mr. Alfonso Cobo Escamilla.** *Universidad Politécnica de Madrid*

- 19:00 - 19:15 • Behavior analysis of mass concrete added steel fiber. *Rubén Serrano Somolinos, Alfonso Cobo Escamilla, M. Isabel Prieto Barrio*
- 19:15 - 19:30 • Conservation of Garden Pavillion in Cerralbo museum; study and characterization of materials from decorated corbels. *Esther Moreno Fernández, Francisco González Yunta, Susana Guzmán Fernández*
- 19:30 - 19:45 • Towards a dynamic model for the urban heat island of Madrid. *Miguel Núñez Peiró, M^a Emilia Román López, Carmen Sánchez-Guevara and Fco. Javier Neila González*
- 19:45 - 20:00 • Thermal characterization of urban heat island (UHI) according to urban morphology of Madrid. *Helena López Moreno, Carmen Sánchez-Guevara, M^a Emilia Román López and Fco. Javier Neila González*
- 20:00 – 20:15 • Overview and analysis of studies on gender career barriers in the construction industry across 15 years. *Elena Navarro-Astor, Marisa Román-Onsalo and Margarita Infante-Perea*

20:15 – 20:30 Closing Ceremony  **Auditorium**

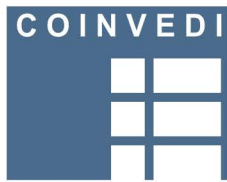


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- PI. 2** A review of current nanoproducts in construction industry for concrete. *Beatriz María Díaz-Soler, María Dolores Martínez-Aires and Mónica López-Alonso*
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- PI. 4** Project and risk management of the restoration of the church of San Martin Obispo, Callosa del Segura, Alicante. *José Ramon Fuentes Bernabeu*
- PI. 5** Photovoltaic energy in edification. *Cecilia Molina Marchand, Carlos Morón Fernández, Alfonso García García*
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- PI. 13** Energy simulation of bioclimatic strategies in vernacular architecture: solar radiation and thermal mass. Case study: El Valle (Cáceres, Spain). *Beatriz Montalbán Pozas*
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- PII. 3** Research and life cycle assessment of high performance cements. *Cristina Marieta, Fernando Mora, Puy Arruti and Iñigo León*
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HERITAGE, REFURBISHMENT AND MAINTENANCE

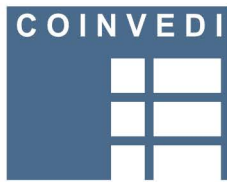
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TRANSPARENT INTEGRATION OF CONSTRUCTION WORKERS THROUGH BUSINESS PROCESS MANAGEMENT SYSTEMS AND INTERNET OF THINGS

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Keywords: *Business Process Management; construction management, construction technology*

1. Introduction – The low usage of technologies in construction companies is well known as it has been highlighted in many studies [1-3]. Common barriers for new technologies implementation on construction sites come from cultural barriers [1] like organizational inertia, resistance to change [4,5], lack of confidence on its effectiveness [5], low Technology skills [5], lack of time to learn [6], and reluctance to share information [7]. To deal with these barriers and promote the technological development, it is necessary a model to integrate construction workers in the building process through a friendly system. The novelty of the present research is the use of the Business Process Management paradigm (hereinafter BPM) [8,9] together with the use of emerging technologies as wearables, mobile devices or Internet of Things (hereinafter IoT), to get this model that enhances communication, collaboration and integration between people, process and technology. The synergy of BPM, wearables and IoT will promote the integration participants-processes through the standardization in modelling and the process automation, mitigating resistance to change due to lack of confidence, fear and adversity. Likewise, it will also provide the integration participants-technology thanks to everyday devices with intuitive and familiar interfaces. In particular we present a specific use case applied to the flooring works that aims to validate the use of the BPM strategy together with the IoT technological approach to improve the integration of people-processes-technology.

2. Methods –To carry out this use case we have used the BPMS open source platform Bonita BPM version 6.3.8 together with a SmartWatch Samsung Gear S model and a Nokia Lumia 910 Smartphone. First, it has been achieved a standardization of the flooring process from its modelling based on the BPMN standard notation. For every human task, it has been designed a multi-device interface with usability and accessibility features specifically targeted to the different profiles. And it has been automated the process execution that enables a transparent integration of the participants in the process development. The accessibility features of the prototype have been validated by the TAW tool according to WCAG guidelines of the W3C.



Figure 2. Prototype in the Smartwatch (a) and Smartphone (b)

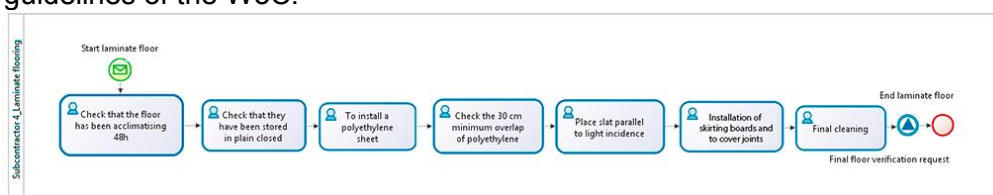


Figure 1. BPMN model of Laminate flooring processes

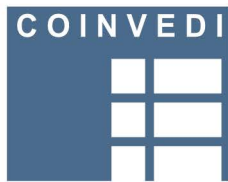
3. Results and Discussion – To validate usability features, the prototype was evaluated through questionnaires, tests and a benchmarking meeting with participants of the companies Acciona, Urbana de Exteriores, 3AG Gestión y Construcción y Aglodelta, Tecnicalia 24 and Moa, S.L. First, an individual electronic survey was done about current practices in site management, technology and availability of information. Then, they tested the prototype according to their profiles and from different devices SmartWatch, Smartphone and Tablet. The foremen profile allowed them the exploration both the global perspective of the work and a level of fine-grained detail. The same goes for workers profile from a global perspective to a level of fine-grained detail of the guided flooring process. Finally, a meeting of benchmarking was convened to discuss the prototype in terms of usability and benefits of implementation where all participants highlighted the intuitive navigation, the simplicity of the system that allows its use without preparation and training, and the high profits in efficiency and productivity of this integrated system and the availability of information in real time and from any device.

4. Conclusions – This paper is part of a broader one where is developed a comprehensive model for managing site execution. It has been done an analysis of the current state of the technological development in construction industry and the restricting factors for integration and deployment of new technologies, overcoming them by introducing the BPM approach in the construction field with the IoT technologies. This work has focused on the flooring process, for which we have implemented a prototype. First testing shows that cultural constraints can gradually being removed thanks to the transparency features, usability, flexibility and accessibility of the selected devices that facilitate the interaction of the construction participants with the flooring process.

Acknowledgments- This work was supported in part by the Vicerrectorado de Investigación, Desarrollo e Innovación, University of Alicante and by the Conselleria d'Educació, Cultura i Esport, Generalitat Valenciana. Also, the present paper has been validated thanks to the involvement of the construction companies Acciona, Urbana de Exteriores, 3AG Gestión y Construcción y Aglodelta, Tecnicalia 24 and Moa, S.L.

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A PROPOSAL FOR THE INFOGRAPHIC COMPUTERIZATION OF THE BUILDINGS BY ICT TOOLS

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Keywords: *BIM; Augmented Reality; Building management*

1. Introduction – Recent researches conducted at national level (Italy) show that the construction sector is driven by the actions on the existing building heritage [1]. In fact, the interventions on the built activate a series of favorable events that go beyond the environmental impact: reduction of energy consumption, increase of seismic capacity of the structures but also a significant growth of the economic indicators and therefore new jobs and professionalization of the affected technical figures [2].

But when you come across a work on existing building the inadequacies of the consolidated way to design and manage the works are evident.

Not trivial are the difficulties in intervening on the existing buildings heritage: the difficulties in obtaining the input data for the preparation of the projects, bureaucratic delays and the lack of reliable information on the built, complicate - or at least extend - the time of preparation of the projects, not mentioning the discrepancies that occur between the 'designed' and the 'made', that extend even further the time of finalization of the works.

In this context, it is evident the innovative capacity promoted by tools and platforms of Information and Communication Technology (ICT) which, thanks to their innovative contribution, are changing the way to work, to share information and to produce documents, representing a valuable tool at the service of technicians and designers, but also of maintenance workers and facility managers.

Their impact on modern society is deep [3] having changed drastically the way to understand the construction market and allowing the progress of the globalization which, in some ways, it is shared.

In this context, we tried the infographic digitization of the building from a case study, using on one hand the BIM intrinsic ability to build and manage a database and on the other hand the AR ability to display the same database on the spot .

2. Methods – The researches in the field of construction investment require the identification of new instruments for the management of existing buildings subjects to interventions of ordinary and extraordinary maintenance.

Based on studies and research conducted in the international arena in the field of ICT in the construction industry, a new approach is proposed to the management and maintenance of existing buildings heritage, in particular through the implementation of the design methodology of Building Information Modeling (BIM) associated with the displayed and immersive ability of the Augmented Reality (AR).

BIM is nothing more than an opportunity, a chance offered by ICT to all the players in the building industry to improve and elevate their level of productivity [4].

Its inherent ability to incorporate in its planning stages the information and specific technical property of the implemented elements, is the source for the search of an additional instrument to make this information more accessible to those who - for example - is charged with the management and maintenance of same property.

Similarly, Augmented Reality, through the ability to extend the perceived reality is the best tool for the display of this information already implemented in BIM environment but that are hard to recognize (because not directly usable in situ, or because hidden behind other constructional elements).

The proposal was created by the evident need to provide any building, both new or old built, of an accessible database and that should be clearly reading by owners, managers, maintenance engineers and technicians in order to computerize a process which by itself is already computerized but that is lacking in terms of accessibility to the input data.

The attention was set on the computerization of the building that input on input and, brick on brick, has been fabricated, enriching the model of extractable information if necessary.

The methodology adopted consist in organizing every step from the planning with a BIM approach therefore each element contains also technical information that will be displayed directly in AR through the implementation of an APP for mobile devices.

3. Results and Discussion – The summary of the research conducted is represented by an APP for smart device implemented ad hoc that is able to put in direct communication the two ICT tools used, it represents the right tool to realize the infographic digitization of the building heritage.

The result of this research is represented by the ability to manage with intelligence the essential information that you need for ordinary and extraordinary maintenance of the property being studied through a direct correlation between the Building Information Modeling and the Augmented Reality. It is possible to arrive to the interactive visualization (thanks to the Augmented Reality) of the main technical characteristics of the employed materials, implemented during the planning phases (under BIM). This visualization represents one of the functions implemented and proposed in this paper, but that can undoubtedly draw an additional path for the total infographic digitalization of the building.

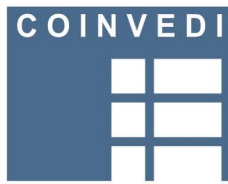
The proposal is a continuation of the main research projects conducted at national level and represented by the project Smart Energy Efficient Middleware for Public Spaces (SEEMPubS) [5] and at international level represented by Augmented Reality for Building and Construction) promoted by the VTT Technical Research Centre of Finland [6].

4. Conclusions - It shows how, moving from a concept of linear design to a circular one you can bring together all the efforts of the actors directly involved in the creation of a work of architecture, in a single database that keeps inside, all the necessary information to the 'execution - for example - of variant projects, or projects of ordinary and extraordinary maintenance, or simply for the management of the work during the entire life cycle

The idea of superimposing the Augmented Reality to that received by exploiting the advantages of the collaborative design (BIM-Based) is a great opportunity for the real estate management, extracting necessary digitized content, real and tangible, reducing the risk of mistakes that, game force, would entail further economic losses. The experience proposed is undoubtedly a good starting point but that limits the applicability to a few isolated cases.

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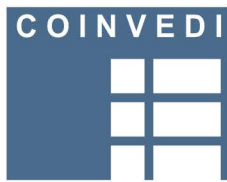


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KANSEI ENGINEERING IN THE LIGHTING DESIGN OF EMOTIONAL SPACES

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Keywords: Lighting; Kansei Engineering; Emotional spaces;

1. Introduction – Lighting conditions have been shown to have an impact on the fundamentals of human life: health, wealth, and safety [1]. These effects have an important impact in the human environment, this is why in designing a lighting scheme it is necessary to reconcile physical, physiological and psychological requirements [2]. Moreover, lighting has often been described as a subject that encompasses both art and science [3].

However, traditionally, lighting designers and architects generally project lighting intuitively, improving their designs by the method of trial and error, based only on their will or on their preferences and without paying attention of lighting research's knowledge or functional requirements, needs and preferences of the end user. Sometimes, this system becomes expensive and inefficient since all design responsibility lies in the will of designers.

Furthermore, lighting research has also been away from the world of lighting designer or user. Studies that have attempted to analyse the user's response to the lighting environment come from the field of psychology or engineering and have not been taken into account the study of lighting design parameters that could respond to user needs. Although they analyse the subjective component of the user's response to a given lighting design, they do not include his involuntary or unconscious reaction. In this sense, the Kansei Engineering [4], technique capable of translating user's emotions on specific design elements, can be of great interest. The study objective is to propose a methodology, through the use of Kansei Engineering, to evaluate and compare the emotional response of users to lighting in order to design emotional and efficient lighting spaces.

2. Methods – The methodology has been developed to achieve the proposed objective and it has been tested it in subsequent field studies. The system has been developed through the following phases:

- PHASE I: Determination of the structure of concepts used by the user to describe and evaluate a given luminous space.
- PHASE II: Establish a framework to quantify the relationships between lighting design characteristics of space and user's emotional response.
- PHASE III: Define the structure of the set of concepts or perceived attributes used by the user to describe and evaluate a lighting space. This conceptual scheme is a key element, as the link between lighting design and the final assessment of the user.

We have conducted an initial field study which has established the semantic space used by students when assessing lighting in their classroom.

3. Results and Discussion –The results show that there are significant differences in students' subjective evaluation of lighting environment. This finding shows the influence of the symbolic or functional attributes of the usefulness perceived by the student when assessing lighting in their classroom.

4. Conclusions - The contributions of this methodology, and the field study conducted until now, constitute a novelty in the field of science as they allow to:

- Identify the variables of lighting design that guarantee the design of efficient emotional spaces, depending on its use, through the establishment of subjective user's response.
- Analysis of subject's semantic space to incorporate subject's emotional impressions from the start.
- Obtain a measure of users' subjective impressions to lighting.
- Establish a protocol which serves as a guide for measuring subjective impressions in the lighting environment of learning spaces to provide information regarding the user's point of view and not just the expert's one, as it has been done so far.

In a further phase, it would be interesting to evaluate the measurement of user's psychophysiological response as a measure of his emotional, unconscious or unintentional response to different lighting scenes, both real and virtual reality. This would provide a complete measure of user's response (subjective through Kansei Engineering and objective by monitoring the subject).

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GENERAL METHODOLOGY APPLIED TO MONITORING A BUILDING TO ASSESS ITS ENERGY PERFORMANCE

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Keywords: *Monitoring; Design; Thermal Comfort*

1. Introduction – Its aim is setting a pattern about how to measure a building if we want to evaluate its thermal comfort. Analysis gets experimental results and information showed in other studies to establish a common frame applied as a standard procedure in further studies

A general pattern can be set on which measuring tasks have to be considered to evaluate in a monitoring phase (1). According to another studies and references, similar measuring tasks can be found on this kind of studies so this is not an aim of this paper. But depending if the study is focused on a stationary or dynamic performance (2), or focused on a simple material or a construction system, monitoring lapse differ on them without an apparently reason. As an example, in a paper where purpose is to get U value of a wall is not enough to take mean daily results (3), but further studies showed that decreasing monitoring lapse up to a minute (4), accuracy in the results were solved. Anyway most of them differ on accuracy goal and there is not a common frame which is an acceptable recording lapse and where to place sensors to get representative data when we study a building performance.

Also, standard regulations establish recommendations to do it, ASHRAE 55 suggest sensor placement and representative heights, according to UNE-EN ISO 7726 y EN ISO 7730. However, are not easy to meet because of operative use or real conditions in the model.

Using experimental data taken in an operative building, we apply statistical procedures based on standard recommendations and previous monitoring lapses used in other studies. In this paper a common frame applied to any kind of further studies, and representative places for the sensors, is established to analyze data and get a good accuracy.

In this case, building is in the Environmental Education Center of Pozuelo de Alarcón, nearby Madrid (Spain) (Fig. 1) uses many passive and active strategies to achieve a good thermal comfort; so it can be a good example to prove and design strategies.



Fig. 1. Frontal view of the building.

2. Methods –Spot measurements were taken during summer 2014, taking data every ten seconds and recording its mean every minute, and scope was place in study ambient temperature in indoor conditions. Monitoring systems used are Data logger OPUS 208 and k-type thermocouples sensors and the study was restricted to the classroom module (Fig. 2); part of the study was focused on the sensor that showed the highest standard deviation in an hourly period (60 data collected); results were analyzed replicating the procedure followed by

the data logger to achieve theoretical data if monitoring lapse would have been set between one and fifteen minutes (Fig. 3).

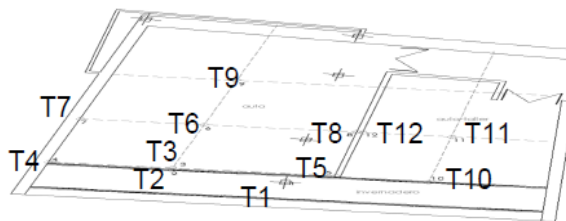


Fig. 2. Sensor placements.

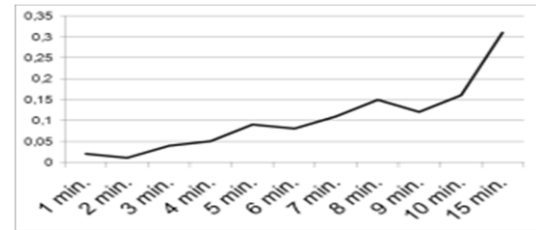


Fig. 3. Standard Deviation analysis.

Also, placement of sensors is studied to find a representative place, method used consist in compare four thermocouples placed in perimetral and central position in a room, and analyze its response to different real conditions.

Sensor placed in the center of the room (T6) is taken as the best sensor placement as mentioned in ASHRAE 55, and compared to other sensors in the perimeter of the room, all of them at the same height (1.5 m.). One of them in a vertical wall exposed to external conditions (T7), another in an interior wall exposed to solar radiation (T2) and the other one in a wall in contact with another room (T8). Analysis was made showing Pearson Coef. using whole data recorded every minute; after these results, replicating analysis using daily and hourly periods and establishing a good correlation when Pearson Coef. is higher than 0.95.

Day	Hour	Data N°	T6			T6-T7			T6-T8			T6-T2		
			Mean (°C)	Stand. Deviat.		Mean (°C)	Stand. Deviat.	Pearson Coef.	Mean (°C)	Stand. Deviat.	Pearson Coef.	Mean (°C)	Stand. Deviat.	Pearson Coef.
Week		10080	26,43	2,29		26,54	2,00	0,971	26,35	2,08	0,993	27,15	2,82	0,978
Hourly results with Pearson Coef. Data results >0.95 (%)			-			52%			68%			4%		

Fig. 4. Pearson Coef. Analysis.

3. Results and Discussion – According to Standard UNE EN-ISO 7726, data taken should have a Standard Deviation lower than 0.20, limit reached when monitoring lapse is higher than ten minutes.

As can be seen in Fig. 4, hourly results comparing data collected in the perimetral thermocouples show big differences. In case of sensor placed in the wall exposed to external conditions only 52% of hourly analysis Pearson Coef. are higher than 0.95; 68% in the wall in contact to another room and just a 4% in the case of the wall exposed to solar radiation.

4. Conclusions – Results show that recording lapse has to be between 1-10 minutes and sensor placed in a Wall in contact with another room shows acceptable data results compared to recommended but without creating great inconveniences during working hours.

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INFLUENCE OF ACCUMULATION OF SERVICE DEFORMATION CONCRETE TRUSSES EFFECT OF RIGID ENCLOSURE

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Keywords: *Active deflection, Deformation, Cracks, collected loads, Pathologies.*

1. Introduction – The objective of this work is to test the direct relationship between active deformation that are generated in the upper floors of a residential building, (fig. 1), with the elements that are in contact with the floors of the structure, is say, with the partitions.

The flexibility inherent in the use of embedded edge beams (flat) in the slab gives these, substantial value in enhancing the active deflection, this assessment has been specially considered in recent EHE-00 standards and EHE- 08,[5], these will in turn generate a discharge or transfer of existing loads on slabs,(Figure 1), by cracking of the walls (partitions and walls), originally not designed to withstand more than its own weight and staying coatings in them; trimmed, plaster, paneling, etc, generally only minor when taking into account its own weight with respect to the partition. These cracks up much of the lawsuits against the responsible professionals today

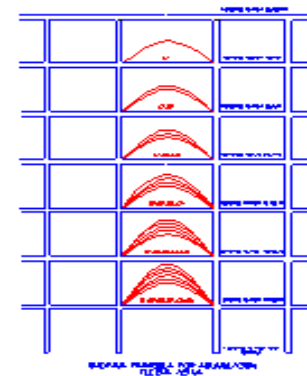


Figure 1

Shares distributed again, collecting and transporting the partition accumulate floor to floor downstream. Deformation generated in each slab are increasing floor to floor, and loads transmitted, generating pathologies of various kinds in partition, able to reach not only aesthetic otherwise ruin their functional damage. This effect can only be explained if there is degree of freedom arrow on the beam ceiling downstairs which is ultimately originating descents.

2. Methods – The methodology is based on the study of a series of test tube, made these for models of buildings, are all having in common the floor geometry being variable and the number of floors that are at height.

2.1-Determination of live loads of receiving the forged siding stoop number 14 p3-p4 beam floor of forged 6th.(figure 2),(figure 3).

Loading total enclosure including cladding is obtained by the expression:

$C = \text{weight of enclosure (kN/m}^2) + \text{weight of inner enclosure. (kN/m}^2)$

$C = (2.36 + 0.6 + 0.15) = 3.11 \text{ kN/m}^2.$

$C1 = 2/3 P \times H \Rightarrow 2/3 \quad 3.11 \times 3 = 6.16 \text{ (kN/ml)} = ct.$

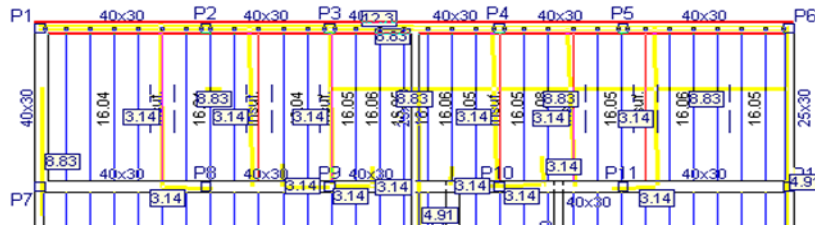


Figure 2



Figure 3

3. Results and Discussion – Once the accumulated charges, floor by floor, transmitted is observed that as accumulate loads on the upper floors on lower increased active deflection in the slab analyzed occurs, the value of the active deflection takes its maximum value in the slab occupying the lowest within the building order this usually coinciding with the open floor of the premises, and this in where the maximum values arrow active detected, with consequences that will have on the structures adjoining.(Table 1).

Number of Floor	Deformation With out loads Ct Situation1 in cm	Deformation With loads Ct situation 2 in cm	% deformation active increment situation 1-2
sixth floor	0,466	0.632	+36.60%
Comparison of active deformation between position 1 and 2			

Table 1

4. Conclusions - El The value of the active deflection undergoes a substantial increase reaching a value of 130.89% at the lower floor slab, while the assembly of each floor also increases reaching 211 %.(Table 2).

Number of Floor	Deformation With out loads Ct situation 2 in cm	Deformation With loads Ct situation 2 in cm	% deformation active increment situation 1-2
seventh floor	0.655	0.655	0,00%
sixth floor	0.429	0.528	25,00%
fifth floor	0,430	0,632	46,98%
fourth floor	0,428	0.720	68,22%
third floor	0,424	0.818	92,92%
second floor	0,466	0.874	87,55%
first floor	0,437	1,009	130,89%
Comparison of active deformation between position 1 and 2			

Table 2

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TECHNOLOGICAL AND CONCEPTUAL LEAPS ON BRIDGES: LEADING SECTOR OF TECHNOLOGICAL EXPERIMENTATION DURING THE LAST TWO CENTURIES

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Keywords: *Large Spans; History; Materials; Evolution.*

1. Introduction – Throughout the whole history of man, all constructed buildings have been conditioned by technical limitations [1]. In the nineteenth century, with the unclusion of iron in the construction field, structural layouts subjected to traction could be used for the first time in history. Before then, any building was based on compressive forces, such as structural systems like the arch, the vault and the dome, which through an intuitive adaptation to the antifunicular scheme, large spans can be constructed by using compressive forces. Centuries of experimentation have allowed us to evolve from the Roman arches (very thick) with the ability to resist many antifuniculars, to the Gothic structures (very thin) designed for a very limited set of scheme loads.

The qualitative leap enabled by new materials was introduced with arch bridges such as in Coalbrookdale Bridge (England, 1775), which reinterprets a previous structural model with the advantages of the new material [2]. Today the arch continues to be used as an efficient system for large spans, as in the case of the Chaotianmen Bridge (China, 2009), that covers 552 meters (Table 1). But this dimensional range is very small compared to other constructive solutions that exceed this structural type. In fact, the arch from 1811 has been surpassed by another structural layout, the suspension bridges [3].

Suspension bridges have evolved through advances in materials and the ways in which these materials are produced [4]. In this regard, the first suspension bridges employing chains later used bars as linear links. The bar bridge built over the valley of Sarine in Fribourg (Switzerland, 1834) managed to cover 265 meters.

But in the mid-nineteenth century, the new material, the cables, got in the lead in the dimensional aspect, and progressed rapidly throughout the nineteenth century in its internal configuration and its wire drawing process. The cables have become a vital resource for the conception of the largest bridges in the world.

Since suspension bridges got in the lead by covering a record distance of 306 meters with the bridge Wheeling (United States, 1849), there have been great strides until today, and now the Great Akashi Kaikyo Bridge (Japan, 1998) covers 1991 meters (Table 2). These dimensional ranges now are technically surmountable, as evidenced by the bridge project to the Strait of Messina (Italy), that is designed and calculated with spans of 3.3 kilometers.

In this scenario it is necessary to take into account the great impact of costs and especially the formwork. In this aspect, employing wires cable-stayed bridges (Table 3) offer an economical option. This typology doesn't reach the dimensional ranges of suspension bridges [5], but considerably reduces costs

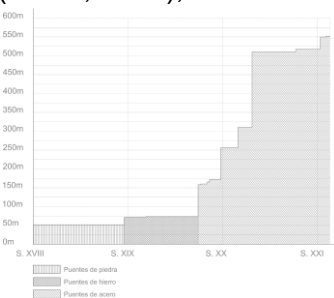


Table 1 Spans on arched bridges

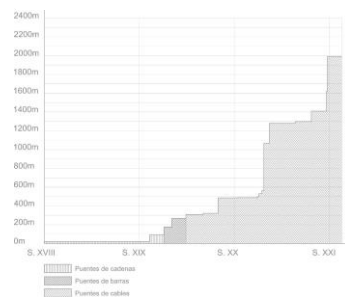


Table 2 Spans on suspension bridges

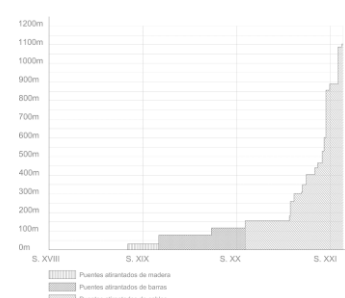


Table 3 Spans on cable-stayed bridges

by not requiring formwork. One of the most common ways to build these bridges is using successive cantilever, usually a very advantageous system.

Over the last two centuries, the bridges have been the leading reference for technology [6], they are the testing ground where limits of what's workable are plotted. This has an impact on subsequent architecture that benefits from this experimental work [7].

2. Methods – This study is the result of a long process of collecting examples of bridges built along the eighteenth, nineteenth and twentieth centuries, establishing a direct link with the advances produced, both in materials and in construction techniques. Throughout the centuries, bridges have been a reflection of the technological landscape of the moment; in this experimental field the largest spans and the limits of what can be constructed are being obtained. So a series of diagrams were elaborated to compare the dimensional limits of each technique, allowing to see the influence of certain developments and historical events in the evolutionary process of the bridges. This study lets you see which solution is best at all times when having to cover a determined span and see which options are available.

3. Results and Discussion – As a result of the study, the diagrams with the maximum reachable spans for each of the techniques explained during the last two centuries are obtained. In addition, the dimensional limit for each construction technique is also highlighted (Table 4), describing the historical overview in which we find ourselves today.

4. Conclusions – Over the last two centuries, the field of architecture moves away gradually from the technical limitations. Bridges have been a field in which there has been a greater technical experimentation. History and technology are inseparable for understanding the evolution of architectural spatiality. The technological variety now offers a wide range of options, each with particular aspects, whether related to the dimensional ranges, construction or economic conditions. The construction is conceived from a technical point of view as the election of the most appropriate choice for an specific problem. Therefore, a good understanding of the technical landscape is necessary for understanding the framework in which architectural production is performed.

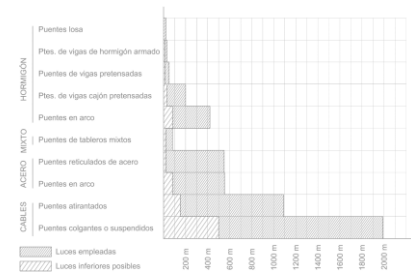


Table 4 Ranges of spans according to the typology

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USER'S DIFFERENCES IN SPATIAL UNDERSTANDING BY ARCHITECTURAL PLANS AND FIRST-PERSON INTERACTIVE VISUALIZATIONS

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Keywords: *Architectural Visualization; Virtual Reality; Spatial Understanding; User-Centered Design*

1. Introduction – Virtual Reality, and first-person interactive environments, simulate real situations through the digital generation of a user-experience similar to the real one [1]. In recent years, this technology has become a common tool applied to different areas as psychology, medicine or architectural design [2]. In the latter, it has already proved to be valuable in processes such as simulation of evacuation in emergency cases [3], assessment of wayfinding [4] or accessibility [5], and decision making during architectural design stage [6,7,8].

In this last aim, one of the main purposes consist of obtaining users' opinions and guidelines during early design phases in order to guarantee that the final solution meet their requirements and criteria, increasing their satisfaction as well as decreasing expensive and uncomfortable modifications during construction and lifespan of the building. When this task has been accomplished, users have usually had to evaluate the expected building by means of architectural plans or drawings, being all of them rough approximations of the real space that differ from it to a greater or lesser extent. Lately, this task has begun to be fulfilled by using Virtual Reality.

As the validity of the responses depends on users' spatial understanding, and lay persons may not have the ability to interpret correctly the designs shown, it seems necessary to assess how users understand it when presented in different formats. Although some studies have focused on evaluating these differences [9,10], few have done it in cognitive issues [11,12].

In this sense, the aim of this study is to contribute to the knowledge about how first-person interactive visualizations can help users to understand spaces compared with traditional ways of representation.

2. Methods – An online survey was made, asking about the interior design of a room that was previously shown.

The space chosen to be evaluated was a breastfeeding room, since it is neither a very habitual nor unusual location, balances functional and emotional requirements, and has appropriate dimensions and factors to be evaluated by users.

The space was shown in two different ways; a typical floor plan and a first-person interactive visualization working on the web browser and allowing users to navigate inside the room as if it was a computer game.

Approximately eighty people answered the survey via Personal Computer, watching fourty of them every stimulus. Most of them were parents who had ever used real breastfeeding rooms before and could express their judgements.

Questions were then asked to obtain both quantitative and qualitative information about spatial understanding. Firstly, users were asked about how easily they had understood the space shown (to acquire their perception of understanding), then some questions about spatial dimensions and number of elements in the space were made (to acquire objective data of spatial understanding and memory), lastly they were allowed to freely express any

opinion or guideline in order to improve the design (the number and detail of the responses was taken into account). This methodology, combining subjective self-assessments and tasks has been previously used during research about spatial understanding in virtual environments [12,13,14,15,16], and had to be adapted to this particular study as there are no universally validated questionnaires of spatial comprehension for built environments due to the specific nature of every environment.

3. Results and Discussion – Statistical analysis of the data gathered to date reveals some differences in user's responses according to the type of stimulus displayed. Although both groups of users self-reported the same level of spatial comprehension, responses about number of elements were statistically significant more precise in those who viewed the virtual environment (Non parametric Mann-Whitney U Test, p-value < 0.05). Additionally, some differences were found in opinions and guidelines, tending to focus in functionality for those who saw the plans and focusing in ambience for those who saw the virtual environment.

4. Conclusions – If further experiments support the results, it would expose how different ways of displaying architectural design information imply different levels of spatial understanding, leading to different levels of reliability when asking opinions and guidelines to users inexperienced in architectural design.

Virtual Reality and first-person interactive visualizations, unlike images and videos, allow people to move freely inside architectural environments, exploring and understanding them in a natural and realistic way, and can be an important option to take into account when presenting architectural designs to clients and users.

5. Acknowledgements – This research was supported by Ministerio de Economía y Competitividad. Spain (project TIN2013-45736-R).

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GWT – NEW TESTING SYSTEM FOR „IN-SITU” MEASUREMENTS OF CONCRETE WATER PERMEABILITY

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Keywords: *concrete; NDT testing; GWT; water permeability*

1. Introduction – A new European Standard (EN 12390-8), considerably change procedures used in many European countries for evaluation of concrete ability to resist water penetration under pressure. Testing methodology proposed in this standard is basing on the determination of the depth of water penetration under pressure in hardened concrete. Standard specifies procedure of applying water under controlled conditions of pressure to the surface of concrete. As an evaluation parameter the depth of penetration of the water front, which is measured after splitting the specimen, is recommended.

It is necessary to mention that current European standards do not define formal requirements concerning water permeation according to practical applications. As a result, relevant data has to be determined by designer in the technical specifications, what is not so simple because engineers are usually not enough experienced and rather expect to find such information in national standard regulations. Nevertheless, some suggestions can be found in German's national standards (DIN 1045 and DIN 1048) which were used as a base for elaboration of EN-12390-8. According to these documents it can be assumed that concrete can be evaluated as water resist if an average of the maximum depth of penetration of the water front, is not higher than 50 mm.

The most important disadvantage of such measurements is their time consuming „laboratory” character what in engineering practice excludes possibility of relatively fast and „in-situ” evaluation of the actual concrete water permeability. For those reasons in several countries wide research has been performed to find a proper solution of this problem. Among other things, **German's Water permeability Test (GWT)** seems to be one of the best concepts which were successfully implemented [1,2].

Present paper reports author's examination which were focused on the experimental verification of this testing system with respect to standard laboratory procedure specified in EN 12390-8. The testing details and procedure of evaluation of the results obtained by means of GWT have been also described. Nevertheless, the main purpose of presented tests was to find relationship between values of the „average water flux” recorded by means of GWT and maximum values of water penetration obtained according to EN 12390-8.

2. Methods – The principle of the German's Water permeation Test is to measure the amount of water penetrating the substrate under controlled pressure conditions. A pressure chamber (Fig.1) containing a watertight gasket is secured tightly to the surface by two anchored clamping pliers or by means of a suction plate. The chamber is filled with water and the filling valve is closed. The top cap of the chamber is turned until a desired water pressure is displayed on the gauge (usually 100 kPa). As water permeates into the concrete, the selected pressure is maintained by means of a micrometer gauge pushing a piston into the chamber. The piston movement compensates for the volume of penetrating into the material. The travel of the piston as a function time is used to characterize the permeation of the test surface. Usually a single test lasts about 5-10 minutes. For comparative measurements the flux „q” may be calculated from the equation:



Figure 1 View of GWT chamber during measurements

$$q = B (g_1 - g_2) / A \times t \quad [\text{mm/sec.}]$$

where:

- B – area of the micrometer pin being pressed into the chamber water (78.6 mm² for a 10 mm pin diameter)
- A – water pressure surface area (3018 mm² for the diameter of 62 mm)
- t – the time the test is performed over [sec.]
- g₁, g₂ – the micrometer gauge readings in millimetres before and after the test has been performed

3. Results and Discussion – Research program consisted of laboratory tests and „in-situ” examinations of three concrete bridges situated along the national road nr 3 in Lower Silesia, Poland, close to Wrocław. For each bridge two structural elements have been selected for testing. In total six elements were examined. Two types of concrete have been considered. Their mechanical parameters were corresponding with concrete of compressive strength representing classes C25/30 and C30/37, according to EN 206-1. Six specimens (cubes 150x150x150 mm) have been taken from each testing place and according to EN 12390-8 laboratory examinations were carried out. Simultaneously, from three to four NDT measurements of GWT in each testing place have been performed as well.

Obtained results have shown significant differences in measured values of water penetration depth recorded for particular types of tested concretes. Detailed data of these results have been presented in Table 1. Analyzing obtained results it could be found that series number **W-2** and **W-6** does not meet the requirements assumed as a water permeability criterion. It is worth of mention that for tested concretes the strength influence on the ability of concrete structure to resist water pressure was not proved. An example, for some of tested concretes similar water penetration depth has been recorded in spite of very different strength parameters. This remark particularly refers to series **W-4** and **W-3**.

CONCRETE DESCRIPTION	AVERAGE OF COMPRESSIVE STRENGTH [MPa]	AVERAGE DEPTH OF WATER PENETRATION [mm]	AVERAGE WATER FLUX [µm/sec.]
CONCRETE W-1	57.0	29	0.161
CONCRETE W-2	38.5	94 > 50	0.331
CONCRETE W-3	43.3	41	0.240
CONCRETE W-4	56.4	36	0.209
CONCRETE W-5	45.9	45	0.317
CONCRETE W-6	37.9	123 > 50	0.368

Table 1 Comparison of testing results of water permeation obtained for different types of concrete

Simultaneously, for all types of tested concretes the flux (q) has been determined as an evaluation parameter. More detailed analysis of the available testing results reveals close relationship between values of water flux determined by means of GWT measurements and the depth of water penetration obtained according to standard procedure, defined by EN 12390-8.

4. Conclusions – Examinations carried out have shown that the results of standard water permeability measurements are with the agreement of „in-situ” NDT tests performed by means of GWT system. According to analysis performed it could be assumed that concrete can be considered as water permeable if $q_m \leq 0.32 \mu\text{m/sec.}$

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HOME AUTOMATION MONITORICED BASED ON ARDUINO AND RASPBERRY

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Keywords: *Construction; Building; Home automation; Arduino*

Nowadays, most people have a clear idea of what home automation concept is. Little by little from its creation, home automation has been becoming in a common term in a world which is constantly looking for technological solution in order to satisfy our needs.

Home automation sector was thought to be a great solution to domestic problems. It could ease inhabitant's life including money saving and comfort, as well as being an energy efficiency solution [1] [2].

Despite all these advantages, home automation system's demand is not as high as expected. Its costs, people ignorance about its benefits and mainly the lack of standardisation, are all problems that the sector has to face and solve to be able to reach each and every house becoming a real solution for all the people [3].

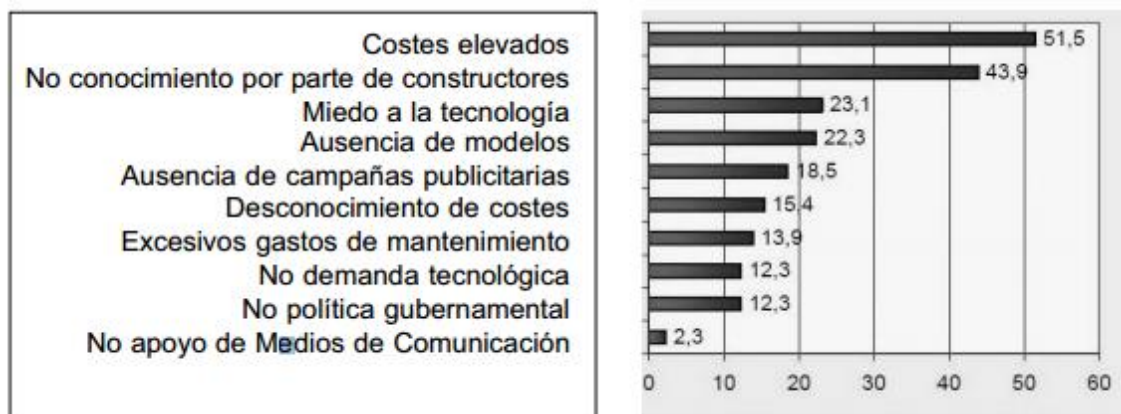


Fig. 1. Inhibiting factors at home automation

With the mind set on resolving these problems a monitoring home automation system applicable to edification has been carried out. It is based on a centralized system formed by some Arduino boards [4], Raspberry Pi [5], different types of sensors and actuators interconnected on a well-defined network to complete the system.

This system is designed in order to gather data which are captured by the sensors. That information is transmitted to the second level which is formed by Arduino boards. They interpret the information and send orders to all the actuators.

Every Sensor-Arduino-Actuator systems are regulated by a Raspberry. This element will control all Arduino boards helping them to command the best possible order. Raspberry will gather the information giving by the Arduino plaques, and will offer the user and technicians the possibility of seeing daily data.



Fig. 2. Arduino Board.

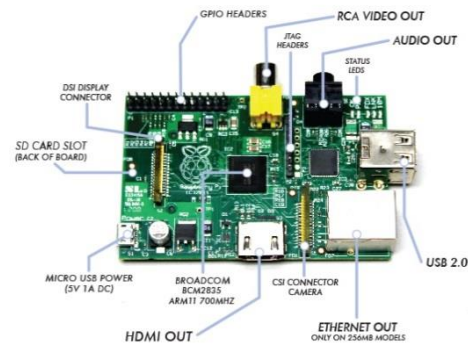


Fig. 3. Raspberry Pi Board.

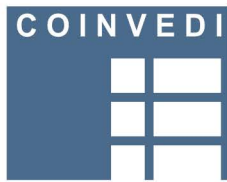
The communication between the elements of the system, or between the system and outer elements is based on wireless technology. This communication way eliminates the wiring, which is necessary in other ways. The main advantage is the lack of annoying job for the user when this system will be installed reducing its installation costs too. Furthermore, it allows future layout changes of the system and makes possible to install more elements, if they were necessary, only configuring the system by means of the Raspberry.

This system allows us to offer a cheaper solution because of its more-common components than the current ones which have specific elements depending on the system. Arduino-Raspberry pi get us a solution to standardisation problem too, thanks to its free-hardware components.

In short, Aduino-Raspberry Pi system provides the possibility of installing home automation facilities at most homes thanks to its versatility and low cost, giving users the comfort they need and being, at the same time, an efficient energy solution which saves energy and money to the user.

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GEOPHYSICAL RECOGNITION OF REINFORCED CONCRETE FOUNDATION STRUCTURES APPLYING GPR

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Keywords: *Foundations, GPR, Prospection, Rehabilitation*

1. Introduction

Evaluation of construction characteristics of foundation structures can be a difficult task when they are in charge, or when excavation or a systematic characterization is needed. In order to evaluate the characteristics, thickness and internal structure of foundations a geophysical campaign has been carried out. The objective of this survey has been to obtain the electromagnetic characteristics of foundation structures and the different signatures depending upon the construction style and the materials with different GPR antennas. Previous knowledge of the footing characteristics has permitted to evaluate the obtained data in order to be used as a quality construction control or post-building identification of the construction style.

2. Methods

The survey has been carried out through the use of 100, 250 and 500 MHz antennas to obtain different resolutions and depths along a footing structure. The use of different antennas has been focused in the evaluation of resolution depending central frequency, element size, depth, contrast and antenna penetration. The objectives of the survey, with the different equipments, have been to evaluate the availability of the identification of the internal horizontal and vertical structure, the resolution in the identification of the different units, the independent elements related to iron-rebars and their meaning compared with the known construction style and characteristics.

3. Results and Discussion

Methodological approach here applied has allowed us to know the following: a) the reinforcing bars arranged in the foundation elements, both at the upper and lower layer, and its vertical distribution; b) the foundation structure and dimensions; c) the existence of different construction phases; and d) the mechanical behavior of reinforced concrete elements of the existing foundation comparing them at a well-known situation.

4. Conclusions

Obtained data has permitted to evaluate the geophysical data in comparison with actual data and the proposal of reached penetrations and resolutions to evaluate its applicability in unknown construction styles and during post-construction characterization. Results also indicate that GPR is a suitable tool for inspection prior to building rehabilitation.

**PRELIMINARY BUILDING MATERIALS CHARACTERIZATION BY MEANS OF
INFRARED THERMOGRAPHY****Rodríguez-Abad I., Martínez-Sala R., Mené-Aparicio J., Zahonero J.**Escuela Técnica Superior de Ingeniería de Edificación
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e-mail: isrodab@upvnet.upv.es*Keywords: Building materials, density, infrared thermography, nondestructive technique*

1. Introduction – Density expresses the relationship between the amount of material and volume. In particular, when building materials are analyzed is one of the most important physical parameters. This is due to fact that density provides information of the material condition and it is closely related with other physical, mechanical and technological properties. In addition, many building materials pathologies are caused by loss of density, leading to a deterioration of the material that might cause the loss of its reliable structural behavior. Therefore, to be able to assess density and its variation is of great importance when building materials are analyzed.

Currently, densities are calculated following the standard [1]. But the onsite evaluation when the building material is part of a building structure following the standard method is complex, since it implies cores extracting. An alternative to currently available expensive and time consuming destructive tests to determine density lay on nondestructive techniques. This fact has promoted the search for other nondestructive methods that would be simpler, faster and that it can be used to investigate large surfaces in a relatively short time. In the last years, some applications of infrared thermography technique in the area of building and construction engineering are being studied and developed [2-3]. In particular, its application in the building materials characterization area is providing very promising and interesting results [4-6].

For all of these reasons, this research evaluated the potential of the infrared thermography for the onsite physical assessment of density of different building materials. For this purpose, laboratory experiments were conducted on three types of building materials: timber, concrete and stone and measurements were performed with a FLIR infrared camera.

2. Methods – Infrared thermography is a non-destructive technique that measures the temperature distribution at the surface of objects. Some properties of those objects can be detected by analyzing the temperature distribution of their surface. An infrared imaging system (an infrared camera) collects the flow of energy, infrared electromagnetic radiation, emitted by a target surface and transforms this energy initially into an electric signal and then into a digital image, called thermogram. Afterwards, with the use of specific software, the surface temperature of objects captured by the camera can be determined. In inspection terms, this type of instrument has certain advantages, since it does not inflict any damage upon the studied material. The inspection is very quick compared to other techniques, and the results are relatively easy to interpret.

Measurements were recorded with a FILR i5 camera. This camera produces thermograms at a resolution of 80 x 80 pixels with an accuracy of 0.1°C (NETD) and then these images were exported to Excel format to be processed. The experiment was conducted on three batches of materials: timber, concrete and stone. Every batch consisted of different samples that had different density.

Prior to images recording, all samples were heated in an oven for 72 h. After that, the samples were cooled for ambient temperature for 1 h and a thermogram was acquired at seven occasions: at minutes 1, 5, 10, 20, 30, 45 and 60 (Figure 1).

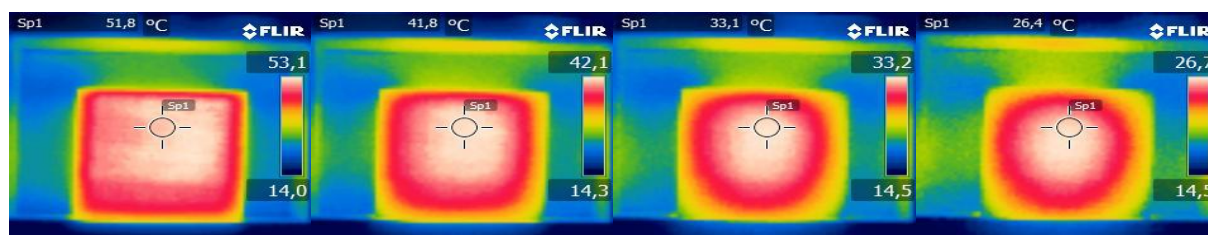


Figure 1 Thermograms acquired after cooling for 1, 10, 30 and 60 minutes a timber sample

3. Results and conclusions – The average temperature registered during cooling for every sample was calculated. After that, the average temperature for every sample was fitted with cooling time. As it can be observed in Table 1 as an example of the general behavior, the variation in the excess of temperature were found to follow an exponential function, regardless of the material under study (timber, concrete or stone) with a high correlation coefficient (R^2). This is in agreement with the concept of a regular thermal regime.

Type of stone	GOLDEN SHELL	AMARILLO FÓSIL	ALMORQUÍ	TEAK SAND	NIWALA	ARCOIRIS
Density (kg/m ³)	1738,2	2048,8	2060,9	2074,7	2105,0	2114,9
Function	85,0e ^{-0,070x}	87,6e ^{-0,071x}	85,1e ^{-0,070x}	75,503e ^{-0,076x}	81,8e ^{-0,070x}	79,4e ^{-0,071x}
R ²	97%	99%	98%	99%	98%	99%
Δ T (°C)	78,38	80,8	79,34	83,6	81,9	80,73

Table 2 Temperature behaviour versus cooling time for 6 types of stones of different densities

In addition, the total difference of the temperature of the sample was observed to decrease with increasing density. This phenomenon was observed in timber and concrete samples, but not in stone samples. We consider this was due to the laboratory experiment design. Due to the small density and porosity difference of stone samples, it would have been necessary to perform the test with bigger dimension samples.

As conclusions, it can be stated that the results of this survey show that infrared thermography is a non-destructive technique with capability to characterize materials commonly used as building materials; such as stone, wood and concrete.

We found that the cooling process of these three materials, tested by means of a Flir camera, may be described in great approximation by functions of time which are exponential decreasing. These cooling curves could be very useful to detect hidden defects but further research is needed in order to know in what extent and manner different anomalies have effect on these curves.

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BUILDING INFORMATION MODELLING (BIM) AND UNMANNED AERIAL VEHICLE (UAV) TECHNOLOGIES IN INFRASTRUCTURE PROJECT MANAGEMENT

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Keywords: *Construction; BIM; UAV; Records*

1. Introduction – Building Information Modelling (BIM) technology is already part of the construction industry and is considered by professionals as very useful tool in all phases of a construction project. The UK government has decided that all major construction projects in the public sector must use BIM technology by 2016. The drivers for the adoption of BIM are the reduction of asset costs and achievement of greater operational efficiency, the facilitation of greater efficiency and effectiveness of construction supply chains, and the provision of assistance in the creation of a forward-thinking sector on which growth ambitions can base upon [1]. The use of BIM has also been applied in China's construction industry and the government has promoted the development of standards so that the related industrial chains in the construction industry could share the application of BIM. The Chinese Ministry of Science and Technology has included BIM in the Outline of the National Long-Term Science and Technology Development Plan (2006-2020) and, additionally, the Ministry of Housing and Urban-Rural Construction revised the construction standards to develop five BIM related standards [2].

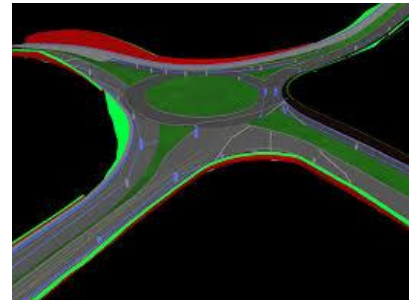


Figure 1: Example of a road BIM 3D illustration

BIM technology is generally used in combination with Geographical Information Systems (GIS) and satellite data during different construction phases. However, this has various disadvantages. Satellite images tend to have lower resolution than the desired accuracy, they may have observation gaps due to atmospheric phenomena such as cloud cover, and also have limited coverage over a certain area due to its orbit around the Earth. Additionally, ground imagery can be discontinuous and time-consuming to collect, thus inhibiting rapid assessments of damage [3]. However, targeted remote sensing via conventional manned aerial platforms can become very difficult to use because of its high cost or inaccessible due to logistic and human constraints [4].

Unmanned Aerial Vehicles (UAV) may be used to support the above need in construction industry. UAVs were initially developed and used for military applications, but as a result of the recent availability of highly accurate and low-cost Global Positioning Systems (GPS), a UAV system's position in a global reference system is nearly everywhere in the world and in real-time [5]. UAVs have undergone significant advances in equipment capabilities and now have the capacity to acquire high resolution imagery from many angles in a cost effective, efficient manner and by using photogrammetry someone can determine characteristics such as distances, angles, areas, volumes, elevations, object sizes, and object shape within overlapping images [3].



Figure 2: The Department's UAV used for the data collection

BIM technology, with the particularly useful 3D illustrations which it provides, can be used to monitor and manage the progress of works effectively and efficiently through the entire lifetime

of the project. BIM technology can provide 4D visualization (3D + time) of the construction programme and construction process, a fact that can be extremely valuable tool for all the parties involved in a construction project. UAV technology can be added to this tool in order to provide more accurate, efficient and possibly automated results. It would be extremely useful to all project participants if UAV use in conjunction with BIM technology, could achieve automated 4D visualization of the works progress. However, there are several technological and practical challenges encountered in this development which must be considered.

2. Methods – The combined use of BIM and UAV technologies is expected to achieve efficient and accurate as-built data collection and illustration of the works progress during an infrastructure construction project in order to achieve effective project management. The methodology used is as follows:

1. Collection of data by using a high resolution camera integrated on a UAV.
2. Generation of data (distances, angles, areas, volumes).
3. Analysis of the collected data for the generation of 3D visual illustration of the works progress by using BIM technology.
4. Direct comparison between the theoretical programmes of works and the 3D illustrations.

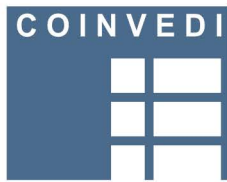
3. Results and Discussion – The methodology described is expected to gather efficiently continuous visual records of the site conditions and 3D (or 4D) visualisation of the works progress. Such data will enable project managers to achieve more effective project management and easily illustrate the actual progress of the works. To date, in a particular study site (construction site), ground control points (GCPs) have been specified and a number of data samples have been collected. The data have been collected using the GNSS Leica Viva+ sensor with an accuracy of less than 2 cm (in 3 dimensions). These GCPs points were used to establish a GCP network in order to correct and geo-reference the images obtained from the UAVs flights. The process of the data analysis collection has commenced and will be used to achieve the 3D illustrations. It is anticipated that by the end of October, 2015, the first 3D images will be produced with the use of the collected data.

4. Conclusions – BIM technology is an integral part of the construction industry and it is considered as very useful in all phases of a construction project. Its ability to give clear and dynamic visualisation and illustration of the works progress can play a vital role in effective project management. UAV technology has also been used in the construction industry for the efficient execution of various tasks.

An integrated use of BIM and UAV technologies may well comprise an alternative process that will enable an efficient and accurate as-built data collection, illustration of the works progress during an infrastructure construction project and ultimately effective project management.

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STUDY ON THE DEVELOPMENT AND IMPLEMENTATION OF BIM TECHNOLOGIES IN SPANISH UNIVERSITIES

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Keywords: *News technologies; BIM; Teaching; Facility Management*

1. Introduction – Although the use of BIM (Building Information Modelling) methodology is gradually paving its way among university professionals and students, it is still not widespread in Spain. It is agreed that BIM is a future trend, but it already exists in many countries. The best way to integrate this technology into the professional world is its implementation in the new university programmes through the Degrees issued from applying the Bologna Plan.

In the same way that CAD systems inevitably evolved from classrooms to the world of work, the development of new innovative university degrees and the gradual adaptation of the existing ones, in close connection with the existing labour market and adequate support from technology companies, will require satisfactory implementation of BIM models [1]. Hence, knowledge on these type of platforms to develop architectural and engineering projects shall grow into an asset that will be part of the university profile of new graduates and shall gradually prevail in professional careers.

2. Methods – The aim of this research is to study the implementation of BIM technology in different countries where its development has grown exponentially in recent years [3], showing results that have greatly improved current society, in contrast to Spain where its introduction at university is practically non-existent. The existing needs on BIM technologies and the training level required will be attained by means of surveys on BIM training.

3. Results and Discussion – Studies carried out in different countries show the benefits of using BIM in the design, development and construction of projects [2]. In the Spanish construction sector there is no efficient coordination between the different parties involved in the project design, construction and management, causing many problems during and after the project. The methodologies used cannot address the current requirements of an increasingly demanding and competitive market, especially concerning time and deadlines. More than half of BIM users in Spain are self-taught as there is much interest in this type of technology but which has not been addressed at university level. All those self-taught agree on the need of organised courses to complete, improve or correct their initial knowledge.

4. Conclusions - The conclusions obtained clearly demonstrate that it is necessary to develop BIM technologies at university level up to their application in professional practice [5]. Surveys show that most users or future users of BIM prefer classroom or classroom & on-line training rather than exclusively on-line training [4]. Therefore, the implementation of BIM technology in Spanish universities is a necessary and inevitable subject.

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INFLUENCE OF THE POSITION OF THE INSULATION WITHIN THE CONSTRUCTION IN ROOFING RETROFITTING IN MADRID

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Keywords: *Roofing insulation, experimental research.*

1. Introduction

Buildings are responsible for 40% [1] of final energy consumption at European level, representing the greatest potential savings (75%). The biggest challenge for Europe in relation to the building is retrofitting the existing buildings stock [2]. Residential buildings account for 75% of the stock of buildings in the European Union, with more than 40% built before the 60s, when the codes of energy efficiency in construction were very limited. Given this scenario it is necessary to characterize the optimal solutions for optimal buildings energy retrofitting [3].

The hypothesis of this investigation is that the energy performance of “inverted roofing versus traditional roofing”, with identical values of thermal transmittance and therefore similarly theoretical behaviour, in practice, varies considerably due to the thermal insulation in inverted roofing is not protected from water.

The objective of this work is to demonstrate the hypothesis using comparative research solutions of inverted roof and traditional roof.

2. Methods

The research is conducted by comparing the experimental and theoretical behaviour of three roofing solutions.

Reference roofing 0.72 W/m ² k	Traditional roofing 0.22 W/m ² k.	Inverted roofing 0.21 W/m ² k.

Experimental evaluation method: The roofing solutions are built in three spaces called experimental cells 3m x 3m x 3m, where 5 of its 6 faces are adiabatic, built specifically to test the characterization of roofing solutions.

The experimental plan has two main objectives:

- Analyse the use of the indoor climate system.
- Analyse the heat flow and its evolution as it passes through each of the layers that make up the solutions proposed for roofing retrofitting.

The range of the mentioned data collection is established every minute and the measurement period is from 16 December 2014 to 17 February 2015

Theoretical energy assessment method: The selected parameters to compare performance are reduction in energy demand and reduction in energy consumption, by means of simulations with DesignBuilder Program.



Image 1. Experimental cells.

3. Results and Discussion

For comparison of results specific days with different weather conditions are selected, getting the results for each day. As an example results of January 18th, 2015 are shown, it was an especially cold day: minimum temperatures of 0 degrees, it was cloudy day with not much incident solar radiation, without precipitation. (Table 1)

	Exterior T.	Inner T.	In.surfT.	Out surf. T.	Gradient	Cons. (Wh)	Cons.Reduct. (%)
Reference roofing	Maximum 3.0	24.1	22.7	7.1	15.6	2772.00	-
	Minimum 0.0	23.9	22.7	2.6	20.1		
Inverted roofing	Maximum 3.0	23.0	23.7	7.0	16.7	2746.00	0.9
	Minimum 0.0	24.1	24.3	-1.2	25.5		
Traditional roofing	Maximum 3.0	23.6	21.9	10.5	11.4	2480.00	10.5
	Minimum 0.0	21.6	20.7	4.4	16.3		

Table 1. Comparison of results. January 18th 2015

It is obtained from the preceding analysis that the greatest reduction in consumption occurs in the traditional roof, reaching a higher value of 18.4% in January 15th; it was a rainy day with mild temperatures. In the other cases studied consumption reductions are lower, but yet 10.5% on January 18th when temperatures were cooler and 6.1% on February 8th when solar radiation was higher.

The inverted roofing reaches its greatest reduction, 4.3%, on February 8th, when there was high solar radiation.

It is noted that, having similar inner surface temperatures, the outer surface temperature is always higher in the traditional roofing, being temperature gradient lower; heat flux penetrates the following layers with more difficulty. The traditional roofing heat loss is lower than the other two roofing in the comparison.

The different temperature swings that occur between the various layers of the roof can be observed from data collected from temperature sensors. In the case of the reference roofing all temperatures are homogeneous, since there is no insulation to break the heat flow. In the inverted roofing the higher temperature gradient between sensors is positioned where isolation is observed. In traditional roofing the temperature swings is higher than either of the other two cases, since the insulation performs better.

3.1 Results of the energy simulations

Energy simulations were performed in order to quantify the reduction of energy demand of each roofing solution. Table 2 gathers the reduction of energy demand obtained from energy simulations.

	Demand (kWh)		Demand (kWh/m ²)		Annual demand (kWh/m ²)	Demand reduction (%)		Annual demand reduction (%)
	Heat.	Cool.	Heat.	Cool.		Heat.	Cool.	
BASE	165.87	83.84	36.86	18.63	55.49	-	-	-
TRADICIONAL	89.30	51.22	19.84	11.38	31.23	46.16	38.91	43.73
INVERTED	90.33	51.11	20.07	11.36	31.43	45.54	39.04	43.36

Table 2. Energy demand reduction obtained from simulations in DesignBuilder Program

Analysing the results we observed a significant reduction occurs in energy demand. In the case of heating the reduction obtained is 45% and in cooling the reduction is around 40%. It is noted that reducing demands for both solutions, traditional and inverted, are similar. In the case of annual demand we obtain reductions of 43% for the two proposed solutions.

4. Conclusions

Consumption is lower in the traditional roofing during all the period analysed, so this is the one with best insulation performance.

The traditional roofing energy savings in consumption are higher when the weather is rainy and the temperatures are milder. The insulation is operating optimally because the waterproofing layer is protecting it so it does not get cold due to the effect of the rain. Under the same conditions, however, the inverted roofing consumption has the greatest increase.

The inverted roofing performance better when the solar radiation is higher, obtaining the maximum consumption savings of 4.3%.

The traditional roofing performs worse in days of high solar radiation, obtaining small savings in energy consumption.

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PROPERTIES OF HYDRATED LIME MORTARS WITH POZZOLANS

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Keywords: *hydrated lime (CL90s); pozzolan; repair mortar*

1. Introduction – The use of hydrated lime (air lime- European designation CL90s) as a binder in mortars involves well-known issues such as slow hardening by carbonation, high drying shrinkage and low mechanical strength however, it offers many benefits such as physical and chemical compatibility with historic masonry, high workability and water retention and, consequently, ease of application and long-lasting plasticity that allow masons to re-work mortars and reset masonry units. Furthermore, lime has good environmental credentials which are based on a lower production energy than cement and the reabsorption of associated CO₂ emissions. In early civilizations, pozzolans such as ceramic dust and volcanic materials were used to enhance the properties of lime mortars and concrete, and many structures remain as a testament to their durability [1]. Nowadays, pozzolans such as rice husk ash (RHA) and Ground Granulated Blastfurnace Slag (GGBS) are added to Portland cement and lime to improve the properties of composites. This paper contributes to understanding the properties of lime mortars with pozzolans by measuring the mechanical and hygric properties of CL90s mortars incorporating GGBS and RHA. Previous authors state that pozzolans enhance the properties of hydrated lime mortars. They report improved mechanical strength, low water permeability, good cohesion between binders and aggregates and a greater durability. Vejmelková et al. [2] concluded that replacement of air lime by 20% metakaolin results in three- to five-fold increase in strength, 25% decrease in water vapour diffusion, 20% decrease in water absorption and improvement of freeze/thaw resistance. Strength enhancement was also confirmed by Arizzi and Cultrone [3], who concluded that the addition of 20% metakaolin greatly improved mechanical performance. Corinaldesi [4] studied brick powder as aggregate replacement in hydraulic lime mortars and concluded that, if finely ground, this strongly improves mortar-brick bond strength; while if roughly ground, it enhances vapour permeability and capillary absorption. Walker and Pavia [5, 6] investigated the reactivity of pozzolans and their impact on the properties of hydrated lime pastes. They concluded that, out of 9 pozzolans, GGBS and RHA were the most reactive due to their high amorphousness; and that GGBS and metakaolin produced the highest strength followed by the high-silica pozzolans. The addition to RHA to cement was reported to increase compressive and flexural strength [7], reduce permeability [8], and enhance durability and resistance to chemical attack [9].

2. Methods – The compressive and flexural strength were measured at 56 days according to EN 1015-11. The flexural test was performed on 40x40x160 mm mortar prisms using a Zwick testing machine at rates of loading of 1mm/min. Compression tests were carried out on the half prisms using a loading rate of 1 mm/min. The porosity and bulk density was tested at 56 days according to RILEM 1980. The water absorption was measured according to UNE [10] and capillary suction according to EN 1925. The mortar microstructure was analyzed with a Scanning Electron Microscope (SEM).

3. Results and Discussion – As shown in Table 1, the replacement of lime by GGBS or RHA enhances strength- which increased with rising replacement level. GGBS mortars achieved higher strength than RHA mortars at all replacement levels. The 30%GGBS mortar achieved the highest strengths, over 6 times the compressive strength of the control mortar and nearly 4 times its flexural strength. Followed by the 30%RHA mortar which recorded approximately 3 folds increase in F_c and 65% increase in F_f compared to the control mortar. This was expected as GGBS is not a true pozzolan but contains clinkers that quickly hydrate

leading to an early strength development. These results are consistent with former authors reporting that GGBS (and metakaolin) pozzolans produced lime pastes with the highest strength, followed by high-silica pozzolans (RHA) with a 68% reduction [5, 6]. These results were confirmed with SEM: Fig1a shows the typical open microstructure of an air lime mortar with clusters of carbonated lime and abundant pores. Fig 1 b/c show evidence of pozzolanic activity in the RHA and GGBS mortars whereby a dense and compact structure is created by the pozzolanic hydrates.

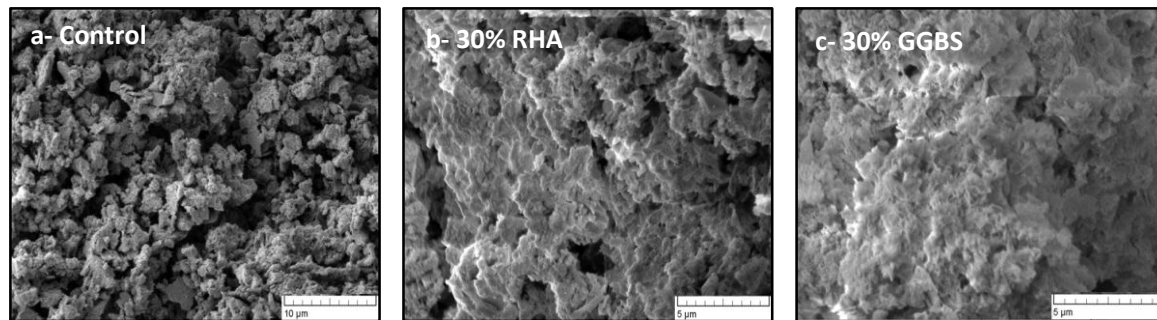


Fig 1. SEM photographs showing the microstructure of the lime and lime-pozzolan mortars after 3 months of curing.

The hygric properties agree with the strength and SEM results: as shown in Table 1, replacing CL90s with GGBS/RHA lowers porosity and water absorption: a 17 and 22% decrease (respectively) was noted for the 30% GGBS mortar when compared to the control. This agrees with Griffin, who reported that addition of GGBS to hydrated lime mortars decreased porosity by c.25%. As seen with SEM, the formation of pozzolanic hydrates results in a more compact and dense structure. According to previous authors, pozzolanic hydrates provide small gel pores and block larger capillary-active pores, resulting in a finer pore structure that lowers porosity and enhances durability [11]. Furthermore, the addition of GGBS/or RHA lowers capillary suction, this is probably due to pozzolanic hydrates blocking pores.

Table 1. Mechanical and hygric properties of lime/pozzolan mortars. F_c- compressive strength; F_f-flexural strength; P-open porosity; W-water absorption; S-capillary suction.

	F _c (Mpa)	F _f (Mpa)	P (%)	W (%)	S (kg/m ² .min ^{0.5})
Control (CL90s)	2.48	0.41	32.36	20.4	2.49
10%GGBS	4.94	0.69	32.88	20.52	2.25
20%GGBS	12.33	1.27	31.96	19.48	1.89
30%GGBS	14.87	1.48	26.83	15.86	1.04
10%RHA	3.53	0.44	31.49	18.98	2.65
20%RHA	6.29	0.57	30.74	18.69	2.37
30%RHA	10.18	0.68	30.32	18.01	2.14

4. Conclusion - The results evidenced that GGBS and RHA can be used as CL90s replacement (up to 30%) in mortars to enhance strength and lower moisture transfer.

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MECHANICAL AND PHYSICAL PROPERTIES OF TWO VOLCANIC TUFFS USED IN TRADITIONAL CANARY CONSTRUCTIONS

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Keywords: Tuff; Masonry; Canary Islands Heritage; Degradation

1. Introduction –The volcanic stones, especially basalts, phonolites and tuffs, are the most common materials used in traditional buildings in the Canary Islands [1-2].

Masonries and decorative elements of façades were commonly made of this soft type of stones. However, in the last decade, the pathologic processes related to their degradation have become evident. The elimination of the render that preserves these stones from exposition to climatic agents is the main reason of such damages. This situation has caused the deterioration of a great number of buildings of Gran Canarias historical heritage (Figure 1). Hence, it is crucial to search for a solution to repair these constructions to guarantee their integrity. Regarding this matter, the analysis and characterization of the materials is essential to evaluate them and decide about the best options to preserve them. We are currently doing a research work on these stone materials, on this particular paper we are going to focus on the mechanical and physical properties of two types of volcanic tuffs.



Figure 1 Materials degradation at Colón's house in Vegueta.

The tuff quarries and outcrops had been largely studied from a geological and engineering properties point of view, focusing on mechanical and physical properties and statistics [3-4], as well as on their chemical [5-6] and mineralogical analysis [7-8]. Despite their importance in the Canary Islands' heritage, no researches have been published relating the properties of those materials with their use in construction. Therefore, the main objective of this research is to study two types of volcanic tuffs used in Gran Canarias building construction. These are a white-dark tuff used in the Vegueta-Triana area (Las Palmas) since the 15th century named "Perojo" and a brown tuff used in San Francisco (Telde) since the 14-15th century named "Telde". Both of them were obtained from masonries of buildings currently in restoration.

2. Methods – Specimens were prepared by cutting the original samples to 400x150x150 mm to test flexural strength, while 100x100x100 mm samples were cut to compression strength test. Shore tests were performed with the original stones. In all cases, tests have been performed following European standards. Physical tests have been focused on finding out the hydric behaviour of stones: water absorption coefficient and water desorption, water absorption by capillarity, bulk density and open porosity have been obtained. All of these tests were performed following European standards.

3. Results and Discussion – As expected, mechanical strength of tuffs is limited in comparison to other volcanic stones or to other common building materials. Furthermore, compression strength values have proven to be about 5 to 8 times higher than flexural strength. This is the main reason to these stones being used massively in constructions as elements subjected to compression solicitations. In addition, results in Table 1 show that their compressive strength is similar to other traditional materials such as, lime mortars with about 5-7 MPa. Comparing both samples, “Perojo” tuff has 22% less compression strength than “Telde”. Regarding the bending strength, differences go up to 76%, and the lower strength is shown by “Perojo”. The reason of such performance is its high porosity and the grade of matrix alteration observed by microscopic analysis. Concerning the physical tests, the lightness of the tuffs is remarkable compared to other common building materials. Whereas “Perojo” has a 20% lower bulk density than “Telde”. Furthermore there is a low strength but high porosity. “Perojo” shows an open porosity which is 63% higher than “Telde”, while water absorption is 39%. Once again, results explain the level of degradation of these stones in façades, especially when a restauration is performed and the stone is exposed to the weathering. The alteration of the matrix is very obvious in the case of a Telde tuff. Moreover, its huge capillarity absorption explains the reasons why damages become critic when stones surfaces are horizontally in contact. Both porosity and pore size determine degradation caused by salts.

Sample	Compression strength (MPa)	Flexural strength MPa)	Shore C hardness	Bulk density (g/cm ³)	Porosity (%)	Water absorption (%)	Water absorption-capillarity 24 h (g/cm ² s ^{1/2})
Telde	6.75	1.22	68	1.58	22.64	15.41	484,36
Perojo	5.54	0.69	52	1.32	36.06	21.57	18382,81

Table 1. Mechanical and physical properties of the tuff stones

Apart from the absorption process, as mentioned by several authors, the desorption process is the base for a better knowledge of the pore structure. In this case, the gain of weight when samples are immersed in water, takes place in less than 24 hours while drying needed several days. This effect can be a problem in wet climates because of its effect on the humidity of the stones and their susceptibility to degradation.

3. Conclusions - It was concluded that mechanical strength and physical performance are the reasons for this type of stones mainly used in massive constructions. The degradation of the matrix, determined by microscopic observation, explains the low mechanical strength and the high porosity. This behaviour should be highlighted in these types of tuffs, given that their volume of matrix is higher than the occupied by the grains. Their exposition to the weathering increases the effect of their porosity and endangers the mechanical stability of masonries.

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EFFECT OF PCMS SWITCH TEMPERATURES FOR BUILDINGS IN MEDITERANEAN CLIMATES

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Keywords: *PCM, Energy Conservation, Low Energy Building, Passive Building*

1. Introduction – To attenuate or lessen indoor temperature fluctuations or shift the peak energy demand (ideally few hours), the thermal mass of buildings can be used to store energy. Nevertheless, the requirements of a thermally massive building often conflict with cost or aesthetics that require buildings to be increasingly lightweight. Incorporating phase change materials (PCMs) into buildings is a way to artificially increase the thermal mass [1]. To store the same quantity of energy, a smaller amount of material is required for latent storage. For example, a common building material, such as concrete can store about 1 kJ/kg when subject to a temperature increase of 1°C, whereas a PCM, such as calcium chloride hexahydrate can store/release up to 193 kJ/kg on complete phase transition [2]. This huge increase of thermal storage capacity for PCMs and their almost isothermal discharge could be used to stabilize ambient temperatures inside buildings. Currently, the available commercial micro-encapsulated PCMs are made with paraffin waxes embedded within small polymer spheres of about 10-20 μm in diameter. When in powder form, PCMs can be mixed directly into the building material or internal wallboard. The main advantage of setting a PCM in wallboards and incorporating it into the internal side of the external envelope of a building is to have a large surface in contact with the indoor air. With this work, our aim is to see how PCMs can reduce thermal loads in real buildings and how they can decrease fluctuation of indoor temperature to improve summer thermal comfort.

2. Methods – The case study involves a typical residential single-family house with an area of approximately 104 m² area.

Two windows are located in the north and south walls and the window-wall ratio is 12% (see figure 1 for the sketch). The constructive system is typical of the Mediterranean countries with a relatively heavy envelope (solid concrete end-terrace roof and measonry brick walls, see table 1 for thermal characteristics of building components). PCM (when being present) of varied switch temperature between 24°C and 32°C is embedded in the wallboard of gypsum plaster of 15 mm nominal thickness. The study is carried out for the city of Djelfa, Algeria a typical Mediterranean city with a sub-continental climate: a mild-warm climate and relatively hot and dry summer.

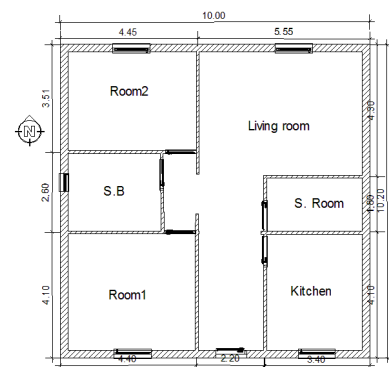


Fig 1. Sketch of the building model.

3. Results and Discussion– The year round cooling performances of a PCM are evaluated. Two very simple indicators are used. The first indicator is for a passive house (free cooling without air conditioning) with a “discomfort index” I_{sum} [3] modified by scaling it for the period): This indicator shows how long (and how much higher) the indoor temperature is above the comfort temperature, which is assumed to be 26°C (overheating). The second indicator is for an air-conditioned house and shows the primary energy demand Q_c , or the

quantity of primary energy that needs to be removed from the indoor building by an active cooling system to confine the indoor air temperature to a maximum of $T_{\text{set}}=26^{\circ}\text{C}$.

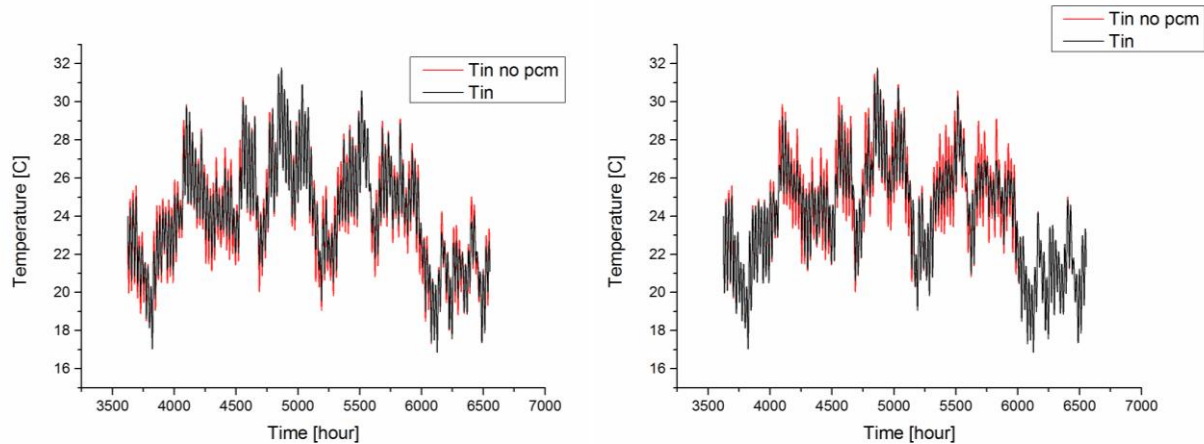


Fig 2. Evolution of the indoor temperature without and with PCM, (a) $T_m=25^{\circ}\text{C}$. and (b) $T_m=27^{\circ}\text{C}$.

Figure 2a shows the indoor temperature with a 30% PCM fraction weight and $T_m=25^{\circ}\text{C}$ and figure 2b shows $T_m=27^{\circ}\text{C}$. From those figures, we can see that for $T_m=25^{\circ}\text{C}$, the PCM performs well early in the hot season in June and in late September, but less so in the middle of the hot season (the hottest days). With $T_m=27^{\circ}\text{C}$, the PCM seems to work mainly in the middle of the hot season (July and August). The adjustment of the switch temperature permits to control of which days of the hot season are concerned by PCM action.

4. Conclusions - The PCMs are found to perform well a reduction of approximately 20% for cooling energy. This PCMs performance is realized even in mild climates characterized by low day/night temperature swings, which make night ventilation less efficient for discharging the PCM.

The PCMs have better performance on surfaces that undergo the widest temperature variation. Incorporating PCMs on the ceiling give the best compromise gain/cost and is relatively easy to realize even in existing houses. This shows their potential use for refurbishment of actual buildings which is the weak point of all energy conservation policies.

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THE EFFECTS OF MgF_2 , CaSO_4 ADDITION AND COOLING MODE ON PROPERTIES OF BELITE CEMENT

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Keywords: *Belite cement; Low carbon; Low energy cement; environmentally friendly cements;*

1. Introduction—Cement production is responsible for 3% of greenhouse gases emission in the world. It is estimated that the production of cement is responsible for 5-7% of the world CO_2 emissions [1]. The life cycle of cement shows that 95% of the CO_2 emissions occur during the production and only 5% during transportation of raw material. The energy necessary for the production of the Portland cement calculated by various authors for different mixtures is of (1674–1799 kJ/kg)[2], but in practice it is considerably greater (3100–3600 kJ/kg). The most energy demanding production stage is the clinkerisation that consumes 60% of total energy, the process of CaCO_3 calcination alone absorbs 1350 kJ/kg clinker [3].

The International Energy Agency recently proposed a global CO_2 reduction plan. For the cement industry, this plan calls for a reduction in CO_2 emissions from 2 Gt in 2007 to 1.55 Gt in 2050, while over the same period cement production is projected to increase by about 50 %. The authors of the cement industry roadmap point out that the extrapolation of existing technologies will only take us half the way towards these goals. Designing new clinkers that require less limestone is one alternative means to significantly reduce CO_2 emissions and energy as well as limestone consumption [4].

The reduction of the lime saturation factor (LSF) leads to an energy saving from 15 to 20% for an LSF of 80-85%[3] and reduces CO_2 emissions by 20- 30% [4]. This reduction promotes the formation of the belite instead of alite. A completely belite clinker is produced with a ratio $\text{CaO}/\text{SiO}_2=2$ to maximize the energy saving and greenhouse gas emissions reduction.

The belite is characterized by a slow hydration which limits its contribution to the mechanical resistance during the first 28 days.[5], [6]. To remedy this weakness numerous methods can be used, as stabilization of the most reactive forms of belite and its chemical activation. Stoichiometric C_2S has five polymorphs varieties (γ , β , α'_L , α'_H and α), stable at different temperatures [6]. The stabilization of the reactive forms of belite (α'_L and β - C_2S) is possible by very quick cooling, or by inclusion of an appropriate stabilizer. Effects of cooling rate and alkali content on the phase composition of belite cements have been studied by many authors [7]–[10] In this study the effects of two mineralization 2% MgF_2 and 1% MgF_2 + 1% CaSO_4 associated with a quick cooling on the properties of the synthesized belite cement are investigated, in order to synthesize environmentally friendly cements of very low lime saturation factor and hydraulic reactivity, compared to alite cement.

2. Methods—The chemical composition and the crystalline structure and composition of the raw materials and the produced clinkers were determined by X-ray fluorescence (PANalytical Per'X 3) and X-ray diffraction (BrukerD8; $\text{CuK}\alpha$, 2–99°2 θ , 0.017°2 θ step). The development of the clinkerization was studied on the basis of the free lime contained in the tested sample, in accordance with the standard NE-2-1-015-1984. The mineralogical composition of the various clinkers produced was determined by the method of polished section with observations on optical microscope. The belite morphology and its chemical composition were studied by the scanning electron microscope coupled with EDAX (Oxford INCA). The hydration heat and compressive strength of the synthesized clinkers was realized according to the French standards NF P15-461[11] and EN 196-1[12] respectively.

Table 1 The different produced clinkers

Designation	Type	CaO/SiO ₂	Mode of cooling	Mineralizers
A	Alite	2.9	Quick cooling	/
B	Belite	2	Slow cooling	/
B'	Belite	2	Quick cooling	/
B1	Belite	2	Quick cooling	2% MgF ₂
B2	Belite	2	Quick cooling	1% MgF ₂ + 1% CaSO ₄

3. Results and Discussion–. The results show that the sintering temperature can be reduced to 1150°C which is 300°C less than Portland cement, with an improvement of the chemical, mineralogical and structural properties of the belite, these results in a hydraulic reactivity comparable to that of ordinary Portland cements, with 28-day compressive strength of 38MPa.

The XRD patterns of synthesized clinkers present many peaks of belite phases β -C₂S and α' -C₂S. The XRD evidences show the absence of free lime (CaO) and γ -C₂S peaks. No characteristic peaks of C₃S, C₄AF or C₃A have been detected.

The belite crystals of the produced clinkers present a rounded shape and a reduced size below than 10 μ m, which should increase their hydraulic reactivity

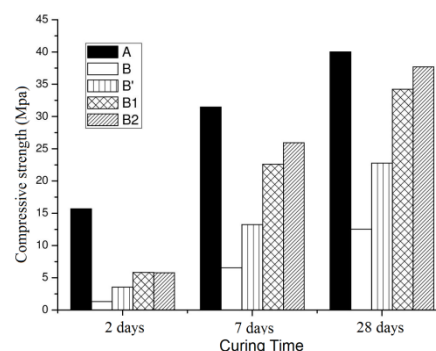


Fig 2 Compressive strength of studied cements

4. Conclusions

The production of belite cement with high hydraulic reactivity comparable to that of alite cement is possible by the association of quick cooling and an adequate mineralization MgF₂, and its association with CaSO₄. This mineralization and the low LSF of these cements makes it possible to obtain them at low burning temperatures: 1150 °C. Which is 150 °C lower than ordinary belite cement and 350 °C compared to Portland cement?

The use of mineralisers improves the crystallization of the belite phases and improves the crystal shape of the belite in addition to the stabilization of the high hydraulic forms of the belite helping them to reach compressive strengths that remain lower than that of alite cement used as reference but corresponds to that of cement Class 32.5 according to NF P 15-301 which is an ordinary Portland cement.

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ANALYSIS MEASURING TRANSMISSION LOSS IN CONCRETE SAMPLES WITH A STANDING WAVE TUBE

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Keywords: *Acoustics; Concrete; Kund's tube;*

1. Introduction – The standing wave tube may be used to determine the transmission loss of material samples using a pair of microphones by the method described in ASTM E2611-09 standard, however it does not ensure satisfactory repeatability and reproducibility to ensure control of the minimum and maximum variability of results without having conducted an interlaboratory comparison using such tests as defined in ISO 140-2 [1].

No European or international standard describes a similar methodology.

The method described in ASTM E2611-09 [2] works best for so-called “limp” materials such as flexible foam, soft rubber, or fiber samples that are typically used as barrier materials in noise control applications .

Therefore, it is known [3,4] that the impedance tube method for measuring TL should be used only to rank samples in a relative sense. The TL obtained for a given sample will not be equal to that obtained using a room method. The most significant differences between this method and the room methods is that the sound impinges on the test specimen in a perpendicular direction only, compared to the random incidence of the room methods. This study attempts to make a comparative study of the difference in results between the two methods for hard building material as concrete in search of a quantifiable correlation between the two that now is not known.

Despite the known disadvantages, it is proposed to use concrete as test material, the method described in ASTM standard E2611-09 [2]. Thus, it is intended to perform the analysis, quantification and classification of the problems encountered, the results obtained and their correlation with proven results using room methods [5]. In a first attempt to draw conclusions that provide insight necessary for the system to be employed and present data that are useful to validate or disprove this method to caution the measurement of sound insulation of concrete through the Kundt's tube.

2. Methods – This test method use a kund's tube and four microphones, at two locations on each side of the sample. Plane waves are generated in the tube using a broadband signal from a random noise source. The resulting standing wave pattern is decomposed into forward and backward traveling components by measuring sound pressure simultaneously at the four locations and examining their relative amplitude and phase. The acoustic transfer matrix is calculated from the pressure and particle velocity of the traveling waves on either side of the sample using the two load method [6,7].

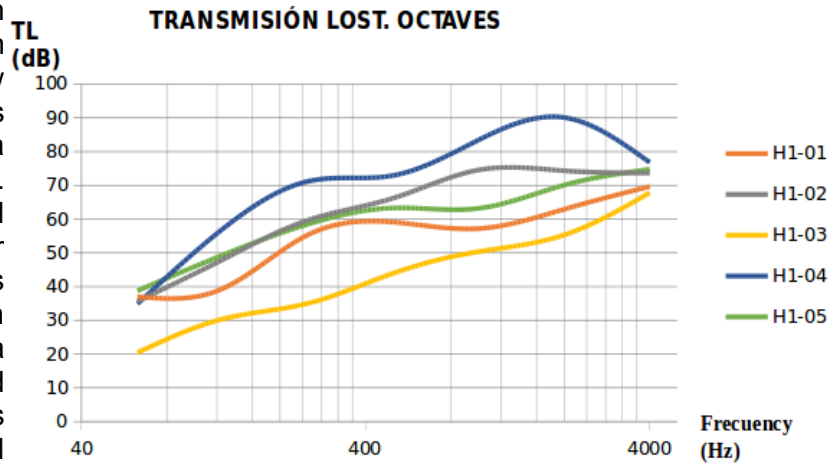
3. Results and Discussion –

The behavior of all the specimens studied follow a common pattern, the slope of the positive graphic in all cases .Both to perform the analysis in third octave as assessment in central octave band frequencies shows that transmission losses increase as the frequency is higher .

The graph shows (graph 1) the results of transmission losses represented in octave band for the reference series . The highest insulation value is reached at 2000 Hz (90 dB). The lowest

value is in the low frequencies (20 dB), the growing tendency of all curves with increasing frequency.

These results contrast with those expected when compared with the mass law and with similar results obtained in trials using a reverberation chamber. Neither the slope and growth is expected under the law predicted by mass nor is it possible to establish a correlation using a standardized room method [5] given the enormous spread of results obtained for samples of identical composition.

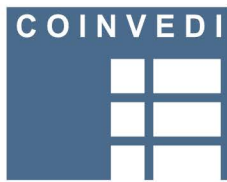


graph 1: Transmission losses represented in octave band.

4. Conclusions - The standing wave tube, in conjunction with a pair of microphones by the method described in ASTM E2611-09 standard, can not be used to determine the transmission loss of concrete samples.

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ATTACHABLE HOUSING MODULES & STRUCTURAL CORE FACILITIES BUILDING SYSTEM

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Keywords: *open system; shipping container; industrialized building; Sustainable (max. 4 keywords)*

1. Introduction – Historically, the adaptation of industrialization processes into Building industry always came second compared with other industries as textile, automotive and food & agriculture. However, the gathered experiences during the last century, enables us nowadays to deliver a finished a high-rise building in matter of weeks.

Building industry still requires industrial solutions to keep increasing its sustainability on every level. The ideas competition INVISIO (1) for the industrialization of sustainable housing set down the goals for a sustainable industrialization and this document pretends to offer a solution to achieve these goals.

The proposed building system, unlike other building systems, makes possible to take out/in a dwelling of a building, totally or partially. It means the building is adapted to the allocation and the dwelling is adapted to the user.

The specific properties of this building system have been analyzed from different points of view of each participant involved in a residential building process. Accordingly, several unique solutions had been conceived by utilizing this building system, which could affect each party involved in the building process.

The aim of the study is to increase building industry sustainability by adopting industrial open system solutions to extend the product life cycle (2), enabling the user to adapt his home to his different life stages driven by money, space needs and/or location and offering to the real estate developers a system to reduce 70% of construction costs.

2. Methods – With the gathered experience with Viviedas (3), it was decided to follow a new approach by using a different housing module to avoid geometrical constraints. Several qualitative studies had been made to check the hypothetic viability of the proposed building system:

A comparison of technical performance between slab & columns systems, piled-up 3D modules systems and the proposed one, attachable housing modules & structural core facilities system.

A state of the art research about existing housing modules, taking into account its structural geometry, mobility, connectivity, worldwide implantation and reusability.

A research for additional functions of the remaining empty spaces (4) in between modules inside the building.

An analysis from different points of view of each participant involved in a residential building process to detect situations in which modules & core building system meet their needing better than other building systems.

A holistic analysis has been run through a digital model to fulfill the requirements of the spanish Building Code (5).

Search for strategies to avoid a possible social reticence of living in a box/industrial building. Additive manufacturing processes still in development has been explored as 3D concrete printing.

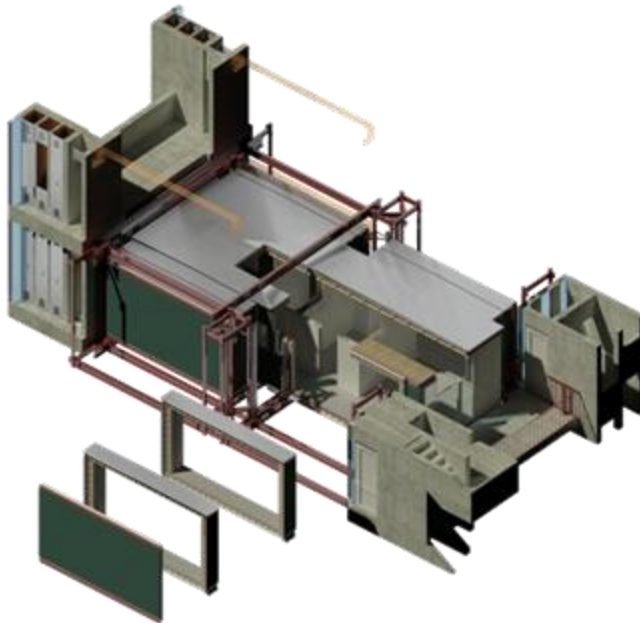


Figure 1 Viviedas project visualization

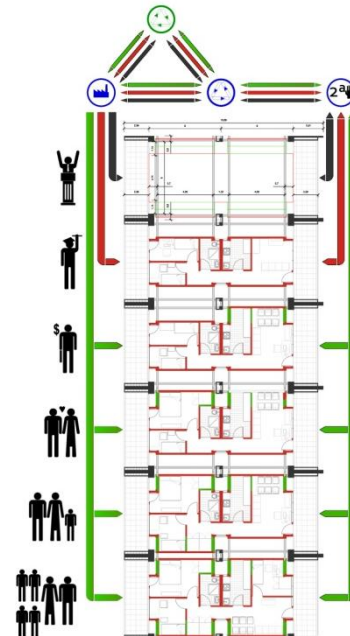


Figure 2 Viviedas project life cycle

3. Results and Discussion – As a result of the independent slabs of every dwelling, highest acoustic standards (5) by nullifying impact noise could be met.

The dimensions for the module have been defined as a high-cube 20 feet shipping container (6.058/2.438/2.896 mm).

Empty spaces have been converted in multifunction spaces by using different plug-ins to occupy this space. Extension, interconnection and energy saving active/passive systems can be integrated.

Compatibility parameters between module and building have been defined.

3. Conclusions – The necessary technical conditions to start using this building system already exists nowadays, never the less recent technologies as 3D printing could help for social acceptance.

As the modules are either moveable or fixed product, accordingly taxes on products laws may apply.

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THERMAL PROPERTIES OF PLASTERBOARD MADE WITH LADLE FURNACE SLAG

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Keywords: *Slag; Gypsum plasterboard, Thermal resistance*

1. Introduction – This work aims to investigate the incorporation of ladle furnace slag in gypsum plasterboard with the purpose to obtain recycled construction materials. Several samples were prepared by replacing the aggregate with different amounts of waste to obtain new plaster materials. It was found that the presence of powder waste modifies the characteristics improving thermal properties and fire resistance behaviour. Furthermore, the physical properties are enough to consider a good overall stability.

2. Materials and methods – The plaster used in this study is characterised as B1 according to European Standard EN 13279-1. The ladle furnace slag (LFS) used in this study was from a foundry producing steel bars with a real density of 3.15 g/cm³. The physical and chemical characteristics of the white LFS are shown in Table 1. As additives, sikaMix® acts as a superplasticizer that reduces the dosage of water, improving plasticity and sikaLatex® that improves surface bonding and reduces surface tension between the slag and the hemihydrate.

Table 1. Chemical composition of ladle furnace slag

Chemical composition	CaO	SiO ₂	Al ₂ O ₃	MgO	Others
Values (%)	56	17	11	10	6

3. Specimen preparation – The gypsum and the corresponding LFS waste were mixed as dry products (Table 2), after which the water was added and mixing was at first by hand and then by machine, according EN 520:2005+A1. The moulds were evenly filled and any excess was wiped away, to accelerate the drying process. Subsequently, it was introduced into an oven at a temperature of (40±2) °C and held there for 24 hours. A sufficient number of specimens were prepared to conduct the tests, with a series of three specimens for each dosage and each test. The size of the specimens was 300 x 400 x 15 mm.

Table 2. Dosage of the plasterboard samples

Sample	slag/plaster weight relation	plaster (g)	slag (g)	water (g)	additive (% with respecting plaster)	consistency w/(s+p)
PB0	0/100	3000	0	1200	0	0.47
PBS20	20/80	2400	600	1200	0	0.40
PBS40	40/60	2100	1400	1365	0	0.39
PBS60	60/40	1500	2250	1463	0	0.39
PBS20L	20/80	2400	600	1200	0.8	0.40
PBS40L	40/60	2100	1400	1365	0.8	0.39
PBS60L	60/40	1500	2250	1463	0.8	0.39

4. Results and Discussion – In order to evaluate the behavior of spatially extended samples at high temperatures, the vertical furnace shown in Figure 1, designed according to

standard ISO 1182: Non-combustibility test, was used. This device provided a cylindrical space with a 75 mm diameter and a 150 mm height where the specimen was placed. The temperature inside the furnace was measured by a thermocouple positioned at mid-height and at 10 mm from the wall. The sample had a cylindrical shape, with diameter 41 mm. When the sample was being prepared and the mixture was still fresh, a thermocouple was introduced through the symmetry axis in away that the tip of the thermocouple was located at the geometric center of the cylinder. In addition there was a third thermocouple, in contact with the surface of the specimen, diametrically opposed to the furnace thermocouple. All the thermocouples were of type K. The furnace and the surface thermocouples were protected with a stainless steel armor. Furnace temperature was increased from room temperature to 800 °C in 2 h, and then remained at 800 °C for 60 additional minutes. The temperatures on the surface and center of the sample were recorded every 10 s.



Figure 1. Non-combustibility furnace at work with a sample inside. Detail of a tested sample.

As an example in Table 3 we show the results for the tubular furnace test using a sample with PBS60 formulation. According the results obtained in this study and based on the requirements of the EN 13501-1, the test allow us to classify this material as Euroclass A2 (non-flammable, without contribution, average grade).

Table 3. Fire resistance results for the sample PBS60

Dosage	Increase in furnace temperature (°C)	Inflammation persistence (s)	Loss of mass (%)
PBS60	2.40	---	17.45

5. Conclusions - The thermal performance of these mortars is considered appropriate, including a substitution of as much as 60% of plaster by waste. The main result is that the presence of the slag improves the protection given by the material when compared with the behaviour offered by gypsum alone.

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STUDY WORKABILITY OF SELF-COMPACTING CONCRETE WITH FIBRES

Celaya Naya, Alejandro; Orna Carmona, Martín; Salesa Bordanaba, Angel

Keywords: *Self Compacting Concrete; Workability; Fibres; Research*

1. Introduction – According to EHE'08 Instruction⁽¹⁾ and EFNARC⁽²⁾, Self-Compacting Concrete is defining as a concrete that, following dosing study and using specific superplasticizers, it is compacted by the action of its own weight, without vibration energy or otherwise compacting method, presenting no segregation, coarse aggregate blocking, bleeding or slurry exudation. Consistency of SCC is higher than the class of higher consistency described in EN 206-1⁽³⁾ and can be characterized by the following properties:

- Fluency or ability to flow without outside help and fill the framework.
- Block resistance or ability to pass between the rebars.
- Static and dynamic stability or resistance to segregation, allowing it finally achieves a uniform distribution of aggregate throughout their substance.

Although the materials used for their design retained from conventional concrete, their characteristics are different and therefore also the tests for evaluating different. These properties may be assessed with assays such as *Flow Extension, Box L, Box U, V funnel, Japanese ring, Orimet, ability to test step grid tests, segregation resistance...*

Before to present the objectives, structure and develop the study of docility made, include bibliographic absence of a study of this nature, ie, bringing together a study of docility of a self-compacting concrete and well targeted using fibres to vary this property. However, it has been found references from different universities and individuals on the study of the mechanical properties of conventional concrete or references about the workability study of it. The aim of this study is to summarize the concrete workability variances in a time graph by adding a specific type and amount of fibre in comparison with the Self-Compacting Concrete (SCC) control sample. The study highlights two important applications, which could be of use in the building industry:

- Given the percentage of fibres to comply with the resistance standards, what is the optimal transport time of the concrete in view of keeping its workability for its posterior use.
- Establish a maximum amount of fibres to be used to obtain the required workability.

2. Methods – Abram's cone⁽⁴⁾ was used in this study to measure and evaluate the workability and pliancy of the SCC. The methodology used would fill the cone with the SCC, avoiding chipping, allowing the concrete to expand in a circular, measuring the time "T50" in seconds, it takes to reach a diameter of 50 cm previously marked in the testing surface allowing it to continue expand, then measure the diameter "df" reached when the flow stops.

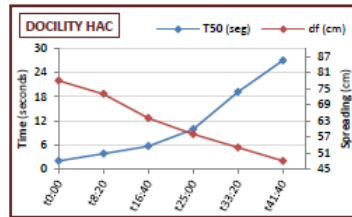
This procedure is repeated over time until it reaches a point where the SCC does not reach the established 50 cm mark or when it loses its capacity to flow, therefore losing the essential characteristics of the test.

Similarly, following the operational methodology used to study the control SCC different types and amounts of fibres have been incorporated into the concrete at the end of its mixture, ultimately studying the data variability.

- Corrugated steel fibre: 0.5%, 1.0%, 1.5%, 2.0%, 2.5%
- Polypropylene fibre: 0.1%, 0.2%, 0.3%, 0.4%, 0.5%
- Glass fibre: 0.1%, 0.2%, 0.3%, 0.4%, 0.5%

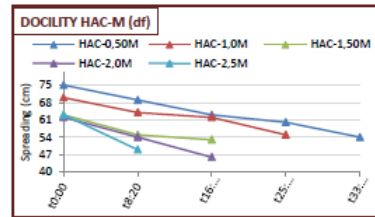
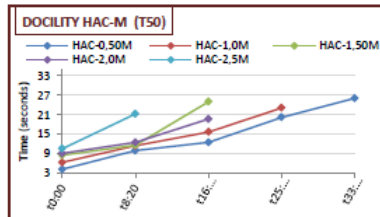
3. Results and Discussions – This tables and graphs that are formed by several tests show the study results.

Self-Compacting Concrete Docility

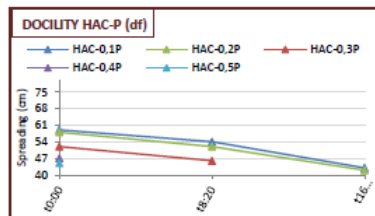
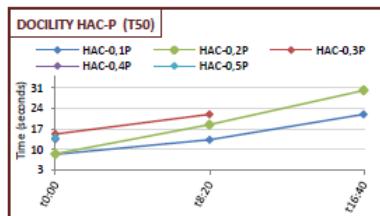


Components	% Vol. Concrete	Quantity (kg)
Gravel	29%	4.587
Sand	43%	6.839
Filler	3%	0.497
Cement	16%	2.580
Superplasticizers	1.20%	0.040
Water	8.7%	1.390

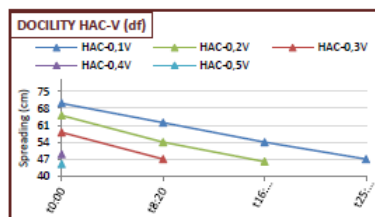
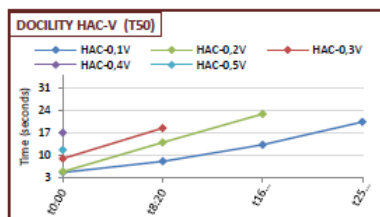
Self-Compacting Concrete Docility with Steel Fibre



Self-Compacting Concrete Docility with Polypropylene Fibre



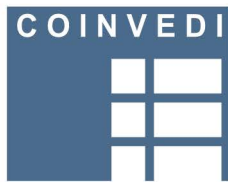
Self-Compacting Concrete Docility with Glass Fibre



4. Conclusions - The results show differences with each type of fibres and also with the SCC control, including the following characteristics:

- The maximum resting time of the SCC control is about 22 minutes before adding a liquefying agent to improve its workability and comply with the EHE'08 regulations.
- The metal fibre in low amounts does not significantly modify the fluency however, when it exceeds 2,0% of the volume of concrete losing its workability and the mixture cohesion.
- The polypropylene fibre concrete significantly reduces the flowing capability, acquiring a plasticity with volume amounts greater than 0.4% of the concrete preventing the mixture from flowing.
- The glass fibre concrete behaves similarly to polypropylene fibre concrete at high dosages (0.4% greater volume of concrete) however, at low dosages, the flow ability is not reduced as with the polypropylene fibre.

Also a comparison was made between compressive resistance of each of test samples, taking into account the different variables: variation in fibre type, amount of fibre added in a percentage and the sample's elapsed time of the number of lifts performed with the Abram's cone before filling. In conclusion, the metal fibre does not significantly increase the compressive resistance, but minimizes the risk of damage/breakage making it more ductile. Polypropylene and glass fibres significantly reduce the ability to resist compressive stresses in concrete avoiding the concrete mass from cracking.



III International Congress on Construction and Building Research

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Universidad Politécnica de Madrid
Avda. de Juan de Herrera 6, 28040 Madrid, Spain

14th - 16th of December 2015

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SUSTAINABLE CONSTRUCTION SYSTEM USING VEGETABLE FIBRE BLOCKS. PRACTICAL WORKSHOPS ON THE CONSTRUCTION SYSTEM AIMED AT UNIVERSITY STUDENTS AS AN ACTIVE LEARNING METHOD

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Keywords: *Construction; Building; Sustainability; Teaching*

1. Introduction – Silvia Cenzano Gutiérrez and Marta Revuelta Aramburu are the developers of the Universidad Alfonso X el Sabio's research project entitled "Research and Teaching of Traditional and Sustainable Construction Systems for Building Compartmentalisation and Building Envelope", and they aim to: improve the sustainable construction system by using building vegetable fibre blocks, commonly referred to as straw bales; to promote and disseminate both the advantages and qualities of this system; and to improve the quality of teaching and enhance student learning through a number of practical workshops that will result in the construction of a shelter on campus at the University.



Figure 1. Example of straw-bale construction of load-bearing wall. [1]

One of the main objectives of the Project at hand is to add to the improvement of teaching quality by promoting hands-on student learning. To this aim a series of practical workshops addressed to Architecture, Building Engineering and Civil Engineering undergraduates have been organised. The activities include project drafting and specific workshops on self building a straw-bale shelter on campus at the University.

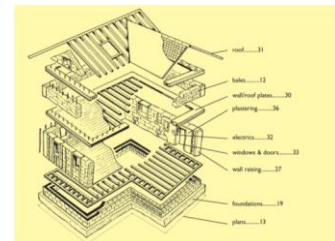


Figure 2. Detail of straw-bale construction of load-bearing wall [2]

2. Methods – The teaching staff providing these workshops includes professionals in various fields of activity, among them the sustainable building experts architect Iñaki Alonso and architect technologist Mónica Cebada, who will take part in setting up the selection panel for project proposals, provide technical assistance and teach some of the workshops.

To date, students have attended the following practical workshops:

1. Lecture given by Silvia Cenzano on drafting straw-bale projects and determinants of construction systems.
2. Setting up the marking panel for project proposals, made up of research project members. Selection of the project proposal to be carried out and built.
3. Workshop on health and safety study, included in the adaptation course to the degree in Civil Engineering, specialising in Hydrology.
4. Several workshops on the drafting of an execution project done together with fourth-year Building Engineering students:
 - a. Drawing up estimates
 - b. Safe work procedures
 - c. Green roofs
 - d. Covering the walls with natural plastering
5. Workshops on construction staking for earthworks.
6. Workshops on building sustainable foundations using recycled tyres: theoretical lectures and practical workshops.
7. Workshop on the reception of timber with PEFC certification and protection treatment.
8. Testing the suitability of soils for plastering.
9. Workshops on foundations.
10. Workshops on the construction of timber horizontal framework.
11. Workshops on colonisation of green roof plants.



Figure 3 Detail of workshop.



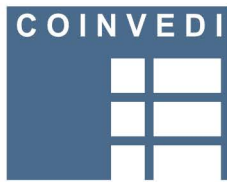
Figure 4. Workshop framework.

3. Results and Discussion – This is an experimental study that aims to obtain information on the effects of implementing a hands-on learning system to improve learning. A number of surveys will be carried out to gather the information and the academic results will then be analysed.

4. Conclusions – The research Project is currently underway, with several of its stages already completed: bibliographical reviewing of the fields of knowledge dissemination and of straw-bale construction systems, the above-mentioned building workshops, several publications in various media... The project will continue during the academic year 2015-2016.

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**ARCHITECTURE FOR CHILDREN: SUSTAINABILITY OF DESIGN, MATERIALS AND
CONSTRUCTION OF BUILDINGS FOR SCHOOLS IN MADRID**

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Keywords: *Sustainable Construction Systems; Schools*

1. Introduction

The design and construction of schools for young children in Europe is a key issue for many reasons [1]. For women professional to be able to work as Civil engineers or Architects, having a career and being a mother would not be a reality until we have enough of such schools. The decreasing numbers of population in Europe show its urgent necessity. So, why students of architecture and engineering would not be interested in participating and establishing the best criteria for doing it? [2]

As established by Chiapparelli [3], cognitive process and emotional development are essential in earlier education and important later. So, research should collaborate to find "structures", understanding this word in its widest and holistic meaning, that can help families with the growth and the education of their children, that can minimally supply the absence of the parents, maintaining as much as possible the interaction between parents and children, and giving special attention to the child in his cognitive process and emotional development.

The research presented in this paper is about how to develop a modern, sustainable and critical approach, for design and construction of schools for young children based on experience on the materials and systems used to build those in Madrid (Spain). Previous research work [4] does not compare buildings with teaching methodologies [5], nor extend and compare those experiences within Europe or does not use a sustainability approach, which will be presented in this paper. Our proposal is that suitability of building construction techniques should consider a wider approach.

2. Methods, Results and Discussion

The focus of the research presented in this paper has been directed essentially towards materials that can be seen, the finishes of the building, as they are the one's that should need renovation more frequently, more available for the methodology used for it. When studying bibliography of previous work, done in Spain and Italy, most criteria to evaluate the suitability of finishing materials, both in the facades and in inner spaces, are related basically to costs, using cheaper-to-build materials with higher maintenance costs or materials that need more initial expenses but with better durability, and taking into consideration the use and "preset" functional requirements of the spaces they are located. But some buildings present project or construction problems related to the lack of confrontation or discussion between architects and future users of the school spaces. So, methodology used for this research is based on comparative analysis of a selected sample of private and public schools built in the last years in Madrid, followed by a series of visits and interviews to the people responsible for everyday maintenance of each school.

Analyzing some constructions works done in recently built schools in Madrid, other facts may arise and the need of comparing buildings requirements with teaching methodologies clearly appears, as many of those are not connected with lack of maintenance or decay. Related to

finishing materials, reasons to change them may be very different as, for instance, in the modification of the facade of the E.I. Reggio. As explained to us, the main reason to change those of the main facade was to achieve an “image” of the school according to its teaching methodology and the construction costs were also significantly different from a conventional procedure: the parents, supervised by specialists, were participating in painting it with several colours.



Table 1 Schools Visited and types of spaces

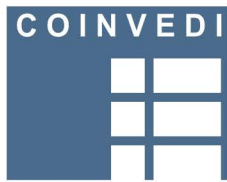
3. Conclusions

Comparative analysis of results and establishing those criteria was part of this study and the first step for a “Thesis di Laurea” proposal, on a site located in Madrid. The project consists on the realization of a “structure”, appropriate to reach the target of the child interaction and socialization and based on the use of logic-interactive of the location through a functional division of the spaces [6].

We explain some preliminary results of our research, for discussion and comments with other researchers, to find the basis for a deeper study to minimize the construction costs of, what we think, is a “non holistic” evaluation method applied to new school constructions in Madrid.

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LIFE CYCLE ASSESSMENT OF NATURAL AND RECYCLED MASONRY MORTARS

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Keywords: *Construction and demolition waste; Recycled aggregate; Life cycle assessment; Masonry mortar*

1. Introduction – The life cycle assessment (LCA) is a methodological tool to measure the environmental impact of a product, process or system throughout its life cycle. It is based on the collection and evaluation of the inputs, outputs and the potential of a system of product to produce environmental impacts through their life cycle [1,2].

LCA has already been applied to the environmental impact assessment of construction and demolition waste (C&DW), both in the production of recycled aggregate [3] and the application of these aggregates in the manufacture of concrete [4,5] or for the formation of base and sub-base of roads [6]. Simion et al. [3] concluded that the production of recycled aggregates generates less environmental impact than natural aggregate processing, with up to 7 times less global warming potential. Knoeri et al. [4] found in their study that the environmental impact of recycled concrete reduced up to 70% compared to conventional concrete. Similar results have been obtained by Mroueh et al. [6], since the use of crushed concrete decreased environmental loads of road construction.

This research aims to quantify and assess the environmental impact associated with the manufacture of masonry mortar made of different replacement of fine natural aggregate (FNA) by fine recycled aggregate (FRA). These mortars have been previously characterized [7] according to the specifications of the reference standard for masonry mortar EN 998-2 [8].

2. Methods – According to ISO 14040-14044 [1,2], the LCA application is based on four stages: defining the goal and scope, analyzing the inventory, assessing the impact and interpreting the results. The goal of this study is to determine the environmental impact associated with the production of masonry mortars made with different replacement of FNA by RFA. This goal determines the system boundaries: the LCA includes production and transport of aggregates, cement, filler and plasticizer, and manufacture of dry mortar in mortar plant. The considered functional unit is 1 ton of dry mortar. Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs for each unit process of the product system. As data source were used direct measures, Environmental Product Declaration and Ecoinvent database. Environmental impact was assessed through SimaPro software tool and Impact 2002+ was the methodology applied for impact assessment. This method relates all types of life cycle inventory results via fourteen midpoint impact categories (human toxicity, respiratory effects, ionizing radiation, ozone layer depletion, photochemical oxidation, aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acidification/nitrification, aquatic acidification, aquatic eutrophication, land occupation, global warming, non-renewable energy, mineral extraction) to four damage categories (human health, ecosystem quality, climate change and resources).

3. Results and Discussion – Taking into account the production of the aggregates, the results show that the impacts generated by the production of FNA are important in terms of human health, ecosystem quality, climate change and resources. FRA production generates negative values on impact categories such as human health, ecosystem quality and resources, and positive values on climate change but it is about 34% of the impacts

generated by the production of FNA. These negatives values mean environmental benefits due to the avoided loads of the recovered materials, as the avoided impact by C&DW recycling is higher than the generated impact by the processing of FNA.

On the other hand, the cement production is for both natural and recycled mortar the largest contributor to all impact categories. According to others authors [5] this is due to the high CO₂ emission during the calcination process in the clinker production. The 25% replacement of FNA by FRA in masonry mortar causes benefits for most of the impact categories, specially the value of land occupation is reduced 38% respect to natural mortar.

4. Conclusions – In this study, a LCA approach was used in order to quantify the environmental impacts of manufactured masonry mortars with FNA and FRA. The comparison between evaluated mortars shows that total impacts of recycled mortar are lower than total impacts of natural mortar because of avoided landfilling of C&DW. Therefore, the use of FRA involves not only environmental benefits increasing recycling rates that reduce the volume of waste disposed in landfills, but it can generate economic benefits seeking new applications that expand the recycling market of these materials.

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MECHANICAL BEHAVIOUR OF TIMBER REINFORCED WITH FRP UNDER COMPRESSION

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Keywords: *sawn timber, composite materials, compression*

1. Introduction – This experimental work analyses the behaviour of sawn timber pieces strengthened with fibre-reinforced polymers tested under compression parallel to the grain. The specimen dimensions are 158x158mm cross-section by 300mm length. The aim of this study is to compare both the strength and strain of the specimens reinforced and non-reinforced. Basalt and carbon fibres have been applied and compared. Wood is natural material traditionally used in construction industry performing different functions like structural elements, claddings, partitions, etc. Timber has excellent mechanical properties in relation with its weight. Its compression strength varies significantly depending on the direction of the fibres. The compression strength perpendicular to the grain approximately is one quarter of that parallel to it (1). The constitutive model widely admitted assume a lineal-elastic behaviour under tension up to failure, and elastic-plastic under compression (2,4). Composite materials applied as a reinforcement of timber structural element are being currently studied as an alternative and optimum option (3,4,5).



Fig. 1: Compression test of a non-reinforced specimen.

2. Materials and testing method – An experimental work has been performed, consisting of eighteen prismatic pieces of scots pine timber. The mean dimensions of the specimens were 158 by 158mm of cross section, and 300mm length. Two different fabrics were used to reinforce the pieces: 300 g/m² carbon fibre and 280g/m² basalt fibre (Table 1). Epoxi resin was used both to make up the composite material and adhere to the timber. Specimens were tested under simple compression obtaining load and displacement values (Table 2).

Type of fiber	Carbon	Basalt	Basalt
Grammage (g/m ²)	300	280	600
Thickness (mm)	0.111	0.103	0.206
Tensile strength (N/mm ²)	3,400	2,100	2,100
Modulus of elasticity(kN/mm ²)	230	105	105

Table 1. Fabrics characteristics

Reinforcement	Fmax (kN)	ΔFmax(%)	δ (mm)
SR C	591,73	-	3,02
FB280	1.363,93	130,50	2,67
FB600	1.377,08	132,72	2,58
FC300	1.151,72	94,64	3,33

Table 2. Maximum loads and displacement values obtained in the compression tests

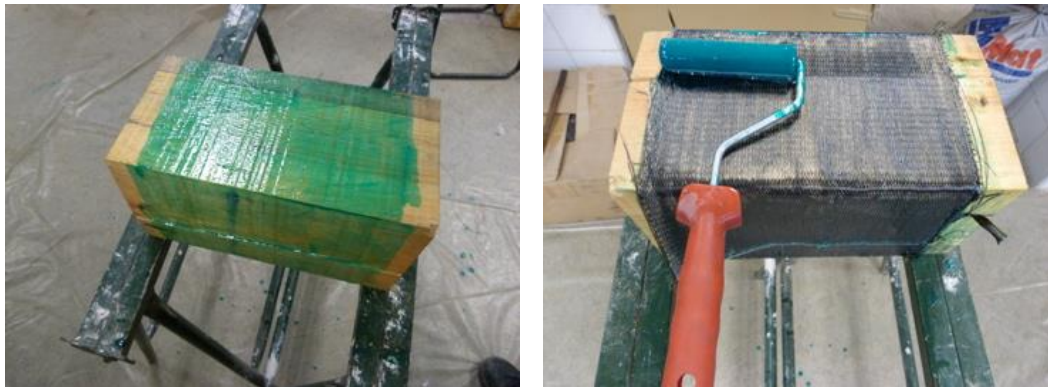


Fig. 2. Reinforcement process. First and termination layer of resin matrix before and after applying the fabric

3. Results – The higher load is reached by the pieces reinforced with basalt-fabric reinforcements, both FB280 and FB600. As it is shown in the table 2, the maximum load increase of the samples reinforced with basalt fabric is approximately 130% in both 280 and 600g/m² grammage. The increase of the maximum load of those reinforced with carbon fabrics is approximately 40% lower. Regarding the displacements, carbon-fabric reinforcement performed bigger displacements than those of basalt-fabric. Figure 3 shows the load-displacement diagrams, where FB280 and FB600 have higher rigidity than FC300.

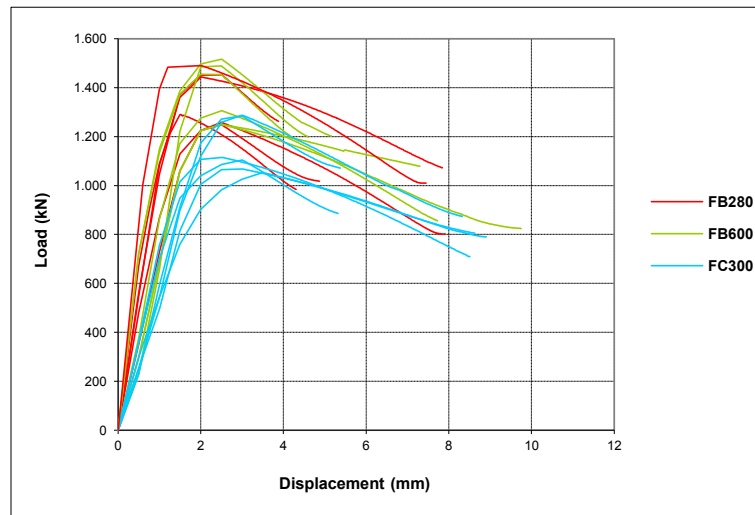


Fig.3. Load-displacement diagrams

4. Conclusions – Carbon and basalt composites increase the maximum load significantly as reinforcement of timber pieces under compression. Comparing the increase of the maximum load of reinforced specimens to those non-reinforced, basalt reinforcements increase is 40% higher than carbon. Basalt FRP obtained better results than carbon FRP, regarding both strength and stiffness.

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WASTE TO RESOURCES

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Keywords: *Resources, Recycling, Building waste, Building retrofitting works*

1. Introduction – According to the document called "Energy efficiency in building rehabilitation" published by the Gas Natural Fenosa Foundation, buildings are responsible for 40% of the energy consumption in the European Union. In Spain this percentage is lower (27.7%) because the weather conditions are in general better than in central and northern Europe. However, in order to reduce the problem the Spanish Government has developed numerous legal regulations by transposing Directive 2002/91/EC [1], as for example the Royal Decree 314/2006 [2] --which includes the Technical Building Code Regulation (CTE) [3]--, the Energy Savings Framework Document [4], and more recently, the Royal Decree of Energy Certification (RD 235/2013) [5]. This RD requires the building/apartment owners to have an energy performance certificate before selling or renting. All these regulations, are promoting new possibilities in the building market regarding energy efficiency systems, elements or materials. However, these new possibilities are still emerging. In this context, many research projects have been developed over the last five years [6], [7], [8] suggesting solutions to improve energy efficiency in buildings. Also, the research group TEMA from the School of Building (UPM) is working on this topic together with the University of Seville, University of Burgos and the University of Zaragoza, developing a research project called "Waste to resources (W2R)". This project differs from others as its main objective is to reduce to almost zero the Construction and Demolition Waste (CDW) generated in building rehabilitation works. In order to achieve this objective, the group is looking for new ways of CDW recycling as raw materials for new conglomerate materials. With these new materials, construction elements reducing building energy consumption will be proposed. In this paper the results obtained in the first phase of the project are presented.

2. Methods – Previous studies on the subject were analyzed and different case studies were proposed. These case studies will be used to apply the project results. Moreover, the most commonly used construction solutions in Spain used to improve buildings' energy efficiency were studied. In addition, information about good practices for CDW management were thoroughly analysed, and several good practices for the building retrofitting works were selected by a panel of experts using the Delphi method [9].

3. Results and Discussion – From the literature review it was seen that the majority of the projects accessed used building models to obtain their results. However, W2R project considers --for the case studies-- the most common building solutions used in conventional construction. These building solutions are understood as the combination of different layers of materials. Moreover, several technical sheets have been developed showing the different damages and lacks of the building envelope, considering the following aspects: insufficient insulation; poor sound insulation; insufficient tightness or waterproof; no vapour barrier; insufficient ventilation in air chambers; and insufficient stability of the material. However, particular attention was paid to the techniques solving the thermal insulation, as the rest of lacks of the envelope affect only the health, functionality and/or the building appearance. Finally, best practices for improving CDW management were collected from regional manuals, guidelines and scientific literature, and were further analysed according to their viability and efficiency in building retrofitting works.

4. Conclusions - There are many research studies focusing on building energy efficiency. These research studies mainly consider building preliminary stages in order to select parameters to determine the building models or case studies --were the solutions proposed and developed within the project are applied--. There are projects that select models of buildings, but these buildings do not respond to all the selected parameters. Also, there are projects that instead of studying building models, they study building envelope solutions. However, despite these projects study a wider range of cases, not all the possible options are analysed. This project tries to cover the largest number of cases and tries to give solutions to a greater range of solutions for improving energy efficiency in buildings, also specifying, for such solutions, best practices to achieve CDW management in order to achieve zero waste building retrofitting works.

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“STRUCTURA, THE SELF-SUPPORTING FACE BRICK FAÇADE TO COMPLY WITH THE NEW CTE DB HE (TECHNICAL BUILDING CODE BASIC DOCUMENT FOR ENERGY SAVING) REQUIREMENTS”

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Keywords: brick; self-supporting; thermal insulation

1. Introduction

The self-supporting face brick façade is the result of long and deep reflection on the different solutions designed for brick facades throughout history; promoted by Hispalys's Face Brick Department, in close collaboration with the Technical Department at Geohidrol S.A., leading company in the research, manufacture and marketing of masonry façade solutions. When all the different solutions for face masonry envelopes are analysed, taking the Technical Building Code's requirements into account, self-supporting facades prove to be the optimal solution owing to their extraordinary simplicity of construction, outstanding mechanical strength and functional advantages, and low additional resource costs.

The main innovation of the STRUCTURA self-supporting façade is to use brick walls as their own load-bearing elements, avoiding typical construction difficulties in traditional confined facades - built between slabs -, thus improving the envelope's hydrothermal behaviour considerably and eliminating the problems that confining envelopes between structural elements can bring.

With no thermal bridges in slab edges or pillars thanks to continuous insulation over the building's structure, the STRUCTURA self-supporting façade appears as the best face brick envelope solution to comply with the requirements of the latest Basic Document on Energy Saving of the Technical Building Code (CTE DB HE), published in September 2013.

2. STRUCTURA: Self-supporting face brick facades

The STRUCTURA façade's main characteristic is that the outer skin of the envelope is built tangent to the building, thus allowing a continuous air cavity (ventilated or not) to cover the whole façade and thermal insulation to be placed in front of the building structure.

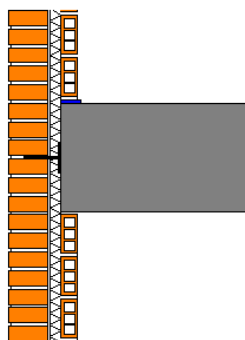


Figure 1.-STRUCTURA self-supporting façade

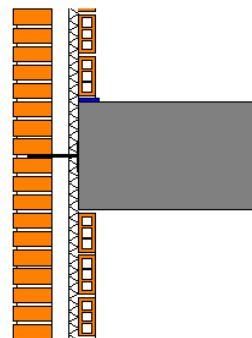


Figure 2.-STRUCTURA self-supporting ventilated façade

Limited between two slabs, traditional double-skin façades encounter an important problem with thermal bridges, which occur on slab edges owing to the lack of thermal insulation in these areas. Further requirements from the new DB HE mean that energy losses caused by these thermal bridges can condition the whole building's compliance with the regulation's thermal requirements.

However, continuous thermal insulation in self-supporting façades prevents thermal bridges from appearing on both slab edges and pillars, significantly improving this kind of solution's thermal quality and reducing the risk of surface condensation in these key areas.

Therefore, the STRUCTURA façade arises as the solution to face brick envelopes which aim to comply with the new thermal requirements of the DB HE.

Self-supporting façade systems are based on exploiting the potential that brick walls can offer to be used as structural elements. In this kind of envelope, the outer skin's weight is directly transmitted to the ground by the brick's own compressive strength. Furthermore, this load accumulation increases resistance to horizontal actions. All remaining structural requirements are fulfilled by the use of brickwork restraint systems directly connected to the building's structure and bed joint reinforcements, providing stability, resistance and crack control conditions required by the standards.



Figure 3.- Bed joint reinforcements



Figure 4.- Brickwork restraint systems to pillars and slabs

Owing to the structural behaviour of self-supporting envelopes, face brick façades widen their scope of application and can be used in both residential and office buildings, with modest-sized façades, and in industrial and retail buildings, with larger envelopes.

In terms of construction, the main advantage presented by a façade's outer skin continuity lies in eliminating the problem caused by the joints between the building envelope and its structure. With this construction system, the key issue of envelope fracture when meeting slabs and pillars is avoided, eliminating the need to use cladding over slab edges and pillars or specially cut or designed pieces to adapt to the lay-out of the structure at each floor level. Likewise, vertical and horizontal perfection can be achieved regardless of any tolerance in the lay-out of the structural elements.

From an acoustic point of view, disconnecting the two skins of the self-supporting envelope improves acoustic insulating properties of these façades as compared to double-skinned confined façades, where acoustic insulation is limited by structural acoustic bridges.

STRUCTURA façades do not entail an increase in cost as compared to conventional confined façades, as overheads stemming from the use of additional resources (brickwork restraint systems and framework) are offset by labour costs and material savings.

3. Conclusion

With outstanding technical advantages and low costs, STRUCTURA self-supporting face brick façades have become highly competitive solutions to comply with the new regulations' thermal requirements.

A REVIEW OF CURRENT NANOPRODUCTS IN CONSTRUCTION INDUSTRY FOR CONCRETE

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Keywords: *Nanomaterial; applications on the market; web-databases of nanoproducts.*

1. Introduction –The development and expansion of nanotechnology in the construction industry is at an early stage compared to other sectors (1). Among the reasons justifying this situation, the lack of knowledge about what nanotechnology can offer in this field on the part of the agents involved in the construction process (2). Currently there are many nanotechnology applications, nevertheless, concrete is the material with higher potential to impact the sector (3). This review reflects the current state of these applications on the market and allows disseminating this highly relevant issue for the sector.

2. Methods –Identifying the current nano-based concrete that are currently used in construction site is not an easy task, because many product manufacturers using nano sized ingredients do not refer explicitly to the nanoform (4). Besides, many companies advertise “nano” products that do not contain any nano-constituent (5). The criterion to select nanoproducts used in construction site is the reasonable identification as a nanoproduct claimed by the manufacturer or by another source. The selection has only taken into account those concretes marketed directly as nanotechnology-based products, i.e., all those nanoproducts applied after and independently from the base product, such as coatings and sealants, have been excluded. To select the nanoproducts, the authors have carried out a systematic commercial web-based search and reviewed the several web-databases of nanoproducts (6-9). In addition, the report “Nanotechnology in the European Construction Industry, state-of-the-art 2009”, has been an important reference for this paper (2).

3. Results and Discussion – The results of this review are shown in (table 1), where product type, brand, and main general advantages and specific functions are stated.

Product type and brand	Main general advantages and specific functions
Self-compacting concretes. Agilia Architectural®, Foundations®, Horizontal®, Metal® and Vertical® of Lafarge (10-14).	The range includes 5 types: - Agilia Architectural®: viewed finishes and textures, special and complex forms. - Agilia Foundations®: any foundation element. - Agilia Horizontal®: slabs and floors (even very reinforced). - Agilia Metal®: steel fibre (no mesh), for elements from 7 cm thick. - Agilia Vertical®: large-dimension walls, even with large gaps.
High initial resistance concrete Chronolia® 15H, 24H and 48H of Lafarge. (15-17)	The range includes 3 types: - Chronolia® 15H: in 15 hours, 15MPa and the circulation of vehicles are done. It can be poured in the afternoon and the formwork can be removed the next morning. - Chronolia® 24H: in 24 hours, 20 MPa and the circulation of light vehicles are done. - Chronolia® 48H: Compressive strength of 25 MPa in 48 hours and circulation of light vehicles on the following day.
Ultra-high performance self-compacting concrete Ductal-FM®, AF® and FO of Lafarge® (18-21).	- Great mechanic resistance, (partial or complete) removal of passive reinforcements. - Creation of complex shapes and extremely thin large-scale elements. - Any type of texture can be reproduced in concrete with maximum precision. - Wide range of colours with an even tone.

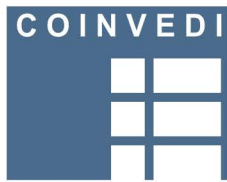
Product type and brand	Main general advantages and specific functions
	- Durability and impermeability against corrosion, abrasion and impact. The range includes 3 types: - Ductal-FM®: with metal fibres. For high performance applications. Compressive strenghts from 150 to 180 MPa and bending strength from 15 to 45 MPa. - Ductal-AF®: similar to the previous one but with an excellent resistance to fire. - Ductal-FO®: organic fibres. The aesthetics prevails over the mechanic aspect.
Antibacterial, self-cleaning and decontaminating concretes i.active Vertical® of Italcementi (22).	- Its properties are not affected by the passage of time since the photocatalyst [nano titanium dioxide] is not consumed. - Available for all different types of concrete according to its exposure and consistency.

Table 1 List of marketed concretes, mortars, cements, limes and plasters based on nanotechnology

4. Conclusions - In the present review, currently marketed concretes based on nanotechnology have been identified. According to the obtained results, nanotechnology is in the early stages of development even if it has the potential to improve technically and economically the construction sector. Finally, it is necessary to improve the communication about advantages of nanotechnology for the sector among general public (potential clients), building agents (architects, builders...) and the staff carrying on research and development activities.

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REAL CASE SCREEN WALL COLLAPSE, AND CAUSES CHECKS CARRIED

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Keywords: *Pathology, wall screen, Intervention Plans, Structural evaluation*

1. Introduction

The elaboration of the geotechnical study is the first of deficiencies. The stratigraphic cut reflected a powerful gravel of 9,40 meters and then several layers of silty clay of medium consistency grays to soft. The project will design a screen wall with embedment of 3 meters and a single row of anchors separation of 4,5 m.

The collapse or wall collapse occurred early in the morning producing the effects set forth below in Figure 1.



Figure 1 collapse of the stretch of wall screen.

The collapse scheme shown in Figure 2.

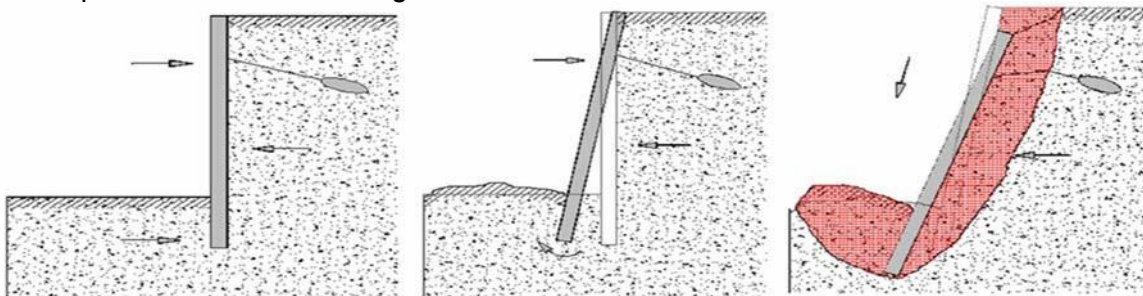


Figure 2 Mechanism collapse of the bulkhead.

2. Methodology

The methodology carried out to determine the causes of the accident is designed for two basic ways: Shortcomings of the geotechnical study and project deficiency (deficiency deficient design and calculation)

Performing an analysis using the following authors and Regulations [1] [2] [3], the number of polls (including the depth of these), should have been higher, as twice the made and the values of the parameters geotechnical values are average and optimistic. For checking calculations of the stability of the wall in its most unfavorable phase it has been manually checked by a spreadsheet program and by Cype screens. Three hypotheses have been developed to expose continuation: Hypothesis I: using the starting values, average values of

the geotechnical parameters, Hypothesis II estimate coefficients netted from Duncan [5] Hypothesis III considering a statistical study of the geotechnical parameters.

3. Results and analysis

he analysis the number of surveys conducted in the study geotechnical surveys insufficient follows four made at least once 7-8, net of regulations and applied literature. If we analyze statistically the value of cohesion with complementary surveys conducted more we find that the average value of 0.6 kPa (6 t / m²) would be reduced for the purposes of calculation to 0.26 kPa (2.62 t / m²) values thus added to the software as the manual spreadsheet jitter values turn out and therefore resizing of wall. The results checks corresponding to the three hypothesis are shown in Table 2.

Table 2 Results of testing different hypotheses

hypothesis		EVENT I	EVENT Ia	EVENT II	EVENT III	result
calculation sheet	Balance	1,67 > 1,5	1,44<1,5	0,75<1	0,58<1	inadequate
	Balance	1,13 < 2	0,9<2	0,72<1	0,67<1	inadequate
Computer program	Balance	1,77>1,5	1,44>1.5	1,03>1	0,9>0,55	inadequate
	Balance	2,12>2	1,77<2	1,09>0,54	0,9>0,45	inadequate

4. Conclusions

About the geotechnical study we can say it was inadequate and ineffective. On structural design this is incorrect in a clear way, because the excavation involves three basements, two lines of anchors in order to resolve what is usually done in similar cases and not, as has been executed, compromising significantly the stability for any actions variability or dispersion of the geotechnical parameters. The design obtained (with a single line of anchors) is excessively sensitive to any variation or undetected deficiency. The latter is supported by the experience and in this case that the embedding of the screen is limited.

On stability checks have to say that excessive optimism calculations favored by the favorable effect of considered ground-wall friction running with thixotropic sludge should be $\delta = 0$, and for passive pressure should not exceed the Φ value / 3 lar considered impermeable clays when the ground should not rule out the possible connection between aquifers because lenses of sand with the subsequent increase in hydrostatic pressure, especially that the calculation is markedly optimistic, considering average values and should be a criterion specialist with the probe corresponding to fractile 95% higher and a characteristic value corresponding to 5% fractile lower characteristic value. Or alternatively use estimates as Duncan or statistics that are recommended by the experts, the junction produced in the collapse of the containment structure.

To dismantle the wall dig the ground to the height of the last cellar, creating a sealed enclosure by piling.

The land disturbance caused by the collapse originated a new foundation design by driven piles, and the new basement retaining wall was performed using traditional techniques of formwork from a Piling.

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USE OF BRYOPHYTES IN THE BUILDING ENVELOPE. A REVIEW OF THE STATE OF THE ART

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Keywords: *Building Envelope; Bryophytes; Moss; Green Roof*

1. Introduction – This communication makes a review of the state of the art of using bryophytes in construction, as part of buildings envelopes.

Bryophytes are nonvascular land plants [1]. In construction, bryophytes are mainly used at remote polar areas, in the context of vernacular architecture of extreme climates, but always associated to a secondary role [2].

At the present, there is an increasing interest in studying the potential of bryophytes as a component of building envelopes, due to the situation of potential environmental catastrophe in which we are immersed [3].

Bryophytes are suitable as substitutes for vascular plants in green façade and roofs systems taking into account some specific characteristics such as: ability to colonize different bioreceptivity construction materials [4 y 5], photosynthetic activity, low maintenance [6], ability for revival [1], high water holding capacity [7]...

2. State of the Art – Due to this interest there are many investigations and several commercial systems that are trying to use these characteristics.

Integrated systems:

System Moss Catch (figure 1) consists on substrate sheets and rolls, in which are disposed two moss species in early stage of development. This system is designed to generate the first stage of an ecosystem that facilitates the implementation of other species. There are varieties of the system specifically designed to be used as building façades, roofs, coating inclined surfaces [8]...



Figure 1 Moss Catch. Roof

Since 2013, the Polytechnic University of Madrid is developing an R+D+i called Briosistema [9]. The project aims to design an envelope consists of vegetal material (bryophytes) on the outside leaning on a textile backing and a metal structure in order to increase the thermal efficiency of buildings.

Facade coatings:

Geo-moss (figure 2) is a modular system made up of ceramics of small format, equipped with a cellular foam coating that serves as a substrate for the growth of moss. The system is installed on a substructure made of aluminum profiles fixed to the support wall and has a drip irrigation system.



Figure 2 Geo Moss. Facade

Also, Annie Martin [10] has developed prototypes of lightweight cladding panels with bryophytes providing small outbreaks of moss on a geocomposite, with trademark "Enkadrain".

Green roofs:

Enka-moss is a very light material, shaped like a mat consisting of two layers, a synthetic fabric to retain water and a three-dimensional filament-wound structure containing outbreaks of moss species. Its main commercial application is to generate green roofs on existing buildings, since the system is very light. Another commercial utility provided for the product is its use as acoustic insulation on facades.

The Pre-vegetated mats Xeroflor system [11] replaces the previous Enka-moss. This system is adapted to the climate of northern Europe, so it is checking its viability in Spain at the University of Burgos.

Michel and Franck-Olivier Chiaffredo Denayer have patented a system consisting of a substrate that creates within a short term the conditions to generate vegetation that otherwise would take nature a longer period of time (figure 3). The vegetation evolves into its natural rhythm, without requiring maintenance and the supply of fertilizers.

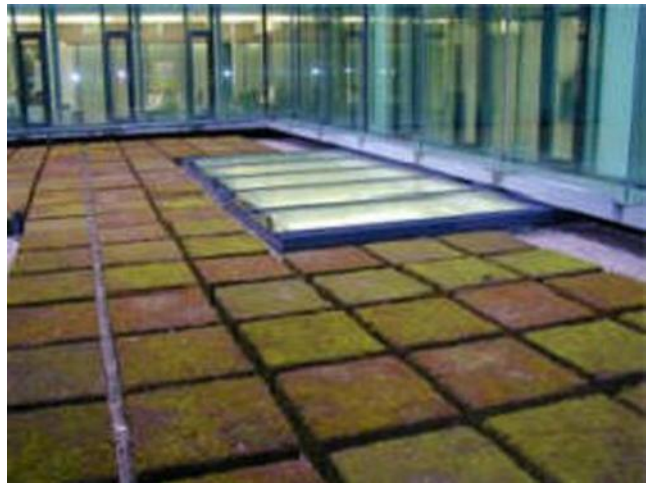


Figure 3 Green Roof. System Chiaffredo and Olivier

Soil stabilization system:

Codra system [8] is a method that uses a moss to improve the microclimate and soil conditions, regenerating vegetation in a short time. It is designed to stabilize the land in an ecologically respectful way with the environment. Coverage of mosses controls soil erosion, absorbs traffic noise and is able to retain moisture. It involves the installation of a structural network on the slope and the disposition of native species of mosses on geotextile sheets, in combination with polymer resins that provide an appropriate hardness to prevent soil erosion and allow vegetation growth.

3. Conclusions – The use of bryophytes opens new possibilities in the sustainable construction field, for its ability to regulate humidity, be a sink for CO₂ [12] and its low maintenance.

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RHEOLOGICAL BEHAVIOUR OF OPC AND GEOPOLYMER PASTES

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Keywords: *Rheology; Alkali activated cement pastes; Blast furnace slag, Fly-ash*

1- Introduction:

Portland cement (OPC) concrete is the most widely used building material in the world. Despite its many advantages, its production involves disadvantages due to its manufacturing process which is very pollutant and energetically expensive. In this way, with the purpose of achieving sustainable development, major efforts are being made in the development of new eco-efficient cements with less energetic and environmental impact.

Among these eco-efficient cements, Alkali-Activated Materials (AAMs) or geopolymers are remarkable[1,2]. They are based on the activation of aluminosilicates of different composition and nature with high (blast furnace slag) or low content of CaO (fly ash and metakaolin) with strong alkaline solutions. This process results in cohesive reaction products with excellent mechanical and durability properties as it is supported by many studies [3, 4]. However, deep knowledge about rheological behavior of these AAMs is still limited despite the importance that the rheology of these systems has in their final and durable properties [5, 6, 7]. At last, knowledge and control of the rheological behavior of these materials will allow to improve scientific knowledge and to contribute to its technological value [8].

2- Methodology:

In this paper, the influence of the nature of the aluminosilicates (two different blast furnace slags, fly ash and metakaolin) as well as the activation conditions (type and concentration of the activating solution, temperature, etc) in the rheology of these systems have been studied. Stress curves at constant rate (100 s^{-1}) and rheological parameters (yield stress) were also determined. All results were compared to Portland cement (OPC) results. Haake Rheowin Pro RV1 rotational rheometer fitted with a serrated cylindrical was used.

3- Results and discussion:

Results have shown that rheology of AAMs depends on one side on the nature of initial aluminosilicate requiring very different liquid/solid ratios depending on the starting material used. Furthermore, clear influence of type and concentration of each activator used has been demonstrated. For alkali activated slag pastes (AAS) the formation of primary C-S-H gel has been observed, whose time of occurrence depends on the nature of the slag and $\text{SiO}_2/\text{Na}_2\text{O}$ ratio used. The rheological behaviour in AAS pastes activated with NaOH alone (AAS-N) or combined with Na_2CO_3 (AAS-NC) fit the Bingham model, like the rheology observed in OPC pastes. The AAS pastes activated with waterglass (AAS-Wg) fit the Herschel–Bulkley model. For aluminosilicates with low CaO content, temperature influence, in reaction products formation, has been observed since they are formed faster when increasing temperature. Fly ash and metakaolin pastes fit in different rheological models, depending on test temperature.

4- Conclusions:

Based on the results presented in this study, the following conclusions can be drawn:

- a) The nature of the activator affected AAS paste rheology. The variations in shear stress at a constant shear rate in AAS pastes activated with NaOH alone or combined with Na_2CO_3 exhibited behaviour reminiscent of the OPC paste pattern. The AAS pastes activated with waterglass showed a signal associated with the formation of a primary C-S-H, whose time of appearance and intensity depends on the different $\text{SiO}_2/\text{Na}_2\text{O}$ ratios used.
- b) The rheological behaviour in AAS-N and AAS-NC pastes, as in OPC pastes, fit a Bingham model. AAS-Wg pastes are adjusted to Herschel Bulkley rheological model.
- c) The test temperature affected fly ash and metakaolin paste rheology (low content of CaO). Fly ash and metakaolin pastes fit in different rheological models heeding at the test temperature.

5- Acknowledgements:

This research was funded by the Spanish Ministry of Economy and Competitiveness under project BIA2013-47876-C2-1-P.

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**APPLICATION OF VENTILATED FACADE SOLUTION IN REFURBISHMENT AND
MONITORING OF THE RESULT: E2VENT SYSTEM ON MILITARY HOSPITAL IN
BURGOS**

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Keywords: Refurbishment; Ventilated façades; monitoring; Energy saving.

1. Introduction – Even though the construction of new building in the last years, the vast majority of the building stock (approximately 35%) is represented by buildings built in the 60's 80's which are predominantly of low energy performance and subsequently in need of refurbishment work. Due to low quality of the urban design or lack of minimum ventilation conditions, the generation of different pathologies increases the humidity and deteriorates the indoor air quality and the life quality of the end user.

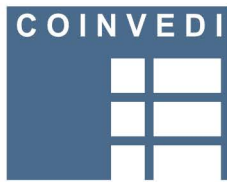
E²VENT is an innovative yet simple modular and adaptable system of ventilated facades. It's main goal is the optimization and efficiency in refurbishment of buildings, with the purpose of reducing the energy consumption and increasing the indoor air quality. This refurbishment improves the aesthetics of a building, increase the value of the asset and provide healthier conditions for the occupants.

2. Methods – One of the main pillars of the E²VENT system is the development of an adaptable smart modular heat recovery unit (SMHRU), adjustable to work into the ventilated facade cavity, able to recover heat from ventilation air, preheating the ventilation air in winter and precooling it in summer. This action is possible due to the design of the latent thermal heat energy storage system (LTHES) based on phase change materials.

E²VENT will have an efficiently control by a building energy management system using thermal and presence sensors and making it responsive to both the dynamic outdoor solicitations and progressive indoor needs.

In order to increase the performance in installation and maintenance jobs, the system will be modular and adaptable to different scenarios or climate zones, so it can improve the aesthetic of the rehabilitated building and its durability.

3. Results and Discussion – With the purpose of testing and guarantee the efficiency of the E²VENT system two buildings have been used as demo. The first one is a multi-storey residential building placed in Gdansk (Poland), the second one is an educational building placed in Burgos (Spain). Both buildings will be monitored during one year without and with the system installed, to compare the obtained results and probe the drop of the average energy consumption. It will evaluate different parameters like amount of CO₂, air age or indoor air temperature.



4. Conclusions – The system foresees: energy savings of more than 40%, by the holistic use of the ventilated facade, the heat recovery of ventilation air. At least a decrease of 40% of CO₂ emissions, as a consequence of the achieved primary energy savings. Reduced thermal and electrical peak loads. And typical performance target of less than 25 kWh/m² year (excluding appliances). Use of heat recovery units, natural lighting strategies, and insulation thickness; are variable depending on the characteristics of the building to be retrofitted. Therefore E2VENT retrofitting system can be adaptable to different types of buildings and climates, which makes the system versatile.

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ANODIZATION OF TITANIUM FOR THE BUILDING ENVELOPE USING DIFFERENT CATHODES AND THEIR PHOTOCATALYTIC BEHAVIOR

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Keywords: *Construction; Anodizing; Titanium; Photocatalysis*

1. Introduction – This work deals with the anodizing of titanium sheets using different cathodes and the test of their photocatalytic properties in the degradation of organic dyes in order to have a first evaluation of their effectiveness as photocatalytic materials in the construction field as façade material. Differences among the photocatalytic behaviour of the anodized specimens were also evaluated, using different cathodes or anodizing durations which may induce differences in the composition and structure of the obtained oxide layer.

Since the first time that titanium was used for the building envelope in 1973 [1], its use has increased notably and became especially well-known with the Guggenheim Museum in Bilbao, Spain [1]. Nevertheless, the idea of first anodizing the titanium, so that we can take advantage of the potential photocatalytic properties of its oxide layer, titanium dioxide, is more recent. As already well-known titanium dioxide has emerged as an excellent photocatalyst for environmental purification [2]. TiO₂ photocatalytic activity depends on its structure, which it is more efficient if it is in crystalline form like anatase or rutile rather than in the amorphous one [3]. Moreover, anodized titanium presenting a thin oxide layer (< 300 nm) presents interference colours that are of particular interest for architectural applications [4].

At the same time the composition of the oxide layer depends on the parameters and characteristics of the oxidation. The type of electrolyte has an important role. For example, it was found out that the use of sulphuric acid promotes a better photocatalytic efficiency of the samples than using phosphoric acid [4]. Other known important factors are the applied voltage and current among others. However, the type of cathode used during the anodizing process was never taken into account as possible factor that influences the photocatalytic activity of the oxide layer. Thus, a photocatalysis test aimed at degrading the dye rhodamine-B is done with titanium samples which have been previously anodized using either carbon or titanium, or platinum as the cathode.

2. Methods – The tested TiO₂ came from three anodizing methodologies with three different cathodes: carbon, titanium and platinum. Moreover they have been also thermally treated afterwards at 500°C for two hours. Samples are labelled with the symbol of the corresponding cathode and TT for thermal treatment (C TT: anodized with carbon counterelectrode, Ti TT: titanium, Pt TT: platinum). All samples were anodized in sulphuric acid 0,5% by weight at 60 V, with a current of 100 mA (10 mA/ m²); a maintenance time of one minute was applied after reaching the highest voltage.

The photocatalytic test was based on the degradation of rhodamine-B dye during six hours of irradiation with a lamp whose spectrum is similar to that of natural light; UV intensity was 1.5 mW/cm². Rhodamine-B, as well as methylene blue and all other dyes, absorbs the visible radiation at given wavelengths: its maximum absorption is at 550 nm. This permits to know

the reduction of its concentration due to the TiO_2 by measuring the variation in its absorbance by spectrophotometry.

3. Results and Discussion – First differences were already noticed in the anodizing process, where a variation in the time required to reach the desired voltage was noticed (approx. 1' with titanium and carbon, 2' with platinum). Figures 1a and 1b show the results of the photocatalysis test done with the three samples, which have been repeated twice.

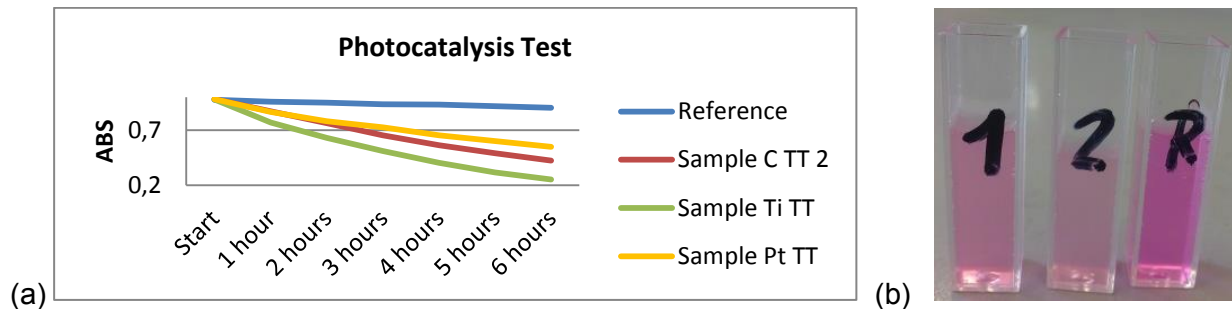


Figure 1 (a) Degradation kinetics of Rhodamine B; (b) RhodamineB solutions in contact with sample C TT (1) and sample Ti TT (2) after 6 h of irradiation

Anodizing with platinum counterelectrode resulted in the lowest photoactivity: to try to improve this behaviour, anodizing was repeated and maintenance time was increased to 90', but without thermal treatment. Results are reported in table 1, which reports the final dye degradation after 6 h irradiation.

Sample (N)	Reduction of rhodamine concentration (%)
Reference	7
C TT	57
Ti TT	74
Pt TT	44
Pt 90'	43

Table 1 Final dye degradation after 6 h of irradiation

The reduction of rhodamine reached by the Pt 90' sample was similar to the Pt TT, so that we presume that with the done thermal treatment and 90' of maintenance time we achieved the same rhodamine reduction.

4. Conclusions - As we can conclude from the photocatalysis tests of the samples, we obtained oxide layers that achieve an important photocatalytic activity. However, there are differences among all of them, as the hypothesis pointed out. Anodising with titanium as a cathode results to be the most efficient. On the other hand the platinum seems to be the sample with less efficiency. Further investigations are needed to better understand this variation in the oxide behaviour.

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EXPERIMENTAL STRUCTURAL BEHAVIOR OF SCAFFOLDING PLASTIC ANCHORS IN REAL BRICK MASONRY WALLS

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Keywords: *Fastening; Anchorage; Masonry; Pull-Out*

1. Introduction – The anchors behavior to pull-out tests in different types of wall samples have been analyzed in many studies [1,5]. However, fewer are the researches performed on real brick masonry walls. Masonry walls constitute a system that can comprise a great number of materials, and therefore, their behavior is influenced by different parameters such as the type of the fastener, the type of brick, the drilling system or the holes of the anchoring configuration. This study analyzes the behavior of anchors placed in real perforated masonry brick walls.

The fracture load and the displacement values of anchorages in different embedment lengths and placement positions have been determined (Figure 1). This on-site obtained data has allowed us to assess how various parameters in anchor settings could affect the load bearing capacity of the fasteners used in scaffolding and brickwork systems [6,7].



Figure 1 Pull-out test

2. Methods – Requirements and assessment and test methods for this fixing types are set out in the Guideline for European Technical Approval of Plastic Anchors for Multiple Use in Concrete and Masonry for non-structural applications (ETAG-020, 2012) [8]. The document has been drawn up by the experts committee of the European Organization for Technical Approval (EOTA). The Part 4 of the document sets out the verification methods, as well as the assessment methods of the fastening systems for their use.

The present research work collects the results obtained in the different tests carried out in accordance with the methodology described in the regulations. The aim was to have a starting point on the pull-out strength of steel eye-bolt anchors sleeved in plastic plugs and introduced at different depths in real masonry perforated brick walls. The experimental study was done in the center of the piece, so that, firstly external finishing was removed. For the pull-out strength study, series of pull-out tests have been performed at different depths and location of the anchor, both inside the wall unit or in the pointing.

Extractions of anchors have been designed and tested using a Hilti tool, HAT 28 M. The equipment consists of mechanical screw acting on a hydraulic load cell. It measures the load applied directly on the anchor, showing it in a manometer. A ruler allows controlling the value of the displacement of the eyebolt during the test

3. Results and Discussion – In this study, series of at fifteen tests using steel eye bolts of 120 mm total anchor length; with 70 mm threaded shank and 50 mm unthreaded shank have been performed. The plugs introduced in the interior of the selected piece of the wall are 70 mm in length and 14 in diameter, and were flush with the outside wall face. The introduction of the eyebolt in the plug is done by rotation. In the tests, the maximum load and the displacement corresponding to that load value have been obtained as a result.

In the first study (Table 1), the influence of the eye-bolt length introduced in the masonry wall was studied. Therefore, in a first series (Series 1), the steel eye-bolt was introduced up to its head, both inlaying the threaded and the unthreaded area of the shank. In the second test series (Series 2) only the threaded part was inserted in the plug

Partial embedment	Load (kN)	Displacement (mm)	Total embedment	Load (kN)	Displacement (mm)
1.1	5	1.25	1.2	5	1
2.1	4.5	0	2.2	5.5	1
3.1	4	1	3.2	8	1.75
4.1	5	1	4.2	9	1,4
5.1	5	1	5.2	4.5	0.87
6.1	5	0	6.2	4.5	1
7.1	2	0	7.2	6.5	2
8.1	2	0	8.2	4	1
9.1	2	0	9.2	6	1
10.1	5	0	10.2	6	1
11.1	4.5	0.75	11.2	5.5	1
12.1	7	0	12.2	6	0.75
13.1	6	1.75	13.2	6	0.75
14.1	7	1.25	14.2	5.5	1.25
15.1	5	2	15.2	6	1
mean	4.6	0.7	mean	5.9	1.10

Table 1 Maximum pull-out load and displacement

4. Conclusions – The maximum load reached by an eye-bolt anchor placed inside of a plastic plug in a real brick masonry wall is significantly higher if the eyebolt is introduced only on its threaded area and not when the totality of the shank is used (table 1). The results offer a mean fracture load value of 5.9 kN when only the insertion is only in the threaded part. In contrast, 4.6 kN when the eyebolt is fully inserted. Also, in the first case, the displacement produced is greater, indicating a greater ductility of the anchor. It is important to highlight that the results of both tests performed in real brick masonry walls [3] show significantly higher values to those obtained in tests carried out in brick samples and published in experimental studies. Data provided in this article have offered real values, which imply an advantage in the safety improvement of the installation of auxiliary means or collective protections in facades, work platforms or scaffolding systems.

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RECYCLING OF GYPSUM PLASTERBOARD LIGHTENED WITH POLYURETHANE WASTE

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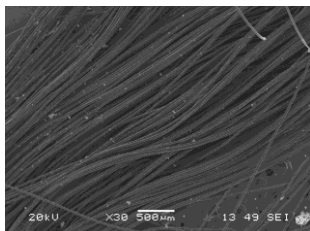
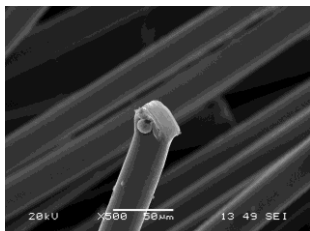
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Keywords: *Gypsum plasterboard, polyurethane waste, polypropylene fibers, recycling process*

1. Introduction – Researchers working with basanita obtained from recycled gypsum board in order to improve the stability of subbase in clay soils [1]. The plaster has been recycled in order to study the alternative being introduced into ceramic blocks made with different ratios of clay and cement [2]. The European project "to Gypsum Gypsum Project" [3], has as one of its objectives to study the recycling of waste from Plasterboard for incorporation in the manufacture of new gypsum plates. Companies in the prefabricated plaster sector recycle the scraps generated in their own industries (rest pre-consumer) and even have projects to collect and recycle debris demolition and new construction [4]. This paper presents the results of an experimental process of reusing waste obtained from waste gypsum plasterboard made from polymeric industrial waste (polyurethane foam) and polypropylene fibres with the aim to manufacturer new gypsum plasterboards.

2. Materials and methods – The plaster used in this study is characterised as B1 according to European Standard EN 13279-1[5]. White Polyurethane Waste (PUW) was taken from the waste generated in the manufacture of insulative panels in the refrigeration and construction industries [6]. Following shredding, it presented itself as a dust with a granulometry of between 0-0.5 mm, with real density and bulk density values of 1080 kg/m³ and 72 kg/m³, respectively. Polypropylene fibers (F2) were supplied by Grupo Pumma (Paviland®). The fibers were approximately 30 µm in diameter and 12 mm in length with a tensile strength ranging between 300 and 400 MPa. Elemental analysis (CHNS) indicated the presence of carbon, hydrogen, nitrogen and sulfur in the fiber. The Scanning Electron Microscopy (SEM) image (Table 1) shows the orientation and dimensions of the fibers.

Table 1. Elemental analysis (CHNS) and SEM of PP fibres

Element	Carbon	Hydrogen	Nitrogen	Sulfur
%	85.57	14.31	0.08	0.04
SEM	 			

3. Experimental procedure – A methodology to recycle is presented to increase the life cycle of waste gypsum. The manufacturing process of the plates is detailed as well as their physical and mechanical characterization by means of standardized for gypsum plasterboard. The experimental procedure used to recycle plasterboard consisted in the grinding of the plates, sieve of the dried material obtained from the fraction less than 25 µm and use the passing of sieve described and doing the grading curve.

This material was used in the manufacture of new gypsum plasterboard with polyurethane and PP fibers, substituting in weight waste material obtained for gypsum with polyurethane (Table 2).

Table 2. Dosage of the recycled plasterboard

<i>Sample</i>	<i>Relación (poliuretano/yeso)</i>	<i>Relación (agua/yeso+poliuretano)</i>
PYL W0,5 (F2) 4%	0,5/1	0.52
PYL W1 (F2) 4%	1/1	0.60
PYL W2 (F2) 4%	2/1	0.82

New gypsum recycled plasterboards were characterized by their bulk density, flexion strength, water absorption rate, water retention capacity, and surface hardness. The tests followed the instructions in Standard EN 520 [7], which establishes the specifications and the test methods for gypsum plasterboard.

4. Results and Discussion – The results shows that in all cases, the incorporation of mixtures residue causes an increased density apparent. The flexural strength of the plasterboard was characterized by its fracture load under flexion. The flexural strength of all dosages improvement with regard to reference plates (0% substitution) reaching increases of up to 51% in a specific dosage. Mixtures which incorporated waste reduce its water absorption capacity in all cases. This reduction is most evident in plates with high polyurethane content (1/2) where the increase in absorption reaching nearly 40% in plates with 15% substitution. Taking as reference plasterboard without waste reused (0%), it can be observe that the mean diameter decreases in dosages with high polymer content (1/1 and 1/2), being coherent with other commented test.

5. Conclusions - It has been shown that waste gypsum boards polymers can be recovered in a simple way, by grinding, sieving and mechanical drying. The waste gypsum plasterboard incorporated improves the performance of the new plates with regard to the reference gypsum plasterboard. These results provide potential line of work for propose alternatives to the problem of closing the life cycle of these wastes, giving a second life to waste the researched plates to produce new plasterboard with gypsum and polymers.

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DECREASE OF THE DRYING SHRINKAGE OF C3S PASTE BY USING CRYSTALLIZED GERMS MANUFACTURED BY BALL-MILLING

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Keywords: *Seeding; C3S; Drying shrinkage; SEM*

1. Introduction – A part of the volume change associated with free water evaporation coming from capillary pores of cement paste is known as drying shrinkage [1-3]. This phenomenon occurs mainly after the hardening of the paste and may lead to subsequent cracking. It becomes severely harmful in certain insulating lightweight concrete with high porosity. Indeed, the drying shrinkage is closely related to capillary tension in the pores of cement paste, which can be expressed as twice the surface tension divided by the pore radius. Thus, it is possible to reduce shrinkage by decreasing capillary pore tension in two ways: either by adding admixtures reducing the surface tension or by increasing pore size. This work was undertaken to confirm the results, obtained in a few previous papers [4,5], about the possibility of increasing the total porosity of C3S paste and of reducing the drying shrinkage by replacing C-S-H gel network [6] by crystals of Afwillite ($\text{Ca}_3\text{Si}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$).

2. Methods – A protocol based on the one reported by Kantro et al. [7] was developed in order to (i) synthesize germs of afwillite by ball-milling of C3S-based slurry; (ii) improve the final weight ratio of afwillite, and (iii) decrease the amount of residual C-S-H. In a second step, C3S pastes were seeded by germs of afwillite and studied using different methods of characterization (Scanning Electron Microscopy, Thermo-Gravimetric Analysis, X-ray Diffraction and Mercury Intrusion Porosimetry). Finally, measurements of drying shrinkage were performed over more than 100 days in order to compare the variations of length between the reference pastes and the seeded pastes.

3. Results and Discussion – Afwillite ($\text{Ca}_3\text{Si}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$) can be synthesized from highly diluted C3S-based slurry agitated with stainless steel balls in Turbula®. With appropriate ball milling conditions, the weight percentage of afwillite in the mixture reaches to 40-50% after 2-3 days of reaction, which represents 65-90% of the theoretical maximum possible. After the removing of the portlandite by leaching with demineralized and de-carbonated water, a purity of afwillite close to 90-100% was confirmed by XRD.

Those crystals of afwillite, once seeded in the C3S paste, promotes the growth of afwillite in paste under conventional hydration conditions, reaching about 45% of the maximum possible after 7 days of hydration. As detailed by Figure 1, SEM images showed the presence of afwillite crystals of 3-5 μm in size, close to remaining C-S-H, highlighting a coarsened microstructure.

Increasing the pore size should lead to decrease the capillary tension. Indeed, the tests of drying shrinkage (shown in Figure 2) confirmed that the variations of length of seeded C3S pastes were significantly reduced (at least by a factor of 2.5) compared to those of reference C3S pastes.

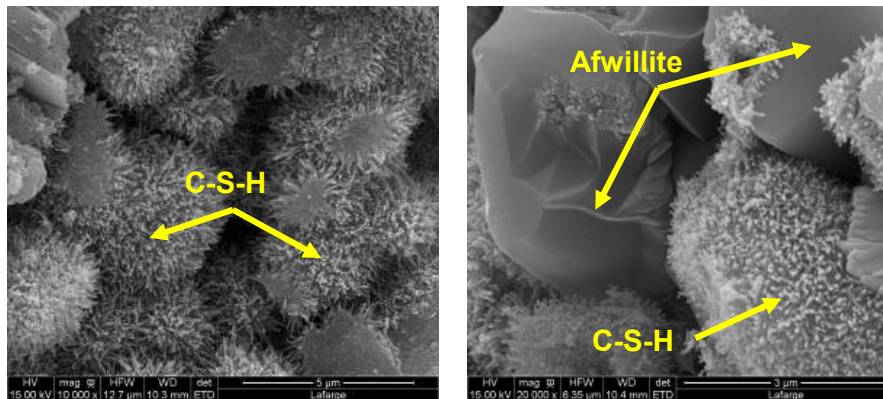


Figure 1. Microstructure of C3S paste (28 days after demoulding) observed by SEM: (a) reference C3S paste; (b) seeded C3S paste.

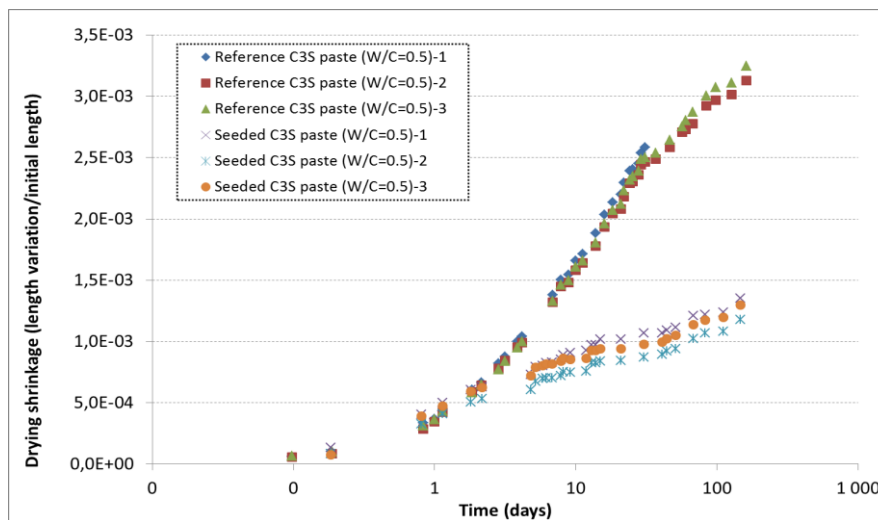
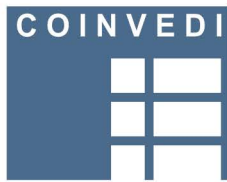


Figure 2. Drying shrinkage properties of reference and seeded C3S pastes (weight ratio afwillite/C3S=0.02).

4. Conclusions - Highly pure germs of afwillite, fabricated by ball milling of diluted C3S slurry, were used to seed the C3S pastes. TGA and XRD analyses gave proofs of a rapid growth of afwillite and the SEM observations highlighted the coarse microstructure induced by the partial replacement of C-S-H gel by the crystals of afwillite. Finally, the tests of drying shrinkage confirmed that the seeding of C3S pastes with germs of afwillite can reduce significantly the length variations according to time.

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GYPSUM BEST PRACTICE INDICATORS

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Keywords: *Gypsum; Best Practice Indicators; GtoG Life+ Project.*

1. Introduction –The use of indicators has become in recent years as a reliable method of evaluation for the decision-making processes [1]. Indicators give quantitative, qualitative or descriptive information about an item and or process [2], to ease the decisions that will be taken on the basis of their results, in order to optimize the processes that are being measured identifying changes and improvements [3]. This study presents a set of Best Practice Indicators (BPIs) aiming to increase the amount of gypsum waste capable of being recycled, as well as to maximize the quality and percentage of recycled gypsum that can be reincorporated in the manufacturing process. Thus, the practices implemented through the whole value chain of gypsum plasterboard have been assessed. That is to say, from the deconstruction dismantling, through the gypsum waste processing, to the resulting recycled gypsum reincorporation into the manufacturing process. Key Performance Indicators (KPIs) are formulated and used to monitor and compare the five pilot projects conducted in the framework of the Life+ GtoG Project “*From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry*”.

2. Methods –The first part of the methodology consists on identifying key areas of influence to be measured from previous preparatory actions, where a thorough review on existing literature, questionnaires distributed among European stakeholders and the gypsum recycling business model are analysed. Such influencing areas correspond to four categories: economic (ECO), social (SOC), environmental (ENV) and technical (TECH); divided into each of the stages part of the deconstruction, recycling and reincorporation process (Table 1). The classification enables the development of specific indicators per stage and thus precise parameters, which facilitates their use and individual evaluation in a classification breakdown for a more effective analysis.

According to this, a first approach of potential Key Performance Indicators (KPIs) and monitoring parameters is produced. Being parameters the variables that combined in an equation compose the indicator and enable the data collection, according to the recycling indicator they are addressing.

With the KPIs defined, application and interpretation of results is carried out by applying the same in five pilot projects set in five distinct national contexts: Belgium, two in France, Germany and the United Kingdom.

3. Results and Discussion– After data collection and analysis, a set of 37 KPIs is finally generated and refined, out of which best practice indicators (BPIs) are selected, specifically aiming to recognize and encourage best practices through the whole EoL, associated to quantitative or qualitative evaluation criteria, in order to show the degree of compliance with a minimum level of performance. Table 1 shows the final 29 selected as BPIs.

Whilst for deconstruction and recycling there are several socio-economic BPIs that have not been selected, mainly due to their variability depending on the different market context, policies and competitive environments from the country under study; in the case of reincorporation all of them are considered.

CATEGORY	STAGE	DECONSTRUCTION BPis
TECH	Audit	TECH1. Existence and deviation of the audit for gypsum systems
	Deconstruction	TECH2. Effectiveness of the deconstruction process
	Traceability	TECH3. Effectiveness of the traceability
ENV	End route	ENV1. Gypsum waste sent to landfill
		ENV2. Transport emissions comparison between recycling and landfilling
SOC	Deconstruction	SOC4. Training of the deconstruction team
		SOC5. Follow-up of the waste management
ECO	Traceability	ECO4. Cost difference between recycling GW and landfilling route
CATEGORY	STAGE	RECYCLING BPis
TECH	Reception	TECH1. Quality of the gypsum waste received
	Storage	TECH2. Gypsum waste rejected
		TECH3. Warehouse storage capacity for gypsum waste
	Processing	TECH4. Output materials of the recycling process
ENV	Processing and transport	ENV1. CO ₂ Emissions from the recycling process
		ENV2. Natural gypsum saved
SOC	Reception	SOC1. Recycler's satisfaction
CATEGORY	STAGE	REINCORPORATION BPis
TECH	Reception	TECH1. Recycled gypsum rejected by the manufacturer
	Storage	TECH2. Recycled gypsum quality criteria
		TECH3. Recycled gypsum required space for storage
	Reincorporation	TECH4. Recycled gypsum content
		TECH5. Recycled content increase
	Production	TECH6. Production waste
ENV	Preprocessing	ENV1. CO ₂ emissions: business-as-usual compared to maximized recycled content in the pre-processing
	Manufacturing	ENV2. CO ₂ emissions: business-as-usual compared to maximized recycled content in the production process
SOC	Manufacturing	SOC1. Manufacturer's satisfaction
ECO	Reception	ECO1. Cost difference between business-as-usual and maximized recycled content quality check
		ECO2. Cost difference between natural gypsum and recycled gypsum
		ECO3. Cost difference between FGD gypsum and recycled gypsum
	Preprocessing	ECO4. Energy cost difference between business-as-usual and maximized recycled content in the pre-processing
	Manufacturing	ECO5. Energy cost difference between business-as-usual and maximized recycled content in the production process

*Non-selected KPIs as BPis: A) Deconstruction: SOC1. Labour time difference between dismantling and demolishing plasterboard, SOC2. Labour time difference between dismantling and demolishing gypsum blocks, SOC3. Productivity, ECO1. Audit cost, ECO2. Plasterboard dismantling and loading cost, ECO3. Gypsum block dismantling and loading cost. B) Recycling: ECO1. Energy cost of the gypsum waste processing, ECO2. Transport cost of the recycled gypsum. C) Reincorporation: None.

Table 1 Best practice Indicators (BPis)

4. Conclusions - To assess the sustainable performance of the gypsum value chain the different stages part of each of the constituting processes have to be considered, classified into common technical, environmental, social and economic categories.

A total of 29 indicators have been selected out of 37 initial KPIs defined, recognizing and encouraging the implementation of best practices (BPis).

The defined analytical framework can be used as a decision-making tool helping to increase the effectiveness of the gypsum EoL recycling route, measuring the performance and progress of gypsum waste management, detecting the possibilities of improvement as well as monitoring changes over time.

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ANALYSIS OF CONSTRUCTION INNOVATION CASES

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Keywords: *Construction Innovation; Materials; Systems; Products*

1. Introduction – Nowadays, in the Construction field, the innovation in the building construction system has much more importance and is more used, than the innovation in materials. In fact, a traditional or conventional material, may become a part of an innovative construction element, by the way it is used in the works process or even for being used in a non-standardized way. In a building construction, it can be innovation in almost all the steps: in the design, in the energy system, in the materials, ICT systems, etc. However, almost all of them are product innovations that are imported from the industry to be used in building construction. In this research, it has been analysed, construction building innovative cases, focusing in the execution phase. It has been analysed the use of innovation in materials, products and construction systems. From simple to complicated solutions, as well as, extreme innovation cases, which are still rarely used in the building Construction.

2. Methods – Since 2003, it has been taking information in innovation of materials, products and systems in more than 40 construction works that have been planned, designed and directed by Iñigo Leon's Architectural Studio. Those works have been synthesized into 5 groups: 1.- Reform: Residential buildings 2.- Reform: Other uses buildings 3.- Reparation: Building outdoor and installation 4.- New Building: Residential 5.- New Building: Other uses. In each of the 40 works, it has been classified the use of innovation in the three different elements described (material, product and system), to determine which of the them is more relevant in the execution phase.

3. Results and Discussion – Results of the study are represented in Figure 1

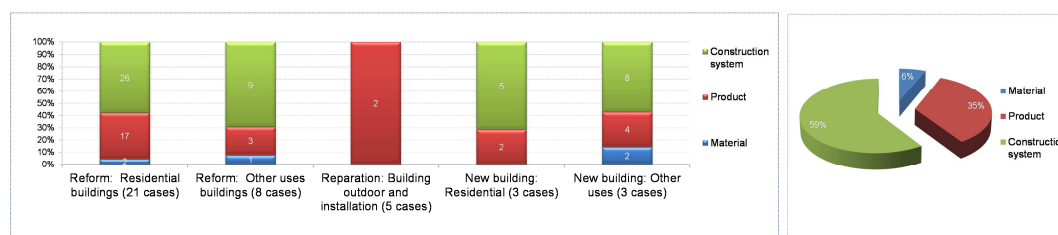


Figure 1

3. Conclusions – Architects are not usually the drivers of the use of innovative building materials in the works. There is an important growing trend in the use of innovative construction systems and also in imported products from the industry. Interdisciplinary collaboration teams between architects and engineers, can enhance and create new materials, to be applied in Construction. For this reason, our research team is composed of architects and mechanical and chemical engineers.

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**MECHANICAL REDUCTION OF ADHERED MORTAR FROM RECYCLED AGGREGATES
AND ITS EFFECT IN CONCRETE****Letelier, Viviana⁽¹⁾, Tarela, Ester⁽¹⁾ and Muñoz, Pedro⁽²⁾**(1) Departamento de Obras Civiles, Universidad de la Frontera, Temuco, Chile. Mail: ester.tarela@ufrontera.cl.

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Keywords: *Recycled Aggregates; Adhered Mortar; Compressive Strength; Recycled concrete.*

1. Introduction –As in other areas, sustainable management has become a social obligation in construction engineering. Following this environmental concern, the use of recycled aggregates in concrete has been widely investigated, showing significant differences in their mechanical behaviour when compared to traditional ones [1].

The main cause of this loss of strength is the adhered mortar to the surface of the aggregates. The interface between the cement matrix and the natural aggregates is known to be a weak zone, and when recycled aggregates are used, a second interface between the old adhered mortar and the cement has to be considered [2]. Hence, the quality and quantity of the aggregates and the old mortar will influence the mechanical properties of the concrete.

Usually the loss of strength is efficiently controlled by limiting the amount of recycled aggregates used [3]. Therefore, several technic regulations consider the replacement of up to a 30% of recycled coarse aggregates in the production of structural concrete.

However, if the main cause of the loss of strength is the adhered mortar, reducing the amount of this mortar may allow increasing the percentage of recycled aggregates maintaining the quality of the concrete. Chemical abrasion procedures have been tested with positive results [4]. On the other hand the use of acids may affect the quality of the aggregates too and its industrial implementation can be complicated.

In this study a new method to reduce the amount of adhered mortar to the recycled aggregates is tested.

2. Methods – A Los Angeles abrasion machine is used to remove the mortar mechanically. The amount of removed mortar will be initially quantified through the revolutions applied, setting different levels to compare the results. The samples tested will have a 40% of their natural aggregates replaced by treated and untreated recycled aggregates. The quality of the final concrete will be tested through the compressive and flexural strength results.

The recycled aggregates were obtained from demolished concrete pavement. Drilled concrete core specimens gave a mean resistance of 54Mpa. The mortar adhered to the surface of these aggregates was reduced using a Los Angeles abrasion machine. To evaluate the effectiveness of this mechanical abrasion different levels were stablished, quantified through the revolutions applied (100, 200, 300, 400 and 500 rev.). These aggregates replaced a 40% of natural ones on different samples, in the 6.3-19mm size range. Note that the percentage refers to the total amount of aggregates, what means that up to 2/3 of the coarse natural aggregates were replaced in all cases.

A control concrete sample (HC) and a recycled regular (no abrasion) concrete (HR) are used for result comparison. All the specimens are dosed for a 30MPa resistance.

The mechanical properties of the specimens are quantified through compressive and flexural strength tests both following Chilean standards. The compressive strength tests are performed after 7, 14, 28 and 90 curing days in cubic 15x15x15cm samples; the flexural

strength ones after 28 and 90 days in prismatic 15x15x50cm samples.

The amount of mortar remaining in the aggregates after the mechanical abrasion process is evaluated following previous authors [5].

3. Results and Discussion—The results for the compressive strength are shown in Figure 1. All of the samples equal or exceed the compressive strength values obtained for the control concrete, agreeing with the high quality of the recycled aggregates. The highest values of compressive strength are obtained when the aggregates have suffered 200rev abrasion. This significant improvement is due, not only to the mortar reduction, but also to the change in the shape of the aggregates provoked by the procedure, flat and sharp particles may lead to layer stratification limiting the durability and strength of the concrete. This positive effect slightly decreases for HR300R, and the reducing trend continues when the abrasion level increases. When the abrasion level is too high micro fissures can appear in the structure of the aggregates weakening them and affecting their quality. On the other hand, a higher gaining rate is obtained when the curing time is longer, because the rehydration process of the remaining mortar can reactivate old cement particles.

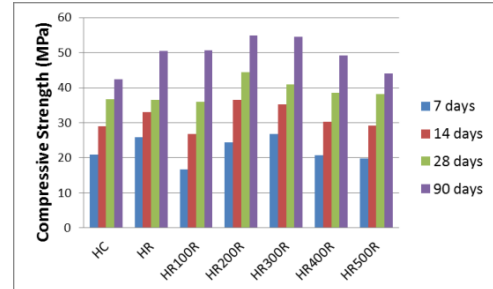


Figure 1: Compressive strength for different abrasion level. The samples with abrasion are designed by HRxxxR. Where xxx is the number of revolutions applied

The effectiveness of the abrasion process has been obtained (up to 300 rev.) for different size ranges. Smaller aggregates present a higher percentage of adhered mortar. In this case, the highest abrasion level applied (300rev) is able to reduce the mortar a 33% for the smallest recycled aggregates (6.3mm-9.5mm); a 32% for the medium ones (9.5mm-12.5mm); and up to a 49% for the biggest ones (12.5mm-19.3mm). These results evidence the effectiveness of the mechanical abrasion applied.

4. Conclusions —The use of mechanical abrasion to reduce the amount of mortar adhered to the surfaces of recycled aggregates is effective, presenting its optimum performance when a 200 revolution erosion is applied.

This methodology allows obtaining concrete samples that present no strength loss when a 40% of the natural aggregates are replaced by high quality recycled aggregates subjected to mechanical abrasion. The gaining rate is even higher after 90 days of curing.

The percentage of recycled aggregates used in structural concrete can be increased if these are treated with simple mechanical abrasion. The residuals of the eliminated mortar can be also reused as cement replacement, maximizing the material reuse.

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ANALYSIS OF THE MECHANICAL BEHAVIOUR OF CONCRETES WITH RECYCLED AGGREGATES AND DIATOMITE RESIDUAL AS A CEMENT REPLACEMENT

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Keywords: *Recycled aggregates; Recycled concrete; Mechanical properties of concrete; Compressive strength.*

1. Introduction – The worldwide environmental problem has led many scientific areas to investigate about sustainable solutions. Concrete is globally one of the most used materials, what justifies the interest in finding alternatives that allow reducing the environmental impact generated by the life cycle of this product.

The effect of the use of recycled aggregates (RA) in concrete has been widely studied. Various authors [1-4] have proven that the use of relatively low percentages of RA doesn't modify significantly the properties of the material and, nowadays, several European technical regulations allow the use of up to 30% of RA in structural concrete.

Natural diatomite studies [5-9] have demonstrated the effectiveness of using this material as cement replacement. However, there are no studies examining its use when it is waste, once it has been used in industrial processes.

As a measure to reduce the environmental impact generated by concrete manufacturing, studies have been performed combining the use of RA and different industrial waste as cement replacement [10-12].

This study analyses the variation in the mechanical properties of concretes with recycled aggregates and diatomite residual as cement replacement. Analysed concretes are dosed for a compressive strength of 30MPa. The recycled aggregates are obtained from prefabricated pipe debris with a compressive strength of 20MPa. The diatomite residual is obtained from breweries that use diatomites as a filtering agent. The goal of this study is to identify what variables and which of their values are the ones that most affect the mechanical properties of the concrete.

Keywords: *Recycled aggregates; Recycled concrete; Mechanical properties of concrete; Compressive strength.*

2. Methods – Four parameters are analysed in this work: the percentage of recycled aggregates (25%, 50% and 75%); the amount of adhered mortar to the surface of these aggregates, that will be controlled by applying a mechanical abrasion process instead of the usual chemical traditional methods (100rev, 200rev and 300rev); the amount of diatomite residual as a cement replacement (5%, 10% and 15%) and the maximum size of the particles of this residual (75µm, 150µm and 300µm). To minimize the number of experimental tests needed Taguchi's statistical method is applied. The tests are performed after a curing time of 28 days. The results are quantified through an analysis of variance method (ANOVA), to establish which variables are the ones that affect the most to the final strength of the material.

The tests developed are compressive strength, flexural strength and Young modulus following the Chilean standards.

3. Results and Discussion– The results obtained show a similar behaviour for the compressive strength, the flexural strength and Young modulus with the variation of the four parameters.

A decrease in the properties is observed in all of the cases when the amount of recycled aggregates and diatomite replacement increases.

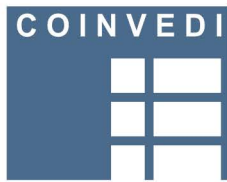
When analyzing the compressive strength, after 28 curing days, the results show a decrease of a 37% if 75% of the natural aggregates are replaced from the resistances of the 25% RA samples. On the other hand, when the diatomite amount increases from a 5% to a 15% a loss in the compressive strength of 18% is obtained. The maximum size of the diatomite reaches its optimum performance for 150µm, with a 15% gaining rate from the 75µm. The mechanical properties of the material recover when the recycled aggregates receive a 300 rev. abrasion treatment, what allows eliminating a 30% of the adhered mortar to their surfaces, the strength increases a 12% from the ones treated with only 100rev.

ANOVA analysis revealed that the most significant parameters were the amount of recycled aggregates, over a 50% of participation rate, and the amount of cement replaced by diatomite residual, over a 25%.

4. Conclusions– Results show that the best behaviour is obtained using a 25% of recycled aggregates, subjected to a 300 rev. abrasion and a 5% of diatomite residual replacement with a maximum size of 150µm. A low percentage of replaced cement by diatomite residual was found to be beneficial for the mechanical behaviour of the concrete, what can compensate for the loss due to the use of recycled aggregates. Hence, it is possible to increase the percentage of recycled aggregates up to a replacement of 50% if it is combined with a 5% of diatomite residual replacing the cement, without observing a significant decrease in the mechanical properties of the concrete. The most influent parameters on the final mechanical behaviour are the amount of recycled aggregates and the percentage of recycled diatomite residual. Results indicate that, controlling certain parameters, equivalent materials can be obtained allowing the reuse of debris and reducing significantly the amount of natural coarse aggregates needed.

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MUNICIPAL SOLID WASTE INCINERATION FLY ASH STABILIZATION AND IMMOBILIZATION INTO SULFOALUMINATE CEMENT MORTARS MATRIX: PHYSICAL/MECHANICAL BEHAVIOUR

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Keywords: Mortars; Fly ash; Solid urban wastes; Sulfoaluminate cement, Immobilization.

1 Introduction. The first objective of the research aims to transform the waste formed mainly by calcium hydroxide and calcium hydroxychloride into another limy-type material (calcium carbonate material). This is achieved by transforming the high soluble heavy metals chlorides into low soluble carbonates. The second objective focuses on the stabilization and use of this MSWI fly ash as part of the aggregates used in the production of cement mortars. Previous studies emphasize [1-3] that the mechanical strength of mortars elaborated with Portland cements and the incorporation of fly ash as a partial substitute for the aggregate were significantly affected when compared to the reference mortars. On the contrary, the use of sulfoaluminate cements (CSA) has been demonstrated [4] to be a highly effective way to safely encapsulate hazardous materials without affecting mechanical strength. In addition, CSA was also chosen due to the perception that sulphur content would make the precipitation of heavy metals in the form of sulphides easier.

2. Methods. A search of the possible reagents has been carried out to use them in the stabilization process of fly ash. In this way, considering previous researches aiming to stabilize heavy metals [5-6] and, at the same time to eliminate part of chlorides of fly ash through washing, an alternative method using NaHCO_3 is established. An appropriate combination of this will exercise a buffer function and maintain pH at an optimum value, for which the heavy metals content in the leachate will be minimal. Likewise, the addition of Na^+ ion in equivalent quantities to chloride ions, in the fly ash washing process, will facilitate the removal of a large amount of chlorides in the form of sodium chloride. In addition, NaHCO_3 is a cheap and safe stabilizing agent and does not alter the pH of cementitious materials. The stabilizing procedure began by washing the original ashes, with a proportion of deionized water/fly ash of 10:1. This mixture was manually stirred by mechanical means, while the calculated amount of NaHCO_3 was added. The recovered paste was dried and grinded to obtain a greyish powder, mostly calcite, which is easily combinable with the selected aggregates for the mortars implementation.

3. Results and discussion. Analytical data shows a high content of heavy metals in original fly ashes, mainly regarding Zn and Pb content and also high levels of chlorides. The problem arising from Cl^- ion excess in cementations mixtures is the one derived from corrosion. Two goals are achieved through the treatment with the NaHCO_3 solution. Firstly, the soluble heavy metal ions existing in the original ashes, due to chloride presence, are transformed into poor soluble solid carbonate or hydroxide precipitates. Secondly, the content of chlorides has been drastically reduced in almost 99% but, despite this, their use is not recommended with steel reinforcing rods [7].

FA XRD analysis of original fly ash (FA) shows broad and low intensity diffraction peaks, characteristic of a poor crystallized material. Two crystalline phases have been clearly identified: Ca(OH)_2 and Ca(OH)Cl . XRD analysis of treated fly ash (TFA) shows one crystalline phase clearly identified: Calcite (CaCO_3).

With regard to dimensional stability, deformation in mortars made with CSA are particularly positive. Not only does the trend mark a conservation of dimensional stability, unlike reference mortars, but also the values offered at 28 days are the best ones obtained with this type of mortars and of all the ones tested. Nevertheless, a greater specific mass loss is observed with values below those offered by the reference mortar.

As a supplementary analysis to the one on dimensional stability, in the density results of the dry mortar samples studied a gradual material lightening occurs when TFA. for those performed with CSA, lightening is reduced by 4.5% for 1/1 proportion, and by 6.5 per cent for the 1/3 proportion.

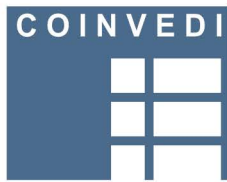
CSA mortars present much higher rates of natural carbonation compared with both Portland and CAC cements [8]. For CSA mortars with proportion 1/3, as well as for TFA mortars of proportion 1/1, a singular feature is observed: i.e. the carbonation front does not start on the surface, but gets in gradually. In this case, an area of surface protection, which is not carbonated, can be seen; this area is much more pronounced in the reference mortar. This fact may be due to the characteristics of the used cement. This cement is produced in a similar process to that of Portland cement but with less energy consumption, different configuration phases and similar or higher mechanical properties than that other cement. CSA cements present a rapid hydration, which can generate a very heterogeneous distribution of pores and therefore, a higher carbonation, which in turn, has been accelerated with the addition of TFA resulting in a total carbonation of the studied surfaces.

Reference mortars behaviour regarding compression of CSA mortars show high initial strengths –although with a gradual strength loss at 28 and 60 days– two proportions, 1/1 and 1/3, made with TFA reverse this trend and present moderate initial strength but with a clear upward trend; in the case of the 1/1 proportion of TFA showing even more than 1% higher values than those offered by the reference mortar. As a consequence, CSA present certain benefits in comparison with ordinary Portland cements [9]. As it is a cement type with high initial strength, when used in combination with MSWI fly ash it promotes its stabilization/solidification in the mortar matrixes. Likewise, as previously said, the used ashes are rich in chlorides and sulfates, which may easily react with the calcium sulfoaluminate in the hydration process and take advantage of the new phases of this hydration to encapsulate heavy metals. Similarly, the sulfide included in its initial formulation, will facilitate the precipitation of heavy metals contained in TFA in the form of sulfates.

CSA mortars suffer higher carbonation rates. Aggregates, together with the evaporation of the mixing water lead to the development of a system of pores promoting CO₂ diffusion. This fact, far from being negative, reduces shrinkage and cracking of the samples during drying and they can give rise to subsequent puzzolanic reactions favoring the increase of compressive strengths.

Conclusions

- The mean data obtained on a sample period of 22 weeks indicates that the MSWI ashes have a high content of heavy metals, at least with regard to Zn and Pb, and also high levels of chlorides and sulfates, making them to be treated as special waste.
- The washing method of the MSWI ashes with the appropriate NaHCO₃ proportion shows a reduction of almost 99% of soluble chlorides. The addition of the Na⁺ cation produces the elimination of these chlorides in the form of sodium chloride. The studied solution exerts the buffer function and maintains pH environment at the optimum values so that the concentration of heavy metals in the leachate is the minimum possible.
- CSA cement mortars with partial replacement of 10% of the aggregate with TFA, present much better behavior than reference mortars, both in compressive strength and dimensional stability.
- The results show that the workability period of mortars made with CSA cements and the inclusion of TFA is much shorter than those offered by the two types of ordinary Portland cement tested.
- In all analyzed mortars the inclusion of TFA implies a carbonation increase of the resulting mortar and therefore, an increase in porosity. However, this does not seem to negatively affect final compressive strengths of the mortars made with CSA.



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VARIATIONS OF THE COLOUR IN THE WOOD OF INNER CONSTRUCTION BY CHEMICAL TOASTED METHOD.

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Keywords: Architecture of Interiors, wood, colour, chemical toasted

1. Introduction

This investigation presents the variations of the colour in the wood for inner construction, emphasizing the expressiveness of wood and of his characteristic “footprint” that difference and customises, respect to the others of his same species and in comparison with other species, using the “chemical toasted method” based in the superficial application of colourless liquid acids on the wood for inner construction, proposing it as alternative to the traditional superficial treatments of charred of the construction wood through the application of fire. The idea of apply acids on construction wood, although initially it could be considered a handicap, finishes transforming in a virtue, from the moment that these acids are applied in a controlled manner, superficially, at ambient temperature inside, creating a layer of protection above inner construction woods changing of a natural form the colour of the wood and improving his appearance. Although there are many products for the color change of the Wood of construction, even naming one being “Colorless” [1] and [2] (There are other authors that have studied the color change in other materials [3]), the approach of this investigation uses like starting point the charred or burned processes applied on outside wood and especially the toasted traditional through the fire of the barrels or wine casks, in inner construction wood, proposing one “conceptual translation” of these processes to the method of “chemical toasted” No only by the layer of protection produced on the wood but also by the obtaining of an extension of the range of colours and textures, improving the expressiveness of the inner construction wood. Finally it presents the description of the processes of charred or burned and toasted traditional of the construction wood and the chemical toasted, for later analyse the advantages observed in the superficial application of acids on the inner construction wood that offers the method of the “chemical toasted”.

2. Methods

In construction of outside wood, the processes contemplated of charred or burned and toasted, that influence in the colour of the wood are: The action of the nature, that in extremely colds climates produce color changes due to bad light, the action of the wind generated in the outer layers of the wood for construction, a mineralization freeze them offering a gray appearance characteristic of this type of construction, the Ultraviolet Radiation as part of the solar radiation that burns the cells of the surface of the wood, but without heating the same, producing an effect of graying and peeling wood, causative of the alteration suffered by the wooden surfaces and of the coatings that on this apply, the Infrared Radiation that heats the surface of the wood, but without burning it producing the evaporation of the water contained in the cells of the surface originating tensions in the interior of the wood that produce fissures, cracks, combined with warping, the methods of dried of the wood from the natural until the application of ultrasounds, the charred or burned traditional realised through of the application of fire to 400°C, the low conductivity of the wood trasmitte by the charred superficial a low proportion of heat to the interior of the wood, acting as insulation, protecting the inside of the timber, his more known exponent is the technician of the Shou-sugi-ban [4] and finally the traditional toasted through the application of fire and finally the traditional toasted of the wood through of fire application of 200°C, used in the production of casks of wine. In all these processes takes part a source of external heat

whether natural or artificial sunlight such as in the case of a flame of fire produced by fossil fuels. The advantage of the toasted chemist in front of the traditional, is the ease of industrial production, uniformity, energetic saving, security and ease of industrial application in the case of colourless liquid acids.

3. Results and Discussion

It uses the space RGB colour and the use of the histograms of the samples realised to compare the variation of colour between samples "Without treating" And "Treated" with colourless liquid acids. It presents 3 types of essays directed to explain the advantages of the "Toasted chemist", studying the chromatic differences between the wood without treating and treated. Essay A: Observation of the change of colour when applying the tool of the toasted chemist. Essay B: Marked of lines of expression (veto, knots, etc), generating one "Footprint" Characteristic and differentiating. Essay C: substantial Change of the appearance of the wood, that can involve the utilización of said change like form to obtain of a cheap wood a similar appearance to a expensive woods.

4. Conclusions

The Advantages of the chemist toasted are: The production process in the case of traditional toasting of casks is artisanal nature, producing few units, with an important intervention of skilled labor and a low yield, influencing fail to produce uniform standards in manufacturing product. On the other hand the colourless liquid acids are easy to apply and are a natural treatment finalist with a dried fast, mechanized production processes that can be applied without skilled labor, controlling the parameters of control of materials, temperature, exhibition, intensity of colour, thickness of the layer generated, integrity of the wood, uniformity, energetic saving, security and ease of industrial application in the case of colourless liquid acids. It observes a parallelism between both processes of charred and traditional toasted and chemical toasted, coinciding in the protection of the wood, but keeping differences, where the charred traditional and especially the toasted traditional regarding the chemical toasted differentiate in the type of process that employs, in the traditional toasted uses the fire and in the chemical toasted the acids, in the first employs a temperature from the 200°C and in the second employs temperature of environment of interior, in the first is not an aim the change of colour and texture and in the second it is, and in the first applies to wood of outside construction and in the second to wood for inner construction. This "parallel duality" leads to a "conceptual translation" which results in turn in the conditions and characteristics of each surface treatment, where in both cases a surface protection of wood is obtained, one using fire and its alternative using acids, the latter option, the acids have a wide variety of types, by extension get a wider range of colors and textures in the interior wood for construction. The use of chemical toasted tool can also obtain a potentiation of the expression of wood, customizing and differentiating, even coming from the economic point of view to consider the possibility, by changing the look of wood, turn a cheap wood in an economically similar to a wooden expensive, and by extension get a benefit from ecologically sustainable and more economically masses wooden expensive, which are in turn having fewer hectares and affect finally in the price of wood.

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MASONRY STRUCTURES: "OLD" AND "NEW" APPROACHES TO STRONGLY LOCAL PHENOMENA

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Keywords: *Masonry; Photoelasticity; Discrete Element Model; Heterogeneous Finite Element Model*

1. Introduction – Many simple methods exist for the analysis of the global behaviour of masonry structures. However the analysis of local behaviour is elusive, especially when the bonding material is in disrepair and the bond strength is dependent from the friction. To explain the causes of this difficulty is far from the scope of the present work. However, since such behaviour can become a practical problem in specific cases, it is necessary to propose alternative models that approximate best local behaviour than the classical models usually employed.

Hereinafter a combination of "new" and "old" approaches is proposed. This will show the nature of the phenomenon and will allow to progress in the development of models that can account for it. In the first phase the strongly random nature of the phenomenon is shown, if only qualitatively. This is achieved through the implementation and testing of photoelastic models. In the second phase an approximation to some qualitative results is attempted through numerical models.

2. Methods – Several photoelastic tests were made, in which different epoxy resin models were put through to compression. The tests were made within a PMMA (polymethyl methacrylate anil) containment box, where compression was applied by conventional mechanical means, using various pieces of the same material.

Two numerical models were implemented. The first is the simplest possible model within the discrete element method (DEM), and is based on rigid blocks in unilateral contact; the second is based on Heterogeneous Finite Element Model in which the contact faces have been modelled as empty spaces, except for a single point of contact.

In both numerical methods the set of possible irregularities in the contact is represented through the point of application of the resultant of the contact forces randomly chosen.

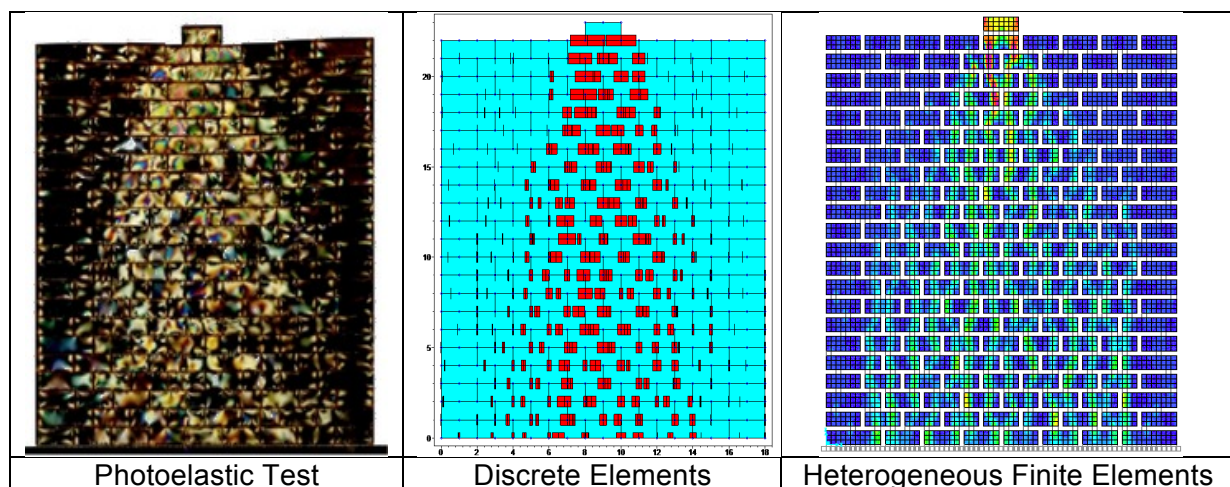


Figure 1

3. Results and Discussion – In a first approach qualitative results -for the first model- and quantitative results -for the other two- were obtained. These results were presented graphically so that they could be compared. An example of these results is shown in Fig. 1.

A simulation using the Monte Carlo method was implemented next. For this simulation, a practical problem was proposed upon the second model: the resistance of a rod anchored in one of the lower rows. 1200 repetitions were performed to obtain the simulation results presented in Figure 2.

The analysis of the results shows the wide variability of the model's resistance, since the minimum value obtained is the tenth of the maximum, and very close to null. Dismissing these very improbable outliers and taking the usual engineering values, the mean value is 234 being 130 the characteristic value (5% percentile) and 338 the 95% percentile. These values fit well with those of a normal distribution with the same mean and variance, although the normality tests indicate that the frequencies distribution cannot be considered normal. The load testing of masonry models would give important information to properly assess the results of both photoelastic and numerical models.

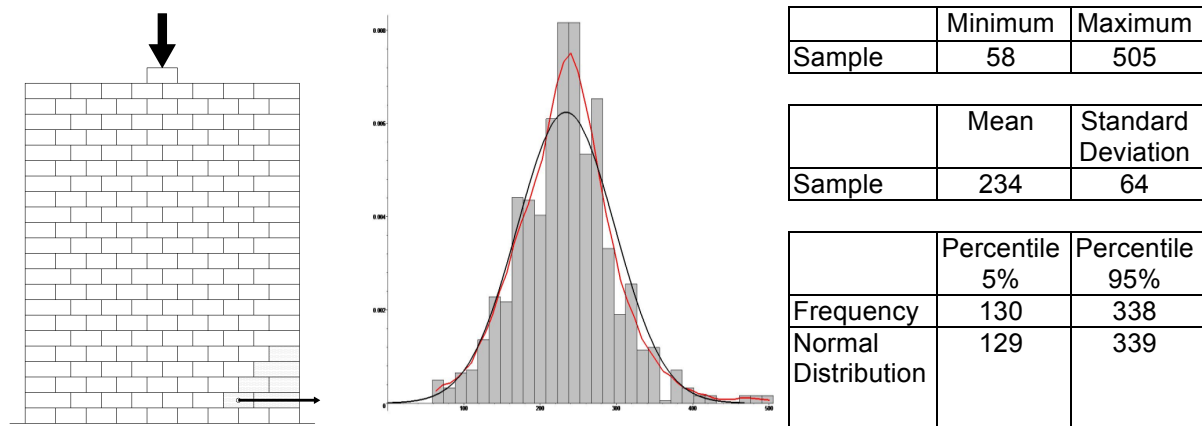


Figure 2

4. Conclusions – Major differences can be observed in the local behaviour of a masonry structure when we approach the material as a continuous or as a discontinuous medium. Especially when taking into account irregularities in the material or in the conditions of the contact between pieces, problems that arise quite commonly in historical buildings. In cases such as these, the appearance of islets of very low or no tension inside the masonry has great relevance in its behaviour. However, these islets go unnoticed when the overall structure is studied globally.

The photoelastic method has proven useful for the analysis of masonry structures, as it allows to visualize these flows of forces inside the constructive elements, and to notice the qualitative behaviour of the factory. Numerical methods based on random distributions of irregularities constitute a very encouraging first step in obtaining a method to quantify this behaviour.

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EFFECT OF THERMAL MASS ACTIVATION ON CONCRETE MECHANICAL PROPERTIES OF BUILDING STRUCTURES

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Keywords: *Energy efficiency in building; Thermo Active Building Systems; Heat exchangers; Concrete.*

1. Introduction – Net Zero-Energy buildings (NZEBS) [1] collaborate to solve the constant concerns about energy supply constraints, decreasing energy resources, increasing energy costs and the rising impact of greenhouse gases on world climate. Thermo-active building systems [2], as low exergy systems, are defined as heating or cooling systems that allow the use of low valued energy, which is delivered by sustainable energy sources, as geothermal energy, i.e., using building foundations as heat exchangers with the soil. (Figure 1)

Thermo-active building structures acts as a high-temperature cooling system (16-20°C) and a low-temperature heating system (25-30°C).

The effect of thermal activation on the mechanical behaviour of these concrete building structures can be analysed on three levels, the effect on the ground [3], on the foundation [4], and on the structural slabs [5]. The impact of thermal loads on the mechanical response of the ground and on the behaviour of energy foundations has been studied, but thermo active slabs studies [6] already performed are focused in estimate the thermal comfort and energy consumption.

The aim of this work is to study the concrete behaviour of thermo-active slabs and foundations due to the inclusion of embedded pipes in which fluids circulate at low temperatures.

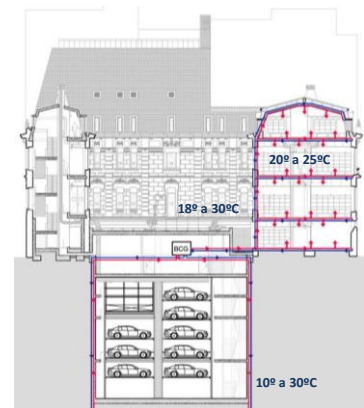


Figure 1 Thermo-active building system. ENERES

2. Methods – In order to assess the effects of the inclusion of pipes and its influence on the mechanical behaviour of concrete, 54 specimens (Figure 2) were made from two different types of concrete, H-25 and H-30: 24 specimens were prepared in cylindrical moulds, 100 mm dia. and 200 mm height, and 30 in cubic moulds, 100 x 100 x 100 cm³. These specimens (Figure 3) with 24 mm dia. polyethylene pipes embedded at different positions, (vertically centred, and off-centre in cylindrical samples, and horizontally centred), were tested to evaluate concrete compressive strength.



Figure 2 Cylindrical and cubic specimens with 24 mm dia. polyethylene pipes embedded in different positions during the manufacturing process.

3. Results and Discussion – In order to compare the results obtained in the tests from different points of view, the most representative values were selected and calculated from the data obtained in the compression tests, these are maximum strength σ_{max} , maximum strain ϵ_{max} , ultimate strain ϵ_u , maximum strain energy E_{max} and ultimate strain energy E_u .

Analysis of the data (Figure 4) indicates that, in the cylindrical specimens, the maximum strains $\varepsilon_{\max}$ are similar in specimens with pipes arranged parallel to the load direction (both centred and off-centre) and decrease when the pipe is laid perpendicular to the load, regardless of the type of concrete. In the cubic specimens, the maximum strains are greater in specimens without pipes, and the lowest values occur for horizontally placed pipes.



Figure 3 Cylindrical and cubic specimens with 24 mm dia. Polyethylene pipes embedded in different positions tested to compressive strength.

The correlation between the strength loss and the position of the pipes, for concrete H-25 and H-30, is shown in table 1. As can be seen, the introduction of polyurethane pipes reduces concrete strength in both cylindrical and cubic specimens, with losses over 20% when the pipe is in a horizontal position, i.e. perpendicular to the load.

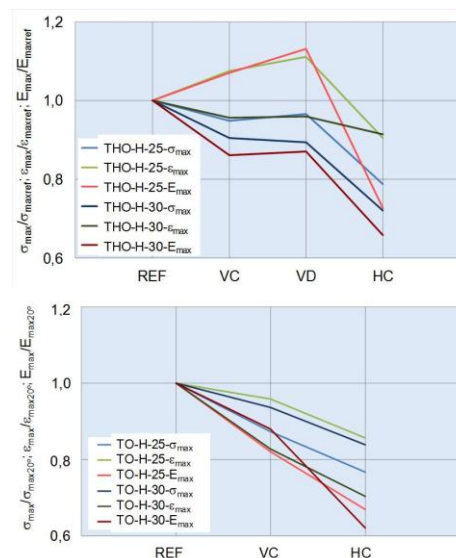


Figure 4 Evolution of maximum characteristic compression test values for different pipe positions in cylindrical (THO) and cubic (TO) specimens.

Concrete type	Compression test	Compression test	Pipe position
	Cylindrical	Cubic	
H-25	Strength loss (%)	Strength loss (%)	Pipeless
H-30	0,00	0,00	
H-25	5,17	12,76	Vertical centered
H-30	9,43	6,37	
H-25	13,45	-----	Vertical decentered
H-30	10,50	-----	
H-25	21,27	23,33	Horizontal centered
H-30	27,85	16,20	

Table 1 Strength loss in concretes H-25 and H-30, for different pipe position. (Losses exceeding 20% strength are marked)

4. Conclusions - From the results obtained in the test can be drawn that the inclusion of polyethylene pipes embedded in concrete specimens reduces their mechanical properties, this reduction being more pronounced for a pipe laid perpendicular to the application of load.

It can be concluded that thermo-active concrete structures perform best when the polyethylene pipes are placed parallel to the load.

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STUDY OF THE INFLUENCE ON THE DEFORMATION AND THE ECONOMIC IMPACT OF THE TYPE OF KNOTS IN WARREN TRUSSES

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Keywords: *steel, struss, deformation,*

1. Introduction – The indisputable advantages of steel structures for large spans, makes the use of trusses is commonly used as structural good results using less material than other structural materials and less weight. Despite these advantages and be a highly recyclable material, the main problem is the energy consumption and CO₂ emissions involved in its manufacture. Production of crude steel in 2010 in the European Union was approximately 172.9 million tons a year, with Germany the largest steel producer in the EU, producing 43.8 million tonnes, followed by Italy which produced 25.8 million tonnes and 16.3 million tonnes Spain [1]. According to a 2002 study, the annual steel production in the European Union 40% is produced in electric arc furnaces (EAF) and the remaining 60% in steel oxygen furnaces (BOF), while in Spain, 75% of the production of steel is produced in electric arc furnaces. The latest study takes into Spain by autonomous communities dating from 2005, which is annually produced 12.3 million tons of steel in Electric Arc Furnaces [2]. The production of steel in electric arc furnaces and ladle furnace slag in Spain generates annual 2.55Mt worth a year, which poses serious environmental problems. These data show the importance of investigating and trying to move toward a building with less environmental impact and sustainability. Considering these aspects, the study aims to study the influence on the deformation produced in Warren type trusses, when they are subjected to different load values and with different types of knots, in order to optimize the amount of material used in structures.

2. Methods – For the realization of this work has designed a Warren type truss with 20m of spans and 1.5m high (Figure 1), with steel S275JR according to UNE-EN 10025-2 and hot rolled sections [3].

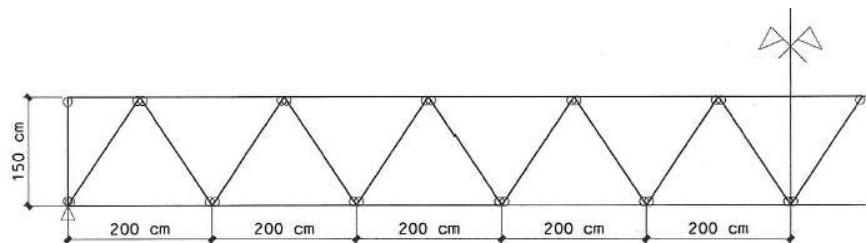


Figure 1 Geometric characteristics of the Warren truss

On the designed truss they are calculated deformations caused by the application of different load values at the knots and assuming different types of unions, through a program of structural calculation and according to the technical code for structural safety in the steel DB SE-A : Steel [4]. Moreover, they have also calculated the deformation in articulated trusses according to previous standards (MV-103 and AE-95), in order to compare the results [5, 6].

3. Results and Discussion – Table 1 shows the relationship in percent between the applied loads, the deformations obtained according to the standards used, the type of knots having the trusses and steel weight in each case, with reference to the truss less load and stiff joints, which has the lowest deformation. The analysis of Table 1 shows that in all types of truss, with increasing loads increase deformations and major increases deformations indicate, for each type, to the trusses with articulated knots. It is also noted that the deformations calculated using the approximate method of steel previous standards are higher than those determined by the current Technical Code. It is also noted that as the load increases to 200%, the trusses articulated need an investment of money above 12% even

with 5.3% deformation over the trusses with stiff knots. Trusses increases to 400% load, amounts of such materials in both types of trusses, causes deformations have articulated structures than 6% relative to that of stiff knots.

Analysis	Point loads in knots (kN)	Types of knots	Increased load (%)	Increased deformation according DB SE-A: Acero (%)	Increased deformation according MV-103 and EA-95 (%)	Quantity of steel (kg/ml)	Price increase (%)
1	20	Stiff	0	0	-----	46,80	0
2	20	Jointed	0	0,67	1,34	50,90	8,76
3	60	Stiff	200	1,79	-----	132,00	182,05
4	60	Jointed	200	7,16	21,68	137,00	194,01
5	100	Stiff	400	9,62	-----	217	349,01
6	100	Jointed	400	15,66	30,02	218	358,68

Table 1 Percentages of increased deformation and increased price, based on the increased load and the type of knot in Warren type trusses

4. Conclusions – The main conclusions of this work are:

- The Warren truss type work best to deformation, in trusses with stiff knots than articulated.
- At higher applied loads, greater deformation in trusses with rigid and articulated knots.
- Deformation values obtained with previous standards to the present Technical Building Code, introduces greater deformations and therefore remain on the side of safety.
- The increase in deformation and the price (based on the amount of material) between trusses with knots articulated regarding trusses with stiff knots, is similar for each type of load studied, being more expensive trusses with knots articulated than those with stiff knots, from the same deformation.

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RE-USE OF GLASS WASTE IN RESTORATION MORTAR

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Keywords: Lime mortars restoration glass waste.

1. Introduction.

We did not find much literature on the properties of lime mortars in which natural sands for glass waste is replaced (1).

However there are many publications in which glass waste is used as substituent in manufacturing portland cement mortars (2) y (3).

In this research, it is studied the possibility of using glass waste to manufacture lime mortars, designed for the restoration of buildings with historical-cultural value, which have been originally done with this kind of binder.

Despite that, from a theoretical point of view it is possible to recycle 100% of glass, in practice there is a few limitations, such as the coloured component contended, which make very difficult to completely reuse the entire recycled glass in the selective collation containers in Spain. Using this residue in the restoration mortars manufacture, is studied here as another alternative for the reintroduction of these materials to the production cycle and its valuation.

2. Methods.

For the design of the first mortar, three different granulometries of sand are prepared, weighting the corresponding quantities of the different sizes of glass residue particle, previously smashed and sieved.

The lime chosen as conglomerate is natural hydraulic lime type NHL-5 and it will be rationed with the relation 1:3 in relation with the glass residue used as sand. The quantity of water is stablished accordingly so the mortar gets a consistency in beat table of 175 ± 10 mm, as it is established in the regulation according to its density.

The characterisation of the mortar is done through tests in fresh state: density, air content, workability, water retention; and tests with the hardened mortar: density, mechanic resistances, steam permeability, absorption by capillarity, adhesion. Finally, two durability tests are performed as freeze thaw cycles and resistance to the crystallisation of the salts (4).

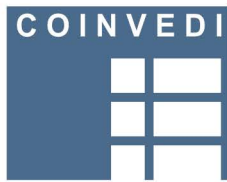
3. Results and Discussion.

The obtained results allow for classifying the mortar as CS II, in relation of its resistance to compression, as regulation UNE-EN 998-1: 2010, which establishes the specifications for the mortars revoque and plaster mortars. Regarding the water absorption, high levels have been obtained, in contrast with discreet results for steam permeability, as the results obtained in the test of adherence to ceramic supports. The high volume of occluded air, measured inside the fresh mortar, concurs with a low density levels, both in fresh and hardened state. The workability period and the water retention in the fresh mortar show appropriate values.

4. Conclusions.

The future development of this research will be focused in the improvement of the lime and glass mortar characteristics, examined in this current research, for their use as restoration mortar in the maintenance and preservation of architectonic heritage.

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EXPERIMENTAL MECHANICAL CHARACTERISATION OF A ESTRUCTURAL LIGHTWEIGHT AGGREGATE CONCRETE ACORDING TO EC-2

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Keywords: *Lightweight concrete, compression, EC-2*

1. Introduction – The self load of a structure is usually higher than the loads it has to carry. It means that these kind of structures are quite often inefficient. The replacement in concrete of the normal aggregate by other lighter materials leads to a significant fall in the concrete weight.

The normal aggregate has been replaced by lightweight aggregate since Roman Empire Ages. It has let singular buildings as Agripa's Pantheon or the Coliseum in Rome. The evolution according to the age of the compression and tensile strength and the Elastic Modulus in a Lightweight Aggregate Concrete (LAC) has been analysed in this paper. The concrete was produced by LAFARGE. Its commercial name is THERMEDIA. The experimental researches has been compared with the predicted values by EC-2.

2. Methods – The research has been done with a mesh produced by LAFARGE. Expanded clay has been used has lightweight aggregate. The density was 700 kg/m³ for lower aggregate and 650 kg/m³ for upper one. The expected concrete's density was 1500 kg/m³. 24 cylindrical 15x30 cm pieces and 12 cubic one were made. The pieces were tested a age of 7, 14, 24 and 90 days. 3 cylindrical and 3 cubic pieces were tested at each age at compression stress and 3 cylindrical ones at tensile stress.

The Eurocode EC-2 [1] says that it is possible to guess all the mechanical values throw the measure compression stress (f_{cm}) at 28 days and the density(ρ), according to table 1.

Parameter	Estimaed value	Relation
$f_{cm(t)}$ (MPa)	$f_{cm(t)} = f_{cm} \cdot \beta_{cc(t)}$	$\beta_{cc(t)} = \exp\{s[1-(28/t)^{1/2}]\}$
$f_{ctm(t)}$ (MPa)	$f_{ctm(t)} = f_{ctm} \cdot \beta_{cc(t)}$	
f_{lctm} (MPa)	$f_{lctm} = f_{ctm} \cdot \eta_1$	$\eta_1 = 0,40 + 0,60\rho/2200$
E_{lcm} (GPa)	$E_{lcm} = E_{cm} \cdot \eta_E$	$\eta_E = (\rho/2200)^2$

Table 1.- Estimated mechanical values according to EC-2

3. Results and Discussion – The table 2 shows the measure values of the broken stress at each age, 7, 14 28 and 90 days. The table compares the tested and the estimated by EC-2 values, cylindrical and cubic pieces for compression and tensile stress. Moreover, the Elastic Modulus is indicated at compression tests. All the values are shown in MPa.

Age (days)	Density (kg/m ³)	Compression					Tensile	
		cylindrical			Cubic			
		Piece	σ (MPa)	E (MPa)	Piece	σ (MPa)	Piece	σ (MPa)
7	1515,29	Meassure	23,17	10.600	Meassure	26,65	Meassure	2,12
		EC-2	24,36	13.633	EC-2	26,80	EC-2	2,05
14	1511,65	Meassure	25,62	10.979	Meassure	29,46	Meassure	2,55
		EC-2	25,09	13.687	EC-2	27,59	EC-2	2,09
28	1511,33	Meassure	25,61	11.145	Meassure	29,45	Meassure	2,59
		EC-2	25,61	13.766	EC-2	28,17	EC-2	2,12
90	1510,98	Meassure	27,00	11.200	Meassure	31,05	Meassure	2,70
		EC-2	26,18	13.852	EC-2	28,80	EC-2	2,15

Table 2.- Measure values of the broken stress at different ages

The figure 1 shows the evolution of the broken compression stress, both for cylindrical (Cci) and cubic (Ccu), and tensile stress (T) at different ages (7, 14, 28 and 90 days). It is indicated as the experimental values as the expected by EC-2 value.

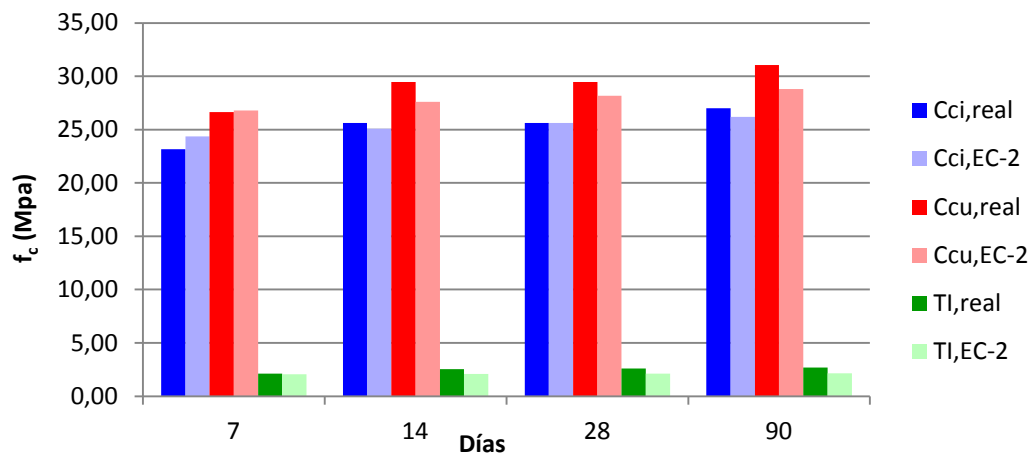


Figure 1.- Evolution of the broken stress at different ages

4. Conclusions – The estimated values by the EC-2, for each situation and each age, are always lower than the experimental ones, except for cylindrical compression at 7 days.

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EXPERIMENTAL PERFORMANCE OF SYNTHETIC WATERPROOFING MEMBRANES IN THE INVERTED FLAT ROOF

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Keywords: *Inverted flat roof; extruded polystyrene board; plastic interaction; waterproofing*

1. Introduction

Synthetic waterproofing membranes are commonly used to waterproof in the building industry. On the other hand, inverted flat roof is widely used in those flat roofs requiring thermal insulation.

The thermal insulation material of the inverted flat roof is the extruded polystyrene board; there is no other possibility, since other thermal insulation materials cannot keep their thermal characteristics in the normal conditions of this constructive system. Figure 1 shows a cross sectional view of an inverted flat roof.

Extruded polystyrene board (XPS) can interact with some materials in the inverted flat roof within usual conditions for this constructive system [1] [2]. This interaction can produce degradation in the waterproofing material cutting down the life cycle of this construction solution.

The main objective of this paper is to present some results of the laboratory experimental process, in which the behaviour of some waterproofing membranes, such as ethylene propylene monomer diene (EPDM), flexible polyolefin (TPO) and plasticized polyvinyl chloride (PVC-P) are analyzed when they are in close contact with extruded polystyrene board (XPS). Interactions and incompatibilities between flat roof materials can produce significant degradation in them [3].

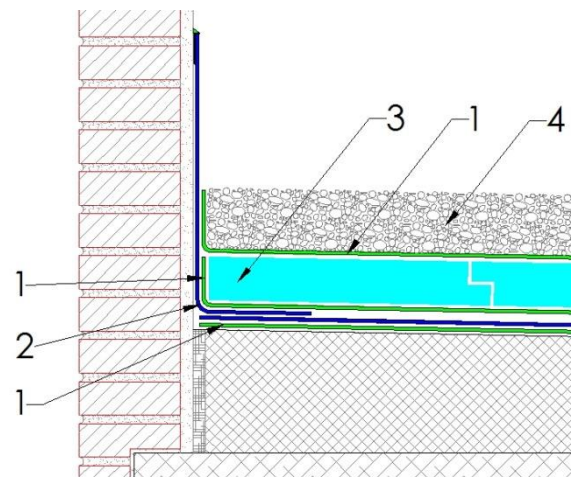


Figure 1 - Cross sectional view of an inverted flat roof. 1 – Auxiliary separating layer; 2 – Synthetic waterproofing membrane; 3 – Extruded polystyrene board; 4 – Heavy-duty protection

2. Methods

The laboratory experimental process developed in this study, is mainly based in the UNE-EN ISO 177:2001 Standard [4], in which it is described a method for determining the tendency of the plasticizers to migrate from plastic materials (into which they have been incorporated), to other materials or plastics, placed in touch with them. This is possible by analyzing the mass loss of the synthetic waterproofing samples, after several days in the draft furnace under specific conditions of pressure and temperature.

A test sample cut from a sheet of the material to be tested is placed in close contact with a material capable of absorbing plasticisers (extruded polystyrene in this adapted experiment). The loss in mass of the test sample is a measure of the plasticiser migration. The temperature of the test was 50° C, the test was performed during 15 days and the pressure between the samples was 4,6 g/cm². Samples of synthetic waterproofing membranes, and extruded polystyrene board were conditioned before every quantity weighed in accordance with the ISO 291:1997 Standard [5].

3. Results and Discussion

Figure 2 shows the mean of the results of mass loss percentage of the different waterproofing membranes tested in this experimental process.

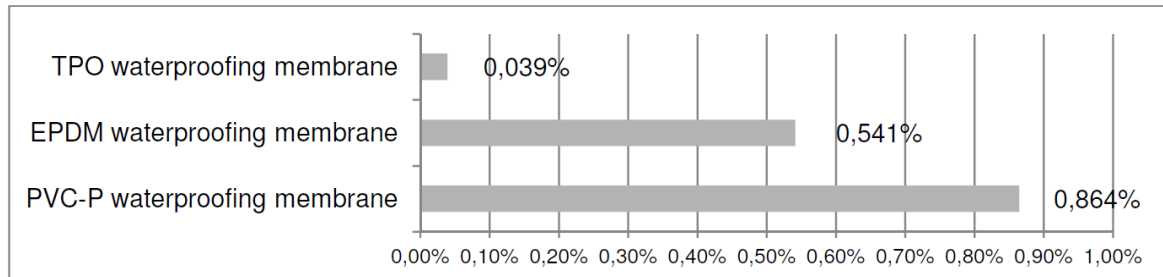


Figure 2 - Comparison of the mean of the results of mass losses percentage, between the different waterproofing membranes tested. Configuration of the samples: direct contact between the waterproofing membrane and the XPS. Test in draft furnace during fifteen days at 50 °C.

The synthetic waterproofing membranes of ethylene propylene monomer diene (EPDM) and plasticized polyvinyl chloride (PVC-P), suffered an important mass loss after staying 15 days in the draft furnace at 50 °C. On the other hand, flexible polyolefin waterproofing membranes (TPO) did not have a significant mass loss in the experiment developed, which it was initially predictable, due to the theoretical absent of plasticizers of this type of membranes.

4. Conclusions

There are incompatibilities between XPS and the waterproofing membranes of PVC-P and EPDM, these may affect to the integrity of the materials.

Flexible polyolefin waterproofing membranes (TPO) are compatible with XPS, there is no need to place an auxiliary separating layer to avoid interactions.

To use an auxiliary separating layer (geo-textile) with a greater mass than 250 g/m², can minimize interactions and incompatibilities, however they still occur.

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OBTENTION OF RECYCLED PLASTER MATERIALS MADE WITH ARTIFICIAL QUARTZ

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Keywords: *Plaster mortar, artificial quartz, aggregates, physical properties*

1. Introduction – The volume of waste materials become higher due to industrial processes, so it's necessary to reuse and recycle products with the aim of achieving the production of useful new materials, derived from recycled materials. This is the case of rigid plasters of Silestone® that come from the wastes of the production and manufacturing. The aim of this work study the value of this material, in order to fabricate gypsum mortars, studying the properties and even improvements and benefits it can bring in the properties of these materials with Silestone® wastes grounded. From this viewpoint, the aim of this work is to study and use these materials like recycled aggregates in plaster mixtures, studying the effects that Silestone® taking place in these materials.

Previous studies indicate that gypsum conglomerates with partial replacement by waste materials (slage, slate,...)are viable and promising. Likewise, the study of the physical and mechanical characteristics of these conglomerates confirm that they are appropriate to use in building and especially, for prefabricated panels. Research about Silestone® waste reuse, has just been focused in mixtures bituminous. Outcome achieved, have been really positive.

2. Materials – Plaster characterised as B1 according to European Norm EN 13279-1 was analysed by X-ray diffraction using a Philips PW1830 diffractometer, which identified calcium sulphate hemihydrate as its main constituent with crude gypsum among its minor components. Silestone® was ground, and their granulometric size was determined. The procedure to obtain the recycled mortar plasters consisted of the progressive addition of ground Silestone® to the plaster.

3. Results and Discussion – All of the mixtures were characterised by their setting time, density in wet and dry states, water vapour permeability, mechanical strength after 7 and 28 days, adherence to ceramic materials and colorimetric values. SEM was used to determine the microstructure and behaviour of these materials. All of these properties were established in accordance with standard EN 13279-2. Furthermore, the fabrication of plasterboard was carried out.

4. Conclusions – The results obtained show the viability of using Silestone® waste as partial substitute for a part of the plaster mixture in the fabrication of mortar mixes with enhanced properties and that these could be of use in the building industry. At the same time, these are environmentally friendly materials that will contribute to sustainable development.

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HOW TO SELECT THE MOST SUSTAINABLE MATERIALS FOR THE ROOF RETROFIT? A SEMI-QUANTITATIVE METHOD APPLIED TO A PREASSEMBLED TIMBER PANEL

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Keywords: *Building refurbishment; Energy retrofit; Recycled materials; Roof*

1. Introduction – In most of the developed countries today, more than 50% of construction works are related to refurbishment [1]. In Italy there are 1.4 households per family and 42% of the housing stock needs urgent refurbishment works, especially to improve seismic reinforcement and indoor thermal and hygrometric comfort [2]. In this context, the importance of refurbishment in the housing sector is crucial, since the improvement of obsolete buildings is often cited in some researches as a valid solution for the current constructions crisis of many developed countries [3].

In the next future, an increasing use of recycled building materials instead of products with a high content of virgin resources should be strongly encouraged. In fact, recycled materials account for a reduced amount of energy consumed for extraction and production, with strong benefits in terms of carbon emissions and depletion of natural resources. Unfortunately, a holistic and practical method for the measurement of the benefits in the use of these materials is still missing. Thus, the definition of a method, based mostly on quantitative criteria, for the selection of different building products and options is needed. Moreover, often the rapidity of the construction works and the economic competitiveness of the retrofit are important aspects, Prefabrication is generally considered a valid solution, which allows to reduce significantly the working time on site ensuring a better quality of the refurbishment [4].

In this paper a prefabricated system for roof refurbishment is presented. The prefabricated panels were designed in order to be manufactured and completely assembled by social cooperatives located in Northern Italy, in the province of Lecco. The aim of the work, based on the results achieved in privately funded research project, is to define a semi-quantitative matrix for the selection of building products with a high content of recycled materials which can be considered in the assembly as both insulation and structural elements.

Figure 1 Structure of the preassembled timber panel designed for the retrofit of roofs.

2. Methods – The goal of the research was to propose a new building element for the refurbishment market, which can be fully manufactured by the involved cooperatives using local products and recycled materials. In order to understand if an alternative is better than another, some “values” should be identified. These selected values, called “categories”, are referred to different aspects, including environmental, social and economic aspects. Through these aspects a semi-quantitative matrix was generated on the basis of the following four categories:

1. *Supply chain* – which includes the distance of the manufacturing process (from raw materials extraction to final production), annual amount of production and annual variability.
2. *Sustainability* – which includes the amount of recycled materials used for production, the share of material which can be recycled at the end of life (EOL), embodied energy for extraction and manufacturing and energy need for product disposal at EOL.

3. *Economic cost* – which includes cost of material supply and cost of production, divided into: automation of production, time needed for a complete production cycle (from transportation to manufacturing to packaging), cost linked to manufacturing area and cost linked to storage.
4. *Usage* – which includes physical characteristics, divided into: durability, vapour permeability, safety; reversibility of use, adaptability to refurbishment and, finally, innovation.

The decision table developed is a matrix that comprises the criteria stated in the value model for the objective hierarchy. The decision-maker is required to score each category for each option according to a defined numerical scale. The scale were set from 1 (poor) to 5 (excellent) and the resulting scores are named n_{ij} . Then, a damping coefficient (f_{ij}) was defined to estimate the weight of each item in relation to all criteria. The weights express the importance of sub-criteria and are set so that the sum for each category is always 100%.

3. Results and Discussion – The score of each category is derived from the weighted sum of the scores, considering the damping factors, obtained in the various subcategories. The matrix contains thresholds, in order to avoid the study of those products which do not present the basic requirements for the project. If the resulting value for each category is not at least equal to 3, the study of the material or component is considered not interesting.

The weighting criteria for the assessment are described by the following equations (1-2, 3):

$$n_i = n_{i1} \times f_{i1} + n_{i2} \times f_{i2} + \dots + n_{ij} \times f_{ij} \geq 3 \quad \text{with } f_{i1} + f_{i2} + \dots + f_{ij} = 1 \quad (1-2)$$

$$N = \frac{\sum_i n_i}{i} \quad (3)$$

3. Conclusions - The study shows how a decision method based on a semi-quantitative approach for the selection of materials for the composition of a preassembled modular panel for refurbishment of roofs can be a practical support for the decision-makers. The decision method here presented is based on a matrix for the assessment of the performance across a broader range of environmental, social and economic considerations. Depending on the actual situation under study, from a technical viewpoint the process might need a proper risk analysis to be carried out avoiding rough mistakes and to verify the quality of a choice. The performance of decision alternatives depends mainly on the relevant weight proposed for the criteria. Consequently, the decision-maker should be very careful when defining the weights for each sub-category in the decision table; for instance, a sub-category can be very important at a specific point of time and place, while it may lose its importance at a later stage. In this work, the weight associated to raw materials supply and costs for production are the most relevant in the results.

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STUDY OF THE VALIDITY OF TECHNIQUES ELECTROCHEMICAL IN THE CORROSION OF REBARS EMBEDDED IN MORTAR SPECIMENS WITH SLAG LFS

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Keywords: *Corrosion, slag, electrochemical techniques, gravimetric technique, LFS*

1. Introduction

The durability of concrete is essential to ensure the life for which it was designed. To this end one of the most important factors is reinforcement corrosion [1]. Initially corrosion processes were analyzed by gravimetric techniques, but since the mid-twentieth century, electrochemical techniques are used to study corrosion. Electrochemical techniques have played a very important role because its accuracy is much higher than the gravimetric technique, and allows measurements as often as necessary [2]. Although there are studies examining the correlation between these methods in reinforced concrete used normally, no studies correlating the results obtained by both methods [3] in a mortar in which White ladle furnace slag (LFS) are incorporated. Steel production generates tons of slag, which are considered waste and causing serious environmental [4]. Considering these aspects, the study aims to test the validity of using electrochemical techniques in the analysis of corrosion of reinforcement embedded in mortar specimens with LFS as dross compared with gravimetric techniques.

2. Methods

In this research, tests with two series of specimens were performed of mortar (dimensions 6x8x2cm³) with Portland cement CEM I / 42.5 R, urban potable water, sand, white ladle furnace slag (LFS), retarders and different percentages of chloride ion, as shown in Table 1.

Label	Description	w/c
MBE-0,0	Replacement of cement (30%) and sand (25%) by LFS + plasticizer (0,15%) + retardant (0,5%)	1,48
MBE-0,4	Replacement of cement (30%) and sand (25%) by LFS + plasticizer (0,15%) + retardant (0,5%) + chloride ion (0,4%)	1,48
MBE-0,8	Replacement of cement (30%) and sand (25%) by LFS + plasticizer (0,15%) + retardant (0,5%) + chloride ion (0,8%)	1,48
MBE-1,2	Replacement of cement (30%) and sand (25%) by LFS + plasticizer (0,15%) + retardant (0,5%) + chloride ion (1,2%)	1,48
MBE-2,0	Replacement of cement (30%) and sand (25%) by LFS + plasticizer (0,15%) + retardant (0,5%) + chloride ion (2,0%)	1,48

Table 1 Dosages of the specimens

For comparing the validity of electrochemical methods in the corrosion study of mortars with slag LFS, we measure potential and corrosion rates using electrochemical techniques (polarization curve) with AUTOLAB / PGSTAT302N potentiostat. With the reference electrode used (SSCE; +0,222V SHE), more negative potentials that -231mV involve corrosion risk associated 90%. Moreover, corrosion rate exceeding 1 A/cm² significantly reduce the durability of reinforced concrete structures, if it is maintained over time. After obtaining sufficient data to evaluate the corrosion behavior of different specimens using

electrochemical techniques, we proceeded to quantify by gravimetric mass loss experienced by the bars.

3. Results and Discussion

Figure 1 shows the relationship between the potential and the corrosion rate. As can be seen both measures are directly related. It is the highest corrosion rate that corresponds to more negative corrosion potential and higher percentages of chloride ion. Specimens with percentages of chloride ions above the limit set by the EHE, are in active state, while samples without chlorides or with 0.4% chloride ion by weight of cement, are in passive state.

Figure 2 shows the relation between mass loss experienced by the bars and the corrosion rate in the slag specimens with slag LFS. As can be seen, the specimens with higher corrosion rate are experiencing greater loss of mass. The corrosion behavior shown by the electrochemical and gravimetric techniques is similar.

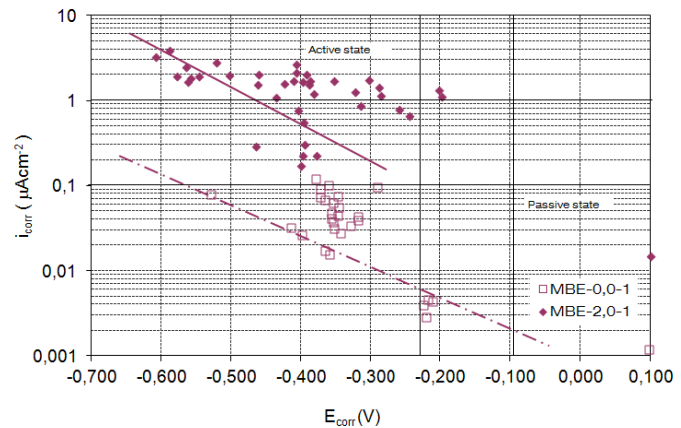


Figure 1 Relation between the corrosion potential and corrosion rate

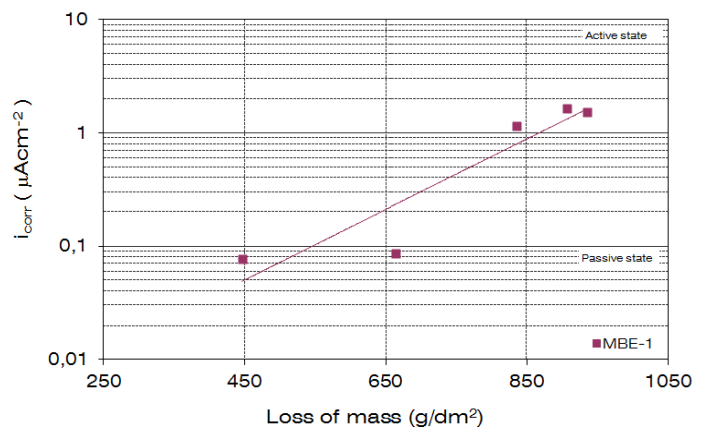


Figure 2 Relation between corrosion rate and the loss of mass

4. Conclusions

- In specimens with white ladle furnace slag, the corrosion potential and the corrosion rate increases with the percentage of chloride ion by weight of cement introduced at the time of kneading.
- The corrosion behavior of mortars without chlorides or percentages of 0,4% by weight of cement, limit set by the EHE instruction, presents corrosion rates specific of passive state, while for mortars with percentages of chloride ion of 0,8, 1,2 and 2,0%, the reinforcing steel corrosion rates are specific of active state.
- The values obtained for determining the corrosion behavior of steel bars by gravimetric and electrochemical techniques have been consistent, hence we can conclude that electrochemical methods are valid for the study of corrosion in slag Mortar LFS.

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CASE STUDY: ADAPTAVATE'S JOURNEY FROM ACADEMIA TO COMERCIALISATION OF ALTERNATIVE BUILDING MATERIALS TOWARDS A CIRCULAR ECONOMY.

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Keywords: *Circular economy; Alternative building materials; Commercialisation.*

1. Introduction – Human development as it has been has catalysed a climate disturbance. It is necessary not only to mitigate it but as well to be ready to endure over it. Housing represents an important role on this environmental reaction as the built environment contributes up to 47% of the UK's CO₂ emissions [1]. Although 80% of these emissions are linked to the buildings 'in use' energy consumption, there is growing interest around building materials and innovation in these materials to reduce embodied energy and embodied carbon [2]. If we are to reach CO₂ reduction targets for 2020 in European Union these issues could also become increasingly important.

Conventional building products brought advantages over the traditional building techniques and materials at a time when sustainability, resource efficiency and emissions were disregarded. These products have traditionally a linear life cycle where end of life means disposal with also a great amount of wastage. Big efforts are done towards a more circular cycle of these materials such as recycling at the end of their life bringing part of them back into the cycle. While these efforts still necessary to increase circularity of these ubiquitous conventional materials, new alternatives have to become available to accelerate the decarbonisation of the built environment [3]. Adaptavate is a young startup company founded by MSc graduates which has identified the opportunity to commercialize innovative building materials from academia towards a circular economy [8b].

2. Discussion – Interest in alternatives to conventional building materials exists within the building sector. There are a number of different factors driving this interest in 'alternative' materials including:

- Improved thermal performance of the building
- Use of building materials containing biogenic carbon which can potential act as carbon sinks [5].
- Interest in the internal air quality of buildings as air tightness increases. This is reflected in the EU financing several projects under the Framework 7 call "EeB.NMP. 2013-2 Technologies and materials for a healthier indoor environment".
- Finally, and of increasing importance, the use of "breathable" materials which will help to reduce 'damp' and internal condensation.

Breathability or moisture buffering capacity is the mechanism by which hygroscopic materials absorb/desorb moisture from the air surrounding them to reach equilibrium. Latif et al. [6] showed that hemp fibre insulations had very good moisture buffering capacity and that this can be used to moderate humidity fluctuations in internal spaces – i.e. walls and roofs. Moderating fluctuations in moisture in internal spaces can help to reduce the occurrence of condensation in buildings, and thus potentially the mold and fungal growth that is often associated with damp, cold living conditions where condensation forms. These conditions can exacerbate or even cause a range of health conditions [7] and are of increasing concern for two reasons. Firstly increasing fuel poverty means households are not able to heat their houses sufficiently to prevent damp and condensation, and secondly the unintended consequences of measures to increase the energy performances of buildings by reducing air

leakage (and therefore heat loss) have resulted in moist air becoming trapped internally and thus causing condensation.

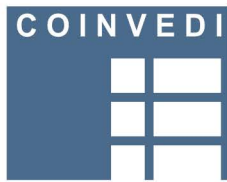
Adaptavate is developing alternative building materials with potential to solve many of the problems previously described. While studying for their MSc Tom Robinson and Alberto Fernandez – founders of Adaptavate – conceived ideas to replace conventional and linear building materials. During this period of research the potential for these ‘alternative’ building materials to be commercially manufactured began to take shape [8a].

3. Conclusions - The journey from product concept to commercialization of a product is invariably a long one, especially difficult for new companies with no track record, and numerous pathways are available which can be followed. Adaptavate initially succeeded in securing a place on a Climate-KIC boot camp, providing intensive training followed by mentoring aimed at helping people with ideas learn how to pitch those ideas to start to look for commercial backing [8b]. Climate-KIC is one of the EU's main climate innovation initiatives aimed at accelerating the rate at which ideas get to market and start making a difference to climate change [4].

As well as needing to develop market knowledge and business skills, Adaptavate also recognized that this must be backed up with solid product development and additional performance data. Here they approached different academia institutions and were able to gain access not only to pilot scale product development equipment and testing but also to networking opportunities. Adaptavate's networks are working and now they have expanded into their own workshops. Through Climate-KIC they have access to an incubation office space in central London and are now linked with several other Universities in the UK who are testing various aspects of their products performance. The next stage is the scale up of production and decisions about which path to follow. This is where networks and support really will play a key role in the development of their products.

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“EFFECT OF THE USE OF GLASS WASTE ON THE PHYSICAL AND MECHANICAL PROPERTIES AND DURABILITY OF MORTARS MADE WITH CEMENT AND HYDRAULIC LIME”.

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Keywords: *Restoration mortars, waste glass, mortar made with cement and lime.*

1. Introduction.

We did not find much literature on the properties of lime mortars in which natural sands for glass waste is replaced^[1].

However there are many publications in which glass waste is used as substituent in manufacturing portland cement mortars^{[2] [3]}.

Previous research of Research Group of Engineering Building (GIIE) with natural hydraulic lime mortars (NHL-5), as binder and waste glass as aggregate, they have allowed to know the characteristics of these mortars, who exhibit low mechanical strength and adhesion, as well as a high concentration of entrapped air.

To improve these characteristics, bastards mortars have been tested with mixtures of Hydraulic Lime and White Portland Cement as binders and waste glass as aggregate.

2. Methods.

It has been used mixtures of natural Hydraulic Lime (NHL-5) and White Portland Cement (BLII/B-LL 42,5R)), in weight ratios of (90/10), (70/30) y (50/50) and as aggregate, sands of green recycled glass.

The binder / sand ratio has been (1/3) and quantities of water required for the mortar reaches a consistency in the shake table has been (175±10 mm.), according to its density.

The mortars were tested both in fresh and hardened status to determine its characteristics.

In fresh state it has determined the density, content of entrained air, workability and water retention, whereas in hardened state, besides its density, the mechanical resistance to bending and compression, water vapor permeability, capillarity absorption and adhesiveness. They have also been subjected to durability tests, freeze-thaw cycles and salt crystallization^{[4] y [5]}.

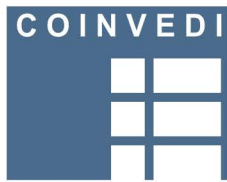
3. Results and Discussion.

A comparison between mortars made with natural hydraulic lime and lime mortar mixes are set (Natural Hydraulic Lime and White Cement).

On this date we have not finished the tests, but we can already confirm improving mechanical strength. We will present the final results in final paper

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GYPSUM PLASTERBOARD DECONSTRUCTION TO RECYCLING ECONOMIC ANALYSIS: THREE CASE STUDIES

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Keywords: *Gypsum waste; End-of-Life; deconstruction; demolition; economics.*

1. Introduction – Deconstruction is identified as an effective means for reducing mixed Construction and Demolition (C&D) waste at a time of diminishing landfill capacities and increasing environmental awareness [1]. However deconstruction is still perceived as more costly and its economic viability differs considerably according to local conditions [2].

This paper discusses the economic prospects of deconstruction, based on the analysis of three case studies part of the GtoG project, European Life+ GtoG Project ENV/BE/001039: *“From Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry”*, where best deconstruction practices were monitored and studied. The study addresses the need for an effective deconstruction process to optimize the plasterboard waste recycling, as well as the impact that taxes have on the economics.

2. Methods – Two scenarios are considered for the analysis: deconstruction and demolition. Deconstruction involves the removal of the plasterboard by dismantling its components, source separation and disposal at the recycling facility whether passing by transfer station or not. Whereas demolition is determined by no segregation, obtaining a gypsum waste contaminated with other waste fractions, which becomes non-recyclable and it is sent to landfill whether passing by transfer station or not.

The total cost calculated for each route depends on the dismantling, sorting and loading affected by the cost of labour and productivity; transport calculation taken into account distance destination and number of trucks depending on the skips capacity, skips rental subject to the works duration as well as waste acceptance fee applied per tonne at the recycling facility or landfill.

3. Results and Discussion – Tables 1-2 presents the general data and calculations for the study, based on real values and cost estimations provided by the deconstruction contractors carrying the GtoG pilot project assessments, and vary in relation to their experience and national market conditions. Assumptions have been also considered, as specified in the tables.

The principal economic differences between the dismantling and loading operations from the deconstruction route can be attributed to the techniques carried out and equipment used. Only mechanical means in the first case, whereas manually and mechanical ones in the second case. Regarding the transport cost per tonne, in D2 is lower for a more significant amount of waste, as skips of higher capacity are used reducing therefore the number of roundtrips as well as the haulier cost.

On the other hand, conventional demolishing is determined by the final disposal fees of the mixed waste that are noticeable more costly than in the recycling option. Transport to landfill presents savings in D2 and D3 owing to the cost derived from the skips' rental, which is a shorter period of time, and mixed waste volume, which has turned out to be smaller than sorted waste, meaning that a less number of skips are needed.

DECONSTRUCTION CASE STUDIES	D1	D2	D3
Country	France	Germany	Brussels
Type of building	9 floors, offices	5 floors, offices	2 floor Offices**
Square meters of plasterboard system (m ²)	6750	3450	2800
Waste Fractions:			
Plasterboards type 1 (t)	67.52	11.64	42.94
Laminates (10 cm Mineral wool)* (t)	0.00	13.00	0.00
Plaster Ceilings (t)	0.00	12.00	0.00
Recyclable metal frames (t)	4.49	1.00	4.60
Mineral wool (t)	1.50	8.00	6.13
Wooden frames (t)	0.00	120.00	0.00
TOTAL of MIXED WASTE	73.51	165.64	53.67

*Non recyclable GW, accordin with recycler's agreed criteria, DB1

**Subject of the GtoG project

Table 1 Description of the case studies

COST OF THE DECONSTRUCTION ROUTE (€)	D1	D2	D3
Dismantling*	3,375.00	1,932.00	3,500.00
Sorting*	14,006.25	7,728.00	8,400.00
Loading*	151.82	8,594.10	780.50
Transport	2,040.00	1,680.00	1,060.00
Waste management option-Recycling	3,182.60	10,260.20	2,115.95
TOTAL DECONSTRUCTION COST	22,755.67	30,194.30	15,856.45
Cost per m ² of platerboard system (€/m ²)	3.37	8.75	5.66
COST OF THE DEMOLITION ROUTE (€)	D1	D2	D3
Crushing, collapsing*	1,350.00	966.00	560.00
Sorting*	13,500.00	7,728.00	5,600.00
Loading*	176.42	7,851.34	2,683.50
Transport	2,280.00	1,440.00	740.00
Waste management option: Landfilling	6,983.45	18,220.40	6,708.75
TOTAL DEMOLITION COST	24,289.87	36,205.74	16,292.25
Cost per m ² of platerboard system (€/m ²)	3.60	10.49	5.82
Cost increasement: demolition compared with deconstruction			
(%)	6.74%	19.91%	2.75%

* Assumption according to average productivity from the GtoG pilot projects

Table 2 Cost of the deconstruction versus demolition route.

3. Conclusions - Deconstruction provides economic and environmental benefits coming from the savage of materials reused and from the disposal fees avoided, compared to the conventional demolition practices.

Landfill tax is one of the crucial economic parameters identified as more impacting in the total cost that should be used to encourage deconstruction, and thus C&D waste recycling.

The deconstruction practices applied on-site may lead to cost savings and enabling an effective dismantling, on- site sorting and loading and recovery but for a fraction due to the GtoG recycler's specific acceptance criteria.

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BIOCOMPOSITES FOR ADVANCED PROFILES ADAPTED TO BUILDING ENVELOPE

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Key words: biocomposites, natural fibres, processing, pultrusion, profile, building envelope

1. Introduction – An alternative composites answer in the envelope sector is the fabrication by pultrusion of narrow interlocking panel sections and profiles. These impact-resistant structural elements have the advantage of quicker, safer installation and their modular design equally answers many identical building and other applications [1][1].

An additional development in this area can be the obtaining of a sustainable alternative to current composite profiles. Previous studies [2-6] have shown that biocomposites manufactured from natural materials such as fibres and bio-derived polymers; offer a sustainable alternative to traditional polymers and composites.

The goal of this development is to replace the typical light gauge steel profile with a state of the art bio-composite integrated system. The finish profiles can also be used to finish existing masonry partition walls, cladding mechanical and extraction shafts and column cladding. The profiles have been designed using bio-polymers, reinforced with natural fibres where possible and necessary (figure 1). Proper formulations of the bioresin, natural fibres and processing parameters have been established. The adaptation of the existing processing pultrusion techniques to the specific characteristics of the new biomaterials and natural fibres has been also assessed.

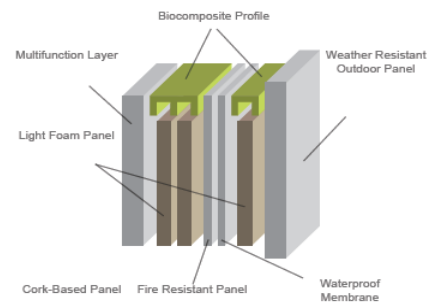


Figure 1. Assembled modular multi-layer envelope based on biocomposites in which is integrated developed biocomposite profile

As a result, demonstrators of pultrusion profiles adapted to building envelopes have been developed incorporating novel materials, natural fibres and bio-based resin.

2. Methods – Processability of biocomposites is complex and has a low output. Because of this, there is a need of new technologies adapted to the behaviour of the bio-based materials. Accordingly, thermoset biocomposite profiles have been developed in the Osirys project at pilot plant level. As reinforcement, continuous and low twist natural fibres have been employed for profile manufacturing.

A homogeneous curing, short residence times and low processing temperatures are required to improve formulations with bioepoxy and natural fibres. For this, specific characteristics of the new bioresins have been also assessed: i) evaluation of curing cycle of selected bioepoxy, taking into account requirements in terms of temperature due to natural fibers processing (160 °C) and ii) assessment by Differential Scanning Calorimeter (DSC) and Dynamomechanical analyzer (DMA) about maximum temperatures to optimise glass transition temperature (T_g) results.

Adaptation of pultrusion process to biocomposites with natural fibres yarns has been required to improve formulations and process parameters to avoid fibres break. A post curing area has been added in pultrusion equipment to adapt to requirements of bioepoxy resin in terms of post-curing.

Different pultrusion trials with glass, flax and hybrid (glass and flax) fibers have been carried out with standard polyester resin and bioepoxy resin in order to optimise processability (Figure 2Figure). Yarns of glass fibers of 4800 tex and 100 % flax yarn of 2000 tex were used to perform them. Pultrusion profiles were prepared for mechanical characterization according to ISO 10406-1:2008 standard. The length of bars was 300 mm. It was prepared an

anchoring system adapted to the geometry of the test pieces (bars) and with the capacity to transmit only the tensile force along the longitudinal axis of the test pieces.



Figure 2. Different phases of pultrusion process obtained by hybrid fibers (flax and glass).

3. Results and Discussion – From DMA (Table 1) and DSC tests, it was shown that optimised results for bioepoxy systems were obtained with a curing cycle at 160 °C. This curing cycle has been evaluated and optimised in the pultrusion process in order to adapt it to the requirements of natural fibers processing.

Sample	Tg onset E' (°C)	Tg peak E'' (°C)	Tg tan delta (°C)
Curing cycle at 150°C	60.49	60.82	77.35
Curing cycle at 160°C	75.43	77.81	91.78
Curing cycle at 170°C	75.82	77.93	91.74

Table 1. DMA results (at different curing cycles) of bioepoxy system

Zone 1	120 °C
Zone 2	140 °C
Zone 3	160 °C
Post curing	100 °C

Table 2. Temperatura pultrusion profile

From DSC results, the most suitable temperature profile (Table 2) has been defined for the pultrusion process and a post curing area has been included to adapt to requirements of bioepoxy system.

Specimens of pultrusion profiles were obtained by pultrusion process at pilot plant level (figure 2). Different compositions of the reinforced bars were evaluated by tensile tests (Table 3).

Pultrusion profile composition	Young's Modulus (MPa)	Tensile Strength(MPa)	Elongation at break (%)
Bioepoxy system + glass fiber	48400 s=2990	786 s=70	1,7 s=0,1
UP resin + glass fiber + natural fiber	46100 s=575	513 s=21	1,1 s=0,1
UP resin+ glass fiber	46400 s=1130	537 s=59	1,2 s=0,1
UP resin + glass fiber + alumina	33700 s=3840	346 s=49	1,1 s=0,3

Table 3. Tensile results of rebars

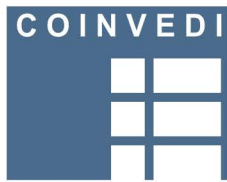
4. Conclusions – An optimised pultrusion process at pilot plant has been obtained to produce biocomposites profiles with bioepoxy resin. Better mechanical results in the pultrusion profiles have been achieved at pilot plant level using the bioepoxy system and glass roving. Nevertheless, flax fibers with low twist can be used to produce pultrusion profiles and no significant differences in the mechanical properties have been found between the profiles prepared with glass fibers and those obtained with hybrid fibres (glass and flax) with unsaturated polyester (UP) resin.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 609067.



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USE OF FINE FRACTION OF RECYCLED AGGREGATES FROM CONSTRUCTION AND DEMOLITION WASTE CDW IN MASONRY MORTAR FABRICATION

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Keywords: *recycled aggregate; mortar; waste treatment; physical and chemical characterization; mechanical properties.*

1. Introduction – Unceasing activity in the construction sector during the last years before the crisis has produced a high generation of waste and an increase in the use of raw materials. Recycling rate in Spain is about 15% of the total production of CDW, which is used mainly as filler in road construction that is also typical for other countries [1].

Various scientific researches have studied the feasibility of incorporating fine fraction of recycled aggregate in masonry mortars production. The bibliography consulted shows varying permitted replacement percentages, partly due to the heterogeneity of recycled aggregates. Vegas et al [2] concluded that mortars can contain up to 25% of fine recycled aggregate without their mechanical properties, workability and shrinkage being affected, requiring no additives. Fernández et al. [3] evaluated the possibility to incorporate fine fraction of recycled aggregates in masonry mortars using CEM II/BL 32.5N. Obtained results show that replacement ratio of 50% can be achieved in mortar for indoor use.

The main aim of this work is the evaluation of recycled mortars properties both in fresh and hardened state using different replacement percentages of natural sand with recycled aggregates. This study results present a contribution regarding the published works, and could help to increase CDW recycling rates.

2. Methods – The testing programme was developed using two types of binders: CEM II/B-L 32.5 N and CEM IV/B (V) 32.5 N. There were suggested three substitution percentages to replace natural sand with three types of recycled aggregates: 50%, 75% and 100% (The mixes containing 50% and 75 % of recycled aggregates were completed with natural sand to reach 100% of necessary aggregate) and cement-to-aggregate by dry weight proportions were 1:3 and 1:4. Preparation of all mixes was performed using the same technique and equipment. There was used 1% of additive over the weight of cement for all the mixes, following the recommendations indicated by the manufacturer.

3. Results and Discussion– Characterization of fine recycled aggregates samples was based on the technical requirements regulated by the standard UNE-EN-13139: “Aggregates for mortar”. The main characteristics of recycled aggregates are their high water absorption, lower density and higher friability coefficient compared to natural sand used as a reference.

Recycled mortars characterization was divided in two stages. During the first stage, flexural and compression strength were analyzed for two types of cement used in the study. According to the obtained results, it is concluded that generally recycled mortars fabricated using CEM IV/B (V) 32.5 N present better results in performed tests. Mixes prepared with 100% of recycled aggregates comply with existing standards regulating mortars for carried out tests.

Test	RA-1 100%		RA-2 100%		RA-3 100%		Ref. mortar	
	1:3	1:4	1:3	1:4	1:3	1:4	1:3	1:4
Wet density (gr/cm ³)	2.11	2.08	2.12	2.11	2.14	2.09	2.23	2.18
Workability (min)	86	89	87	92	90	87	160	150
Dry density (gr/cm ³)	1.76	1.69	1.77	1.74	1.79	1.74	2.01	1.97
Real density (gr/cm ³)	2.13	2.15	2.18	2.18	2.15	2.13	2.30	2.26
Bond strength (N/mm ²)	0.43	0.40	0.43	0.40	0.42	0.39	0.49	0.50
Shrinkage (mm/m)	0.088	0.115	0.091	0.104	0.083	0.091	0.025	0.034
Water abs .capillarity (kg/m ² *min ^{0.5})	0.62	0.84	0.67	0.85	0.68	0.83	0.56	0.59

Table 2 Recycled mortars CEM IV/B (V) 32.5 N

Workability period of fresh mortar is measured as a period of time in minutes that it takes for mortar to reach strength of 0.5 N/mm², using a penetrometer (UNE-EN 1015-9). Obtained results are similar to those presented by Jimenez et al [4] with replacement ratio of 40% using ceramic recycled aggregate and Vegas et al [2] with replacement ratio of 25% using recycled aggregates from concrete rubble.

The highest values of dry density were presented by natural sand. Values observed in recycled mortars were quite similar, and observed density values are caused by low density of recycled aggregates. Obtained results are similar to the findings of other studies [2] [4].

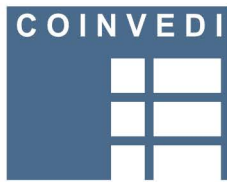
Real density of hardened mortar was analyzed with a stereo-pycnometer, used for measuring volume of solid objects. Obtained values of recycled mortars are poorer compared to reference mortar values. Observed differences between real density and dry bulk density are directly linked to the total porosity. Thus, samples with the highest real density and the lowest dry bulk density, as in case of mixes elaborated with 1:4 dosage, present the highest volume of porosity and the highest communication between pores.

The results show higher water absorption by capillarity of recycled mortars due to the high absorption of recycled aggregates. Similar tendencies were observed by other authors in their studies, presenting similar absorption by capillarity values, however with lower percentage of recycled aggregates incorporation [2] [4].

4. Conclusions - Mechanical strength of recycled mortars fabricated with 100% of recycled aggregates is poorer compared to mixes made with natural sand. Better results were obtained in the mixes made with CEM IV/B (V) 32. 5 N.

- Compression, shrinkage and bond strength values of recycled mortar comply with established standards, allowing its use in construction using studied recycled aggregates in suggested proportions.

- Cement-based mortars (CEM IV/B (V) 32. 5 N) may be fabricated with recycled aggregates coming from ceramic, concrete and mixed recycling processes, using 1:3 and 1:4 cement-to-aggregate dosages, complying with the limits established by the Spanish standards in carried out tests.



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EFFECT OF SUPERPLASTICIZER BASED ON MELAMINES ON THE PROPERTIES OF LIGHTWEIGHT MORTAR PLASTER MADE WITH POLYURETHANE

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Keywords: *Superplasticizer, Gypsum mortar, Polyurethane waste, Mechanical properties.*

1. Introduction – Superplasticizers, or high-range water reducers, are organic anionic surfactants. Once dissolved in water, the gypsum plaster particles are released, improving cohesion and system rheology. The role of these additives can take three different directions: to reduce the water/gypsum ratio of the mix, maintaining its workability, improving the workability for a specific water/gypsum ratio or reducing the water or gypsum content but maintaining the same workability and mechanical strength [1].

With the reduction of water through the use of these additives, it is possible to make stronger gypsum mortar that is less porous and harder wearing [2]. From a chemical perspective, superplasticizers are organic polyelectrolytes in the high molecular weight polymeric dispersant category [3]. Melamine-based copolymers can significantly improve the porous micro-structure of hydrated gypsum, reducing porosity. Other researchers have noted this improvement in the performance of gypsum mixes, due to the reduction in the water/gypsum ratio, therefore reducing total pore volume and average pore diameter, offering a more compact internal structure [4].

The influence of melamine based superplasticizer is studied in relation to the properties of blended mortar plaster made with recycled polyurethane foam. The characteristics of the test specimens are defined and tested in both a fresh and a hardened state.

Our results show that the addition of additive based in melamine influence the properties of the mortar plaster, enhances its mechanical properties increasing its Shore C hardness and its absorption by capillarity.

2. Materials – Construction gypsum is classified as B1/20/2 in Standard EN 13279-1 [5], the specifications of which stipulate an initial setting period of over 20 minutes, with a compression resistance of ≥ 2 N/mm². According to the manufacturer's specifications, this gypsum presents a purity value of 87.66%. X-ray diffraction (XRD) for the purposes of mineralogical characterization identified calcium sulfate hemihydrate as the main component of the material. The real density stood at 2320 kg/m³ and laser diffraction of the granulometry indicated that 50% of the sample presented sizes of below 50 μ m. White Polyurethane Waste (PUW) was taken from the waste generated in the manufacture of insulative panels in the refrigeration and construction industries. Following shredding, it presented itself as a dust with a granulometry of between 0-0.5 mm, with real density and bulk density values of 1080 kg/m³ and 72 kg/m³, respectively. BASF additive employed in this research was a melamine-based superplasticizer (MasterRheobuild 2100®). The choice of this additive was partly justified by the improvements they offer to the gypsum products and partly because they are frequently used in building, based on the manufacturer's recommendations. Additive dosage was based on a % of the weight of the gypsum plaster (0.8, 1.4 and 2%).

3. Methods—All of the mixtures were characterised by their setting time, density in wet and dry states and mechanical strength after 7 and 28 days, Shore C hardness and its absorption by

capillarity. All of these properties were established in accordance with standard EN 13279-2 [6].

4. Results and Discussion –

Results of analysis of density and mechanical properties are showed at Table 1.

Specimens	7 DAYS			28 DAYS		
	Density (gr/cm ³)	Flexural strength (Mpa)	Compression strength (Mpa)	Density (gr/cm ³)	Flexural strength (Mpa)	Compression strength (Mpa)
REFMR0,8	1,49 gr/cm ³	6,01 N/mm ²	18,64 N/mm ²	1,50 gr/cm ³	4,89 N/mm ²	17,22 N/mm ²
1/0,5WMR0,8	1,35 gr/cm ³	4,46 N/mm ²	14,07 N/mm ²	1,35 gr/cm ³	3,05 N/mm ²	10,86 N/mm ²
1/1WMR0,8	1,19 gr/cm ³	2,93 N/mm ²	8,46 N/mm ²	1,19 gr/cm ³	2,45 N/mm ²	6,75 N/mm ²
1/2WMR0,8	0,94 gr/cm ³	1,27 N/mm ²	2,60 N/mm ²	0,93 gr/cm ³	1,25 N/mm ²	2,75 N/mm ²
1/3WMR0,8	0,67 gr/cm ³	0,44 N/mm ²	0,82 N/mm ²	0,67 gr/cm ³	0,42 N/mm ²	0,76 N/mm ²
REFMR1,4	1,51 gr/cm ³	6,88 N/mm ²	21,46 N/mm ²	1,53 gr/cm ³	5,45 N/mm ²	21,41 N/mm ²
1/0,5WMR1,4	1,27 gr/cm ³	3,56 N/mm ²	10,80 N/mm ²	1,24 gr/cm ³	3,03 N/mm ²	9,56 N/mm ²
1/1WMR1,4	1,12 gr/cm ³	2,30 N/mm ²	6,10 N/mm ²	1,11 gr/cm ³	2,52 N/mm ²	5,82 N/mm ²
1/2WMR1,4	0,91 gr/cm ³	1,18 N/mm ²	2,60 N/mm ²	0,89 gr/cm ³	1,34 N/mm ²	2,55 N/mm ²
1/3WMR1,4	0,68 gr/cm ³	0,7 N/mm ²	0,9 N/mm ²	0,67 gr/cm ³	0,51 N/mm ²	0,89 N/mm ²
REFMR2,0	1,53 gr/cm ³	5,78 N/mm ²	16,62 N/mm ²	1,56 gr/cm ³	4,73 N/mm ²	24,32 N/mm ²
1/0,5WMR2,0	1,37 gr/cm ³	3,50 N/mm ²	10,06 N/mm ²	1,35 gr/cm ³	3,33 N/mm ²	12,73 N/mm ²

Table 1. Results of density and mechanical properties of different samples

The results obtained show the viability of using MasterRheobuild 2100® additive in a 0.8% as additive to enhance mechanical flexural and compression strength, reduced water/gypsum+polymer ratios, increased apparent dry density of the mortar plaster with polyurethane.

5. Conclusions –

The improvement with the introduction of this additive in their respective mixes is based on decreased porosity, due to the reduced water/binder ratio as a result of the additive. The dispersing effect can be increased through the addition of short side chain polymers of low molecular weight. The melamine-based copolymers can significantly improve the porous micro-structure of the hydrated gypsum, reducing porosity, resulting in reduced porosity and stronger and more compact matrices.

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POTENTIAL USE OF RECYCLED AGGREGATE IN STRUCTURAL CONCRETE

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Keywords: *construction and demolition waste; recycled aggregate; structural concrete; Spanish Structural Concrete Code EHE-08.*

1. Introduction – The big amount of waste generated by construction industry has led to environmental policies that aim at minimization, reuse and recycling construction and demolition waste.

When construction and demolition waste (C&DW) is treated in suitable treatment plants, the quality of the recycled aggregate (RA) is apt for building construction [1], mortar manufacturing [2] and road construction [3]; therefore, it can be a highly competitive product both technically and economically, as well as environmentally viable [4].

The resulting RA are mainly composed of concrete particles from natural or ceramic aggregates. However, they often have impurities, such as crushed clay brick, crushed ceramic materials and gypsum, contributing to the presence of contaminants, for example chlorides, sulphates, siliceous gel, oil or any other damaging material. These defects, together with the mortar adhered to RA particles, have a negative influence on the physical, mechanical and chemical properties of recycled concrete. The adhered mortar is the main cause of the low quality of RA compared to natural aggregate (NA) [5].

Nowadays, recycled aggregates manufacturers produce different fractions according to productivity criteria rather than the necessity of the construction building to get a quality structural concrete. Nevertheless, the Spanish Structural Concrete Code (EHE-08) [6] requires aggregates, included in their field, to meet certain technical requirements included in the European Standard EN 12620 [7]. Moreover, the EHE-08 encourages the use of RA in article 28 and annex 15.

The aim of this study has been the characterisation of RA produced in a C&DW treatment plant, which works in the province of Granada (Spain). For this reason, the physical and chemical properties of several RA samples with different granulometry were analysed, for the purpose of assessing their suitability to be included in concrete mixtures for structural use. Subsequently, these aggregates have been compared with other CE-marked natural aggregates (NA) used for structural concrete. The experimental results have shown that RA are acceptable according to conventional methods used with NA, taking into account the requirements established by the regulations [6,7].

2. Methods –

- Recycled aggregates (RA) - Four different fractions from a treatment plant of construction and demolition waste, located on the coast of Granada, were studied: (i) fraction 001, corresponding to an unselected fraction, resulting of simple impact crushing before the vibrating screen process; (ii) fraction 002 is the coarse fraction (10/50 mm); (iii) fraction 003 is medium size (6/10 mm); (iv) finally, fraction 004 is the fine fraction (0/6 mm).

- Natural aggregates (NA) - Three different NAs produced in a local quarry in Granada, Spain, were compared with RA: (i) natural coarse aggregates, NCA, (6.3/16 mm); (ii) natural medium aggregate, NMA, (4/8 mm); (iii) and natural fine aggregate (0/4 mm).

For each one of the RA fraction, geometrical requirements have been studied –physical, mechanical and chemical– according to EHE-08 code [6], for both natural aggregate (Article 28) and RA (Annex 15), as well as the requirements of EN 12620 “Aggregates for Concrete” [7].

3. Results and Discussion – The samples studied showed good results in regard to granulometry, except for the general requirements of maximum (D) and minimum size (d), and the sand content (<4mm), which did not fulfilled the requirements of EHE-08 [6]. In regard to the size distribution, in all the samples studied there were continuous and not uniform granulometries; although, compared to several grading methods, all fractions have been observed to need an adjustment of the particle size for a better adaptation to the reference curves.

In regard to the physical, mechanical and chemical requirements, the water absorption and sulphate content did not meet the EHE-08 code [6].

3. Conclusions – According to the results obtained from the study carried out with four RA fraction produced at a construction and demolition waste treatment plant, located on the coast of Granada, we can conclude that the quality of RA could be improved generally by mixing it with natural aggregates, and specially by using measures such as manually moving away gypsum before the crushing process in the treatment plant of construction and demolition waste; the immersion of aggregate in water to reduce the chlorides; as well as an adjustment in particle size. This would allow to obtain a final product suitable to compete with natural aggregates, economically and environmentally speaking.

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RE-DESIGN OF PLASTER PREFABRICATED ELEMENTS

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Keywords: *Recycled Materials, Gypsum mortar, construction elements, ceiling*

1. Introduction – The construction sector is the main consumer of natural resources together with the industry. Around 20 to 50% of the material resources are consumed during the building process [1]. In addition, each square meter of construction involves --on average and only considering the environmental impact caused by the materials -- 0.5 tons of carbon dioxide emissions and 1600 kWh of energy consumption (depending on the building design). Moreover, at present, 81% of the total waste produced in Europe comes from the industry and building sectors. In 2012 more than 800 million tons of construction and demolition waste (CDW) were generated in Europe [2]. Despite these wastes can be easily recycled, Europe has a CDW recycling rate around 50%. This percentage is far from the objectives set by the European Directive for the year 2020 (70%). This situation has led to the development of many initiatives to minimize the environmental impact of the building construction. One of these initiatives seeks the re-design of traditional materials for building considering environmental criteria. Among these criteria are: reducing resources such as raw materials, water, energy, etc.; improving the performance of materials and even taking into consideration multifunctional materials. The research group TEMA from the School of Building is working on the first of these criterias considering the buildings as a “digester” of CDW. This is, using CDW as raw material for building materials manufacture. Numerous studies have been found [3] [4] [5] re-designing concrete and cement mortar by including several CDW as raw material. Instead, few research studies analyzing the addition of waste, as a lightened fill in a gypsum mortar applied in prefabricated elements for building were found [6] [7] [8]. Therefore, this paper shows the partial results of a project that aims the re-design of new precast plaster elements with environmental criteria, in particular the results about elements for ceilings that improve the acoustic performance of gypsum ceilings currently used today.

2. Methods –An experimental Plan was designed to identify the CDW more suitable for an eco-mortar to manufacture precast plaster for ceiling elements. During the study, the type of gypsum used was characterised as A1 according to European Norm EN13279-1 [9], and the additives added to the plaster composites due to improve mechanical strength were: fibres, plasticisers and bonding agents. Different physical and mechanical properties were measured in prismatic specimens (160 x 40 x 40) mm³. All the specimens were characterised by their density in dry state, their mechanical strength after 7 days and their Shore C hardness, according with standard EN 13279-2 [10] and UNE 102039 [11]. The results were compared amongst the gypsum composites analyzed and they were all defined based on their comparison to a reference sample made with no additives or aggregates. With this eco-mortar different boards for ceilings were designed. Numerical simulations have been performed (Straus7) on different boards designed for suspended ceilings, in order to check their viability by comparing them with plaster boards which are currently on the market. Acoustic absorption tests were also done in different plaster composites.

3. Results and Discussion –Gypsum mortars with recycled EPS from construction elements obtained better results than the other mortars analyzed, so were considered most suitable for the manufacture of acoustic ceilings. Because the decrease of the mechanical properties of these mortars, other studies to improve their mechanical behaviour were done, and the results were that the addition of plasticisers and bonding agents does not improve mechanical strength in comparison to the EPS plaster composite with no additives, producing the floating of the EPS waste into the plaster.

With the gypsum mortars studied, a new sandwich plate is proposed to be used in suspended ceilings. Moreover, the new sandwich plate is dimensioned by comparing its mechanical flexural behavior with the traditional plaster boards currently used, through finite element simulations

4. Conclusions - It is possible to add EPS waste in plaster composites to reduce the density of plaster materials. The new plaster plate proposed in this study reduces weight up to 13,5% compared to traditional plaster boards currently used, keeping a similar mechanical performance. The proposed design allows incorporating about 110 g of EPS per m² of ceiling and thus reduces plaster consumption around 14% compared to the commonly used plaster plates.

Therefore, it is possible to re-design prefabricated gypsum elements for ceilings with less environmental impact than the boards sold in the Spanish market.

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DRY INDUSTRIAL MORTARS DOSED WITH SLAGS

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Keywords: *Steelworks slag; steelmaking aggregates; masonry mortars; dry industrial mortars*

1. Introduction – The investigation develops innovative solutions in regard to the environment in the raw-material extraction process for the manufacture of mortars and concretes for construction. To do so, the use of alternative raw materials is studied, specifically the use of solid wastes generated in the iron and steel industry.

The volume of waste generated in the steel manufacturing processes has gradually increased over recent years, due to the increase in steel production, a direct consequence of progress and global economic growth, especially in the emerging economies.

This investigation aims to use Electric Arc Furnace slags (EAFS) and Ladle Furnace slags LFS, through their joint incorporation as aggregates in the preparation of “dry industrial mortars” in substitution of natural aggregates. The mortars presented a similar behaviour with all of the normative application references.

2. Methods – Mortars with CEM 42.5R cement, siliceous sand and limestone fillers as natural aggregates and EAFS and LFS as steelmaking aggregates are designed. Commercial additives are also employed in the mixtures, a water-retaining additive Cimsil C22 and an aerating-plasticizer Premortermix 201 of SIKA® company. A dosage 1:6:w by component weight and different possibilities for the substitution of natural aggregates by steelworks aggregates were used as specified in **Table 1**. The amount of water added in the mixtures to obtain mortars of plastic consistency according to the standard UNE-EN 1015-3 is shown in **Table 1**.

Sample	Natural aggregates/ steelmaking aggregates	CEM I (gr)	Natural aggregates (gr)	Steelmaking aggregates (gr)	C22 (gr)	PM 201 (gr)	Water (gr)
MR	100/0	300	1800	0	-	-	286.2
MEB	50/50	300	900	900	-	-	292.5
MED	0/100	300	0	1800	-	-	324.0
MR-C22	100/0	300	1800	0	2.1	-	299.7
MEB-C22	50/50	300	900	900	2.1	-	293.7
MED-C22	0/100	300	0	1800	2.1	-	286.2
MR-201	100/0	300	1800	0	-	1.8	239.4
MEB-201	50/50	300	900	900	-	1.8	243.9
MED-201	0/100	300	0	1800	-	1.8	249.2

Table 1. Mortar mixtures

The mortars are characterized in fresh and hardened state, studying its entrained air content, density, water retention, workability, mechanical strength, adhesion, water absorption and permeability in order to evaluate and compare the behavior of the samples made with steelmaking slags compared to the dosed with natural aggregates.

3. Results and Discussion – As an example, in **Table 2** they are shown the results of mechanical strength at 28 days of curing.

Sample	Flexural strength (N/mm ²)	Compressive strength (N/mm ²)
MR	3.82	15.11
MEB	4.95	17.66
MED	5.09	17.84
MR-C22	2.47	9.70
MEB-C22	2.71	10.60
MED-C22	2.79	10.62
MR-201	3.10	10.61
MEB-201	3.13	9.80
MED-201	3.63	11.47

Table 2. Mechanical strengths

Mortars are obtained with a standard compressive strength at 28 days of curing approximately 15 N/mm² when mixtures containing no additives and 10 N/mm² when incorporated additive.

According to the results, designed mortars MED-C22 and MED-201, which are made with EAFS as coarse aggregate and LFS as filler, could be named as specified in UNE-EN 998-2, as "M-5a" or "M-7.5a" mortars because in work it could not be guarantee the value obtained under optimal laboratory conditions of 10 N/mm².

An economic study was conducted to determine the profitability of the use of steel slags in the preparation of dry industrial mortars. It is suggested that the mortar plant should not be located beyond a radius of 150 km to guarantee its viability and so that the price of transport will not imply an obstacle to its use.

Equally, the material should be at "zero cost", for the recycling to be competitive, as any increase above zero would imply a higher final cost and would no longer be attracted from an economic point of view.

4. Conclusions – "M-5a" dry industrial cement mortars have been designed, in which the coarse aggregate is composed of EAFS and the filler of LFS. Highly workable mixtures of a plastic consistency have been achieved, with good water retention and with a standardized compressive strength at 28 days of curing at least 5 N/mm².

The results indicate that technically viable mortars may be obtained for use them in construction and building, exploiting a waste product that would otherwise be deposited in landfill sites with no particular use.

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REUSE OF CONSTRUCTION AND DEMOLITION RECYCLED AGGREGATES FOR THE PREPARATION OF ALKALI ACTIVATED CEMENT MORTARS. CHARACTERIZACIÓN AND MECHANICAL BEHAVIOUR.

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Keywords: *Construction and demolition waste; Alkali activated cements and mortars; Recycled aggregates; Mechanical strengths*

1. Introduction – In 2012, 35% of the waste generated in Europe were construction and demolition waste (C&DW). In Spain, 54 % of C&DW is clay-based. Many studies have confirmed the viability of using clay-based waste as a sub-base in road construction [1], as well as a pozzolan in Portland cement manufacture [2] and as an alternative raw material in the preparation of cement raw mix [3-4]. Also this waste is routinely used as an aggregate in portland cement mortar and concrete [5]. Given the composition of this material, it favours concrete performance and durability, as substantiated by its compliance with national and international concrete specifications.

Nonetheless, research on the use of this recycled aggregate to prepare alkaline cement mortars (AAMs) and concretes has yet to be forthcoming. The clay-based waste, composed primarily of Si and Al oxides, may potentially respond to alkaline activation. [6]. The present study aimed to determine the pozzolanicity of this material in OPC systems and the mechanical strength of mortars made with alkali-activated slag and fly ash, using variable proportions of clay-based aggregate. The effect of partial replacement of the slag and ash themselves with finely ground fractions of the waste was also explored.

2. Methods – The materials used in this study included CEM I 52.5R Portland cement (OPC), a vitreous blast furnace slag (SL), a fly ash (FA) and clay-based waste (C) consisting of hollow brick taken from a construction site. Chemical composition of C shows that it is composed primarily of SiO₂ (57,21%) and Al₂O₃ (18,60%) and it has a vitreous phase around 60%. Samples C and Cc (fired at 1000 °C) were tested for pozzolanicity (EN 196-5). The possible pozzolanicity of C was tested with two types of mortars: OPC with siliceous aggregate (OPC-S) and mortars containing clay waste (C) (particle size <45 µm) at a 20% replacement ratio (OPC/C (80:20)-S).

Prismatic specimens were moulded with the 8-M NaOH (N)-activated C and Cc pastes to analyse the aptness of this waste for use in the preparation of alkali-activated materials. These pastes were compared with 4 % Na₂O waterglass (AASLWg)-activated slag (SiO₂/Na₂O=1.2) and with 8-M NaOH (AAFAN)-activated fly ash. Tests were also conducted on blends of clay-based waste (C) and vitreous slag (SL) or fly ash (FA) at replacement rates of 80:20 and 50:50. The 7-day pastes were tested for mechanical strength. OPC mortars were prepared with clay-based waste (C), which was used to replace the aggregate. The aggregate substitutions of the siliceous sand (S) by clay-based waste (C) were 100 and 20 %. A further variable studied in the mortars was the state of the clay-based waste: normal (dC) or saturated in water/alkaline solution to prepare the mortar (wC) when they were used as aggregates. Alkaline mortars were also prepared with the non-fired clay-based waste (C), but here the waste was used to replace both the binder and the aggregate. All samples were tested for bending and compressive strength at 7 days and selected samples were tested at 2, 7 and 28 days.

3. Results and Discussion – Further to the [OH⁻] and [CaO] ion concentrations (mmol/l) found with the Frattini test both C and Cc proved to be pozzolanic after the eighth day.

Mechanical strength values of mortars containing 20 % ceramic waste C as a pozzolanic addition to cement, were (around 16%) lower than in mortars where a 100 % OPC binder was used. These findings show that the pozzolanic reaction and concomitant C S H gel formation generated by the waste contributed to mechanical strength because at all ages, the reduction in strength was smaller than the waste-for-cement replacement ratio (20 %).

Mechanical strength findings for the clay-based waste pastes tested to ascertain their response to alkaline activation show that strength values were lower in CN and CcN pastes, than in AASLWg and AAFAN pastes. C clay waste responds poorly to alkaline activation, despite its chemical composition and vitreous phase on the order of 60 %. This apparent indication of scant response constitutes anomalous behaviour whose explanation calls for further research.

The mechanical behaviour of OPC mortars with replacement of the standard siliceous sand with (saturated, wC, or non-saturated, dC) clay-based waste in OPC mortars show that total replacement of the aggregate lowered the 7-day mortar compressive strength by 38 or 54 %. This effect depends on whether or not the waste was water-saturated. When the aggregate was partially replaced (80:20), 7-day strength declined by 23 %. The 28-day strength value for mortar made with 20 % clay-based aggregate was 21 % lower than in mortars containing 100 % siliceous sand as aggregate. These results show that the clay-based waste can be used as an aggregate in OPC mortars.

In alkali-activated slag mortars, the clay-based waste had an adverse effect when used as aggregate, whether saturated or otherwise in the activating solution. That effect might be attributed to the absorption of part of the activating solution by the waste, preventing slag activation, although such an explanation would not apply to the solution-saturated aggregate. When both aggregate and binder were replaced, the slag mortars developed no 7-day strength. Here also, the explanation may be found in the absorption of the activating solution by the clay-based waste. Moreover, the activating conditions (low activator concentration and ambient temperature curing) were scanty ideal for materials with low Ca contents (such as clay-based waste). The end result was the non-formation of a sufficient amount of reaction or cohesive products for the specimens to harden.

Strength declined less in the fly ash mortars containing saturated than in the materials with non-saturated recycled aggregate. The partial replacement of fly ash with clay-based waste proved to have no adverse effect. Moreover, similar strength values were observed when both the binder (ash, 50:50) and the aggregate (80:20) were replaced. These findings confirm that given the chemical and mineralogical composition of clay-based waste, it can act as a binder similar to (albeit less effective than) fly ash and as a partial replacement for aggregate.

4. Conclusions - The main conclusions of the work and its most relevant contributions from the present study are: The Frattini test showed that clay-based waste (with a chemical composition based primarily on SiO_2 and Al_2O_3) is highly pozzolanic; Nonetheless, it does not respond to alkaline activation, nor does it have a beneficial effect on strength when blended with vitreous blast furnace slag or fly ash; Such construction waste can viably replace up to 20 % of standard siliceous aggregate in OPC mortars.

The performance of such recycled aggregate in alkaline cements depends on the nature of the aluminosilicate (slag or fly ash) and the replacement ratio.

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BEHAVIOR ANALYSIS OF MASS CONCRETE ADDED STEEL FIBER

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Keywords: Steel fiber ; compressive strength; *post-cracking*; *spalling*

1. Introduction

The mass concrete is a brittle material with a low tensile strength , and incorporate fibers is to bridge through the cracks that develop, providing " ductility " (post - cracking) [1].

It is established that one of the important properties of the steel fiber in concrete is its resistance to breakage and crack propagation, increasing the extensibility and strength in both the first crack and end of the process, the fibers are able to maintain the concrete matrix and fibers together even after rupture of the element [2].

When the reinforcement is in the form of short size fibers, effectively they act as rigid inclusions in the concrete matrix. The steel fiber reinforcement can not be considered a direct replacement of longitudinal reinforcement in concrete components, but because of the inherent material properties of fiber concrete, the presence improves the resistance of members, backing conventionally cracking [3].

On this basis, the aim of this work is to study the effect conferred by incorporating steel fibers to plain concrete structures, compared with commonly used concrete, estimating the bearing capacity of a concrete structure with mass adding steel fibers and comparing concrete structures without fibers.

The behavior of mass concrete structures incorporating adding steel fibers from the point of view of its ability to withstand the applied loads without cracking and breaking is determined by studying their maximum stresses and deformations.

2. Methods

An investigation into the behavior of a compression fracture cylindrical specimens (200 mm x 100 mm Ø) concrete mass (HM- 25) containing addition of steel fibers 20 mm long and 0.5 mm thick is presented. These specimens are compared with other standard specimens without additions. Were used steel fibers in 1% to 2 % by weight of cement , was assayed for the maximum breaking stress and maximum deformation, comparing the results with concrete without additions.

12 specimens of the same batch of mass concrete structural strength 25N / mm² , of which 3 of them contain an addition of 1% of steel fibers and the other 3 2% by weight of cement and the remaining 6 are made with concrete without addition. They were then tested for compression failure UNE -EN 12390-1. Universal Press MIB 60 / AM is used as testing machine compression resistance race in order to get the data of the software and the subsequent analysis of force (kN) and stroke (mm) as shown in figure 1.



Figure 1 Burst test experimental compression

Considering the area of "A_c" section results are treated for "σ_c" compressive strength of concrete in N/mm² and "ε_c" strain of the concrete and analyze the most representative data from the graphic strength-strain.

3. Results and Discussion

Figure 2 shows the compressive behavior of specimens with 1% steel fibers and specimens without addition. Concrete with steel fibers adding 1% by weight cement, concrete withstand higher voltages without addition but lose ductility once it reached the maximum voltage.

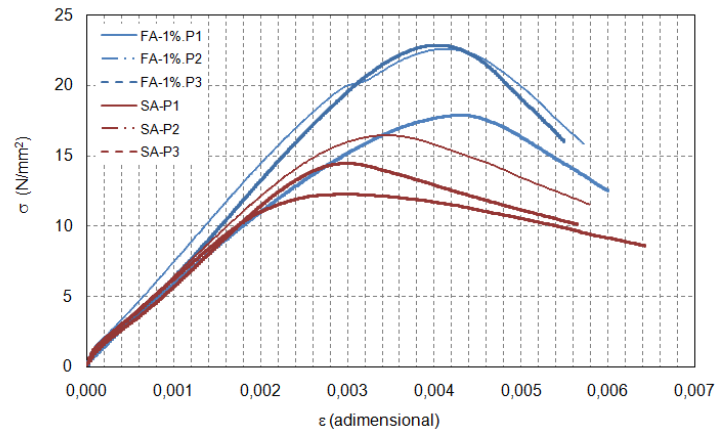


Figure 2 Compression behavior in samples with 1% steel fibers without additions

As shown in Figure 3, under normal ambient conditions, concrete with steel fibers added with 1% endure higher stresses than those with steel fibers with 2 % addition. It is demonstrated, therefore, that the addition of steel fibers in amount of 1% and 2 % by weight of cement, leads to improved mechanical properties of the concrete. The addition gives concrete greater ductility and increased toughness and delayed the appearance of fissures, which reverses in durability of the element.

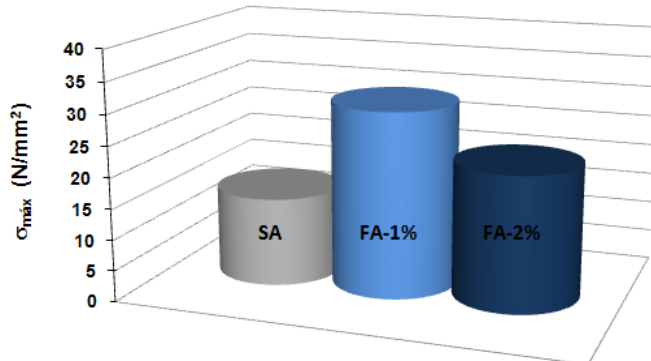


Figure 3. Comparison of the average maximum compressive stress on specimens with 1% and 2 % of steel fibers without additions

4. Conclusions

Incorporating steel fibers in the concrete mass prevents explosive release of concrete (spalling). Adding fiber percentage does not improve its resistance capacity, but decreases. Conclude that the incorporation of steel fibers is a very good alternative to traditional concrete, because it improves its resistance and has advantages over traditional concrete.

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PLASTERBOARD PARTITIONS: A WAY OUT TO REDUCE CONSTRUCTION WASTE ON SITE

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Keywords: *Building; Waste; Reduction; Plasterboard*

1. Introduction – Minimizing waste and resource consumption are important issues of sustainable construction. Reducing waste generation not only avoids or reduces onsite waste generation, but also helps to reuse/recycle [1]. Currently, in the building sector, the main construction companies are considering environmental issues and seeking the implementation of good practices. However, still the vast majority of construction companies (small and medium enterprises) need to accept this trend [2]. Moreover, the construction industry in Spain generates large volumes of construction and demolition waste (CDW) achieving a low recycling rate compared to other European Union countries and to the target set for 2020 [3]. The government is taking action to tackle the problem, by changing the legal regime for CDW in order to reduce onsite waste generation by promoting the use of best practices [4]. Reducing waste onsite involves both design decisions and building technology/materials selection [5]. Prefabrication has been identified as a solution to reduce waste arising during design and construction phases [6]. This paper shows an ongoing study on the use of prefabricated plasterboard partitions in buildings and its impact on waste reduction in Spain.

2. Methods – A total of 802 dwellings from seven different residential building projects were analysed --representing a total of 115743.55 m² --, with similar construction features and following a Mediterranean conventional construction, including materials and techniques (table 3). Four of them were built with traditional ceramic hollow bricks and three with plasterboard partitions. Further, CDW generation was obtained through an on-site data collection system, based on the delivery notes issued by the CDW manager (figure 1). More than 8000 data of daily total CDW generation were collected and CDW generation ratios per square meter of building construction were obtained. Further, in order to know the CDW generation ratio during masonry activities, a theoretical data collection was used based on Arquímedes database from Cype Ingenieros software.

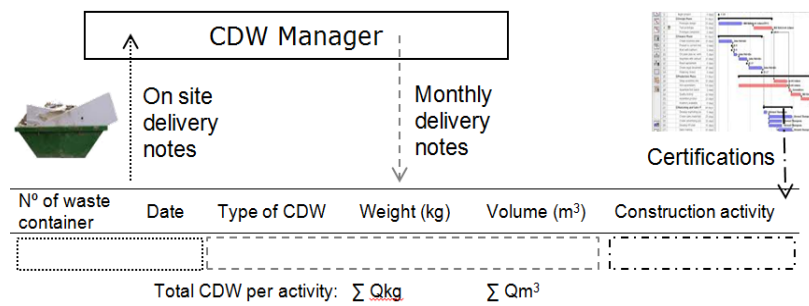


Figure 1 Example of data collection

3. Results and Discussion – Total CDW generation ratios (table 1) obtained in each construction project are similar to the ones established by other studies [7, 8]. Results show that construction projects having plasterboard partition walls have smaller generation ratios. This average indicator allows for an estimation of the total waste generated once the built surface of the project is known --in building constructions with the same characteristics as the ones studied--.

In particular, for building projects with interior brick partition walls, this ratio is calculated around $131.01 \text{ kg}_{\text{CDW}}/\text{m}^2_{\text{built}}$ and $0.192 \text{ m}^3_{\text{CDW}}/\text{m}^2_{\text{built}}$, while for plasterboard partitions it is set around $113.00 \text{ kg}_{\text{CDW}}/\text{m}^2_{\text{built}}$ and $0.186 \text{ m}^3_{\text{CDW}}/\text{m}^2_{\text{built}}$. This means building works generate 15.94% - 3.04% less total waste, in weight and volume respectively, when using plasterboards than when using traditional bricks.

Site	$\text{m}^2_{\text{built}}$	Ratio for total waste	
		$\text{kg}_{\text{CDW}}/\text{m}^2_{\text{built}}$	$\text{m}^3_{\text{CDW}}/\text{m}^2_{\text{built}}$
O226	23569,00	125,99	2,14E-01
O192*	26692,00	117,37	2,12E-01
O156*	30760,00	95,41	1,69E-01
O105	20435,00	116,01	1,68E-01
O59*	11395,71	126,22	1,78E-01
O32A	5983,00	163,52	2,16E-01
O32B	5983,00	118,53	1,70E-01
MEAN RATIO		123,29	1,90E-01

* Built with plasterboard partitions

Table 1 Total CDW generation ratios

Construction sites	$\text{kg}_{\text{CDW}}/\text{m}^2_{\text{built}}$	$\text{m}^3_{\text{CDW}}/\text{m}^2_{\text{built}}$
Hollow brick	33,42	2,89E-02
Plasterboard	23,05	2,00E-02

Table 2 Mean ratio CDW generated during masonry works



According to the construction activities generating more waste, masonry and finishings activities can be highlighted, as they generate over 30% of the global CDW, both in weight and volume. Moreover, when comparing traditional and plasterboard buildings CDW generation ratios during masonry and finishings works it is noticed that CDW per square meter is reduced around 31% when using plasterboard solutions.

4. Conclusions - The results revealed that construction waste reduction is one of the major benefits when using prefabrication elements compared with conventional construction. The average total CDW reduction was about 16% in weight and 5% in volume. Also, when using plasterboard partitions, CDW generated during masonry activities can be reduced around 31% compared to traditional hollow brick partitions. This implies that a wider use of prefabrication could considerably reduce construction waste generation in Spain and improve their management.

Acknowledgements - The authors would like to thank ARPADA Company, particularly the Department of Environment and Quality, and the Department of projects, for supplying the information about building works performed by the company that was basic for this study.

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STUDY OF THE ACOUSTIC RESISTANCE OF TRADITIONAL CANARIAN MORTAL WITH POLYSTYRENE ADDITIVES

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1. Introduction –

The aim of this research is to study the acoustic resistance of traditional Canarian mortar with expanded polystyrene (EPST) additives. The main lithology of Canary Island includes volcanic formations and rocks, as it is a volcanic origin archipelago [1]. Therefore, there is a shortage of clayey raw material which is the base of many traditional construction materials like bricks, vault, etc.

This particular feature has substantially conditioned the building activity of Canarian inhabitants, using as cladding elements vibrated concrete blocks, which are unusual made with “picón” (pyroclastic) which scientific name is LAPILLI. [2]

With the approval in 2007 of the Technical Building Code [3], studies on acoustic and thermal resistance in envelopes and partitions built with concrete vibrated blocks lightened with lapillus were carried out. These blocks are currently on the market [4]. The results of these studies showed that both partitions and envelopes did meet neither noise nor energy demand limitation lay down by the Technical Building Code. A solution to meet these limitations was to add a backing board built with blocks or drywall [5], [6].

2. Methods –

The analysis was developed through the two following methodologies:
Descriptive study. - The sample consisted of seven specimens of 60x60cm and 5cm thickness. The blocks were made with concrete vibrated and lightened with lapillus (serie I).
Comparative study. - In order to compare the results obtained from the descriptive study, another two series of seven specimens each were tested, introducing in a dosage variable regarding to the percentage of expanded polystyrene (EPS_T) additives. (Series II y III)

3. Results and Discussion –

Tests were carried out according to UNE EN 140-4:1999 of “Measurement of sound insulation in buildings and of building elements- part 4: field measurements of airborne sound insulation between room”. The partitions tested are placed in the basement floor of the Universidad de La Laguna building, in the central campus. The characteristics of the premises tested met the regulation specifications. Five tests were conducted in a wall between two offices.

1. Wall built with vibrated concrete blocks of 15cm thickness coated on both sides with plaster (17,40cm total thickness).

To conduct the other four tests, a hole of 180x120cm was made and filled with the following materials:

2. Serie I blocks masonry, stuck with plaster.
3. Serie II blocks masonry, stuck with plaster.
4. Serie III blocks masonry, stuck with plaster and coated with plaster on both sides (1cm).

The acoustic insulation between the two premises was improved by adding EPSt to the blocks. As a result, serie II blocks masonry showed 2dBA acoustic isolation improvement comparing to that of serie I.

Serie II blocks masonry had better results than serie III, even though it had higher percentage of EPSt. The explanation of this result could be that serie III blocks contain a higher amount of pores interconnected. Also, it was detected that in some cases polystyrene beads were not coated with mortar and some of them appeared accumulated in small groups, allowing the sound go through the board easily.

Finally, serie III blocks masonry was sealing with plaster on both sides. A good result was obtained, getting approximately the same acoustic isolation than the original partition with 15cm vibrated concrete blocks masonry coated with plaster.

ACOUSTIC ISOLATION TESTS		Dnt,w (dBA)
Test 1	Original wall between two offices built with 15cm vibrated concrete blocks masonry coated with plaster on both sides.	39
Test 2	Original wall modified with six serie I blocks (PI) of 0,60 x 0,60 x 0,05cm size made with the same dosage than the 15cm vibrated concrete blocks.	27
Test 3	Original wall modified with six serie II blocks (PII) of 0,60 x 0,60 x 0,05cm size made with the same dosage than the 15cm vibrated concrete blocks with a 36,85% of expanded polystyrene addition and 300 cm ³ of water.	29
Test 4	Original wall modified with six serie III blocks (PIII) of 0,60 x 0,60 x 0,05cm size made with the same dosage than the 15cm vibrated concrete blocks with a 73,70% of expanded polystyrene addition and 500 cm ³ of water.	26
Test 5	Original wall modified with serie III blocks coated with plaster on both sides (serie PIII-A)	37

Table 1. Acoustic test results.

4. Conclusions – The result of this research shows that EPS_t additive improves the acoustic resistance of traditional concrete Cannarian blocks. Masonries built with these kind of blocks without backboard can meet the CTE specifications. As a result of this research a patente has been registered. These blocks are currently in a commercialisation process.

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THE INFLUENCE OF GLAZING OVER THE PARAMETERS AND ENERGY RATING ACCORDING TO THE BUILDING ORIENTATION AND THE FAÇADE OPENINGS PERCENTAGES

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Keywords: *g-value; U-factor; opening percentage; façade orientation*

1. Introduction – In general, glazing is the building's envelope element which has the most impact on energy performance. One of the reasons is, its inherent characteristics allow the solar radiation to enter inside, and another would be the higher percentage that is represented on a façade's opening. In addition, this element becomes even more important as opening percentages increase, which has resulted in many studies that have been performed considering different conditions, buildings, climate zones, etc.

Some of these studies are based on establishing a window rating system that allows the solution of the one which offers better performance in energy saving to be obtained. In Denmark, Nielsen et al., [1] focus on a simple calculation method for glazing and windows' energy performance based on a net energy gain indicator, which is the solar gain minus the heat loss. In a similar way, Urbikain and Sala, [2] propose a window energy rating system, WERS, for residential buildings for two climate zones, C1 (Bilbao) and D1 (Vitoria), as defined in the Spanish Building Code.

Other studies consider different technical aspects of openings. Persson et al., [3] focus on how the window size influences over the energy balance, considering a semi-detached terraced houses that are highly airtight and insulated in Gothenburg, Sweden, reducing the windows size in the south façade and increasing them at the same time on the north one. Gasparella et al., [4] state that even with triple glazing being used on the most efficient unit, in terms of insulation level, it is also characterized by its low g-value which is an asset in summer due to lower solar radiation input, but a liability in winter since the heat gain is reduced inside the building. Seunghwan Yoo et al., [5] analyze the thermal behavior of different window systems over the heating energy consumption considering a common apartment unit in South Korea, in order to assess their effect on the energy rating.

The object of the present research is to determine the influence of two of the characteristic parameters which define the window's glazing; U-factor and g-value, over the parameters and energy rating for existing buildings considering different opening percentages and orientations. In addition, it is also established which façade order has more impact on the energy saving and most importantly, the best value for both parameters together in every orientation considered.

2. Methods – This study focuses on a hypothetical 200 m², two storey-detached dwelling with a square geometry located in the city of Seville, to which some technical considerations have been established with regards to its thermal envelope and installations.

A set of hypotheses and combinations have been considered. Six opening percentages, ranging from 10 to 60%, which contemplates

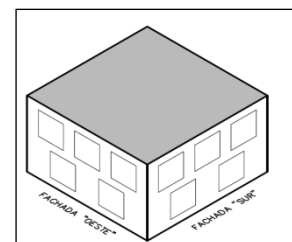


Figure 1 Hypothetical dwelling

the current Spanish Building Code on its simplified option [6], four orientations matching the cardinal axes and the two characteristic parameters from three different glazing types, a single pane, considered as baseline, and two others of better performance such as double clear and low-e windows, both commercially available. The six opening percentages increase proportionally with five of them for each façade. The glazing characteristic parameter values were changed during the study, while the rest of the building construction's elements remained the same.

In order to allow as much solar radiation as possible over the glazing surface, no shading from neighboring buildings is considered, nor shading devices except for the one produced by the window setback itself. A simplified energy rating tool for existing buildings is used. [7]

3. Results and Discussion – A total of 186 results were obtained, 31 for each opening percentage. From them it has been determined the orientation and glazing type which has the most effect on the parameters and energy rating (Table 1).

A noteworthy result is that was that for the heating demand, glazing which obtains the best result is the double clear pane, despite

Number of orientations			One	Two	Three	Four
DEMAND	HEATING	Orientation	N	N - W	N - W - E	N - W - E - S
EMISSIONS		Glazing	Double C	Double C	Double C	Double C
DEMAND	COOLING	Orientation	E	E - W	E - W - S	E - W - S - N
EMISSIONS		Glazing	Double LE	Double LE	Double LE	Double LE
ENERGY RATING		Orientation	E	E - W	E - W - N	E - W - N - S
		Glazing	Double LE	Double LE	Double LE	Double LE

Table 1 Parameters and energy rating, orientations and type of glazing

having a higher thermal transmittance than the

double low-e window. On the cooling demand the opposite occurs. Therefore, when selecting a type of glazing, more importance should be given to the characteristic parameter values.

From the results obtained, the best value combination is established considering the solar and thermal transmittance for each four orientations in order to increase the building's energy efficiency.

In case equal window characteristics are set for all orientations, the higher percentage of façade opening results in worsen the building's energy rating.

4. Conclusions – Taking into consideration the climate zone studied, Seville, Spain, the first conclusion is that the g-value parameter has a higher incidence on the global demand and energy rating than thermal transmittance. Secondly, it is established which orientation greater energy savings can be achieved independently (table 1). Thirdly, the ideal values for both parameters that should be considered in each orientation in order to improve the energy rating.

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“SYMBCITY” PROJECT FOR SOLARDECATHLON 2014. SUSTAINABLE REFURBISHMENT OF BUILDINGS AND REDENSIFICATION OF CITIES

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Keywords: *Sustainable building, urban regeneration, energy efficiency, retrofit*

1. Introduction – Concern for urban environmental and social sustainability and the current economic situation have lead to an increasing interest in the recovery of the suburbs of our cities, which have been the subject of most of the programs and grants for the promotion of rehabilitation, taking in account energy efficiency criteria [1]. Based on the concept “sustainable redensification” this project proposes the “colonization” or refurbishment of available spaces on the roof of existing buildings, for demanded uses in each area of the city, and the retrofit of their facades, generating new urban complexes that originate symbiotic organisms in association to benefit all implicated parts. This increase of density and its profitability will allow to finance energy efficiency and accessibility upgrades of the existing buildings, which share their surface.

SymbCity prototype is part of the development of this project from “Plateau Team” (selected team for the “Solar Decathlon 2014” competition) composed by students and professors from Alcala University and Castilla-La Mancha University, as a proposal of new NZE lodgements on top of existing buildings.

This regeneration proposal includes urban, social, technical and economical analysis, finds new places of business opportunities and creates a symbiosis between the new and old, to improve the energy efficiency of existing buildings. The relevance of the didactic roll of this competition has already been revealed in scientific forums as evidenced by several of the articles in a recent special issue of “energy and buildings” (2) y (3)



Figure 1 scheme of symbcity implementation

2. Methods – SYMBCITY HOUSE. DWELLING CONTEXT

SymbCity construction begins with an external wooden structure. The structure creates an extra space (about 1 meter wide) for the existing building, increasing its surface and creating an air chamber where heat from solar gains can be stored, reducing heating consumptions in winter. Following a standardized pattern, we generate the three main areas of the new houses. The first one contains the bedroom and the house living core, where most daily activities such as cooking or eating, take place. The second space is the multifunctional room, working as a “patio” or greenhouse according to different seasons. The third space is the technical block, containing facilities and wet rooms, which have been designed with an independent structural frame.

BIOCLIMATIC STRATEGIES. ENERGY EFFICIENCY

The walls of the new homes are composed of timber frame and thick layers of insulating material, achieving passivhaus standards, while Phase Change Materials combined with clay plasters in the internal side of the wall keep a balanced indoor temperature without extra energy supply. Solar gains are carefully controlled by eaves and other sun-shading devices.

This way, we obtain a good balance between passive and active energy saving strategies, achieving a Nearly Zero Energy consumption. The multifunctional room is a very flexible space. It can be adapted to seasonal weather changes. It becomes a cool place in summer, with sun shading, cross ventilation and a vertical garden which keeps the air fresh. During the cold months, the envelope is completely closed, becoming a greenhouse which provides extra heating to the house.

CONSTRUCTION & ENGINEERING SYSTEMS

SymbCity House is a fast and industrialized construction. The whole system has been built with local wood based materials. We introduce an innovative system of industrialized wall sections. With this system transport and on site jobs are cheap and fast, reducing the energy waste during the construction period.

The heating and cooling system is based on a low temperature radiant floor and ceiling, supplied by heat-pump with very low electricity consumptions. Besides, the constant monitoring of the house activates a series of simple mechanisms (fans and openings) in order to take advantage of external conditions or protect the house against them.

PV panels are installed all over the roof to supply extra energy for the whole building.

3. Results and Discussion – Thermal behaviour of SimbCity house during the summer period has been successfully tested during the competition and doesn't differ too much from the simulations done during the project. In a first approach, this rehabilitation strategy seems appropriate for existing buildings from 3 to 5 floors, and 10 to 20 dwellings [4]. Therefore the calculations, made over a year term lead to the following results: The actual average energy demand for heating and cooling of a residential building in central Spain with this characteristics is about 125 kWh/m², if we consider a major retrofit of the complete building envelope, adapted to legal requirements, we could expect demands about 40 kWh/m². So we assume savings of 85kWh/m². The average conditioned surface of a typical building from these neighbourhoods is about 800 m², therefore we achieve 85x800=68.000 kWh/year per building. From our project budget we consider an investment of 443.100,00 € is required (by the neighbours) to complete SymbCity construction. After building and selling new homes on the roof, a benefit of 227.500,00 € is obtained. Taking in account the energy savings, each of the neighbours (16 in this case) would have to pay about 13.475,00 € for this intervention. If they can obtain a subsidy (11.000 €), neighbours would have to put less than 3,000 € each.

4. Conclusions - The main conclusion is that the proposed methodology provides a comprehensive view, at a neighbourhood level, of this redensification strategy. Early analysis shows that this type of intervention may be feasible in homogeneous residential buildings in a great scale that allow replication of housing prototypes and constructive solutions systematically.

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ENERGY DEMAND BENCHMARKING OF NON-DOMESTIC BUILDINGS IN SCOTLAND

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Keywords: *Energy demand; efficiency; benchmark; non-domestic*

1. Introduction – This paper presents the *prima facie* outputs of a Knowledge Transfer Partnership (KTP) between Edinburgh Napier University and the City of Edinburgh Council (CEC). The project aims to define mid and long term strategies and procedures to reduce energy demand and carbon emissions in non-domestic public building.

This preliminary study's goal is to deliver a better understanding of CEC's estate by profiling its buildings and benchmarking its fuel consumption. The projects origin comes from a growing public awareness and the need for a more sustainable society. This concern has been the driving factor for new policies at various scales aiming to achieve prolonged sustainable development.

Since the first release of the European Energy Performance of Buildings Directive (EPBD) in 2002 [1], the construction industry is under constant pressure to produce more energy-efficient buildings. In Scotland, the Climate Change Act (2009) has set a greenhouse gas emissions reduction target of 42% by 2020 [2] and in 2010 the publication of "Conserve and Save: The Energy Efficiency Action Plan for Scotland" set a 12% target reduction of energy (end-use) consumption by 2020 [3]. Edinburgh City Council demonstrated its commitment to this in 2011 with the release of "Sustainable Edinburgh 2020"; where ambitious targets for a 40% cut in carbon emissions were set, including a 12 % energy efficiency improvement across all sectors.

2. Methods – CEC's estate consists of a majority of non-domestic buildings, the rest being public housing stock. Educational buildings such as nursery, primary and high schools are predominant among the public buildings. The primary source of data for this study was a building information database used for maintenance and asset management purposes. This data was first analysed by the creation of a Virtual Basic Application macro that extracted and displayed various building parameters such as floor area, occupation, age, and energy demand. Some of the properties were further analysed as they had been fitted with a Building Management System (BMS). A literature review was carried out to benchmark the estate; resulting in useful comparators such as CIBSE Guide F (2012) ^[1] Energy Benchmarks providing typical and good practice energy demand figures. Categories and building types were then defined into construction type and building methods. The age of all buildings was not readily identified since reliable historical data records were not available. Historical, architectural and social context were studied to establish a best fit characterisation archetype. As a result a matrix overlaying building archetype and building usage was obtained.

3. Results and Discussion – Estate composition was broken down per archetype based on buildings usage and age. Nine age categories and 8 uses were identified. Preliminary results don't yet present any correlation between age and energy efficiency. As mentioned before, the building distribution shows an important cluster of mainly educational buildings. Over the last 15 years the number of schools built has decreased dramatically compared to the second half of the 20th century. However the gross floor area for each is generally much higher than before. The data analysis demonstrates a change in urban planning policy; where larger schools in a catchment area have replaced smaller community schools. Regarding the CO₂ emissions, educational buildings account for about 50% of the total estate emissions with about 28,000 tonnes of CO₂ emitted annually. Offices are the second highest group including the largest emitter of the whole estate (just under 2,000 tonnes CO₂/year for a single building). 82% of the educational building stock is composed of premises emitting less than 240 tonnes CO₂/year. This consists of the main cluster grouped around the median (149 tonnes CO₂/year). The wider spread of the 18% left is attested by the index of dispersion as shown in (table 1). These statistical findings allow an assumption for potential savings of about 8% for the educational CO₂ contribution which implies a 4% overall reduction in the estate greenhouse gases emissions.

Educational Buildings	Index of Dispersion	% of educational building stock
0 -240 tonnes CO ₂ /year	33	82%
240 -1820 tonnes CO ₂ /year	242	18%

Table 1: Index of dispersion for educational building stock

Limitations of this study lie in data accuracy and availability. Out of the first 535 premises analysed that now forms the database, about 30% didn't have any construction date and a further 34% had no floor area data. Dealing with the latter, gross internal area is considered as no rationalisation by net used or heated space was available. Notwithstanding, from an initial 535 premises the sample was reduced to 366 buildings by eliminating out-of-scope premises, such as gardens, parks and monuments, originally categorised as non-domestic.

4. Conclusions – This study delivers an archetype categorisation of the City of Edinburgh Council's estate, providing energy and CO₂ profiles for each building type. This research comprises three main stages and this paper focuses on the outcomes of the first: Methodology & Processes. It emphasises the detailed methodology in use to describe a sample this size. It sets the relevant processes in order to enable the second stage about building selection and modelling. Future work will include the selection, modelling and model calibration of representative buildings in order to assess opportunities of refurbishment, their life cycle assessment and cost. Assumptions for potential savings will be validated with an assessment of the refurbishment technologies and intervention replication across the estate.

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ANALYSIS AND PROPOSALS OF ENERGY SAVING FOR THE BUILDING STOCK OF THE VALENCIAN COMMUNITY

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Keywords: *Energy saving; Sustainability; Construction; Building Technology*

1. Introduction –The vast majority of buildings in Valencian Community have been constructed before the *Código Técnico de la Edificación* (CTE) [1], so their energy savings conditions are precarious. Moreover, much of this building stock (Fig. 1) was built previously the first standards that took into account energy saving, which was the NBE-CT-79, thermal conditions in buildings [2].

Therefore, there is a building stock that has large energy losses, and we need to act on it. Current measures, such as energy rating, helps to improve energy efficiency, provides reasons and solutions to property owners.



Figure 1. Block of flats built in the 50s with problems of thermal insulation

This housing stock also requires maintenance works, such as waterproofing for roofs or painting facades. Today, communities of property owners, besides these works that have been executed, also request the execution of works for the energy improvement of their building.

The main objectives in energy rehabilitation are the decreasing of energy demand and improving thermal comfort conditions [3]. The main objective of this publication is to analyze the methods for improving the quality of the thermal balance of the building envelope, which depends mainly on the thermal transmittance " U_T ", which produce more energy savings.

2. Methods – The study of the year of constructions of the buildings in Valencia brings us closer to understanding the design of their facades, roofs and windows frames, and therefore obtaining U_T common values. The improvements that are being applied to these buildings are mainly: (a) increase the thermal insulation on the walls, (b) renovation of roofs, (c) replacement of windows frames (d) and replacing glasses. Once the housing stock has been organized according to their energy losses, the most commonly used interventions are analyzed, describing the materials, the construction process, cost and level of improvement obtained. The use of thermal insulation on the outside can directly solve the thermal bridges of the facade, such as the connection between the facade and the slabs, the facade and pillars or the edge of the windows.

In traditional buildings, other systems are used, as the mass of the walls and their thermal inertia, design criteria as the window size and orientation. These buildings do not use the energy strategies described in CTE and are outside the scope of this paper.

3. Results and Discussion – The analysis of building stock, from the extracted data from the National Statistics Institute [4], shows the results in Table 1. The buildings have been grouped into three periods, the first before the NBE-CT-79, a second time after this legislation and a third period where the reference standard is the CTE. U_T values have been obtained in every period, from the construction characteristics of the envelope.

Construction Year (C.Y.)	Building number (% building)	$U_{T, Facade}$ (W/m ² K)	$U_{T, Roof}$ (W/m ² K)	$U_{T, Glasses}$ (W/m ² K)
C.Y. < 1979	600.238 (57,72%)	2,68	2,57	5,70
1979 < C.Y. < 2006	361.432 (34,76%)	1,80	1,40	3,30
2006 < C.Y.	78.223 (7,52%)	0,82	0,45	2,70

Table 1. Building stock in Valencian Community

From the study of a model test, results included in Table 2 are obtained, about the construction of various solutions for improvement on energy savings. The model is a block of flats built before 1979 and another built after the entry into force of the NBE-CT-79, four storeys high, with a building depth of 10 m and a percentage of 10% windows.

Construction Year (C.Y.)	Heat energy savings (%)			
	Facade outer insulation	Facade inner insulation	Roof insulation	Replacing glass
C.Y. < 1979	39,1%	23,1%	15,3%	9,7%
1979 < C.Y. < 2006	24,4%	9,6%	6,2%	5,0%

Table 2. Energy savings

4. Conclusions – The building stock in Valencia, before 2006, has serious problems of energy savings, and users are increasingly more conscious of the importance of energy rehabilitation of buildings. The work on the facades is what produces greater energy savings, being the largest area and where it is easier to reduce the thermal transmittance values. The use of thermal insulation on the outside is more effective for saving energy, as it directly solves thermal bridges in the facade. In the studied model, replacing window panes is the method that generates fewer saving, due to the geometry of the building. Energy savings after the rehabilitation is higher in older buildings.

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GtoG Life + Project: First Steps towards a Gypsum Circular Economy

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Keywords: *Construction; Building; Gypsum; Recycling; EU project*

1. Introduction – The construction sector represents an important constituent of the European economy. However, this sector generates one of the heaviest and most voluminous waste streams in the European Union, the so-called Construction and Demolition (C&D) waste. This waste arises from activities such as the construction of buildings and civil infrastructure, or their total or partial demolition including renovation activities and maintenance. It accounts for approximately 30% [1] of all waste generated in the EU and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil [2], many of which can be recycled. Despite the fact that gypsum is 100% recyclable, there is currently a large proportion of gypsum waste that is being landfilled and backfilled, while recycling systems in Europe are only operating in France, Benelux, Denmark, Finland, Sweden, Norway and the United Kingdom.



Figure 1: the project image

The GtoG project focused on 8 EU target countries (Belgium, France, Germany, Greece, Poland, Spain, the Netherlands and the UK), where it was estimated that around 1,150,000 tonnes of plasterboard waste was generated in 2012. In most of these European countries a low recycling rate of gypsum waste was observed. The aim of the GtoG project is to produce plasterboards with up to 30% content of recycled gypsum coming from both production (pre-consumer gypsum waste) and C&D waste (post-consumer gypsum waste).

2. Methods – The GtoG project has put in place an integrated approach to holistically manage post-consumer gypsum waste, starting from the major refurbishment/demolition sites to the reincorporation of the recycled gypsum in the manufacturing process via the processing of gypsum waste as a secondary raw material.

The project structure has been conceived to be simple and complete at the same time. Indeed, the project has developed all its technical activities through three actions:

- Action A, which analysed and evaluated the current practices in deconstruction/demolition, gypsum waste characterization, processing/recycling of the gypsum waste for the production of recycled gypsum and its reincorporation into the manufacturing process. This action represented a sort of introduction to GtoG, where a technical, economic, environmental and legislative analysis was carried out for the different stages of the value chain.
- Action B, the project implementation actions, where 5 pilot projects applying best practice deconstruction techniques, the decontamination and the waste qualification,

processing and reincorporation in gypsum manufacturing plants have been carried out in Belgium, France (2), Germany and the UK.

- Action C, which monitored the impact of the project actions. The end result has been a report on best practice indicators, the carbon footprint of gypsum: landfilling versus landfilling route, and the roadmap for implementing a gypsum sustainable value chain.

3. Results and Discussion – The project's results are presented below:

- The inventory of current practices for deconstruction, recycling and reincorporation in the manufacturing process of the recycled gypsum.
- The European handbook of best practices for controlled deconstruction of gypsum system and the European manual of best practices for the audit of building prior to deconstruction.
- European guidelines on gypsum waste acceptance criteria.
- Guidance document for the quality criteria of the recycled gypsum - Technical and Toxicological Parameters.
- Assessment of the optimal European average percentage of recycled gypsum that could be incorporated in the production process aimed at 30% in the pilot plants.
- Report on best practices indicators for deconstruction, recycling and reincorporation in the manufacturing process of recycled gypsum.
- Assessment of the carbon footprint of gypsum recycling versus landfilling on the plasterboard value chain.
- The inventory of best practices for deconstruction, recycling and reincorporation.
- Roadmap for future implementation of a sustainable value chain.

4. Conclusions - The main conclusions of the project represent the recommendations that the project's partners proposed to the main actors of the gypsum value chain.

- Across Europe, the plasterboard market maturity differs, as the plaster consumption and recyclability rates change very much. Moreover, the market is only one of the factors that influence the recyclability of plasterboards. Therefore, a fit-for-all solution might not be the most adequate. It is, then, advisable that the proper setting up, establishment, development and support of the plasterboard value chains should be done at country level, with a constant and significant exchange of best practices all around Europe.
- There is a need for detailed and reliable statistics on waste available from construction and demolition activity.
- Deconstruction (dismantling and sorting on site) is essential for recycling and should become the focus of European regulatory and non-regulatory measures in the future.
- The design for disassembly is one of the issues where the European Commission could focus his attention. This will increase the materials recyclability and will promote a mentality of waste prevention.
- One of the main lessons learnt from this project is that "closing the loop" cannot be limited to a single operator responsibility. Construction and demolition companies, waste collectors, recyclers and manufacturers have to collaborate intensively in order to achieve this goal.

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TOOL FOR EVALUATION OF SUSTAINABILITY of ARCHITECTURE, INCLUDES SOCIAL ISSUES: POVERTY, CULTURE, AESTHETICS AND LANDMARKS AS EMOTIONAL ASPECTS

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Keywords: *Evaluation of architecture sustainability, social aspects, lacks, esthetics culturally and milestones*

1. Introduction – Poor countries in general consume a little of energy and because of that they have a little of influence in the carbon footprint and in the ecological damage to the planet, but instead they have a lot of social lacks for example they don't have enough dwelling, in other cases the houses don't have basic services causing health problems, unemployment, etc. (similar to Macías, M., & Navarro, J. G. (2010) [1], and Ihlen, Ø. (2009) [2], The problem with the poverty and lacks are that they eventually appears in countries of the first world like Europe and North America.

On the other hand different cultures must be understood adequately its characteristics in some aspects that are subjective and cultural like overcrowding for example, that in the Western world has indicators as two people in a room and the Shoaras for example live several families in a big space, because sexual life is not in the House , etc.-

These tools evaluate too the heritage, the identity, esthetics and the milestone architectonic like part of the social aspects, these aspects should be evaluated in the all world, that's why these aspects should be considered in the evaluations but in different standards considering the different places and cultures where the carbon footprint and the energetic consumption are not the only aspects for the evaluations.

2. Objective – Search a different tool which is not abstract or adaptation of the most common, which consider sustainability in a broad and comprehensive sense as it is their definition, considered also aspects social, cultural and emotional as part of these.

3. Methods – a.- it is based principally in experimenting in an emergent and different country like Ecuador, visiting their different climatic zones. In this project propose indicators, not like an adaptation of the international tools, instead of that propose independent indicators to avoid the adaption or the copy of any of them. b.- In this state confront the proposal with the principal international tools, watching different lacks aspects that these don't include and considerate important. c.-. Propose a tool, this tool will improve and polish in the different travels of the different weathers, including international countries..

4. Results and Discussion - in the table [1] "Comparison with tools and places." show the aspects detected and its difference or coincidence with the tools more frequently, shows that the social aspects are more important in poor countries, and aspects of carbon footprint are more in rich countries, while aspects of emotion are very important today in both is say in the whole world, and almost have not been considered in the tools up to now.

5. Concusions - The tools should to evaluate different aspects moreover of the energetics, because the sustainability by concept includes the social aspects and the human aspects. Inside of these social aspects should consider the lacks of the poverty and the world should overcome. And inside of the human and the social should reward the respect of the patrimony, esthetic and create news milestones.

Aspects to be considered in the proposed tool		Considered in other tools			Importance or weight weighted relative				PESO PONDERADO PROPUESTO PARA HOY	aspecto		
		Much	little	almost nothing	poor countries		rich countries			objetivo	subjetivo	
										cuantificable		
SOCIAL ASPECTS lacks and social deficits						C No tienen ese problema			25%			
Contribution to reduce the housing deficit												
Creation of national sources of work, in materials, constructive system and use												
Stimulate the economy to produce work and income for the poorer classes												
Availability of basic services, potable water, electric light, convenient sewage treatment												
Avoid risks of disasters												
Good condition of the facilities												
Minimal material, non-toxic, but according to the cultures, climate and use												
Innovation with good results												
Good condition of the building												
Climate comfort, luminous, auditory, others, but according to the cultures												
each culture (2 hab per room does not in any culture)												
healthy House that does not cause disease												
SYNTAX OR ASPECTS OF FUNCTIONAL QUALITY									0,25			
Well-being of their occupants												
Accessibility and inclusion of all												
QUALITY OF CONTEXT												
Green spaces. Special value for the native landscape												
Trade, sport, Oslo, education, health												
Availability of transport												
ASPECTS OF ENERGY CONSUMPTION					Premiar				0,25			
Uses of bioclimatic systems, orientation, vegetation, ventilation, walls trombe in accordance with the climate												
learning of ancient cultures												
green roofs												
Uses of energies renovables wind, solar heating, solar photovoltaics, other												
public transport, and bikes												
Trails pedestrians covered from rain and sun												
innovación												
Real consumption of LPG, electricity, water, Waste of energy												
Management of the building, manual of use recycling and waste materials management not so common in emerging Paice												
Environmental impact study approved												
ASPECTS RELATED TO THE EMOTION					more and more important more and more important more and more important more and more important more and more important	more and more important more and more important more and more important more and more important more and more important			0,25			
esthetics												
This is milestone												
Conservation or rescue of heritage												
Conservation of the identity and culture												
Arts and crafts including												
</												

Table 1 Relational matrix of aspects considerer and their weight and

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USERS'S IMPACT ON THE METHODOLOGY IMPROVEMENT OF ENVIRONMENTAL ASSESSMENT AND ENERGY CERTIFICATION OF BUILDINGS

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Keywords: *Building; Energy; Behaviour; Users.*

1. Introduction.

One of the most recurring problems into the different systems about environs assessment for buildings is specially take into account the users of itself. This situation generated uncertainty about the final results to the technical professionals that work in this kind of assessment. On the other hand, programs dedicated to energy study of buildings can take into account the presence of users but in many cases they do so in opaque form or without transparency.

Studies of real information about the energy consumption data reveal that the general may be valid, but as the scale of intervention is reduced, the differences between the simulation data and monitoring may experience significant changes. Technical aspects such as heat loss, air renewal or feedback with the actual incidence of energy poverty in many of these buildings (1) (2) have a great importance, since in many cases alienate partners social and authorities (3) advocates in supporting measures that have to do with developments in the legislation regulating the matter. In addition to expanding the areas of research to deepen knowledge aimed at the sustainability of existing and future buildings.



Figure 1. El Usuario. Fuente: DGF.

Finally, the lack of homogeneity in the literature on energy and the consideration of different aspects according to the intended purpose (seal, label, certificate, regulatory requirements...) collaborate in creating great confusion in society, confusion, that from the field of engineering and architecture are called to solve.

2. Methods

Basically the investigation was supported by a research in a documentary collection review. It followed two steps:

- a) A search in the most important international scientific bases, and
- b) Collecting records of national and international conferences related to the energy sector

In the documentation, including standards, it analyzed considering if it is based on the following variables:

- a) Real cases
- b) Simulation cases
- c) Representative samples, and

d) Territorial scope thereof

The investigation makes a review of the different rules, procedures and evaluation systems, mainly energy aspects that quantify the involvement of occupants in buildings.

3. Results and Discussion

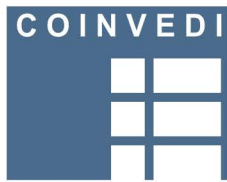
- There is disagreement between standards, both from a qualitative and quantitative point of view.
- They are not taken into account indicators that generate randomized situations closer to the actual simulation.
- The rules for calculating thermal loads, ventilation or hot water considers the occupation, but the energy certification standard not, at least directly.
- Considering averages interpretation undermines the small scale.
- There is not a tested methodology that includes the user globally.
- The lack of social and statistical studies on user behaviour to address the complexity and variability of results leaves to a complex and most comprehensive multidisciplinary study, progress in this field.

4. Conclusions

- Current methodologies not systematically consider the user to expand their reach.
- The individual or person is a rare reference to the rule and yet the standard is done for the welfare of individuals or the people.
- Current evaluation systems contemplate the user in different ways, this dispersion does not favour the advance of technology, and it introduces uncertainty factors of alerts or unwarranted cut variables to consider.

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REVIEW OF BUILDING ENVIRONMENTAL ASSESSMENT METHODS FOR RESIDENTIAL BUILDING ENVELOPES. APPLICATION TO SOUTHERN SPAIN: A CASE STUDY IN SEVILLE

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Keywords: *Environmental assessment methods; Residential typologies; Building envelopes; Energy efficiency.*

1. Introduction – The building assessment methods aim to determine the impacts and aspects of the building providing a decision making guide to select alternatives which help to make the buildings more sustainable.

The importance of improving energy efficiency in the building sector is a consent deed widely discussed, as it represents the 40% of the total energy consumed by the European Union [1]. Buildings have been recognized as major emitters of CO₂, contributing to climate change [2] due to their ecological footprint, especially when taking into consideration its high dependence on resources for its performance [3]. Furthermore, it is estimated that buildings contribute to at least one third of the greenhouse gases emissions, primarily through the use of fossil fuels during its use phase [4].

Thus, the problem lies in how to classify the level of sustainability of a building, especially to simplify a direct comparison between them [2]. This is one of the reasons why building environmental assessment methods in construction have arisen as a means of evaluating the performance of buildings and the impact they have, using a wide range of environmental considerations. These assessment methods have evolved rapidly since the appearance of BREEAM (Building Research Establishment Environmental Assessment Method) in 1990, helping to increase the promotion of environmental expectations and influencing directly or indirectly the performance of buildings [5].

The research strives to establish a comprehensive review of the existing methods to determine their suitability for the evaluation of the residential building typology case when studying its energy consumption, especially in the envelope evaluation case.

2. Methods – A review of existent building environmental assessment methods containing schemes adapted to residential building typologies has been performed. A list of features and criteria for their evaluation is developed, and subsequently applied in order to compare the various databases.

Below it is the list of tools included in the study, as a result of the research conducted and sorted by regions.

- Europe: BREEAM - UK CFSH - UK, HQE - France, DGNB - Germany, Protocol ITHACA - Italy, GREEN - Spain
- America: LEED - USA, SbTOOL - Canada, Green Globes - Canada / USA
- Rest of the world: CASBEE - Japan, Design & Green Star As Built - Australia, BEAM - Hong Kong

Their methodology, documentation, data quality and comprehensiveness are thereby analyzed. From the conclusions obtained, an experimental analysis is run to an existing residential building of Seville and to its envelope, by applying the two most suitable methods. The discussion focuses on the results obtained, comparing criteria and indicators from both methods.

The methodology developed to achieve the goals is composed of the following phases:

- Phase I: Study of the residential fabric of Seville and establishment of the case study. In this phase of the research, the characteristics of the existing housing stock of Seville are determined. Thus, its main features are defined, and the case study can be chosen as one of the type that has a greater impact.
- Phase II Study of building environmental assessment methods and selection of the most suitable systems. During this stage, a selection of current available tools is studied, determining the suitability for application to the residential fabric Seville and the case study.
- Phase III: Application of building environmental assessment methods. The case study will be evaluated by the methods determined as the most appropriate in the earlier study phase.
- Phase IV: Comparison of results and discussion. The results will be evaluated and discussed, drawing conclusions.

3. Results and Discussion – Despite the existence of a considerable number of environmental assessment methods, only a few contain data on the impact produced by the envelopes. Our analysis reveals that VERDE tool and BREEAM stand out for their adaptability to the case of residential building typologies.

The format of the evaluation results is similar in both cases. However, relating to the introduction of data of the different envelopes, VERDE Certification tool allows the introduction of each element that makes up the envelope. Nevertheless, the choices are fixed, not allowing a precise definition of the element. In the case of BREEAM tool, the introduction of elements of the envelope is not allowed. In spite, the “examiner” (technician) scores the level of sustainability of the envelope based on their judgment of the evidences. Finally, we would like to point out that VERDE Certification tool indicates that the building loses are 49,400 kWh / year in its current state. This has impact on the final assessment in paragraphs I01 Climate Change. Meanwhile, regarding BREEAM tool, the current state of the building before rehabilitation shows us that the building is not efficient, as its environmental impact is disproportionate and cannot get rated as approved. This level is achieved by passing at least 30%. In this case the total score is 27.86%.

4. Conclusions - This review can provide a starting point in the selection of a building environmental assessment method to evaluate residential building typologies. With all the information gathered herein, researchers are equipped to make a well-founded choice, and the selection process is certainly improved.

Furthermore, the study takes into consideration which role the energy certification methods have in the enveloping evaluation, both in their general and simplified options. Moreover, the work presents the problems arisen from the comparison itself, as the results provided by the methods come in different forms. Thus, the election of an environmental assessment method can be influenced by how the output is presented.

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PACKAGING IMPACT REDUCTION IN PRODUCT STAGE: ECO-REDESIGN OF CARDBOARD BOXES

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Keywords: *Packaging waste; eco-redesign; best practices; minimization*

1. Introduction – Packages represent 50% of the volume of construction and demolition waste (CDW) in a construction work, furthermore, in contrast to the increasingly widespread environmental policies, it can be proved that products supplied to the construction work nowadays have suffered an increase in the volume of their packaging, to improve their level of protection and reduce their return percentage [1].

Environmental impacts are largely determined by the way a product is designed and produced; following Bethany Murray, 80% of the impacts of products are defined during their design stage, therefore focus must be set on circular economy to reduce waste and increase resource efficiency [2]. Eco-design arises as a response to the need to introduce environmental criteria in the stages of production, distribution, use, recycling and final treatment of the product with the purpose of preventing or reducing the environmental impact throughout its life cycle. The incorporation of environmental criteria for the prevention or reduction of the environmental impact of the products can be in existing products or in the initial stages of a new product design. Thus, eco-design is a new product design taking into account environmental criteria, and eco-redesign concerns an existing product taking into account the same criteria. EcoReDesign is an approach to "designing-out" as many environmental problems as possible, whilst still producing a high quality, cost effective product [3] and/or packaging.

The Spanish Royal Decree 782/198 develops Law 11/1997 of Packaging and Packaging Waste, and establishes the relation Kw/Kp as the main indicator to quantify the packaging reduction efforts. Kw is the total amount in weight of packaging waste generated during one year, and Kp the total amount of products packaged that same year.

This study focuses on cardboard boxes for sockets, previously identified, together with switches boxes, as the source of predominant cardboard waste in residential sites [4], to quantify the impact of its eventual eco-redesign. Earlier Australian researchers approached the impact of plastic packaging by comparing the environmental performance of two plastic-based packaging systems [5].

2. Methods – Previous results analyzing packaging waste generated in residential work sites showed that paper and cardboard waste is mainly generated during the building services phase, 70% of it corresponding to switches and sockets form the electricity sub-stage, generated towards the end of the construction works [4]. To quantify the impact of eco-redesign of a cardboard box for switches or sockets, an experimental comparison of two different suppliers is proposed, supported by the indicator Kw/Kp. Moreover, a research on other sectors, mainly food and beverage, is performed, to later select some best practices to propose as strategies for manufacturers to minimize the box weight.

3. Results and Discussion – The data were collected through a field study, where the boxes of two brands were chosen as representative of the main source of cardboard packaging waste: Simon 31 and Jung LS990. Both were weighted with and without their

content. The first one uses one layer cardboard for its boxes, and each socket is presented in a small individual box inside a bigger one containing 10 units. The frames are presented on the same way, by pairs, each box containing 20 units. The second sample, JungLS990 uses one layer corrugated cardboard, and does not present individual boxes, but a carton grid dividing the space in the box for the sockets, and the frames appear together on the same box. The data collection is performed by weighting the boxes with and without their content, obtaining the results summarized on tables 1 and 2:

Simon 31			Observed weight (g)		
Content	Units	Empty box	Full box	Individual empty box	Individual full box
Frames box	20	182	616	8	52
Sockets box	10	156	1032	8	96

Table 1. Simon 31: packaging weight.

JungLS990		Observed weight (g)	
Content	Units	Empty box	Full box
Frames box	10	38	234
Plastic fronts box	10	96	416
Socket mechanism box	10	98	612

Table 2. Jung LS990: packaging weight.

With data from tables 1 and 2 an adaptation to index Kw/Kp is used to calculate the total amount of packaging waste for the analyzed models (table 3):

Model	Packaging weight (Kw)	Product weight (Kp)	Index Kw/Kp
Simon 31	814	3950	0,20608
Jung LS990	232	1030	0,22524

Table 3. Index Kw/Kp for analyzed packaging.

The lower the ratio of the weight of the packing and the weight of the packaged product, less packaging has been employed for a same amount of product, therefore Simon 31 model has a more efficient packaging than Jung LS990.

4. Conclusions - Packaging is in volume the biggest non-stony recyclable waste on a building site and it is defined during the product design stage. After comparing boxes from different brands it can be said that with some small changes they can be optimized to save some material.

If this study is extended to other prevailing packaging made of plastic and wood, the amount of packaging waste will be reduced. And before that, more important following the waste hierarchy, manufacturers could save on transport and material. Hence it is worth considering the redesign of at least the predominant packaging for construction products.

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ECOLOGICAL FOOTPRINT OF MANPOWER IN CONSTRUCTION IN SPAIN, MEXICO AND CHILE. FOOD CONSUMPTION

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Keywords: *Ecological Footprint; Building construction; Manpower; Food consumption.*

1. Introduction – Since the mid 90s the ecological footprint (EF) has become an important indicator for measuring environmental sustainability in economic activities. One of the most important contributions of EF indicator is that, synthetically calculated using ecologically productive land (hectares per capita) required to meet the mode of production and consumption of a territory, and absorb gaseous waste generated as a result of use of fossil fuels [1], [2]. In this paper applying it to their food intake particularly that associated with the manpower involved in the construction of residential buildings in Spain, Mexico and Chile use is made.

In construction the consumption associated to manpower is divided into that arising from the workers' transportation, the municipal solid waste and that caused by the food consumption on the construction site [3]. To calculate the EF of the building sector, it is necessary to take into account the consumption caused by all actors involved in the execution of the work.

This paper develops the new methodology for determining the daily menu of a person of any country evaluates the EF these foods produce and determine the impact of labor as a resource in the construction process.

From the data of the project budget, for the amount of manpower involved in the process, methodology applied to construction buildings EF [3], food consumption data from the Food and Agriculture Organization of the United Nations (FAO) to determine the daily menu per person [4], and the data of the corresponding land productivity Global Footprint Network (GFN) [5], the EF of the manpower in different countries is obtained. Finally the cases of Spain, Mexico and Chile are assessed.

2. Methods – For our case study, that is to say, in the construction phase of residential buildings, only the food intake footprint is considered, in other words, the footprint associated with food consumption. This is estimated in terms of: time (work duration in days), the working time is taken as 8 hours per day (40 hours per week), number of employees, number of meals on the construction site, and food types. The project budget is used to calculate the food footprint, since construction projects include the manpower cost per hour worked. From the cost of manpower per hour (€/h), the total working hours is obtained for the construction project under study.

Consumer goods in general and food in particular, are usually expressed in tonnes consumed, and then transformed into hectares to obtain EF rates [1].

A new methodology is proposed for the calculation of the EF generated by a worker's meal, where data from the FAO [4] and the GFN [5] are analysed and combined (using weighted averages) in order to determine a daily meal footprint. In the previous methodology, Solís-Guzmán et al. [6] and González-Vallejo et al. [3] based on Domenech's work [7], calculate the EF of a worker's meal from economic data and evaluated a 10 Euro cafeteria menu. In the new approach, the menu is defined based on FAO data [4] for Spain, México and Chile, that can be grouped into a general classification. Their corresponding intensity factors are

published by the GFN [5]. The energy intensity is obtained from Wackernagel and Rees [2], as in the original methodology.

3. Results and Discussion - The amounts of food consumed daily are defined by weight (Table 1), and a summary of the results of the analysis of EF is shown in Figure 1. The amount of food (kg) consumed per day per person is highest in Spain, followed by Mexico which is very similar and finally Chile, where it is consumed about 1 kg of food per person per day less (Table 1).

Consumption (kg /person/day)		
Spain	Chile	Mexico
3.84	2.63	3.28

Table 1. Comparative consumption: Spain, Chile and Mexico (2011)

The greatest impact from the EF of the crops, sea and energy is produced by Spain and Mexico in the case of the EF of pastures. Chile produces smaller EF of food (Figure 1).

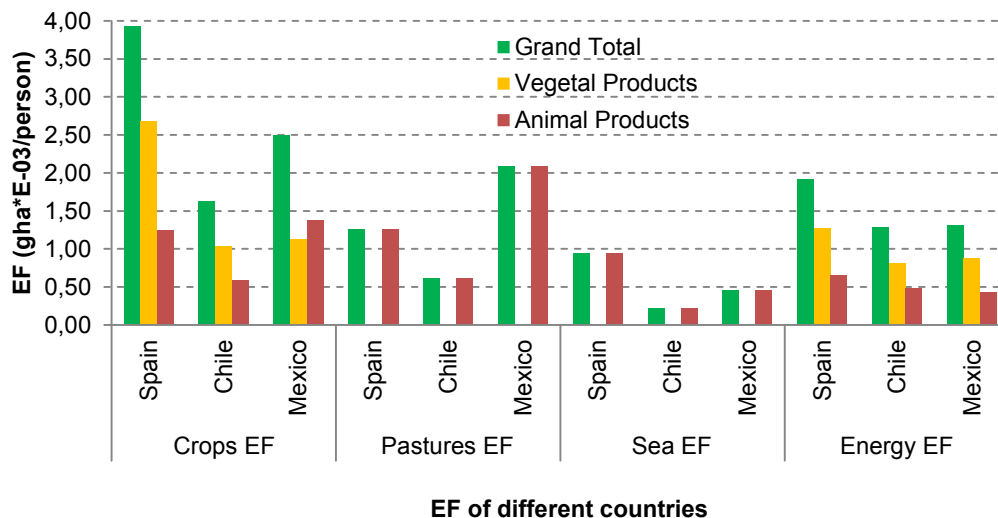


Figure 1. Comparative Food EF: Spain, Chile and Mexico

4. Conclusions - The amount of food consumed and the EF in Spain and Mexico have similar values, however in Chile is much lower. The new methodology reduce the EF of food consumption from 25% to 5 % approximately in several projects evaluated.

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THERMAL CHARACTERIZATION OF URBAN HEAT ISLAND (UHI) ACCORDING TO URBAN MORPHOLOGY OF MADRID

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Keywords: *Urban Heat Island, Energy simulation, Energy retrofitting, Building characterization*

1. Introduction – Present research is framed within the project MODIFICA (MODElo predictivo - edIFicios - Isla de Calor urbanA) aimed at developing a predictive model for dwelling energy performance under the urban heat island effect in order to implement it in the evaluation of real energy demand and consumption of dwellings as well as in the selection of energy retrofitting strategies. It is funded by *Programa de I+D+i orientada a los retos de la sociedad 'Retos Investigación' 2013*. The objective of the research is to establish a critical analysis of climate records used in energy simulation tools, usually derived from weather stations placed in the outskirts of the city where the thermal conditions can differ up to 6°C [1]. Hence, the research is aimed at developing a predictive model for building energy consumption that gathers the location in the city, the urban morphology and the associated UHI, improving the future energy retrofitting interventions. In order to achieve the general objective of the research and besides the analysis and the updating of the UHI conditions, different urban morphologies needed to be studied in order to relate them to the UHI effect and to understand which building typologies can be found in each uniform thermal area. The objective of the research presented here is to define Madrid's variety of urban morphology and building typology and to establish their relation of different thermal areas of the urban heat island.

2. Methods –First part of this study consisted on cataloguing and characterizing the morphology of the urban areas of Madrid. Nine homogenous areas were identified according to their morpho-typological characteristics [2] [3]. The list of homogenous areas is summarized in Table 1.

HOMOGENEOUS URBAN AREA	NEIGHBOURHOOD TYPE
Historic area (HA)	Sol
Planned growths, square block high altitude (PSH)	Goya
Planned growths, rectangular block high altitude (PRH)	Delicias
Planned growths, rectangular block low altitude (PRL)	Quintana
Spontaneous growths (SG)	Berruguete
Open building (BA)	Barrio del Pilar
Pheriferal extensions (PE)	Acacias
Communal courtyard closed block (CCB)	Palomeras Bajas
Single family house (SFH)	Piovera

Table 1. Classification of homogeneous urban areas for the city of Madrid. Personal source.

The study "The urban climate. Remote sensing of UHI of Madrid" [4] from 1993 that established the isotherms within the city of Madrid was used as the starting point for assigning temperature values for each neighbourhood.

Next step of the research was to study differences in dwellings' energy consumption according to their relative position within the city. We further study the energy consumption during summer nights, when the energy consumption is known to be particularly unfavourable. This is because urban areas experiment a relative large temperature increment caused by the UHI, which ultimately results in a widespread usage of refrigeration equipments. Figure 1, depicts the thermal differences across neighbourhoods in the city of Madrid. The highest temperature values are reached in the city centre, with an average value of 28°C. The tendency of temperature values is to decrease while moving towards the periphery, where average temperature eventually drops to 23°C.

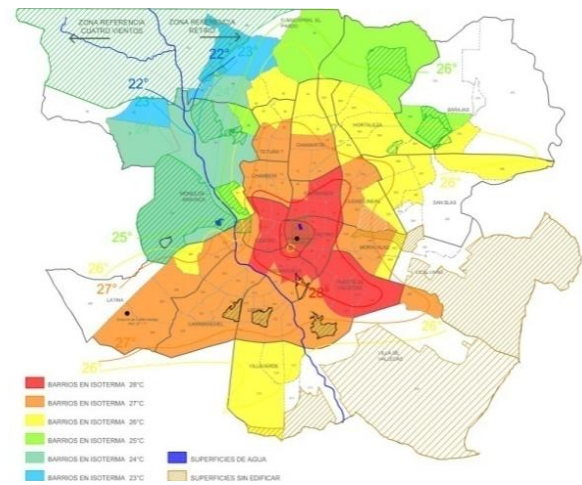


Figure 1. Temperature of the neighbourhoods of Madrid, summer-night. Personal source.

3. Results and Discussion– As is shown in the figure 2, the previous analysis clearly evince the influence of urban morphology on the temperature of the city, and its correlation with homogeneous areas with the same isotherm type. It is noted that the historic center (HC) and planned growths (PSH, PRH and PRL) have the higher temperatures recorded (27°C and 28°C), the open buildings (OB) show high-medium temperature (26°C and 27°C), communal courtyard closed blocks (CCB) have medium values (25°C), peripheral extensions (PE) cover the strip of the 24°C- 27°C, due to typological variety and finally single-family house (SFH) reached the lowest values (23°C). Results of the thermal performance and energy consumption of different building typologies are yet to come and are expected to be presented in the conference.

HOMOGENEOUS AREA	ISOTHERM TEMPERATURE					
	23°C	24°C	25 °C	26 °C	27 °C	28 °C
HC						
PSH						
PRH						
PRL						
OB						
PE						
CCB						
SFH						

Figure 2. Relation between homogenous areas and isotherm where is located. Personal source.

4. Conclusions - First results show strong differences in microclimatic conditions amongst different urban morphologies. It can be drawn that these differences of up to 5 degrees pose relevant deviations in the thermal performance of dwellings and must be relevant in the decision making process of energy retrofitting

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RESEARCH AND LIFE CYCLE ASSESSMENT OF HIGH PERFORMANCE CEMENTS

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Keywords: *Cement; Nanofibers; LCA*

1. Introduction – Research of new cement formulations is of outstanding interest for satisfying the new requirements in architectural and infrastructure projects safely, affordably and sustainably [1]. On the other hand, the development of nanofibers has opened a new field in material reinforcement, for example, the addition of nanofiber reinforcement to different matrices allows the crack growth control at nanoscopic scale, creating a whole new generation of “crack-free” materials [2]. However, nanomaterials could have high-energy demanding fabrication process or environmentally dangerous raw materials such as chemical products, and being the cement a material with a high environmental effect, every new cement formulation should be evaluated using a process-based life cycle assessment methodology [3]. In the present work, the Life Cycle Assessment (LCA) of cement with carbon nanotubes (CNTs) has been done to track the environmental impacts through their fabrication and to compare with those of traditional cements.

2. Methods – Environmental evaluation of the cements has been carried out using a process-based life cycle assessment methodology with distinct stages to generate a comprehensive overview of the product’s total environmental effect: Goal and Scope definition, System Boundaries and Life Cycle Inventory and Data collection and Impact Assessment Method. This is a “cradle-to-gate” LCA that includes upstream inputs such as raw materials extraction and processing of the input materials and energy as well as the inputs and emissions associated with fabrication. LCA results have been obtained by using Simapro 8.0.1 software and CML-IA baseline v3.00 method.

3. Results and Discussion – LCA results for the CEM I 52,5 N and the cement with the CNTs are presented in Figure 1.

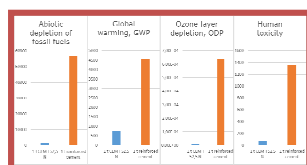


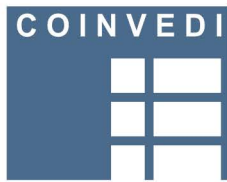
Figure 1 LCA results of the CEM I and the cement with the CNTs for the most important environmental impacts.

As can be seen, the nanoreinforcements are highly environmentally harmful. Categories such as Terrestrial and Fresh water ecotoxicity or Global Warming are seriously affected by intensive energy consumption (2,2E06 kWh/t). The impact over Human toxicity, Abiotic depletion and Ozone layer depletion is due not only by energy consumption, but also to harmful raw materials, such as hydrochloric acid.

4. Conclusions - The inclusion of CNTs increases considerably the environmental impact of cement production. Therefore, we propose new alternatives to CNTs as reinforcement for cements, such as inorganic nanotubes or plastic nanofibers.

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PHOTOVOLTAIC ENERGY IN EDIFICATION

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Keywords: *Photovoltaic energy; building; electricity*

1. Introduction – Current electricity production amounts to 160 TWh in the world that meet only the 0.85% of global electricity demand. In the European Union the hydroelectric, wind and photovoltaic (main renewable) energies have reached the 3% of electricity demand, achieving (in periods of increased production) up to 6%. Up to now, the manufacture of solar cells and photovoltaic installations has been exponentially increasing since 2001. Moreover, this cost has been greatly reduced while efficiency has been increased; making the average cost competitive with other conventional energy sources.

2. Methods – Photovoltaic energy is booming as a renewable energy. Scientific advances in this field are enormous since the appearance of the photovoltaic cells.

Photovoltaic panel has allowed the first integration of renewable energy on the edification. This progress has reduced costs and increases the efficiency. These improvements give also aesthetic alternatives for facades summit new modules with the incorporation of the panels on them (sealed or not, even can be placed with insulation) creating non-commercial sizes and even offer flexibility. [1]

3. Results and Discussion – The guidelines to reduce greenhouse gas emissions given by the European Energy Research Alliance (EERA), are focus on to get a reduction of the energy in the edification. In order to make this happen, the research lines are the study of the integration based on the type of construction.

4. Conclusions - Photovoltaic panels undoubtedly produce the energy of the future, a clean, renewable and silent energy. Nowadays this alternative of energy is the union of the binding energy and the building all giving a distinctive and modern image to the edifications. [2]

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ENERGY SIMULATION OF BIOCLIMATIC STRATEGIES IN VERNACULAR ARCHITECTURE: SOLAR RADIATION AND THERMAL MASS, CASE STUDY: EL VALLE (CÁCERES, SPAIN)

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Keywords: Energy and sustainability; Design Strategies; Vernacular Architecture; Energy Behaviour.

1. Introduction – The bioclimatic architecture is defined as one that is designed to take advantage of the climate and environmental conditions in order to achieve a situation of indoor thermal comfort. By that, the traditional architecture should show a bioclimatic behaviour, because it was designed to be adapted to the nearest environment, and linked to geographical factors, especially to climate as one of the priority. According to the climatic zone, the architectural elements are created in a huge variety and cultural richness of popular existing buildings, and thus construction responses are not equal everywhere [1], [2], [3] (fig. 1).



Figure 1 Traditional village adapted to the hillside to gain solar radiation.

This adaptation has been lost in today's houses. Because of the unsustainable energy consumption and resources concerns, several studies have been recently launched in order to discover bioclimatic strategies that reduce the use of energy [4], [5]. However these strategies long existed in the popular architecture of every zone of the planet, in architectural models with construction systems, spatial designs and specific aesthetic results [6].

Therefore, the aim of this article is to provide results through simulation energy models [7] that support the bioclimatic behaviour of traditional buildings, as well as to save some of the strategies that are appropriate in a particular area with the objective of the reuse in new houses design, and the recovery in refurbishment actions [8], [9], [10]. In this case, it has been studied the timbered or masonry architecture in El Valle in the Sistema Central of the Península Ibérica.

2. Methods – First of all, there has been a climate study to provide the necessary data on temperatures and moisture in the study zone (fig. 2).

Afterwards, representative architectural patterns of the area are defined (fig. 3), and modelled in an energy simulation software (design builder) and it has been obtained the energy behaviour of each one.

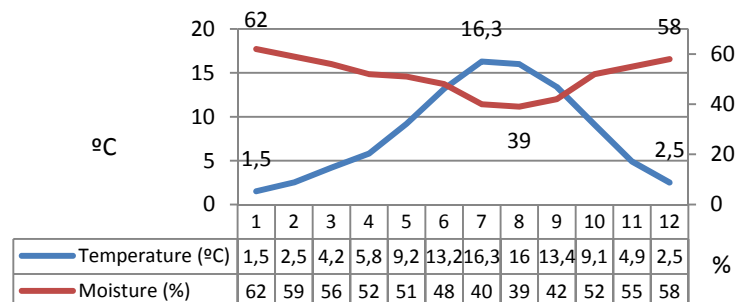


Figure 2. Monthly average climate data: minimum temperature and maximum moisture in El Valle.

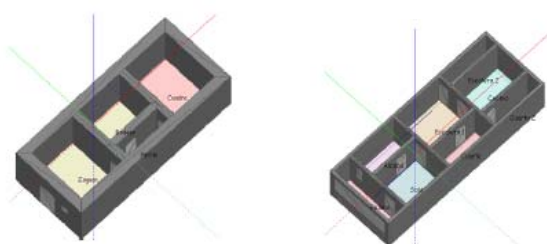


Figure 3. Example of a ground and first floor in a building type of timbered architecture in El Valle

In the last stage it has been studied the following strategies about solar radiation: solar position, orientation, houses design, shadows, colour envelope, or window spaces; and about thermal mass: exterior walls and ground, in cold period and warm one [11].

3. Results and Discussion -. Heat exchanges results have been obtained in every space, in the two semesters (warm and cold), and in the envelope area (walls, glasses, ceilings, floors, roof and partitions), and the two strategies: solar radiation and thermal mass (table 1).

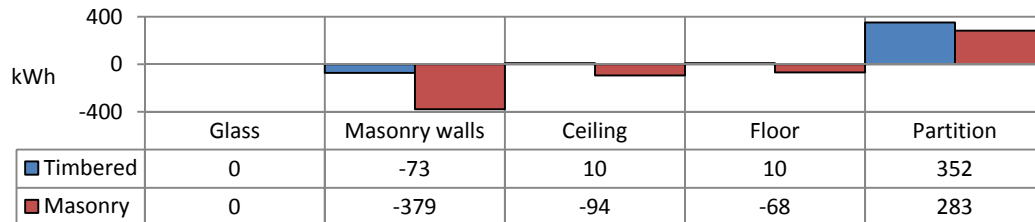


Table 1. Example of the heat exchanges (gains and losses): the living-room of a timbered and a masonry building in El Valle (simulation n°1)

The results obtained in the simulation about solar radiation shows that in cold months, there are not meaningful solar gains by the envelope in masonry or timbered houses, so modifying the orientation, the shadows, the window spaces or the colour envelope. In the warm months, there are not very different gains modifying the shadows (narrow streets, or bigger eaves), only the special design of the house result beneficial (compact houses and blocks).

The simulation realized with thermal mass strategies shows that, in cold semester, the heat exchanges in masonry walls are much higher than in timbered houses, and, in this way, thermal stability can be obtained. The contribution of the ground is important, in the cold months the heat go into the house by the soil, as profits; and in the warm months the heat go out of the house by these part of the envelope.

4. Conclusions -. In the light of the results obtained, the solar radiation is not a ultimate strategy in these mountain houses, except about the compact design of the architecture. About the masonry walls and ground thermall, it may be noted that both result profitable to the energy efficiency in this case.

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LUMINOUS AND THERMAL IMPACT OF FIXED SOLAR SHADINGS DEVICES

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Keywords: *Fixed solar shading; Daylighting; Solar Heat gains; spatial Daylight Autonomy*

1. Introduction – Although the most visible aspect of Directive 2010/31/UE [1] has been an upsurge in requirements for thermal insulation in buildings, due to a rise in the number of air-conditioning systems in European countries, the Council of the European Union gives priority to strategies which enhance the thermal performance of buildings during the summer period, especially those which avoid overheating, such as shading devices. Those measures should take into account climatic and local conditions [1, 2]. Without doubt, countries with warm climates have a large constructive tradition in avoiding excessive solar thermal radiation into their buildings, being good examples of this the urban structure of their historic city centres, the residential courtyards and the development of solar protection devices [3, 4]. But the importation of architecture from the northern Europe, where local climatic conditions and daylight requirements based on the Daylight Factor metric provide buildings with large glazed surfaces, having very important problems of glare and overheating, especially in sunny climates [5, 6].

To fix these problems, movable solar shading devices at the inner side of glazings is widespread. However solar thermal radiation is not avoided to enter. In addition, usually these devices are not well used and a common scenario is having the blinds closed and the electric light on, increasing, of course, the energy consumption in both thermal and lighting active systems [5]. As a result, in warm and hot climates, where there are many hours of direct solar radiation, there is a great amount of available daylight but it is not usually used in its entirety [7]. In fact, in Spain, artificial lighting consumption accounts for up to 30% of total electric consumption in office buildings [8]. The goal of making good use of daylight provision however needs to be tempered by the need to prevent the undue occurrence of very high levels of daylight illuminance since these are associated both with visual discomfort and the likelihood of excessive solar gain (i.e. increased cooling loads) [9]. This goal requires taking into account climatic and local conditions. Nowadays it can be carried out by means of whole building energy simulation programs. However, while there is a long history to predict the temperature and humidity conditions, the prediction of daylighting conditions is based, for more than 50 years ago, in the calculation of Daylight Factor.

In real architectural practise, due to the low frequency of cloudy skies in the sunnier climates in southern Europe, daylighting studies have fallen into disuse, considering the Daylight Factor distribution, at best, as representing the worst daylighting conditions. So, artificial lighting is usually designed independently to daylighting and there isn't normally a correlation between thermal and luminous studies due to the nature of Daylight Factor. The development of the Climate-based Daylight Modelling (CBDM) and thus the appearance of dynamic daylight metrics such as Daylight Autonomy (DA) and Useful Daylight Illuminances (UDIs) [10] provide further information on the variable behaviour of daylight throughout the year. A dynamic daylight simulation provides hourly or sub-hourly daylight illuminances reaching each sensor point of the workplane based on local climate conditions, so nowadays the gap is being bridged.

Facing these recently new advances in daylighting, the priority given to solar shading devices and the evidence of the break between thermal and daylight analysis, the main objective of this work is to correlate both thermal and luminous impact of applying fixed shading devices to give a more comprehensive view of the effects of global solar radiation inside buildings.

2. Methods – Overhang, horizontal and vertical louver of different obstruction angles which range from 0° to 60°, stepped by 15°, are studied for the main four orientations (North, East, South and West) and for two locations: London, as an example of cloudy weather, and Seville, as a reference for sunny weather. Every model is simulated using internationally well-recognized software for thermal [11] and dynamic daylight simulation [12] to get hourly results of the amount of solar heat gains entering through glazing and useful daylight illuminances, from 300 lux to 3000 lux, reaching each sensor point of the workplane, throughout daytime hours of a year based on climate data compiled on standardized weather files for simulation [13]. Also spatial Daylight Autonomy, a daylight metric recognized by IESNA, is calculated [14].

3. Results and Discussion – Monthly results are shown for every solar shading device (overhang, horizontal and vertical louvers) to assess not only the correlation between solar heat gains and useful daylight illuminances on the workplane but its evolution throughout entire year. The discussion is focused on the appropriateness of each type of device studied taking into account the amount of solar heat gains that it allows to enter and the daylight performance provided for being applied on different orientations analysing the differences between cloudy and sunny-dominant climates.

4. Conclusions – Facing a panorama of importation of a non-climate-dependant architecture which large glazings covered by uniform shadings no-matter location or orientation seeing as a sign of loosing sustainable heritage knowledge of good architectural practises this work recover and scientifically study those knowledge and intuitions related to fixed shaded devices to provide a set of recommendations for new and existing buildings in accordance to priority strategies promoted by the European Commission. These recommendations not only consider the thermal impact of blocking the entrance of solar radiation inside buildings but the influence on the daylight performance to get a balance between thermal and luminous demand for a comfortable sustainable architecture.

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TOWARDS A DYNAMIC MODEL FOR THE URBAN HEAT ISLAND OF MADRID

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Keywords: *Urban Heat Island, Energy Simulation, Energy Consumption, Climate Change*

1. Introduction – Present research is framed within the project MODIFICA (MODElo predictivo - edIFicios - Isla de Calor urbanA) aimed at developing a predictive model for dwelling energy performance under the urban heat island effect in order to implement it in the evaluation of real energy demand and consumption of dwellings as well as in the selection of energy retrofiting strategies. It is funded by *Programa de I+D+i orientada a los retos de la sociedad 'Retos Investigación' 2013*.

Despite great advances on building energy performance have been achieved during the last years, available climate data is derived from weather stations placed in the outskirts of the city. Hence, urban heat island effect is not considered in energy simulations, which implies an important lack of accuracy.

Since 1980's several international studies have been conducted on the urban heat island (UHI) phenomena, which modifies the atmospheric conditions of the urban centres due to urban agglomeration [1][2][3][4]. In the particular case of Madrid, multiple maps haven been generated using different methodologies during the last two decades [5][6][7]. These maps allow us to study the UHI phenomena from a wide perspective, offering however an static representation of it.

Consequently a dynamic model for Madrid UHI is proposed, in order to evaluate it in a continuous way, and to be able to integrate it in building energy simulations.

2. Methods – The project is built up in two phases, taking as its starting point the UHI study of Madrid from 1993. First, an update of the isotherm map is presented, based on thermographic airborne images of Madrid in addition to statistical data of urban density and rural temperatures over the last three decades.

Secondly, an hourly development of the isotherms is created, as well as the characterization of uniform thermal areas inside the city. In order to do that, weather stations from the city council and the national meteorological service were used. This data lead to an hourly and daily characterization of every area, and to its integration within the building's energy simulations.

Barajas

Cuatro caminos

Ensanche de Vallecas

Figure 1 Location of sampling weather stations

3. Results and Discussion – Final results are expected to show a new dynamic map of isotherms for Madrid, linked to a climate correction database based on urban heat island effect. In order to show in this abstract the existing differences in daily temperatures, data from two weather stations is plotted in *Figure 1*, as well as current energy simulation weather data (Barajas' weather station).

Temperatures presented in *Figure 2* belong to a typical day from the hottest month of the year. It is noticeable not only a significant increase in temperatures from the downtown weather station (*Cuatro Caminos*), but a delay in the hour of peak temperatures due to city thermal inertia. In the suburbs of Madrid (*Ensanche de Vallecas*), there is not a significant increase in temperatures, but thermal inertia also delays temperatures, what poses an important factor to be taken into the implementation of passive strategies such as night thermal ventilation.

Figure 2 Daily behaviour of temperatures in July

4. Conclusions – The UHI phenomena is characterized by an spatial and temporary behaviour, being irregular through time. Data from local weather stations allow us to correct hour-by-hour values gathered in outskirts-weather stations normally used in energy simulations. The implementation of a dynamic model is required for energy simulations in order to improve decision-making, especially concerning passive design.

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INFRARED THERMOGRAPHY APPLICATION IN ENERGY AUDITS OF BUILDINGS

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Keywords: *Energy Audit; Buildings; Energy Efficiency; Infrared Thermography.*

1. Introduction – Considering the publication of the *Directiva 2012/27/UE* [1] relating to energy efficiency, energy audits have been transformed from being only recommendations for energy savings to be considered mandatory procedures for certain types of business in the Member States since December 2015; this new requirement will take effect in Spain with the final publication of the current *Proyecto de Real Decreto* [2] which transposes the directive into the Spanish system. On the other hand, the infrared thermography is a technique that allows thermal inspection of buildings, detecting thermal irregularities in their envelope (according to European regulations [3]), as well as to examine their facilities (conditions of electrical conduits, efficiency of boilers, detection of leaks, breakage of pipes, etc.).

Given all this, it is reasonable to consider that the use of infrared thermography as a complementary tool for energy audits in buildings can grant greater thoroughness and quality, since it allows to detect (in a simple, non-invasive and real-time way) thermal deficiencies that affect the energy efficiency of the building, both in envelopes, installations and equipment; which could hardly be achieved with other techniques.

Ultimately, the main objectives of this research are (i) to determine the correct use of infrared thermography in the energy analysis of buildings and to verify its application in conducting energy audits thereof; (ii) to conduct a proposal for a standard methodology (with its corresponding final report) for energy audit of buildings based on currently applicable regulations [4], specifying the parts of the audit process where the authors propose to include thermal inspections by using infrared thermography.

2. Methodology – First of all, after searching for documentary references and regulations about the problem, we proceed to read, contrast and select all the reference documentation. Subsequently, we set a theoretical approach for the two major themes (energy audits [5,6,7] and infrared thermography [8,9]). Then we develop fieldwork through thermal imaging of the Polytechnic IV building at the University of Alicante with a thermographic camera. After the analysis and processing of these images through various types of computer software, we study the main techniques, conditions and other aspects to consider for the energetic inspection of buildings by using infrared thermography. Finally, we develop a methodology regarding the main aspects to be considered for the performance of energy audits supported by the use of thermal imaging inspections with infrared cameras.

3. Results and discussion – The most significant results of the research carried out are: first, those extracted from the fieldwork in the building studied (realization of in situ infrared thermography); they show, on the one hand, the correct techniques for thermal imaging (focus and framing) as well as the measurement conditions (sunlight, wind, time of day, temperature and relative humidity, among others) and, secondly, that the knowledge and correct interpretation of certain parameters when analysing images using computer software (emissivity and reflected apparent temperature of studied objects) significantly influence the data obtained, and they can lead to a great distortion of the actual temperatures of the elements analysed.

On the other hand, we have identified in which phases of the audit process is considered that infrared thermography has an efficient application to propose their use, namely: in the inspection phase of the building envelope (U-value of walls, thermal inertia of the building, seals and thermal bridges, sealing, etc.), in the inspection phase of heating, cooling, ventilation and hot water systems (equipment and pipes), during the inspection phase in the distribution system of electricity (generators, transformers and pipes) and during the inspection of other systems in selected buildings with specific applications (systems of production of thermal energy, etc.).

4. Conclusions - Once the research has been carried out, it can be concluded that infrared thermography has an application in energy audits of buildings because of its intrinsic characteristics, providing optimal results in certain phases of the audit process that have been suitably identified. The main contribution of the work is the elaboration of a standard procedure for carrying out energy audits in buildings, determining how and where to use thermal imaging to optimize the results of the audit, as well as the proposal of a specific report to present the conclusions obtained during the process.

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STUDYING THE BEHAVIOUR OF CERAMIC FLOORING AS HEAT ENERGY COLLECTOR, IN BUILDINGS CONSTRUCTED FOLLOWING BIOCLIMATIC CRITERIA

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Keywords: *Construction; Building; Bioclimatic; Ceramic Pavement*

1. Introduction – Bioclimatic architecture consists of a set of design and construction activities, focused on improving users' comfort inside the building. Taking into account the adaptation and adequacy to the climate of the zone where it is located.[1]

In Bioclimatic building, it is essential a balanced use of local materials for a passive energy approach, being essential their characteristics of environmental impact and thermal inertia.

An effective harnessing of incident solar energy is essential for maximum comfort into the building, with minimum energy consumption of non-renewable resources [2].

Solar radiation -besides being variable depending on time-, gets to totally die out at a given moment, making it crucial to take full advantage of the conditions of accumulation over the daylight periods, when more energy input takes place.

The purpose of this paper is to analyze, using an experimental study [4], the performance of the flooring as a heat energy collector over the winter months, in a building constructed using bioclimatic criteria (Fig.1). What matters in our case is to detect a proper energy storage, in which retained energy is released slowly, depending on a proportionality factor called thermal diffusivity, that in the case of our ceramic flooring is $5,5 \times 10^{-7} \text{ m}^2 / \text{s}$



Figure 1. Flooring of Aula Educación Ambiental, Pozuelo de Alarcón

The building chosen to conduct the study is the "Environmental Education Classroom", located on the southern slope of a small hill, near the Forest Park Somosaguas in the Madrid suburb of Pozuelo de Alarcon [3].

2. Methods – The experiment is performed in a room of the chosen building, with a glass wall on the south facade, with an upper brim of 2.79 m², and a skylight on the ceiling of this room (at the opposite side of the glass wall) measuring 0, 80 x 5.5 m.

The flooring consists of a ceramic paving, nominal dimensions of 20 x 9.5 x 4.5 cm, placed linearly, onto a layer of cement mortar.

Specifically, the incident radiation in the room will be measured during 2015 winter months. However, we have monitored the flooring in summer 2015, specifically in the month of July, as base reference for the main study. The results of this first monitoring of reference are presented.

On the surface of the flooring 20 K thermocouples were placed, forming a grid on the ground, and data for 8 days (Figure 2) were collected. Also other data were collected on those same days, relating to room temperature in the classroom and outdoor temperature, humidity and radiation data too.

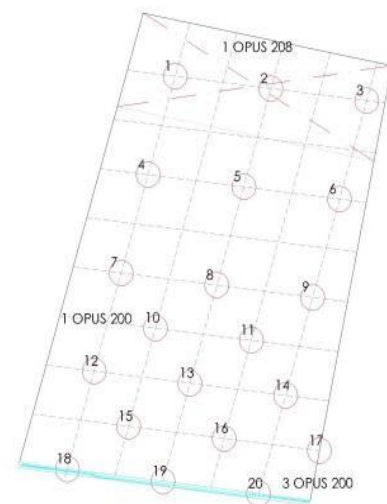


Figure 2. Thermocouples distribution

3. Results and Discussion – Using Surfer software we obtain the thermal distribution on the flooring. We realized that in times of high diurnal temperature, the flooring peak temperatures are produced in the area next to the glazed windows, reaching a maximum of 30.5°C in the flooring, while interior room temperature is 32.0 ° C and 40.3 ° C outdoors. The area under the skylight -where high temperatures could be expected-, records significantly lower temperatures. (Figure 3). This difference can be attributed to the existence of double glazed windows that delay heat dissipation.

During the night, as expected, the area registering higher temperatures is the central area of the screed, while in the front and lateral sides lower temperatures are recorded. It is also observed a delay of the flooring peak temperature, considering the peak incidence of solar radiation in a 6-hours average time.

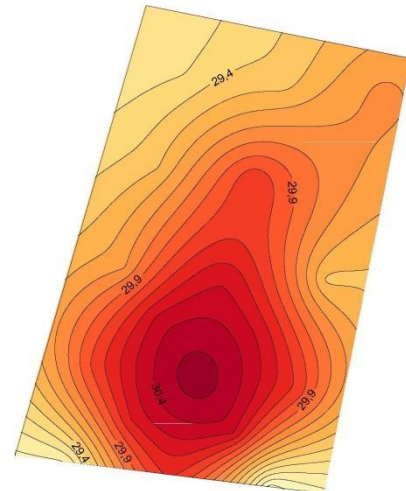


Figure 3. Surface temperatures 08/07/2015 18:00

3. Conclusions – Is established that the ceramic flooring acts as a powerful heat storage due to its high thermal inertia. Therefore, its use as a heating element during the winter months (when solar radiation incident on the screed is higher due to architectural design) can be considered an important passive strategy of thermal comfort for interior spaces, contributing to a significant energy saving.

We found that the number of sensors used and their distribution on the screed, provide sufficient information about temperature distribution. This result optimizes the preparation and implementation of the pilot phase scheduled for winter months and, in general, can be extrapolated to any other case regardless of material, design and location. Finally, the use of the material's heat accumulation, its heat charge and discharge to stabilize the internal temperature levels, is important in cases where the diurnal variations in outdoor temperatures should be large, as in our case study. However, with only summer of 2015 data, the analysis is incomplete, being necessary to study the months of winter, when the temperature variations are quicker.

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SUSTAINABLE CONSTRUCTION SYSTEM USING VEGETABLE FIBRE BLOCKS. THE IMPORTANCE OF PROMOTING SUSTAINABLE CONSTRUCTION SYSTEMS

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Keywords: *Sustainable Construction; Information Promotion and Dissemination; Teaching Improvement; Biomaterials*

1. Introduction – Silvia Cenzano Gutiérrez and Marta Revuelta Aramburu are the promoters of the Universidad Alfonso X el Sabio's project research project entitled "Research and Teaching of Traditional and Sustainable Construction Systems for Building Compartmentalisation and Building Envelope", and they aim to: improve the sustainable construction system using building vegetable fibre blocks, commonly referred to as straw bales; to promote and disseminate both the advantages and qualities of this system and the research that was carried out; and to improve the quality of teaching and enhance student learning through practical workshops that will result in the construction of a shelter on campus at the University. The building sector is responsible for a highly important percentage of polluting CO₂ emissions worldwide [1]. And building construction also generates an enormous amount of waste throughout the building's life-cycle, from construction to demolition; a minimal proportion of this waste is successfully recycled. The result is a highly polluting and a fairly unsustainable industry.

In view of this situation, new techniques and resources are currently being implemented to optimise the site potential and the local climatic conditions, thus minimising a building's energy consumption, reducing emissions and maximising use of waste. The latter focuses on the use of various types of construction materials, namely natural, recycled or those whose extraction does not require a complicated and expensive process. Research is now underway for the use of straw bales in building construction projects since straw is the main post-harvest waste in cereal crops such as wheat, oats, barley or rye. The technique of straw-bale construction first started in the United States in the late 1800s and it soon showed some significant advantages: excellent thermal and sound insulation properties, simple building skills, fire resistance, low-cost material, high stability and seismic resistance, etc.

A scientific, rigorous dissemination of sustainable construction systems could put forward to the public the advantages and properties of straw-bale construction, promoting understanding and public acceptance of this style of construction, and educating people about how green building is no longer an unattainable dream or a solution that would offer poorer comfort conditions than the most common options existing nowadays. Strategic



Figure 1. Participants in one of the self-construction sustainable workshop

communications and scientific dissemination to the public will increase lay understanding of the existing sustainable construction options, enhance people's awareness and effect positive behavioural change. "Education—in all its forms and at all levels—is not only an end in itself but is also one of the most powerful instruments we have for bringing about the changes required to achieve sustainable development." [2] (UNESCO's former Director-General Koïchiro Matsuura)

It is important to stress the fundamental role of public awareness, education, training, public access to information and public participation in fighting climate change and protecting the environment. This need is also reaffirmed on Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) [3]. In order to achieve this, the Project includes different dissemination methods from the more traditional—articles published in newspapers and periodicals or conference posters—to the more innovative ones that allow for an interaction of students, teachers and people on social networks interested in this sustainable construction option.

2. Methods – The Project addresses this challenge with multiple actions, including collecting photographic evidence of each of the workshops that have taken place during the construction of the shelter, production of press releases that are then uploaded on the project's blog, video captures, interviews with this sector's professionals and experts, dissemination of the university's social platforms and broadcasting channels promoting the project (Twitter, Facebook, LinkedIn), design of posters announcing the workshops at the University, or writing articles on the Project. Participants in the workshops are also encouraged to promote the Project whenever possible so as to reach the largest amount of public.

3. Results and Discussion – To date, numerous results have been obtained. Probably, the most significant is a blog with updates on the various practical workshops on the construction of the straw-bale shelter at the University's campus:

<http://construccionbalasdepajauax.wordpress.com/>.

The blog includes category pages, such as "Desmontando un reportaje" ("Deconstructing an Article"), with access to informative texts on Bioclimate Architecture, project-related topics or pages including parallel actions carried out by the members of the project, such as "Gente a la que seguimos y/o nos acompaña" ("People We Follow and/or Come Along"). The blog also includes different sections with information on similar events to take place in Spain, Europe or worldwide; and webpages from businesses, associations or groups that are also carrying out similar projects.

4. Conclusions – There has been a growing interest in the straw-bale construction system used in this Project, as shown by the more than 900 May visits to the blog or the e-mails from people in Madrid and other Spanish populations such as Cáceres or Galicia willing to participate in the workshops; and University students have readily taken on the project. These data will enable us to continue developing the Project during the following academic year of 2015-2016.

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Figure 2 Informative blog on the construction system.

ENVIRONMENTAL IMPACT OF THE LIFE CYCLE OF BUILDINGS.

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Keywords: *Building; Natural Resources; Environmental Impact; Life Cycle.*

1. Introduction – Construction is responsible for the consumption of more than 40% of the natural resources, 30% of the energy and produces more than 30% of the emissions of greenhouse effect gases; and is responsible for a significant part of the consumption of wood and water in the world [1]. The reason for this considerable impact is to be found in the manufacture of construction materials, the construction itself and the subsequent use, that ends with the demolition. Given the need to implement improvements in the environmental aspect in construction is needed testable and reliable indicators that are sensitive to changes.

Although various methods can be applied to the construction sector, such as energy analysis [2] and material flow analysis [3], there is now a tendency to use simpler methodologies, so that society can understand them more easily. Of these, the ecological footprints (EF), the carbon (CF) and water (WF) are the most prominent. This success is, first, because the results they produce are understood by the non scientific community, and second, to its ease of application in environmental policy and decision making [4].

The objective of this research is to develop the EF, CF and WF indicators for the elements that are part of construction project budget [5], seeking to be able to calculate the footprint of any project, see Figure 1. The new model will estimate, since the design phase, the building footprint during its lifetime.

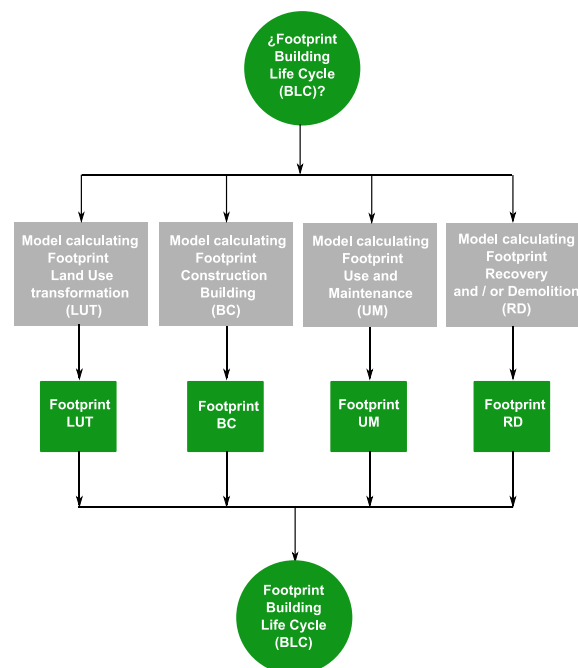


Figure 1 Footprint calculation scheme (Carbon, Water, Ecological footprints) life cycle.

2. Methods – Quantification models for two of four stages (urbanization, construction, use and maintenance, and rehabilitation or demolition) will be developed individually but coordinate.

Edification project budget are used such as link to incorporate environmental impact, this aspect is added to project cost. This actuation allows an economics and environmental comparison of global project in addition its specific building solution.

Methodology is like a "environmental budget" which facilitates understanding by sector's technicians and its enforcement. Developed model allows evaluate each residential edification project because all calculation parameters for each aspect are considered to calculate environmental impact.

3. Results and Discussion – The case study is an urbanization which it has 7.123,78 m² surface. 25 residential buildings and 2 flats are been built on it. All these are 15.820 m² built.

Result obtained for two first stages from Building Life Cycle (BLC) (Urbanization and construction) are shown. To see Figure 2 and 3.

Urbanization's EF, represents 8,66% in relation to Building EF. It's worthy to distinguish the percent for manpower and materials of each stages. Manpower percent for urbanization is higher than for construction due to it requiring fewer materials. However the use of machinery and manpower increases in urbanization. Area occupied by the building is negligible with respect to environmental impact generate to necessary resources for its construction.

4. Conclusions - The behaviour that will have a building during its first two phases of life cycle can be estimated with the model developed.

Those sources of greatest impact can be localized for each phase. This allows control and cope to reduce the environmental impact.

The results obtained for the phases of land transformation and construction, enables the continuation of studies for remaining phases of BLC.

Currently it is investigated for the full impact of BLC_ through EF, CF and WF indicators.

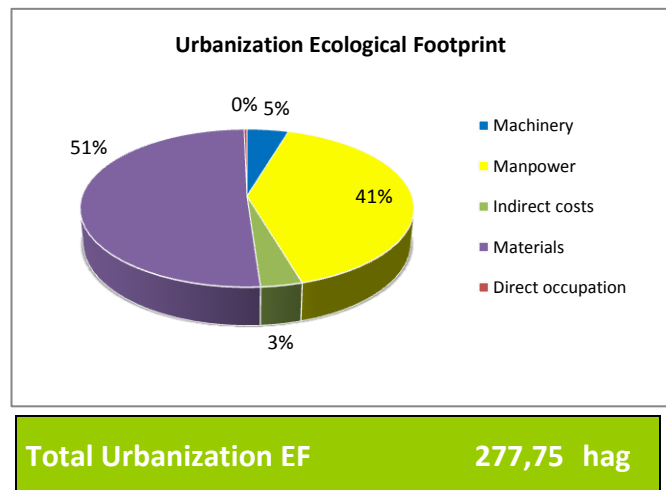


Figure 2 Urbanization Ecological Footprint results.

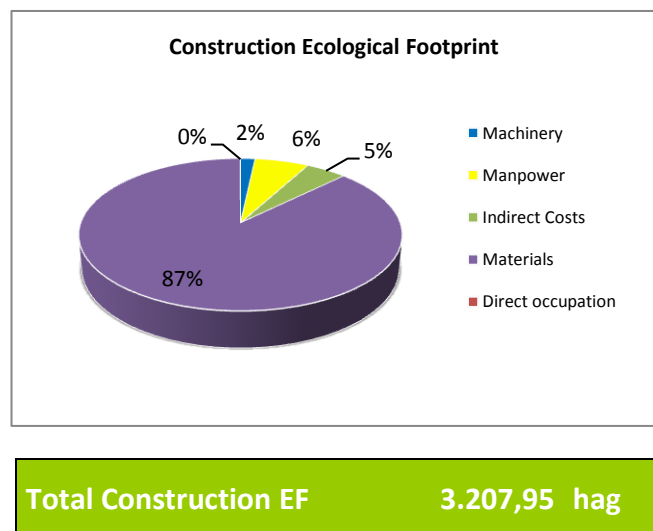


Figure 3 Construction Ecological Footprint results.

Acknowledgement

This research was conducted by the project "La huella ecológica de la recuperación de edificios: Viabilidad económica y ambiental" (HEREVEA), Agencia de Obra Pública de la Junta de Andalucía.

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ASSESSING COST-EFFECTIVENESS OF ENERGY CONSERVATION MEASURES IN THE EXISTING SOCIAL HOUSING BUILDING STOCK: AN ITALIAN CASE STUDY**Salvalai, Graziano ⁽¹⁾ Iannaccone, Giuliana ⁽¹⁾ and Sesana, Marta Maria ⁽¹⁾**

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Keywords: *Social Housing, Building retrofitting; energy efficiency*

1. Introduction – Nowadays, energy is among the principal factors of the social and economic development of our society, dealing with important issues of present times, such as politics and the environment. Upgrade the energy efficiency of the residential building stock is a well-known issue. The existing buildings stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) member states, of which residential use represents 63% of total energy consumption in the buildings sector [1]. The buildings energy performance improvement, especially regarding the public dwellings, is among the actions that should be pursued to reach the Kyoto and Copenhagen goals. Such consideration is hereby developed in relation to the social housing stock managed by ALER (Social Housing Agency of the Region Lombardia, Italy), assumed as case studies for the research study, summarized in this paper. Statistical studies show that nearly 76% of Italian dwellings were built before 1981 and 49% are more than 50 years old. The average annual increase in new dwellings in the 1981–2011 period was only 1% [2-3]. These values are above the European average. In Northern Italy the energy consumption of existing buildings has been estimated, on average, around 18-20 litres of oil fuel per square meter per annum [4-6]. Each building has its own characteristics, but for each building solutions exist to enhance the thermal comfort and reduce energy consumption. The main objective of the study is to accomplish a preliminary energy performance audit of the social housing stock of the Region Lombardia, and test on it several energy retrofit actions, in order target which situations show the best result in terms of cost/benefit ratio. This procedure will help Social Housing Agencies identifying where to pursue more accurate analysis, helping them optimizing time and economic recourses.

2. Methods – The study moves from the broad literature regarding rating methodology to assess energy performances in residential buildings, with particular focus on the refurbishment and energy efficiency approaches [7-8], and applies it to the delimited case study of the social housing of the Region Lombardia. The energy evaluations on the social housing of the Region Lombardia, was based on a bottom-up method, which is constituted by the following steps. Firstly identification of a base case model as reference building able to represent mostly the regional social housing stock, secondly energy analyses of the identified base case model with dynamic simulation for the calculation of the annual primary energy consumption for heating. Third step was the retrofit options' identification using appropriate energy models, economic and analysis tools to individuate and quantify economically a possible range of retrofit alternatives. The selection of retrofit measures comes from a balanced compromise between capital investment and benefits that could be achieved due to implementation of the retrofit measures over time. Economic analysis, which facilitates the comparison among alternative retrofit scenarios, can provide an indication of whether the retrofit alternatives are energy efficient and cost-effective. A variety of economic analysis methods can be used to evaluate the economic viability of building retrofit measures.

3. Results and Discussion – the energy retrofit actions were the core of the methodology followed for the retrofitting evaluation on the Regional social housing stock. The operations to improve energy efficiency of the buildings have been grouped in three levels.

Primary actions mainly concern the energy retrofit of the building envelope, especially regarding the improvement of its insulation capacity; in this case two increasing steps of insulation levels have been evaluated: considering buildings of different age, the oldest require more insulation (construction built before 1991 did not fulfil the requirements of the National Law10/1991, which prescribed a minimum insulation level for new constructions), while more recent ones are characterized by a more efficient technology, with a little insulation material within the envelope layers. The study reaches preliminary results, approximating to only two degrees of insulation and a single material (XPS, extruded expanded polystyrene).

Secondary actions concerned the minimum requirements to refurbish an average building: heating system refurbishment and replacement of single-pane windows with double-pane ones.

The preliminary payback period of the retrofit scenarios for each category has been evaluated matching the following calculated data: starting investment cost related to the efficiency improvement measures with annual energy saving, calculated as subtraction of pre- and post-retrofit energy costs.

4. Conclusions - This paper represents the output of a project developed for the Social Housing Agency of the Region Lombardia, aiming at exploring the benefits of deep retrofitting measures to increase the energy performance of the Regional social housing stock. A deep state-of-the-art evaluation of the existing building stock and the collection of data related to the Regional social housing has been accomplished. After the elaboration of a base case model to ease the processing of such a large amount of data, the energy balances have been computed. Once delineated the baseline scenario, different actions for the improvement of energy-efficiency have been simulated. It can be concluded that the minimum energy retrofit scenario is constituted by the replacing of the heating system and the single-pane windows with double-pane ones which could provide a sustainable cost/benefits ratio, ensuring an average reduction of energy consumption equal and respective CO₂ emissions reduction with a determined payback period. The achieved results have been possible thanks to the energy audit and dynamic simulations performed on the reference model, which has helped speeding up the calculations.

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THE ADAPTIVE APPROACH TO THERMAL COMFORT IN SEVILLE

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Keywords: *Energy saving; Adaptive comfort; Adaptive approach; Sustainability (max. 4 keywords)*

1. Introduction – The comfort standards in mechanically conditioned office buildings have been widely studied through comfort model gathered in ISO 7730 [1] developed by Fanger [2]. There is not a consensual approach towards occupant's comfort in dwellings yet.

In Spain, the 35,5% [2] of the housing stock was built before 1980 which means it was built under no energy efficiency regulations. In this context, the present research is aimed at the reflection about the user's comfort limits, in order to estimate the temperatures of each one, and the use of air-conditioning systems in a housing stock generally neglected, that sometimes results excessive and brings an unnecessary energy waste, through the application of the adaptive approach.

Up to date, several adaptive comfort standards have been developed (ASHRAE Standard 55-2013 [3], UNE EN 15251:2008 [4]). These standards focus on buildings where occupants can make some adjustments and achieve their comfort through behavioural and psychological adaption. The application of these standards can provide an important contribution in energy retrofiting.

2. Methods – The chosen model, a naturally ventilated flat of a housing block which was built in 1979, is located in a Mediterranean climate, in the city of Seville. This city possesses a great percentage of housing blocks, consequence of the urban expansion in the 60', where the presence of active conditioning systems is limited.

Within this research, standards ASHRAE 55-2013 and UNE-EN 15251:2008 were applied to this building type, so as to estimate the comfort thresholds and analyse the number of hours inside and outside the comfort zone.

In order to provide as accurate as possible results, field measurements as well as occupants' survey responses were collected in the case study flat. Besides, the results of the assessment made through the standards have been checked against the results of the surveys.

3. Results and Discussion – Figure 1 shows the results of the application of ASHRAE Standard 55-2013 and figure 2, those from the UNE EN 15251:2008 of the study period in winter. The comparison between the results of the application of both adaptive models shows that more hours fall within ASHRAE Standard comfort zone than within UNE EN 15251:2008's.

The rest of the results are yet to come but they are expected to show the number of hours in which occupants should feel thermal comfort. These data, compared to surveys results will provide a better insight into the ability of these standards to predict thermal comfort in dwellings.

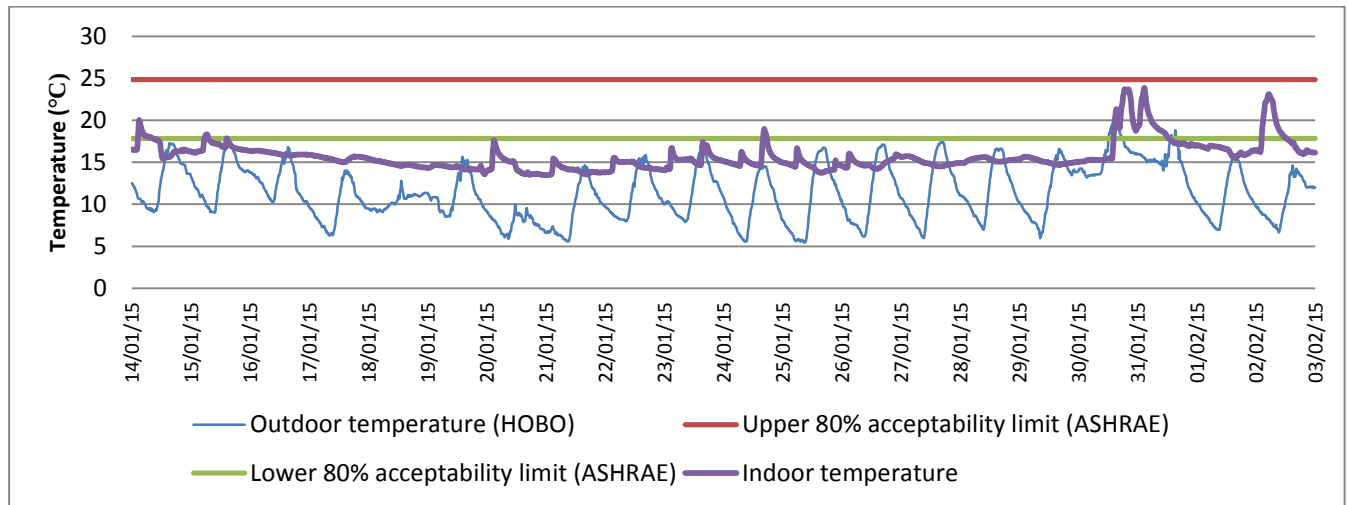


Figure 1: Indoor temperature oscillation. Results of application of ASHRAE Standard 55-2013. Northeast facade.

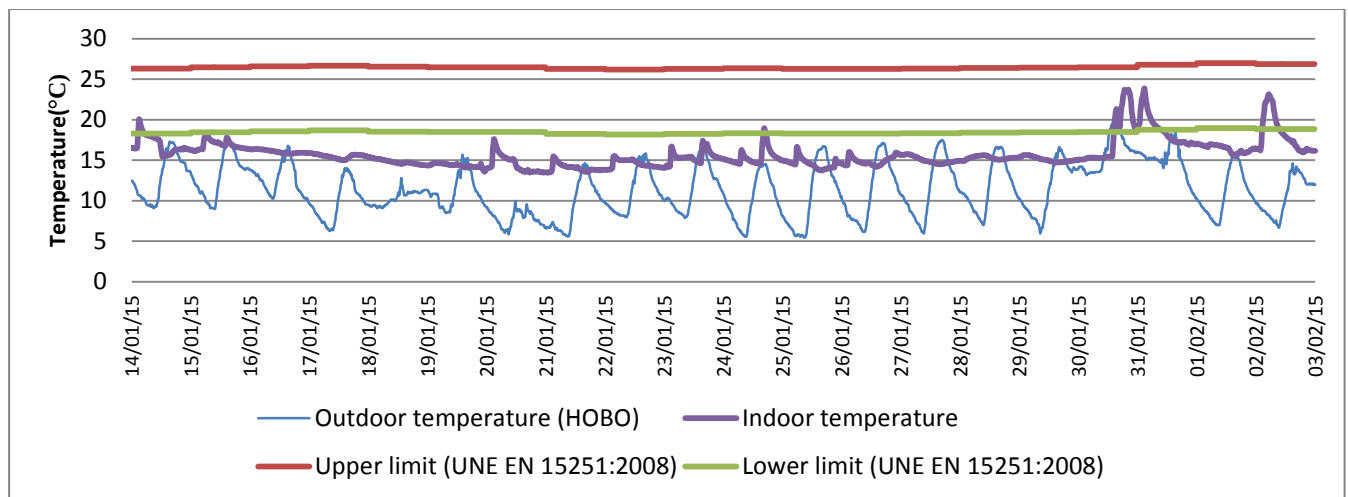


Figure 2: Indoor temperature oscillation. Results of application of UNE EN 15251:2008. Northeast facade.

4. Conclusions – The conclusions of this research will provide valuable information in order to focus future works towards the most appropriate passive strategies to achieve thermal comfort.

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FUEL POVERTY ANALYSIS IN THREE SPANISH AUTONOMOUS REGIONS. SOME RETROFITTING POLICY CONSIDERATIONS

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Keywords: energy consumption, energy policy, fuel poverty, housing stock, low income, retrofit, vulnerability

1. Introduction - A person is to be regarded as living 'in fuel poverty' if he is a member of a household living on a lower income in a home which cannot be kept warm at a reasonable cost [1]. This situation is mainly triggered by three factors: low household income, lack of energy efficiency and high energy invoices.

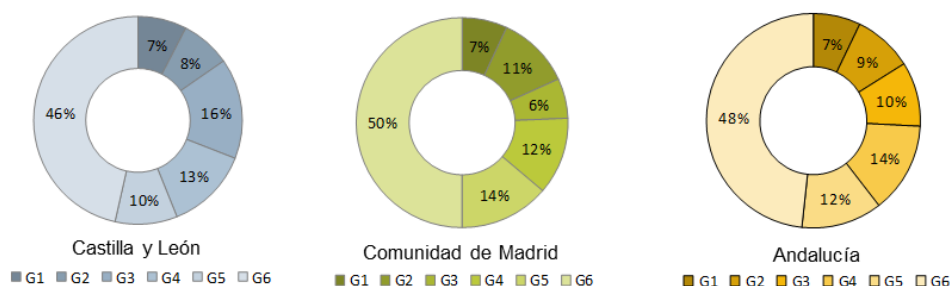
Some European countries have already made some advantages towards officially defining fuel poverty in their countries [2, 3]. Nevertheless, in Spain only some research has been done [4] and an official definition of the term is yet to come.

This research explores the relation among households' income, energy expenditure and housing stock in three autonomous regions in Spain in order to evaluate the housing stock of the fuel poor as well as to identify those households more in need. The results of the research allow establishing energy retrofitting priorities of existing housing stock as well as identifying current retrofitting policies limitations on order to tackle fuel poverty.

2. Methods - Three autonomous regions were selected as study cases: Castilla y León, the Autonomous Region of Madrid and Andalucía. These three regions were selected in order to consider households living in main Spanish climatic regions.

Fuel poverty incidence was established through existing statistical data: the EU-SILC survey [5] and the Spanish Family Budget Income survey [6] according to main existing methods.

Then, households were classified according to their income and energy expenditure resulting into six groups for each autonomous region, as can be seen in Figure 1. The relation between these six household groups and their housing stock was evaluated. Main housing characteristics of each group were analysed through statistical variables, as plotted in



Group	Criteria	Castilla y León	Comunidad de Madrid	Andalucía
1	Monetary and fuel poverty	77.053	164.445	215.113
2	Monetary poverty	78.655	266.085	270.035
3	Fuel poverty	158.925	144.819	296.278
4	Fuel and monetary vulnerability	131.658	280.101	415.270
5	Monetary vulnerability	98.061	326.845	367.684
6	No vulnerable	472.247	1,181.778	1,460.740

Figure 1 Household group classification according to income and expenditure

3. Results and Discussion - Results show an important incidence of fuel poverty. The 23% of households in Castilla y León, the 13% in the Autonomous Region of Madrid and the 17% in Andalucía spend more than the 10% of their income in energy. The division of households into six groups according to their income and energy expenditure, presented in Table 1 showed important rates of vulnerability in the three regions.

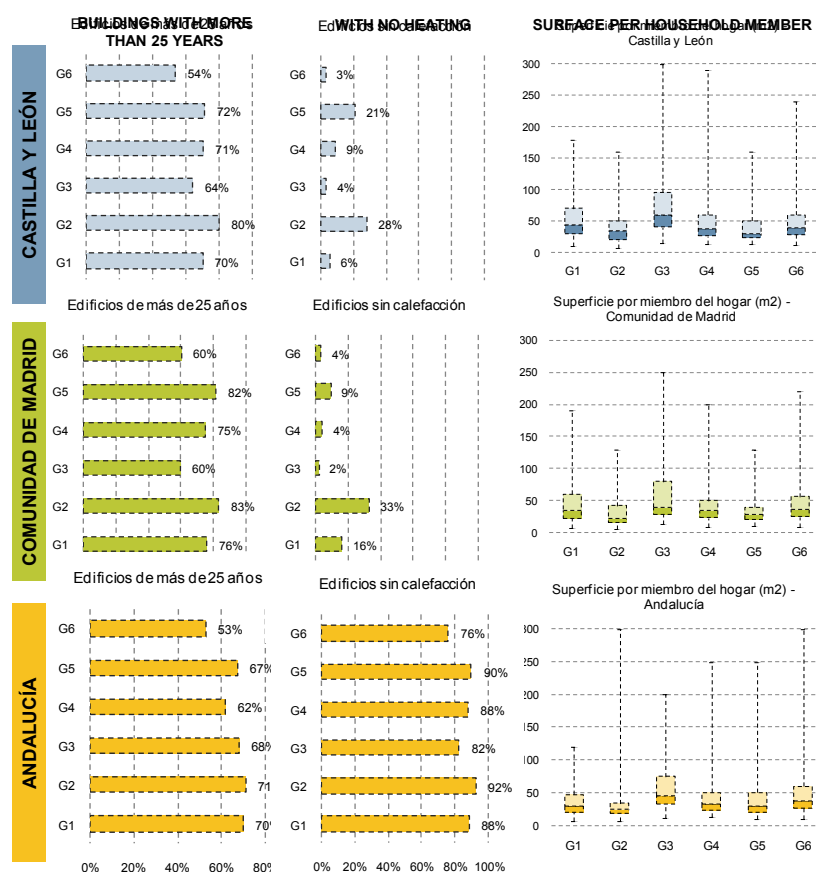


Figure 2 Characterization of the housing stock of the six household groups

By contrast, Group 3 is made up of small families living in big and relatively new houses with a good presence of heating systems. All this indicates that this group, despite having excessive energy expenditure, is not under important difficulty.

3. Conclusions – First conclusion of the research is the urgent need for an official definition of fuel poverty in Spain given the important incidence of it among Spanish households. Flaws in actual statistic have been identified. Finally, through the revision of current retrofitting policies, barriers to tackling fuel poverty in Spain are extracted and presented.

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ENERGY EFFICIENCY IN OUTERMOST REGIONS' BUILDINGS

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Key words: *Sustainability; Building; Climate; Transport*

1. Introduction

EC Directive 2012/27/EU, related to energy efficiency, which modifies EC Directives 2009/125/EC and 2010/30/EC and abolishes EC Directives 2004/8/EC and 2006/32/EC has the purpose to promote energy efficiency in buildings situated in the European Union. This directive considers the outer climatic conditions, as well as the local conditions, among others. Considering the Directive's common framework, the Member States have established energy efficiency calculation methods for its buildings as well as minimum requirements implementation.

In the European Union there are nine outermost regions (from now on OMR) that belong to Spain, France and Portugal. These regions have certain common features related to their geographic features: remoteness, insularity, small area, land relief and adverse climate (*article 349 of the Treaty on the Functioning of the European Union*). Due to these circumstances, the European Union allows to take steps to cover the special status of the OMR.

Looking at the OMR's geographical position and climatic features compared to the European Union ones, there are some key circumstances about their buildings energy efficiency. The European mean latitude vary between 40 and 60 North latitude, having continental climate, against the OMR very scattered latitude, that vary between 15 and 25 degrees from the Equator, presenting an oceanic climate. The mean transport distances into the European Union vary from 500 and 1200 kilometres overland (train or lorries), but in the OMR these distances vary from 3000 and 7000 kilometres in which is necessary the combination of land and sea transport.

Taking into account that weather conditions define the building, in mild climate zones it is more efficient the usage of ecological design, in order to get an adequate degree of comfort [1]. Also from a consumption point of view, it has to be seen the energy cost of building material transport in outermost regions that, due to their features, suppose an important environmental damage. This continuous moving of bulky and heavy materials makes an increasing of the estimated 40% of global energy consumption that comes exclusively from construction works [2].

The objective of this research consists on investigate the implementation of this European Directive related to energy efficiency to OMR's peculiarities related to their local architecture.

2. Method

In order to achieve the defined objective, the European Directive 2012/27/EU and the common framework that consists of building being at least a 20% more efficient by 2020 is analysed, as well as the OMR's formalization into the European Constitution according to European Union Functioning Treaty Articles 349 and 355 and its reach. It is also analysed the state regulations of Spain (DB-HE, CTE), France (FRANCE RT 2012) and Portugal (DECRETO LEI Nr. 118/2013) that derive from the European Directive for energy efficiency in building. Furthermore, the specific climate of each OMR is analysed according to data from the World Weather Information Service (wwis.inm) and get related to the ones of the European continent and each of its countries. Every OMR climate is analysed from a building

and thermal comfort point of view, in order to get the maximum energy efficiency. To that end, it is compared with the traditional architecture with local conditions and also the conventional style of architecture against the buildings made with imported building materials.

3. Results and discussion

In particular case, the Spanish OMR has a latitude difference of 12 degrees to Madrid, the French OMR have a mean latitude difference of 34 degrees to Paris and in the Portuguese OMR the latitude difference is less than 6 degrees to Lisbon. As a result of the latitude, oceanic climate and altitude and gradients that OMRs have, there exist major climate differences regarding their mainland countries in the cases of the French and Spanish OMRs and not so much in the Portuguese OMRs. The main European cities are far away from the thermal comfort range of temperatures with adequate clothing that vary from 20 and 26 degrees centigrade [3], while the OMRs are situated within this range (fig. 1).

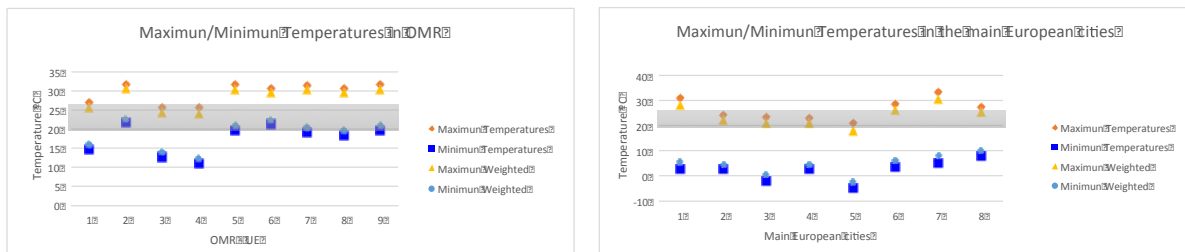


Figure 1: Comparative temperature graph in the OMRs and in the main cities where it can be seen general margin of average temperature.

4. Conclusions

The OMRs, due to their specific geographic features cannot be treated the same way as the countries they belong, so it is obvious that should get a specific regulation referring to energy efficiency, in which its buildings could be adapted to the specific conditions. In order to achieve it, we will see these aspects:

- Portuguese OMRs do not have very different latitude compared to their belonging country, having almost the same climate.
- Spanish and French OMRs have a warmer and stable climate, completely different to their countries. Also, these OMRs have a minimum quantity of maximum heat or maximum cold days (less than 10 days per year).
- Any OMR has an Energy Efficiency Directive adapted to their circumstances.
- Energy costs originated from the construction materials transport are higher than the existent in the European continent.

OMR's traditional construction shows which is the best type of building from an energy efficient point of view.

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STUDY OF THE INFLUENCE ON THE STRESS AND THE ENVIRONMENTAL IMPACT OF THE TYPE OF KNOTS IN WARREN TRUSSES

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Keywords: *steel, truss, stress, energy.*

1. Introduction – The benefits of using steel structures for large spans, are among other facilities, its lightness compared to other structural materials, their machining and ease of assembly and the possibility of recycling. Despite the above advantages, has the disadvantages, being a nonrenewable natural resource, require high energy consumption for production, generate significant CO₂ emissions as well as large quantities of waste, both gaseous and solid [1]. Considering that in 2010 crude steel production in the European Union in electric arc furnaces and oxygen steel furnaces totaled 172.9 million tons, the slag generated in the European Union amount to 9,34Mt of slag produced only in electric arc furnaces and 8.37 Mt year in ladle furnaces, which are deposited in landfills that generate serious environmental damage, which is essential to the study of proposals to make more sustainable and less environmentally damaging buildings [2]. Considering these aspects, the study aims to study the influence of tensions and energy consumption in Warren type trusses, when they are subjected to different load values and with different types of knots, in order to optimize the amount of material and energy consumption.

2. Methods – It is designed and analyzed a Warren type truss, as shown in Figure 1, hot rolled steel S275JR according to UNE-EN 10025-2 [3]. On the designed truss are calculated the stresses produced by the application of different load values and assuming different types of knots, through a program of structural calculation and according to the technical code for structural safety in the steel DB SE-A: Steel [4]. From the data obtained, we proceeded to study the amount of material and energy consumption between the different calculated trusses [5].

3. Results and Discussion – Table 1 shows the relationship between the applied loads, the type knots used in the trusses, the stresses obtained in the calculation, the quantity of steel and the energy consumed in each case, with reference to the least loaded truss and knotted stiff.

The analysis of Table 1 shows that for all load values in the upper and lower chords, stresses are greater in the case of trusses with knots jointed in those with stiff knots. You can also observe that the quantity of steel and energy consumption, increase with increasing applied loads and are always higher in trusses with joints knots than trusses with stiff knots.

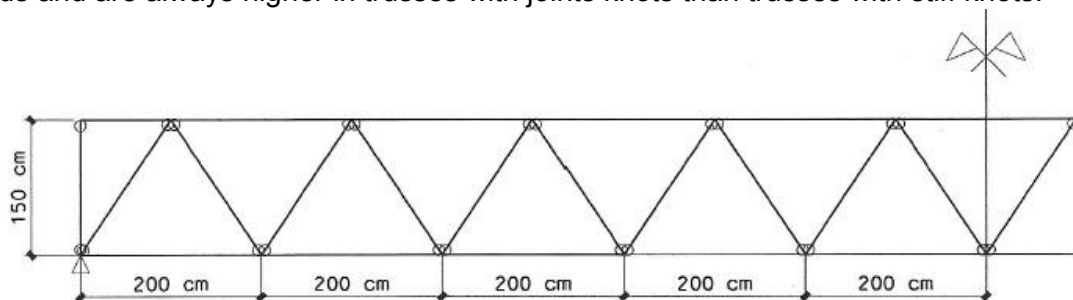


Figure 1 Geometric characteristics of the Warren truss

Point loads in knots (kN)	Types of knots	Elements	Increased load (%)	Stresses maximum (N/mm ²)	Quantity of steel (kg/ml)	Steel (kg)	Energy consumption (MJ)
20	Stiff	Upper chord	0	184,63	46,8	936	44722,08
		Lower chord		183,26			
		Diagonals		127,79			
20	Jointed	Upper chord	0	185,61	50,9	1018	48640,04
		Lower chord		183,46			
		Diagonals		164,64			
60	Stiff	Upper chord	200	157,58	132	2640	126139,2
		Lower chord		183,00			
		Diagonals		171,5			
60	Jointed	Upper chord	200	190,12	137,6	2752	131490,56
		Lower chord		183,26			
		Diagonals		178,36			
100	Stiff	Upper chord	400	185,22	217	4340	207365,2
		Lower chord		185,81			
		Diagonals		205,8			
100	Jointed	Upper chord	400	201,88	218	4360	208320,8
		Lower chord		199,92			
		Diagonals		178,94			

Figure 2 Values of stresses and energy consumption, depending on the type of load and types of knots used

4. Conclusions – The most important conclusions of this work should include:

- The elements that form the Warren type trusses attain larger stresses in knots jointed than those with stiff joints.
- Increasing loads is a significant increase in energy consumption, being always greater in trusses with knots jointed than stiff joints.
- To achieve similar stresses materials, the quantities of material to be used they are higher in trusses with jointed than trusses with stiff knots.
- The possibility of using stiff knots in trusses type Warren, is a good alternative from an economic and environmental point of view.

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EXPERIMENTAL DESIGN, MONITORING AND ANALYSIS OF THE THERMAL BEHAVIOR OF THE EXTERNAL THERMAL INSULATION SYSTEM (ETICS) IN THE RETROFITTING OF A RESIDENTIAL BUILDING

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Keywords: Retrofitting; Insulation; ETICS; Building

1. Introduction –The need to reduce energy consumption in the building edification [1] implies designing new constructive systems. These systems help to reduce both consumption and energy losses in order to achieve adequate thermal comfort for people in any type of building. In existing buildings the best option is the rehabilitation based on thermal insulation.

The aim of this paper is the design, the monitoring and the analysis of the first results of the thermal behavior of the ETICS system in facades [2]. This restoration system consists in the addition of the thermal insulation on the outside, helping to create a continuous envelope on the facades.

The analysis is done by comparing a rehabilitated part of the building with ETICS system and another part which has not been rehabilitated and it is taken as reference [3] [4]. Both of them have the same characteristics. Temperature measurements were taken with type K thermocouples according to the previous design of the monitoring and in the same period of time.

The object building of the study is situated in Benimamet Street, in San Cristobal de los Ángeles, in the south of Madrid. It was built in the late 50s. The 51st entrance hall, which is restored, and the 47th entrance hall, in original conditions, has been studied. (Fig.1).

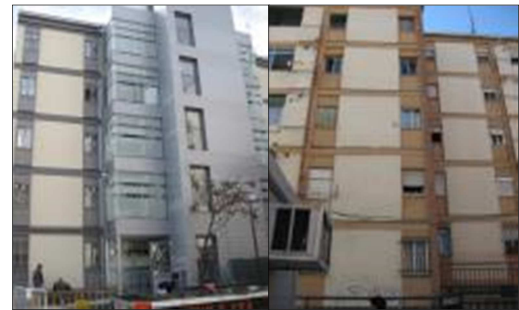


Figure 1. Main facades. Portal 51 and 47. Source: Authors

2. Methods – The study facades of the buildings are the main one facing north and the back one facing south, both in the case of the restored part and in the non-restored part. The study was conducted in the houses located on the third floor of the building. In both cases, it has been taken into account the structural characteristics and the situation in the building.

The monitoring design is developed considering the similarity of the two houses studied. The type k thermocouples are connected to the corresponding data logger according to the Figure 2 (Fig.2). These were placed on the outside and inside facades and windows, in order to observe the differences of the thermal behavior.

Temperature measurements are collected every 10 seconds and stored every 2 minutes.

Measurements were made during the month of March and after the calibration process it was decided to study the period from March 2 at 22:00h to March 5 at 22:00h, 2015.

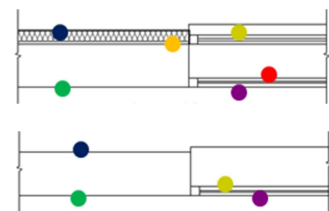


Figure 2. Thermocouples distribution. Restored (up) and non-restored (down) facades.

3. Results and Discussion – The most relevant results of the first comparative analysis between the two cases are significant according to the thermal behavior.

The difference between the restored facade and the non-restored facade in the case of the north facing, both the inside and the outside, is appreciated (Fig 3).

Outdoor temperatures are practically the same in both cases with average of 12.70°C and 12.30°C, as it might be expected. Regarding the interior temperatures, in the case of the rehabilitated facade is kept constant with an average temperature of 22.43°C and 2.58°C of difference throughout the period. On the other side, the non-restored one shows fluctuations of about 6.41°C with an average temperature of 15.88°C.

The difference in temperature between the outside and the inside is always wider in the case of the restored facade, with differences from 3°C to 17°C.

In the non-restored facade the temperatures even coincide in some cases, when the outside temperatures are the maximum and the difference between the outside and the inside are 8 degrees at most.

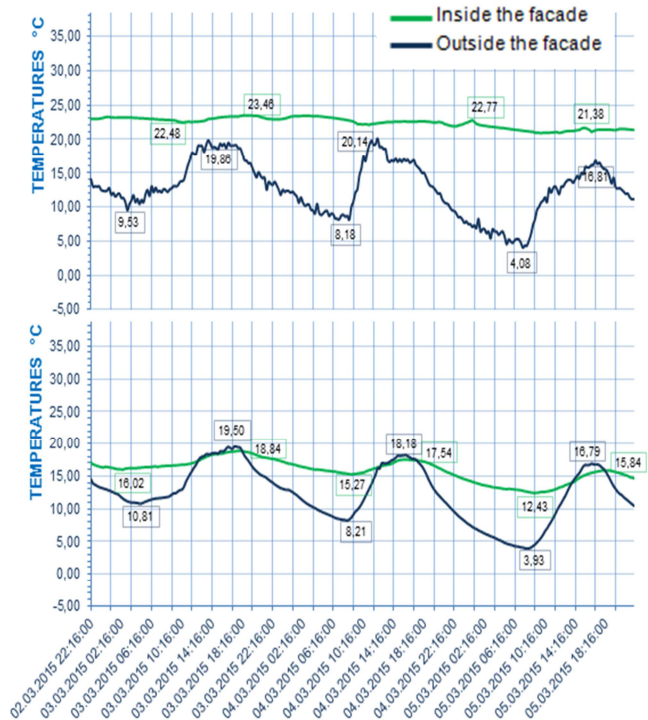


Figure 3. Thermal behaviour. Restored (up) and no restored (down) north facades.

4. Conclusions – The methodology, the placement and the number of data choosing for this study are the correct to provide the information needed to study the thermal behavior of the facades. The results indicate that the rehabilitated housing maintained an internal temperature of about 22°C, matching the standard comfort temperature, while in the non-restored facade the temperatures are kept about 16°C. By attaching the ETICS system there is always a minimum temperature difference of 3°C between the inside and the outside, indicating that the system provides excellent insulation from outside.

Rehabilitation with ETICS is favorable in all cases to maintain a constant temperature inside the housing and thereby optimize consumption and energy savings.

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THERMAL AND HYGRIC PROPERTIES OF INSULATION MATERIALS SUITABLE FOR HISTORIC AND TRADITIONAL FABRICS.

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Keywords: *internal insulation; hygric behaviour; thermal properties.*

1. Introduction – Retrofitting insulation to existing buildings lowers the energy requirement for heating and cooling, reducing CO₂ emissions and energy consumption thus lowering the environmental impact of the building sector. This has been widely recognised and several initiatives exist for improving building energy performance by retrofitting insulation. External insulation is not usually appropriate for historic buildings on account of the architectural and historic significance of their facades, so internal insulation is often preferred however, there are risks associated with this option, primarily the accumulation of moisture within the wall and consequent structural and material decay. Moisture accumulation occurs on account of the two primary reasons: first, the reduced permeability of an insulation can impede the wall drying towards the interior. In addition, lowering of the wall temperature by the insulation can reduce the drying capacity of the wall and increase moisture condensation. Moisture can have a negative effect on the occupants by reducing thermal comfort and endangering human health. Moisture accumulation also deteriorates the thermal performance of walls and/or insulation because of the higher thermal conductivity of water compared to air. This paper investigates the thermal and hygric properties of seven internal insulation options including thermal paint, aerogel, cork-lime, hemp-lime, calcium silicate board, timber fibre board and PIR board. Their performance is compared to a traditional lime plaster finish.

2. Methods – The *specific heat capacity of the insulation* was measured in an adiabatic surrounding. Heated samples were placed in containers filled with water at 13°C and the water temperature rise monitored at 30 min intervals. *Bulk density and open porosity* were calculated measuring the dry, saturated and hydrostatic weights. From the density and specific heat capacity, the *thermal mass, diffusivity and effusivity* of the insulation were calculated according to the equations in table 1. The *thermal conductivity* of the insulation was calculated by comparing the in-situ u-value of a wall with and without insulation. The *pore size distribution* of the insulation was analysed by gas sorption using a Quantachrome Nova 4200e. The moisture *adsorption* in 75.5, 85.1 & 97.6% RH environments was determined by placing the insulators in sealed containers with saturated salt solutions (ISO 12571:2013). The reference moisture content (adsorption at 80% RH) was deduced by extrapolation. The *water vapour permeability* (EN 12086:1997) and the *water absorption coefficient by capillarity* (EN1925:1999) were also determined. Samples of the bulk insulation and facing material were measured individually. To further measure *capillarity*, a vertical tube was affixed to the insulation surface in accordance with RILEM 1980. The height of the water column is 12 cm which corresponds to a pressure of 1177.2Pa, roughly equivalent to 98mph wind in driven-rain conditions.

3. Results and Discussion –The aerogel and PIR have a particularly low *thermal conductivity*, followed by the timber board and cork lime and then the CSB and hemp lime (Table 1). The lime plaster has the greatest density, thus the highest thermal conductivity being therefore the poorest insulator. It also shows the highest thermal mass and greatest diffusivity (followed by the calcium silicate board with less than half). Therefore, even if able to store a considerably superior amount of heat, the plaster changes temperature faster than the other insulators. The thermal paint (covering lime plaster) does not make a measureable contribution towards either thermal conductivity or thermal mass. The cork-lime and hemp-lime have c. double the thermal mass of the other insulators, a valuable attribute for

attenuating fluctuating external temperatures. The hemp-lime is less dense than the cork-lime however, it has a significantly greater specific heat capacity resulting in a comparable thermal mass. The CSB has higher conductivity than most of the insulators and does not benefit from the good thermal mass seen in hemp and cork lime. The timber board has reasonably low thermal conductivity and high specific heat capacity. The very good insulating properties of the aerogel and PIR with low thermal diffusivity and effusivity, should positively contribute towards thermal comfort.

Material	Thickness mm	Density ρ (kg/m ³)	Thermal conductivity λ (W/mK)	Specific Heat Capacity C_p (J/kgK)	Thermal mass $C_p \rho$ (KJ/Km ²)	Diffusivity $\lambda / (C_p \rho)$ (m ² /sx10 ⁻⁸)	Effusivity $\sqrt{\lambda C_p \rho}$ (J/m ² Ks ^{1/2})
LP	40	1820.0	0.800	863.90	62.89	50.88	1121.53
P	40	1820.0	0	866.80	63.10		
AG	19.5	509.4	0.016	1233.50	12.25	2.61	101.54
CL	40	806.2	0.065	866.50	27.94	9.26	212.54
HL	40	602.6	0.090	1068.00	25.74	14.06	241.33
CSB	35	402.0	0.089	819.40	11.53	27.08	171.39
TB	45	231.3	0.050	1217.80	12.68	17.61	118.23
PIR	37.5	233.4	0.034	1421.10	12.44	10.33	106.59

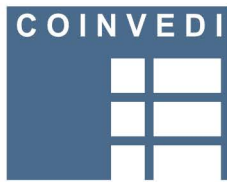
Table 1. Thermal properties of insulation. LP-lime plaster; P-thermal paint; AG-aerogel; CL-cork lime; HL-hemp lime; CSB-calcium silicate board; TB-wood fibre panels; PIR-Polyisocyanurate board.

Lime plaster is considered **hygroscopic** however, it stores less moisture than any insulation. Also, it has a lower porosity and vapour permeability than the insulation (excluding the PIR and aerogel which have vapour barriers) and a low proportion of capillary active nanopores. The thermal paint on the lime plaster lowers vapour permeability delaying drying. The cork-lime and hemp-lime showed greater liquid transfer by capillarity than the lime plaster which is attributed to their organic components. The CSB is exceptionally capillary active however, its low capillarity surface plaster delays drying. The aerogel and PIR show low adsorption and a high water vapour resistance probably due to their vapour control layer. The bulk material in the aerogel and PIR has porosity in the range suitable for capillary transfer although this is inhibited by their hydrophobic nature. The TB has a middle range porosity and abundant small pores. The plaster on the TB is probably reducing its vapour permeability.

3. Conclusion - All the insulators (except for the thermal paint) have low thermal conductivities and a relatively low thermal mass compared to the lime plaster. The aerogel (AG) and PIR board have the best thermal performance with particularly low thermal conductivity and low thermal diffusivity and effusivity, which would contribute towards indoor comfort. The cork lime and hemp lime show slightly greater thermal conductivity and approximately double the thermal mass of the other insulations which is a valuable attribute for attenuating fluctuating external temperatures. The CSB has a higher thermal conductivity than most insulators and does not benefit from the good thermal mass of hemp and cork lime. From the hygroscopic behaviour, it can be concluded that the cork-lime, hemp-lime and CSB are capillary active insulation systems while the PIR and aerogel are vapour tight systems with low vapour permeability and liquid moisture transfer; presenting the highest moisture contents (in particular the PIR board with RH >90%) which raise concern over durability. The use a capillary active/vapour open insulation facilitates drying of the wall moisture and is a more appropriate method to accommodate water when internally insulating solid walls.

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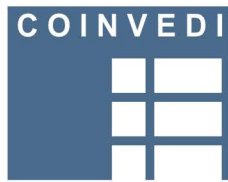


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Escuela Técnica Superior de Edificación
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14th - 16th of December 2015

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THE IMPACT OF SOCIAL CHANGE ON CONSTRUCTION METHODS

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Keywords: Pluralization of lifestyles, construction methods, social change, flexible building space

1. Introduction – In this paper it will be determined which kinds of changing of the society are expected in the upcoming future. It will be discussed if those changings in the society will have an impact of the building industry. the result of the research will be an answer to the question if the construction methods of today can offer the needed building space of tomorrow.

2. Methods – The methodology to reach that purpose is based on the following different methods:

- a) Literature research and analysis of studies about the future trends in the society [1].
- b) Analysis of needs of architectural and construction companies, as well as those of the real estate companies [2].
- c) Analysis of needs of users by using surveils [3].
- d) Collection of requirements of contractors and clients from architectural projects

3. Results and Discussion – Our society is changing faster and faster. The technical development times are constantly growing shorter, whereas the rate of development is increasing exponentially. Hence, the treatment of the environment is also changing. The society responds to these changes by becoming more and more flexible and adapts itself to new situations. Studies [3, 4] show the increasing changing of social behaviour especially in the areas of living and working.

In contrast to this, the construction of living- and working-space is static and the construction industry is conservative [5]. The further development of construction methods and materials is also slow. For centuries, the same materials have been used.

The gap between the requirements to building-space of the society on the one hand and the offered building-space from the building industry and the real estate on the other hand is getting bigger and bigger. The User has to adapt himself to existing room configurations, even if those do not fit to his requirements. Studies from the 'future institute' [1] show that Cities will grow rapidly in the next 25 years (urbanism). Space in cities will get sententious and will become more valuable. People from different cultures will be mixed more and more together (Globalism). The importance of individual living space will grow (Individualism). The department of 'living space research' of the government of Vienne, the capital of Austria, presented a research paper in 2008 about the changing requirements in the living space [4].

The result of those studies is, that a plurality of styles of living and working together in our society is detectable in a faster and faster changing society. Through the increasing plurality of styles and the increasing speed of this pluralisation, the requirements to a real estate or to the space in real estates will change faster and stronger.

In addition to those studies, in a survey [2] with 130 companies from the building industry and the real estate the necessity of adaptable office space is shown. In a survey with residents and inhabitants [3] 'a flexible room structure' is one of the big three wishes from these residents. Residents wish to live in living space, which is flexible and easily adaptable to changing requirements, but today the building industry is not offering such building space

Contractors and Clients of architectural offices [6] ask more and more for solutions to adapt building space easily to changing requirements to avoid reconstruction of building space and get 'life cycle costs' of those smaller.

People avoid building-space which lacks proper function. People avoid space which is under modification or adaptation work In Germany and Austria actually a vacancy of around 10% is already permanent existing [8].

4. Conclusions - The result is a growing vacancy of the existing real estate [3],[4] in the future as it is starting right now. With this vacancy, the costs for adapting the space to the new requirements rise enormously. With todays construction methods it is not possible to offer building space which is ready for the requirements of people in the upcoming future.

A possible solution is the transition of flexible building space! Dynamic rooms, which are easily adaptable, offer a durable sustainability of building space. To make flexible building space possible, the building industry has to change in two categories:

- 1) designer and architects have to rethink their planning tools and planning strategies to offer and to design usable, adaptable space for the future and not to produce predefined rooms.
- 2) The building industry needs flexible systems from the building industry, which are as simple as a non-professional user can treat them. Building space is really flexible if the user has the possibility to change it by himself, suddenly or when ever he want, again and again and again.

Easily adaptable in this case means: Systems which are sustainable, re-useable and usable by the society without work- and time-expensive professionals. To get those systems running, accepted and used by the user, they have to offer a good usability for a non-professional person. Building space flexibility in this case does not mean to use a light wall system such as a gips wall system. It means a building space dividing system including simple adaptable electricity, heating and plumbing system, so that building space is easily dividable by almost everyone. Just if this is a standard in buildings, building space will become truly flexible.

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COINVEDI

III INTERNATIONAL CONGRESS ON CONSTRUCTION AND BUILDING RESEARCH (COINVEDI)



**HERITAGE, REHABILITATION
AND MAINTENANCE**

HERITAGE, REHABILITATION AND MAINTENANCE

THE THERMAL UPGRADING OF 'HARD-TO-TREAT' HISTORIC BUILDINGS: EDINBURGH'S NEW TOWN

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Keywords: *energy efficiency, conservation, refurbishment, historic buildings*

1. Introduction

The 2013 Scottish House Condition Survey shows that an estimated 940,000 (39.1%) of Scottish households are classified as 'fuel poor' (i.e. those households that spend more than 10% of their household income on fuel to maintain a satisfactory heating regime) [1].

This paper documents an innovative project partnership between Historic Scotland, the Institute for Sustainable Construction at Edinburgh Napier University and Castle Rock Edinvar Housing Association in which 5 traditional (circa 1800's, solid wall 'hard-to-treat') residential tenement properties located within Edinburgh's historic New Town (Category B listed) each received energy-efficient upgrades to walls and windows.

A variety of measures were tested, achieving significant reductions in fabric heat loss without impacting upon the character and appearance of the building. All of the properties evaluated in this paper are occupied by tenants who fall under the 'fuel poor' or 'extreme fuel poor' categories. The occupants all remained in-situ during the refurbishment activities.

2. Methods

The five tenement properties featured in this paper are all good examples of typical pre-1919 construction. Externally, the properties are of traditional sandstone construction (solid wall) typically 400 to 600 mm thick (ashlar to the front elevations, rubble to the rear) and natural slate roof coverings. Internally, the properties featured timber floors, timber sash and case windows, timber doors and mainly lath-and-plaster internal linings.

The U-value, or thermal transmittance, of a building element or component is defined in BS EN ISO 7345:1996 as the "heat-flow rate in the steady state divided by the area and the temperature difference between the surroundings on each side of a system." (BSI, 1996, p.5) [2]. The methodology for measuring the in situ U-value was undertaken in the well-established format, as described by Baker (2008) [3]. The interventions tested during the study are shown in Table 1.

Building Element	Intervention
Walls	• Rigid phenolic insulation board (rigid insulation) • Expanded polystyrene bead insulation with bonding agent (blown insulation)
Windows	• Timber single glazed secondary unit • Timber double glazed secondary unit • Aluminium double glazed secondary unit

Table 1.

The interventions were specifically selected by Historic Scotland because they were deemed to be physically compatible with the existing building fabric (e.g. by not adversely affecting the existing building physics), and also enabled the retention of the existing fabric (e.g. lime plaster on lath finishes).

The in-situ U-values were measured using thermopile-based heat flux transducers (Hukseflux HFP01) of 80 mm diameter and 5 mm thickness, providing a typical accuracy of $\pm 10\%$. In addition, K-type thermocouples were used to record temperatures, connected to Grant Squirrel data loggers with 24 bit A-D conversion resolution. As a precautionary action, additional temperature and humidity Tiny Tag loggers of a typical accuracy of $\pm 0.3^\circ\text{C}$ were used to measure internal and external conditions.

3. Results

Figure 1 considers each of the five interventions tested by the (average) U-value reduction (%). As can be seen, the most effective intervention was found to be the timber double glazed secondary unit, which provided an 88% U-value reduction. The least effective solution was the blown insulation (expanded polystyrene bead insulation with bonding agent), which still provided a 40% U-value reduction.

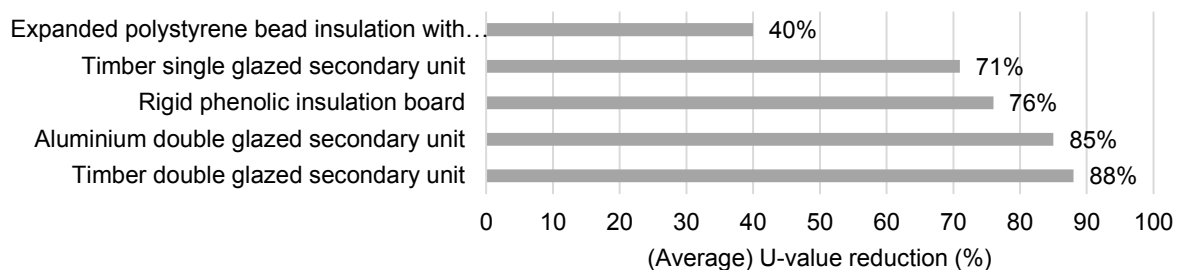


Figure 1. Average U-value saving for each intervention.

4. Conclusions

This study involved trialling a number of interventions with the aim of improving the thermal performance of the building envelope (and thus energy efficiency) in pre-1919, Category B listed, traditionally-constructed tenement flats in Edinburgh's New Town. In testing five different interventions, the results demonstrated a reduction in the U-value of between 40% - 88% on the elements (walls and windows) tested during the study. The results are significant as each of the interventions was approved by Historic Scotland, in reference to the stringent criteria that is placed on alterations to Listed buildings in Scotland.

This paper has provided further evidence of effective solutions that can help reduce energy consumption in the home. The wide-scale implementation of such measures – a so-called mass-retrofit – would not only help Scotland meet its carbon emission targets but would also help many households to escape the adversity and indignity of fuel poverty.

The project won the award for best refurbishment project at the Carbon Trust's Low Carbon Building Awards in 2012.

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A STUDY ON THE PATHOLOGIES OF FOUNDATIONS ELEMENTS IN ANDALUSIA

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Keywords: *Andalucía; Foundation; Building; Pathology*

1. Introduction

The adequate knowledge of the building pathologies is one of the key aspects that help to understand the performance of the building elements, the intrinsic and extrinsic factors affecting them as well as the errors that can be potentially committed in their execution, both at the project or implementation stages. Andalusia in one of the largest regions in Europe and, to the best of our knowledge, no specific study dealing with the most common pathologies related to the various elements that constitute the foundation of the buildings was available to the date. Only a precedent analyzing structural pathologies nationwide has been found in the Ph.D. Thesis of Vieitez-Chamosa [1]. This research aims at gathering the results obtained through the expert reports of incidents occurred in recent years, obtaining and classifying them to draw useful conclusions that may be of interest for the directors of execution of the work [2]. In this connection, it must be born in one's mind that, according to Professor Lasheras [3], it can be stated that a defect is a lack of quality in origin.

2. Methods

According to Zanni [4] the diagnosis is the most important step in any rehabilitation or conservation work, especially now that the new constructions should not be the main focus of the building sector. In accordance with this criterion, in order to proceed to determine the causes that make it necessary to repair or preserve our housing stock, the pathological causes that lead to pathologies must be known.

To weigh this situation up, the Musaat Foundation promotes this research that has benefited from a documentary source never before used. Court rulings with a judgment, based on the claims registered in 2008, 2009 and 2010 were studied. All these performances were insured in terms of its civil responsibility for the Mutual of quantity surveyors and technical architects of Spain [5] [6] [7]. The total of available data (100% of claims) [8] corresponding to the building facilities under study were analyzed and classified within the following building types:

Building typology	Nr. of pathologies	% of pathologies
Detached house	22	33%
Housing block	20	30%
Semi-detached and terraced houses	11	16%
Rehabilitation Housing block	3	4%
Detached, semi-detached or terraced house rehabilitation	2	3%
Other (residential and industrial)	9	13%
TOTAL	67	100%

Table 1: Pathologies according to building typology.

3. Results and Discussion

Once the referred expert reports of incidents and the court rulings with judgement were analyzed, the results obtained are shown in Tables 2 and 3 and in Figure 1.

Foundation element	Nr. Patholg.	% Patholg
Walls	36	54%
Slabs	20	30%
Footings	8	12%
Piles	1	1%
Slab on grade	2	3%
TOTAL	67	100%

Table 2: Pathologies according to the foundation element.

Symptom or damages	Nr. Patholg.	% Patholg
Infiltration humidity	42	63%
Fissures of the element	14	21%
Fissures in walls or flooring	10	15%
Slipping	1	1%
Other damages	0	0%
TOTAL	67	100%

Table 3: Pathologies according to symptoms or damages.

Among the five different types of foundation elements that make up the study, the first of them has a remarkable presence; and, more interestingly, the most common damage has a direct involvement with this element, which gives it a very strong impact on the results.

List of causes under study

A – Poor or Lack of waterproofing
B – Lack of tight joints
C – Lack of drain / Poor drain
D – Differential settlements
E – Water table fluctuation
F – Lack of construction joints
G – Poor steel reinforcement

H – Expansive clay / expansive soils
I – Inappropriate constructive solution
J – Land conditions / characteristics of the terrain
K – Lack of vibration / Poor Vibration
L – Poor compaction
M – Hillside foundation
N – Insufficient undergrounding of the sanitation network
O – Undermining and dragging of fine silt

Figure 1: Direct and indirect causes of the pathologies

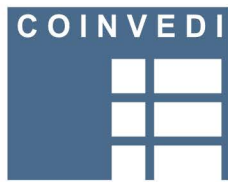
4. Conclusions

From the results of this study the following conclusions may be drawn:

- The most frequently affected (84%) building elements are walls (54%) and slabs (30%).
- The most usual pathology is not related with the lack of mechanical resistance or with the characteristics of the terrain, but with infiltration moisture.
- There is a significant relationship between the elements exhibiting the largest number of pathologies and the most redundant damages.
- In accordance with all the above exposed, causes A, B and C in Figure 1 are also the most frequently found with 48% (25%+13%+10%) of the total.

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EDUARDO TORROJA 1949/ INTERNATIONAL COMPETITION ON INDUSTRIALISE HOUSING IN POST-WORLD WAR II

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Keywords: industrialise, housing, *patents*, *Eduardo Torroja*

1. Introduction – The huge housing demand existing in Spain in 1949 could not be met by traditional construction systems. The severe social problem thus generated was not exclusive to Spain: the countries that had participated in World War II were facing the same challenge, i.e., the need to build large numbers of housing units in record time. Industrialised systems consequently underwent intense development, generating a wide range of alternatives specific to the material and industrial resources and policies in place in each country.

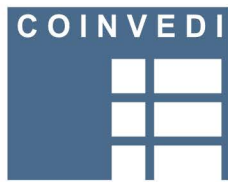
In that year, Eduardo Torroja, director of the institute that now bears his name, organised an unprecedented international competition around industrialised housing. A total of 89 designs were submitted by authors from 17 countries. The aim was to establish industrialised housing systems specifically intended for Spain. That competition, today a nearly forgotten chapter in the history of housing industrialisation, is one of the three most significant milestones in Eduardo Torroja's strategy to drive progress in housing construction.

2. Methods – The research study has been made as I + D National Project. It was possible to do it because the data of this International Competition were founded at the Eduardo Torroja's Institute. [1]

3. Results and Discussion – Due to the enormous international impact of the competition, the Institute for Construction and Cement Engineering, headed by Eduardo Torroja, was obliged to push the deadline for proposals back by nearly a full year, whereby the jury's decision was not forthcoming until 1952. A total of 89 papers were submitted, including 27 by Germany; 18 by Spain; 7 by France; 6 by Switzerland; 5 by Italy; 4 by Belgium; 4 by United States, 3 by Austria; 3 by Netherlands; 3 by Japan; and one each by Ireland, Argentina, Sweden, India, Finland, Morocco and what was then the Belgian Congo (ITCC, 1949). This wide range of international proposals included a diversity of approaches, which not only mirrored the status of housing industrialisation outside Spain, but also the specific standardised elements in place in the industry, as well as the ancillary resources and modern machinery available in the most highly evolved international markets. Eduardo Torroja's challenge did not go unanswered. He had called upon the world to reflect on Spain's specific housing problem.

Most of the proposed solutions, put forward by construction companies and international organisations. Some were attempts to adapt their patents and systems to Spain, others entailed new designs, and yet others were industrialised construction systems that had been successfully implemented elsewhere.

Only a small number of proposals were submitted by individual architects or groups of architects due to the heavy emphasis on industrialisation laid down in the rules, which called for solutions involving a many-faceted and interdisciplinary perspective: architecture, housing and industrialisation, in which the third factor was decisive and indispensable. The aim was to provide new architecture with a suitable "kit of parts", without which it would be unable to



provide a rational solution to the severe social problem that had arisen. Architecture needed to be industrialised and housing construction became the most important component of that machinery.

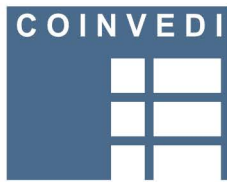
4. Conclusions – As expected, in light of the extremely demanding requirements established, none of the 89 proposals submitted to the International Housing Competition on industrial design singly furnished an industrialisation scheme that could be implemented economically in Spain, given the material, economic, industrial and human resources available in the country at the time. For that reason, the jury decided not to award the 100 000-peseta first prize, which, according to the rules, was to be granted to the *best project for industrialising housing construction and building 50 000 units yearly*.

Nonetheless, in recognition of the quality of many of the submissions, the obvious significance of the reflections taken as a whole and the effort deployed by the 17 participating countries to respond to Torroja's request for international support, the jury also decided to divide the 100 000-peseta prize among five projects: two, for 35 000 pesetas each, were awarded to Jules Cauvet (France) and Jesús Carrasco-Muñoz (Spain), and the other three, worth 10 000 pesetas each, to Arbeitsgemeinschaft Hebel (Germany), Bremen Wirtschaft Wiederaufbau-gesellschaft M.B.H. (Germany) and Société française de Constructions et Travaux (France) (Jury Report, signed on 29 December 1952). As the jury's report explained, these five submissions proposed the industrialised systems best suited to the conditions prevailing in Spain.

The 89 proposals submitted contained descriptions of a total of over 200 patents (IETcc 1949). That valuable information was to serve Torroja to chart the course toward Spanish industrialisation, based on decisions on what and how to manufacture in Spain, which international patents were to be preferably given access to the national construction market, and which were to be acquired for domestic production. He was able to make those decisions on research and scientific and technical priorities drawing from the authority of his position as Director of the institute and the Central Laboratory, and from the financial support he garnered outside Spain.

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SPECIAL FOUNDATION FOR A MODULAR EDUCATIONAL BUILDING NEXT TO THE ARAB WALL OF GUADALAJARA

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Keywords: *Special Foundation; Reinforced Injection (max. 4 keywords)*

1. The building – The necessity to provide new degrees in “Modern Languages” and “Translation and Audio-visual Communication” at the University of Alcala from course 2011-2012, in the facilities of the Faculty of Education of Guadalajara, made necessary the construction of a new provisional building, awaiting the construction of the new campus of the UAH in Guadalajara.

The new building, made with prefabricated modular construction elements, occupies a parcel of 83 meters in length by 18 of wide, and has 2,800 m² in 4 levels [1], being the highest building of this typology built in Europe.

2. The place - It is located next to historical area of Guadalajara city, in proximity to the Arab wall of the city, next to the Door of Madrid, in the channel of one of the streams that limit the historical city. In this zone, throughout history, singular spaces have been located as the Military Engineering Academy, being part of their maneuver zone [2].

In this parcel there was a construction antecedent by the University in 2001, for gymnasium and classrooms, but they never were built.

3. Geotechnical constraints - The parcel occupies a very conflictive geotechnical land, on an old alluvial channel, used historically like garbage dump, having been filled up at different times. By the channel, a large diameter collector runs presenting breakages in the zone of the parcel. This circumstance produces that the resistant capacity is null, in a variable depth stratification.

The foundation must be deep, until reaching a stable level, able to endure a high and variable phreatic level, in a very aggressive soil. The cost considered in 2001, for a foundation with CPI-4 piles with depths between 11 and 18 meters, reached the amount of 166,000 € (equivalent to 220,000 € in 2011).

The new construction to make implied new added conditions to the considered ones in 2001, among which we can specify the necessity of a cost reduction, a reduction in the implementation times, to solve the existing geotechnical problematic, and to guarantee a level of settlements practically null. These new conditions force to a new approach of the conventional solutions.

4. The alternative solution - It's necessary to consider arranging a linear superficial foundation supported on relatively distant points, following the concept of “bridge”. This is equivalent to insert a “deck” as intermediate element with the building, and to arrange “piles”

of sufficient size that allow not to make solid all the land. The non deformation condition does force to a great rigidity in the deck.

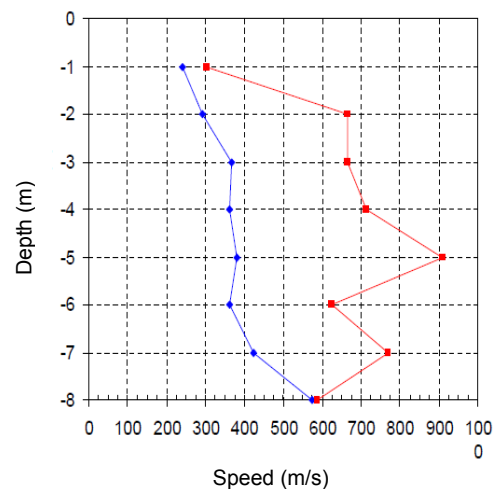
Piles generation is obtained by means of the treatment of the land with reinforced injections [3]. The “bridge deck” generation is obtained with reinforced concrete large-edged beams.

The solution was executed with a cost of 49,973 €, and in a term of 5 weeks, fulfilling therefore the reduction requirement established.

5. - The verification of the effectiveness of the treatment

Once land treatment was made, previously to the execution of the board, a series of seismic tests, cross hole [4], were performed to verify the treatment efficiency. The result was very satisfactory when obtaining a final speed (red line in the associated graph) twice the initial (blue line in the graph). The depth of the fillings in this zone is 5 m; the depth of treated zone in this point was 7 m.

Also from the end of the execution of the building, in September 2011, to the present time it has been making movement controls of the reinforcement vertical structure of the building (with very high sensitivity to differential horizontal and vertical movements), not recording any movement in the laying of foundations.



Both data ratify the adequacy of the chosen and executed solution.

6. Conclusions - In geotechnical processes there are great variety of circumstances that force us to pay attention on applying general solutions, being feasible the analysis and study of alternatives. In the studied case it is combined the application of a different concept from the conventional one (similar but different), and the use of a land treatment technique such as the reinforced injections.

In the process followed besides to verify the viability of the proposal, it has been possible to prove its effectiveness and economy, being therefore an applicability future option and extrapolated to other situations of foundations in conflictive soils, thanks to the great versatility of the applied technique.

For its application in the building sector it is essential an interdisciplinary vision, and it is necessary not only to investigate on real applications and possibilities, but also to show the results to the scientific and professional community.

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BUILDING INFORMATION MODELING (BIM) FOR EXISTING BUILDINGS

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Keywords: *BIM; Existing Buildings; Requalification project; Interoperability*

1. Introduction – Subject of the paper is an assessment of the potential of BIM in a sustainable requalification project [1][2][3][4][5][6][7][8][9][10]. The acronym BIM denotes a numerical approach for computational modeling of an integrated design process. It is thought to manage the design process, from the initial design steps to the operating-life simulations, using the various elements of multi-level design, standardized processes and shared methodologies [11][12][13][14][15][16][17][18]. The benefits of working in this way can include fewer delays, fewer disputes and better project risks management [19][20][21].

Looking at the recent international policies about the digital improvement of processes (such as the Digital Agenda introduced by EU in 2010), for a smart, sustainable and inclusive growth, the aim of the research is to explore the way for an efficient digitalization of the processes of sustainable requalification projects.

2. Methods – This study, looking at the so-called Smart Cities, will consider a large-scale residential district where, greater complexity and more impulses could represent and simplify the case of the City Information Modeling. For this reason and in order to test the actual functionality of BIM methodology in a requalification project, as study case will be considered residential buildings located in Genoa, Italy. This complex of social housing, already under the study of the “R2Cities” European project whose aim is to develop and demonstrate a replicable and innovative requalification methodology, covers an area of about 51,000 square meters and it is made of twelve buildings hosting 674 dwellings. Parametric analysis will be performed on them to, firstly study the state of fact of buildings and then, to compared the effects of different possible requalification projects. Those type of analysis will be realised exploiting BIM systems, managing multiple parametric elaborations on a single information-model. All the performed analysis will be compared with standard procedures in order to quantify the accuracy of BIM tools.

This research will proceed by: BIM-modeling (figure 1) of the state of fact of two representative buildings, BIM-analysing of their performances mainly regarding the energy behaviour, validating and calibrating the simulations (figure 2) using case-tailored methodology and regression analysis, comparing design alternatives and choosing the right intervention.

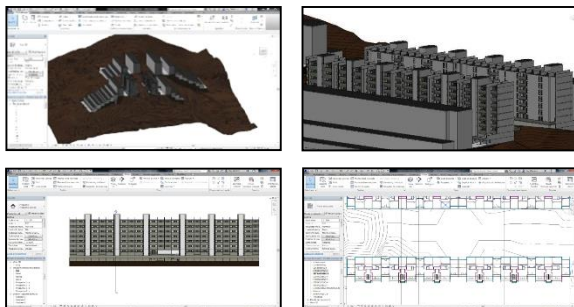


Figure 1 BIM-Modelling Phase

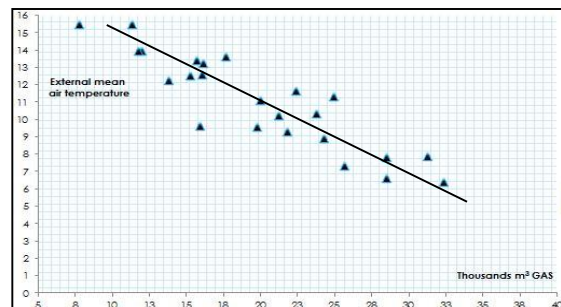


Figure2 Validating Phase

3. Results and Discussion – During the study of this case, will be observed that the use of BIM could effectively led to significant benefits in terms of execution-times and project control. In addition, however, in some cases the time-request for a BIM digital elaboration could be considerably higher than the one of a traditional process, introducing the research of a minimum threshold of intervention below which it is not convenient to use this kind of approach. This research work aims to create a BIM-experience, as complete and operative as possible, whose results about BIM methodology applications, organized in form of positive/negative contributions balances, weak points identification and strategic proposals for improvements, could be used as helpful contribute to the proper introduction of these new design approaches.

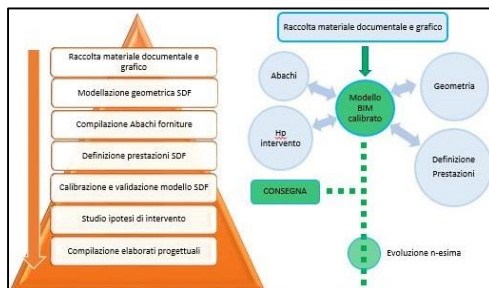


Figure 3 BIM methodology process

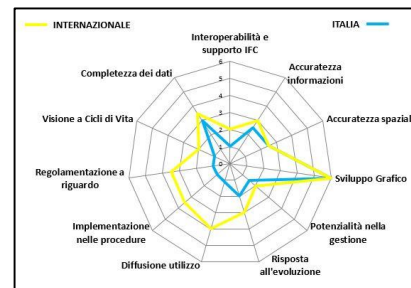


Figure 4 BIM Spider Graph

4. Conclusions - This work will highlight the benefits achievable using BIM-methodology in redevelopment projects, showing useful balances between positive contributions and unexpected shortcomings. Possible future developments of this study could find and illustrate further aspects of these systems that, even if adverse, will be useful to encourage the comprehension and diffusion of BIM.

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PROJECT AND RISK MANAGEMENT OF THE RESTORATION OF THE CHURCH OF SAN MARTIN OBISPO, CALLOSA DEL SEGURA, ALICANTE.

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Keywords: *Project Management; Stakeholders; Architectural Restoration; Risk Management*

1. Introduction – Respecting and promoting the conservation of built heritage is a goal long sought by society and government agencies. This would have been regulating the rights and obligations of property owners with a certain historical and architectural value, although the result was not desired at times due to multiple factors. Law 5/2007, of February 9 Cultural Heritage Valenciano is the most updated legal framework, public and private aimed at preservation, dissemination, promotion and enhancement of cultural heritage in the area of Valencia action. However, financial aid may be insufficient to crave all existing heritage.



Figure 1 Aerial view

Internationally, since the first half of the twentieth century have been establishing various treaties on the conservation, consolidation and restoration of architectural heritage, stressing the importance of the involvement of multidisciplinary teams to ensure effective interventions in architectural heritage. For this, we apply similar techniques to those used in other disciplines such as medicine, where properly protocolize phases of the intervention in a patient. A previous and accurate diagnosis, where any doubt about what is happening to the property is therefore required to dissipate. Thus we avoid oversized therapies to achieve an optimum balance between cost and results and produce minimal impact on architectural heritage using funds available in a rational way, or that could



Figure 2 External view

cause other damage nonexistent before the performance, and that for not properly diagnosed or erroneous conservative techniques are employed. The Administration proposes strategic plans for economic investment in rehabilitation, but does not establish the characteristics rigorously enforced by the agents, opening the door to the participation of unqualified agents. The Archpriest Church of San Martín Obispo, is a Renaissance religious temple was built in the sixteenth century, while it is over an ancient Muslim mosque in the thirteenth century, declared a National Historic Artistic Monument by Royal Decree 2865/1980 of 14 November. Pending obtain financial resources from the Administration undertake the necessary work permit restoration of the temple, the priest raises undertake the work with its own resources, a fact which requires further optimize the way in which these resources are invested. It is then that process optimization is proposed by applying management techniques to ensure the achievement of the final goal, at the lowest possible cost and minimizing those major risks that may arise during the development process [1], [2].

2. Methods – The method used involved the selective removal of part of the American project management methodology [3] based on the PMBOK adapted to the specific needs and requirements in a performance in the built heritage, particularly in the Church of San Martín Bishop of Callosa de Segura, Alicante. Previously to issue a diagnosis, proper management of



Figure 3 External view

stakeholders [4], [5], considered key in terms of the strategic contribution to the process [6], [7], after it arises to analyze the risks and able to respond to them before they occur [8], [9], if necessary relying on survey techniques and trials to strategically focus the development of the performance. Management all initially identified risks will determine the strategic planning of the action [10]. Once the risks focused, orderly phases will those initially established [11], but for the future development of the performance iteration method will continue as new variables will appear [12].

The processes applied to the property under consideration, which have yielded the results that arise in this work have been:

- Planning Risk
- Risk Identification
- Qualitative Risk Analysis
- Quantitative Risk Analysis
- Planning Risk Response
- Risk Control

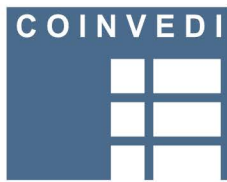
3. Results and Discussion – By applying management processes has been achieved to move from an initially planned 430,000€ investment to another just 20,000€, guaranteeing this new proposal the intended restoration, without inncesarios overruns, showing that in many cases it is proposed to act on the built heritage regardless strategic approaches to optimize the investments initially intended.

TRADITIONAL METHOD		PROPOSED METHOD		
Estimated Cost	Respect Existing Heritage	Estimated Cost	Respect Existing Heritage	Cost Reduction
430.000 €	NO	20.000 €	YES	95%

4. Conclusion – The result has been an initial savings of 95 % of the planned investment. It requires the application of modern methods to optimize financial resources and quality performances in the built heritage, compared to classical methods in our country.

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STRATEGIES TO DRIVE THE GENERALIZATION OF HOUSING STATES RENOVATION BASED ON THE GENERATION OF ENERGY SURPLUSES

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Keywords: *Sustainable refurbishment; Energy surpluses; Integrated Urban Regeneration*

1. Introduction – The Toledo Declaration in 2010 consolidated the concept of Integrated Urban Regeneration (IUR) as a strategic instrument for future urban development in Europe capable of solving problems of energy, social, and economic nature of its cities, such as high energy consumption, degradation of urban areas, unemployment, energy poverty, elderly dependency, and social exclusion. The concept of IUR approaches dwelling retrofitting at ensemble or district levels and takes into consideration not only urban and architectural issues, but also social, cultural, environmental and economic. This way, intervention is not only intended on dwellings, but also on common parts of buildings and their external spaces, allowing the upgrade and improvement of the whole housing state.

One of the main barriers for the generalization of IUR is economic. Consequently, numerous proposals are being developed all over Europe aiming at overcoming this problem. In this line of research, projects such as Symbcity for the Solar Decathlon Europe 2014, the residential building *Rudolf Zeller Gasse* in Vienna, or the Advanced Housing Renovation in Kierling [1], propose to increase the number of floors of existing buildings to generate economic returns with which to fund the intervention. All these proposals are developed at the building level. Due to the property system in other European countries it is easier to intervene on social residential buildings because they more often belong to a single owner having a higher freedom to take own decisions, whereas in Spain most social houses are owned by multiple neighbors with differing priorities, due to different dwelling conservation states and affordability levels, that have to reach consensus before embarking upon the building renovation. Multiple ownership represents an important barrier in Spain for the generalization of IUR.

Within this context the proposal developed in this paper is born, whose aim is converting the residential housing states to be renovated into entities capable of generating a product that can be sold to an investor, and thus pay for building and urban renovation without significant additional costs for homeowners. The product to be sold is the energy surplus from hybrid solar panels (that generate solar thermal and photovoltaic energy) to install on the roofs. This surplus will be used to charge plug-in electric and hybrid vehicles in a station to be implemented inside the housing state. These vehicles could be the city's taxi fleet since its cooperative is nowadays implementing sustainability improvements.

2. Methods – In the first place, a housing state in Zaragoza, named *Balsas de Ebro Viejo*, was selected because it fulfilled conditions to make favorable the potential development of this experimental project. These conditions include the need of urgent renovation and the existence of a neighborhood association capable of participating in the project process management. *Balsas de Ebro Viejo* is a house state with 1.260 dwellings situated North of Zaragoza. It was built between 1964 and 1975 and developed by *Obra Sindical del Hogar y de Arquitectura* under the program *Plan Sindical de la Vivienda*. In this period, characterized by high housing deficit in Spain, housing states were built at high speed, and at the present time they present numerous construction pathologies.

In the second place, a study at district scale was performed with the objective of characterizing and determining its vulnerabilities regarding urban characteristics, construction, and building services.

Next, buildings energy behavior was simulated. Buildings were classified in two categories: towers and blocks. The energy demands for heating, cooling and domestic hot water (DHW) were estimated for the two building types. Once these demands were defined, a hypothesis for the distribution on roofs of hybrid solar panels was made with the objective to study the percentage of electricity, heating and DHW that could be covered. As expected, it was checked that the totality of the thermal demand could be covered as well as the part of the electricity demand concerned with elevators and buildings' common parts, and still an important surplus of electricity energy is left, that can be stored and used to fund the integrated urban renovation. In this study, the energy surplus is considered to be sold in a station for plug-in electric and hybrid vehicles. The manager of such a station can be a public and/or private entity. In the case of the study it is the city's taxi fleet cooperative.

3. Results and Discussion – Following the methodology previously described, the energy surplus after covering the thermal demand of dwellings and the electricity demand of buildings' common areas and elevators, which can be sold for fund generation, is up to 315.465 electricity kilowatt-hours, around 250 kW·h per dwelling.

With a market price of 0,15 € per electricity kilowatt-hour and of 0,068 € per thermal kilowatt-hour, the savings are up to 50.261 € per year due to self-supply in elevators and electricity in buildings' common areas, plus 198.138 € per year due to self-supply in energy demand (DHW and heating) of dwellings, plus 47.320 € per year from the sale of the energy surplus. The latter figure can be increased up to 52.052 € since an interest of 10% can be applied for the transfer of urban areas for the station.

By adding all these figures up, an annual income of 300.450 € is obtained, representing around 238 € per dwelling, which can be used to fund the housing state renovation. If during the first years neighbors continue paying an equivalent amount to the current energy, they will not need to pay further renovation costs. Once the renovation is fully paid, they will experiment a reduction of their bills, since they will only have to pay for the part not being covered by the self-supply.

4. Conclusions – Current economic situation requires the development of strategies for IUR from an interdisciplinary perspective, which allows to bring together current knowledge on different fields, such as architecture, economy, engineering and urban planning. These strategies have the potential of becoming not only in catalysts for the improvement of the residential stock in Spain but also in the driving force to foster the battered construction sector.

Energy surplus-related strategies still need further definition regarding energy storage and management, processes of support and social guidance for neighbors, etc. but above all they will require great political will and involvement that contribute to find feasible solutions towards the development of sustainable cities.

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STUDY ABOUT HIGROTHERMAL PARAMETERS IN THE REHABILITATION OF CAVE-DWELLINGS

Jiménez López, Luis, Moreno Soriano, Susana and Acha Román, Consolación Ana

Keywords: *Rehabilitation, cave house, sustainable, cave-dwellings*

1. Introduction – There are about 25.000 cave dwellings between the provinces of Almeria and Granada, lot of them to rehabilitate according to studies of local government, taking part in *traditional architecture* [1] in this area. Those constructions, some which are millenary, are being a guide for new projects and architectonic models as a consequence of climate change and energetic crisis of those years.

But, are they really bioclimatic buildings? Is it worthy to rehabilitate?.



Image 1

The excavated or troglodyte architecture is a kind of architecture which has passed to considerate *cave-dwellings* [2] *from sub-standard housing to housing of the future (image nº1)*, as M^a Eugenia Urdinales Viedma of the University of Granada defines in her article. This type of buildings uses, partly, natural resources of surroundings of the chosen place to build as it is just consolidated ground. It takes advantage of its thermal inertia to obtain indoor thermal comfort. According to owners, they do not need fountains and energetic systems to maintain it.

However, appropriated programmes of simulate do not exist to able to demonstrate its condition of bioclimatic dwellings, the use of equipment to monitor and the obtainment of suitable parameters, specially of moisture and temperature, are being necessary to demonstrate the thermal comfort as current housings. In this way, the rehabilitation of them is a starting point.

2. Methods – To consider a cave house a bioclimatic and sustainable house [3], the following study is elaborating:

- A cave in the village of Cuevas del Almanzora has been chosen which is rehabilitated and used as current residence.
- Later and for a time, an in-depth analysis of moisture conditions and inside temperature in different rooms and deeps (3) and outside (1) is been realized. It is to know if the environment conditions and thermal comfort are been carried out, by the climograph of Givoni (image 2). For this, equipments of continuous every 30 seconds of relative moisture and dry temperature are been used.

3. Results and Discussion – With the obtained dates in some months of study (part of winter, spring and summer) of higrothermal measurement (image nº 3) in different dependences, they have been compared with current regulation, and with different methods of bioclimatic designer. The study sets that all rooms compared with the established in the current regulation, and it has seen with different methods of bioclimatic design that the parameters of thermal comfort accomplish in the majority of the dependencies except in some cases in which the moisture is excessive for lack of a regulation of the automatic or controlled ventilation.

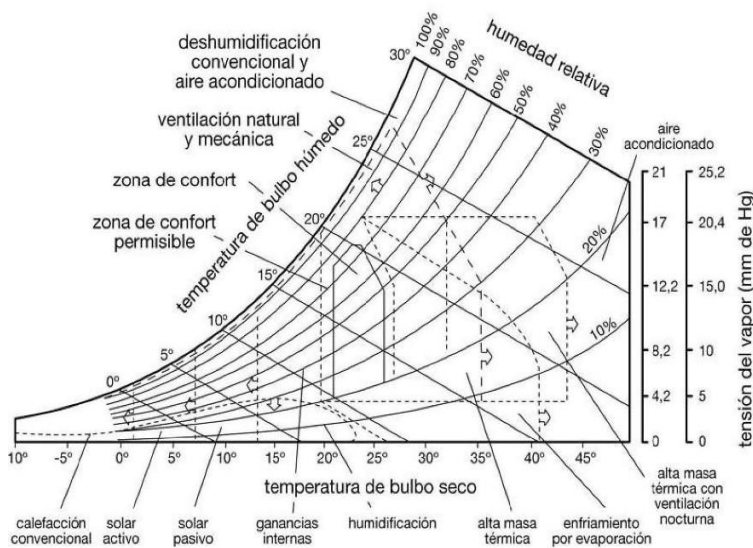


Image 2

Also it has seen the same dry temperature does not support during the whole year but it remains it constantly, changing between 20 and 25 °C, except in the kitchen, which apart of its use such as, coincides with one of the entrances to the cave-dwelling where the data of temperature changes and overcomes 25°C. In order not to be excessive, a mechanical regulation of the ventilation is being also necessary with the average moisture.

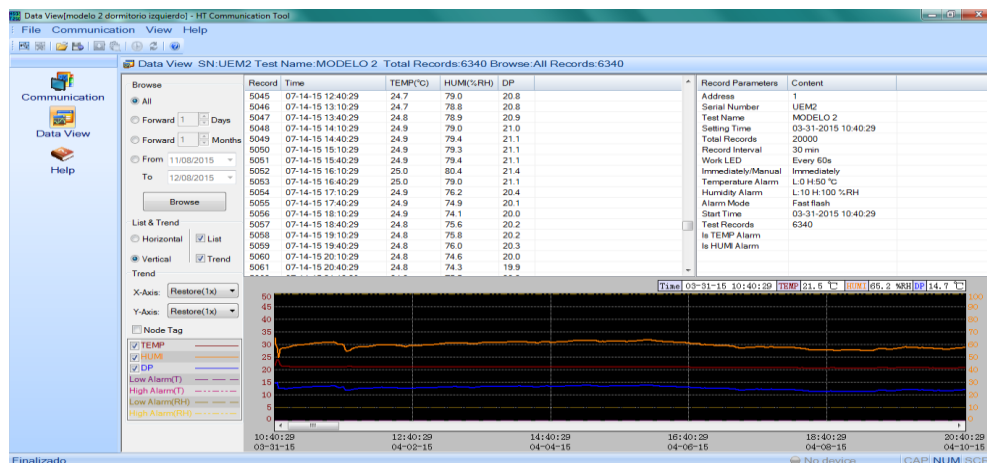
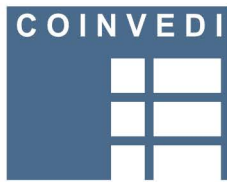


Image 3

4. Conclusions – The monitoring higrothermal of this cave dwelling is going to serve as base to analyze the necessary strategies in order for the recovery and the rehabilitation of cave-dwellings of the area are viable, in addition for the study of piece of new typologies of *bioclimatic housings* [4]. The data demonstrates the unnecessary use of equipments of air conditioning and its thermal inertia makes dry interior temperature supporting very uniform, being inside the edges of the thermal comfort, although a study of the ventilation is going to be necessary to complement, considering that relative moisture has been detected. Also it has seen they do not support the same temperature during the year but that they do inside the edges of thermal comfort.

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CONSERVATION OF THE CERRALBO MUSEUM GARDEN PAVILLION; STUDY AND CHARACTERISATION OF MATERIALS FROM DECORATED CORBELS

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Keywords: *Conservation; protective paintings, materials characterization*

1. Introduction – The Cerralbo Museum, built in 1893 and located in the District of Argüelles in Madrid, features a beautiful garden with a pond surrounded by numerous statues. Designed in a romantic landscape style despite its reduced dimension, the Palace that currently hosts the Museum was built by **D. Enrique de Aguilera y Gamboa (1845-1922)**, the 17th Marquis of Cerralbo. The Marquis collected art and antique pieces that he gathered throughout all his life, that are now exhibited in the museum.



Fotografía del templo de los años 1920-1930



Fotografía del templo actual 2012

In one of the corners of the garden, a small auxiliary Pavilion called "*El Temple*" was built. Its valuable ornamentation was part of the varied collection of the Marquis; his interest in antiquities drove him to rescue some architectural elements from ruins.

The capitals, decorated corbels, columns and column bases (both the balcony ones and those on the way from the garden), as well as busts, coat of arms and other ornamental elements, are considered antique elements of "*El Temple*". They all have gone through several renovations (figure1), and in fact, these days there are works being carried out to consolidate the structure and restore the pavilion (Figure 1).

Figure 1 Cerralbo Museum in 1920 (above) and in 2012 (below)

The structure of "*El Temple*" consists of a system of perimeter load bearing walls on the ground floor, where the structural roof rests. Six columns were built on these walls, which sustain the roof slab that is crowned by a balustrade supported on a decorated frieze and a cornice. Below this cornice, there are several carved wooden baroque decorated corbels (probably re-used from a XVII century building), in the eclectic style of those times.

The conservation project, carried out by BAB Architects, prescribed certain building recommendations that would stop the damage process, that were preceded by a preliminary study to analyse and diagnose the damages. The recommendations will help to guarantee the elements' preservation.

Different elements (decorated corbel, balusters, bricks, etc.) have been characterised and identified in order to make the necessary decisions, since there were no previous documents that identified the original materials that compose the mentioned elements. This paper shows the analysis carried out of the decorated corbel and, in particular, of the protective and decorative recovery paints originally applied to those ornamental elements. This information will contribute to the decisions that will be required related to future restorative activities such as cleaning, prosthesis, volume reintegration, protective treatments, etc.

2. Materials and methods – Figure 2 shows the damage in the decorated corbel, with a considerable amount of volume loss due to fungi attack. The inner part of the engaged corbel inside the wall is rotten.



Figure 2: Decorated corbel below the cornice and in the receiving state

Samples were collected from different areas of the decorated corbel and prepared for its observation under microscope (figure 3). The following are the analysis techniques that have been applied: X-Ray Fluorescence testing (FRX), Ray-X diffraction (DRX) and Scanning Electronic Microscopy (SEM).



Figure 3: Wood samples and specimen preparation for its microscopy observation.

3. Results and Discussion – From microscopic observation, we can conclude the existence of two treatment layers with different coatings, depending on the area. In addition, we observe that the microstructure matches with conifer wood and shows resin channels. The FRX results identified the chemical components of the two mentioned layers. We would like to highlight the presence of Pb in the inner layer.

4. Conclusions – We can conclude that the protective paint on the wooden decorated corbel has been made of two different layers. The analysis carried out shows that there is a first coat from “*albayalde*” or white lead. This is a basic lead carbonate which, when mixed with linseed oil came out as a very consistent, highly covering, resistant to atmospheric agents painting, while being flexible and easily applicable. Chemically, it is a white solid with formula $(\text{PbCO}_3)_2 \cdot \text{Pb}(\text{OH})_2$. Over time, and being in contact with some atmospheric pollutants (hydrogen sulphur), it transforms into a darker lead sulphur. The second layer is an oil painting with vegetable oils as thickener, probably linseed oil, and turpentine oil as paint thinner. The pigments based on iron oxides coloured it and increased its light and weather resistance.

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A CASE STUDY OF THE STRUCTURAL REHABILITATION OF HOUSING UNITS COMPLYING WITH TEN-YEAR INSURANCE POLICIES

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Keywords: *Rehabilitation, Construction techniques, Wood treatments*

1. Introduction – The building subject of this study, presented a supporting structure of wooden slabs resting on pillars of the same material, load bearing walls of brick and vertical closed timbered and plaster. The solution adopted was to improve habitability and redistribution of interior space while maintaining the structural characteristics of the building, changing the distribution of floor plans and facilities, without altering the characteristics of the container, or affect its structural elements.

In this document the method of action is described in the process of rehabilitation and consolidation of the building, the construction techniques used and the treatment given to the wood. Also, were also collected to verify the effectiveness of the treatments applied. All the solutions, both constructive as conservation and consolidation of the material met all the requirements of existing legislation, achieving obtaining decennial insurance required, with the supervisory intervention of a Technical Control Agency (OCT).

2. Methods – Meetings prior work with the OCT where the requirements for the approval of the actions performed settled. First it was agreed to conduct a comprehensive study of the current state of the structure, this study was developed in three phases: technical survey of the work, analysis of defects and, finally, the conclusions that led the study.

2.1. Detailed recognition of the work: The procedure to eliminate all existing partitions and leave the structure view in order to assess the condition of the wood, to identify the species of wood used, the measurement of all sections of the elements resistant, all confirm the situation existing structural elements, and make visual classification of wood.

2.3. Conclusions of the study: analyzed the macroscopic structure of wood was identified as the Pinaceae family, Pinus and Pinus Sylvestris L., establishing nominal sections of the joists and beams. Applying the UNE 56544-07 parts were classified as "MEG" and a strength class C18.

3. Structural calculations – ESTRUMAD 2007 the program using two models one regardless degradations to assess the overall behavior of the structure, and the second models impairments included was used. Calculations determined the existence of pillars and beams, did not meet the structural requirements, while the joists if met.

4. Constructive solutions – The first constructive solution proposed to increase the number of pillars to executing this solution avoiding the need to strengthen the beams, except to submit significant degradations, however, this solution pillars placed in areas not compatible with the original design of the project. On the other hand, maintaining existing pillars the number of beams to reinforce was high. To minimize the transformation of the pillar-beam articulated rigid joints raised.

Constructive solutions for reinforcing pillars were raised upon the material of the side pillars removed, the enforcement proceedings was to attach to the main pillars retirees side. For reinforcing beams existing structural elements of wood were also used, they were attached to the beams to the joists section removed; obtaining section beams 340x180 mm.

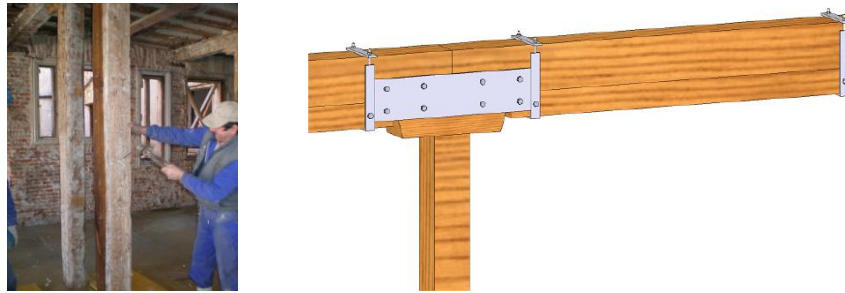


Figure 1: Reinforcement of pillars and beams

It was proposed to apply a protective treatment to the existing wood and reset for Class Use 2 to ensure its effectiveness prior to the application of wood surface treatment of degraded areas exposing healthy wood was removed. Treatment is in two phases: the first phase consisted in performing an injection of protective product; the process should ensure the introduction of a minimum dose of 60 gr product per meter o 20 gr/hole. In the second phase a surface treatment was performed by spraying protective product ensuring a dose of 250 to 300 gr/m². The efficacy of treatment was justified by tests.



Figure 2: Treatment by injection and spraying. Sampling

The analytical results of tests conducted showed that injection treatments were performed satisfactorily. Not spray treatment, in which the analysis performed to determine the dose indicated unsatisfactory product records in the new timber while the timber existing proved suitable. As the method of applying the same in both cases (new and existing wood wood), it was concluded that the wood humidity at the time of treatment, influence the absorption and retention of product applied. To resolve this situation it was decided to reapply the product on new wood, obtaining a good result verified by analytical results subsequently achieved.

5. Conclusions - All constructive actions for the replacement of damaged material, reinforcement of existing beams and pillars, as well as consolidation fungicides and wood treatments have helped the recovery of the original structure, respecting the structural characteristics of the building, its construction typology and adapting to current regulations. The decision to choose the wood and suitable treatments for the recovery of the existing wood, were based on objective technical tests to ensure the protection of the building and its structural elements. The collaboration between the technicians of the Project Management, Construction Company and OCT have been decisive to achieve the desired objectives, namely, the recovery of the building, its adaptation to the current operational requirements, adaptation to regulation current and obtaining of the invoice ten year Insurance.

THE INSPECTION WITH NON NONDESTRUCTIVE TECHNIQUES AS A TOOL FOR SUSTAINABLE INTERVENTIONS IN BUILDINGS WITH WOODEN STRUCTURES

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Keywords: *Nondestructive techniques; Wooden structures; Sustainable intervention proposals*

1. Introduction – Wood is a natural material used since Antiquity for building structures due to its mechanical properties. Most historic buildings include construction elements and systems made of wood, such as slabs or pieces used in roofing. However, the biological nature of wood makes it vulnerable to attack by biotic agents such as fungi or insects, as well as abiotic factors like fire or environmental conditions (mainly sunlight and rain). Moisture stimulates the process of wood degradation, and although water is not harmful in itself its presence increases the risk of deterioration.

When planning the rehabilitation or restoration of an existing building, ignorance or lack of information can lead to misdiagnosis and restoration works that are inappropriate. The use of nondestructive techniques such as infrared thermography [1], ultrasound [2] and Resistograph [3] supports the diagnostic works to gain objective knowledge of the wooden structure and its conservation state. This turns towards more sustainable and environmentally-friendly intervention proposals [4] reusing the highest amount of existing materials. Also, this kind of interventions preserves the heritage value, in the case of historical and monumental buildings.

In this paper several case-studies of monumental buildings in Andalusia are presented. These are *Ntra. Sra. de los Dolores Church* and *Ntra. Sra. De la Granada Church* both in Huelva, *San Felipe Neri Oratory* in Cádiz and *El Corral del Conde* in Sevilla.

2. Methods – In all cases, technical evaluations were performed as a preliminary step for a subsequent intervention. The diagnosis process was carried out using non-destructive techniques to complement the previous visual inspection tasks. So, the non-destructive techniques usually used were infrared thermography, ultrasound and Resistograph. The methodology for each technique was the result of experimental works conducted in lab on the same type of wood that is studied in situ later.

- Ultrasound tests enable to determine *in situ* the strength capacity of timber by determining the dynamic elasticity modulus ($E = V_L^2 \cdot d$, where V_L is the longitudinal ultrasound speed and d the wood density). Also, the loss density, as a consequence of wood decay, can be determined using the perpendicular ultrasound speeds, V_N . From the laboratory tests on damaged wood, the following intervals for the diagnosis of this wood type were established:
 - $V_N > 1200$ m/s: healthy wood.
 - V_N between 1200-600 m/s: wood beginning to deteriorate (density loss up to 30%).
 - $V_N < 600$ m/s: deteriorated wood (density loss above 30%).
- Infrared thermography mainly provides areas with a high moisture content and different materials. High moisture content indicates areas with a high risk of damaging.

- Resistograph relates the penetration resistance, RM , and wood density ($d=20,48RM + 204,4$, where RM is the resistographic measurement). The results obtained are always compared with the density values determined by small specimens of healthy wood. Also, Resistograph allows to localize decayed wood as a result of a low penetration resistance.

In each case, the inspection tasks were adapted to the particular needs and taking into account the possibilities of in-situ proceedings. In the case of *Ntra. Sra. De la Granada Church*: Infrared thermography, ultrasound and Resistograph were used as nondestructive techniques to complement the visual inspection. In *Ntra. Sra. de los Dolores Church* and *San Felipe Neri Oratory*, infrared thermography and ultrasound were used. Finally, in *El Corral del Conde* ultrasound and moisture content measurements were performed.

3. Results and Discussion –Results provided information about the conservation state of each wooden structure. The resistance capacity and the damaged areas were determined in order to propose a sustainable intervention project.

In the case of *Ntra. Sra. De la Granada Church*, the results obtained with non-destructive techniques were contrasted with the results from a visual grading to assign a visual quality, for the timber rafters, of MEG equivalents to a C18 strength class. In this case, it was checked that the use of non-destructive techniques to determine strength characteristics could, in certain cases, be more limited than a visual classification for defects.

In *Ntra. Sra. de los Dolores Church*, the use of infrared thermography made it possible to identify areas with different moisture content and possible signs of decay. On-site ultrasound measurements had a value of velocity perpendicular to the grain (V_N) higher than 1200 m/s. This demonstrated that the conservation state of this wood was acceptable and, therefore, the wood was healthy. The strength capacity, obtained by longitudinal measurements, V_L , turned out to be very high, C30 and C35.

In *San Felipe Neri Oratory*, damaged areas with high moisture contents were identified by infrared thermography. Ultrasound tests let to quantify the level of decay in the damaged wood.

In *El Corral del Conde*, the results analysis showed a significant density loss and fall in the compression resistance at the base of the pillars. Both, density loss and fall in the compression resistance were found at the base of the pillars up to a height of 50 cm.

4. Conclusions – In all cases presented non-destructive inspection techniques were used to complement the visual inspection tasks. The use of these techniques allowed to evaluate the existing structures in order to ensure the maximum reuse of the existing materials in the subsequent intervention projects.

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BUILDING RETROFIT THROUGH PREFABRICATED PANELS: AN OVERVIEW ON THE STATE OF THE ART

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Keywords: *energy retrofit, prefabrication, panel, state of the art*

1. Introduction – The main aim of this paper is to provide an overview of the use of prefabricated panels in external building retrofitting. Building retrofit represents a pivotal point in terms of energy efficiency, connected to the great amount of existing buildings, both public and private, all around Europe. The need of intervention is underlined by the European Directives: EPBD 2002/91/EC, EED 2012/27/EU, Renewable Energy Directive 2009/28/EC and 2010/31/EU that set requirements linked to retrofit and building renovation.

Prefabrication is a primary retrofit strategy, involving both facades and roofs renovation. Currently most building renovations address isolated building components, such as roofs, windows, façades elements or services [1]. This strategy shows its limits, as it does not involve any long-term energy reduction and often results in expensive solutions. Single renovation measures does not allow optimal results as new problems can arise, including local condensation or overheating.

There have been alternative concepts, developed through several research projects across Europe, involving innovative whole building renovations with prefabricated panels [2]. Each project has its own features, linked to the different contexts and conditions in which they took place. The aim of this paper is a critical classification of these projects, stressing differences and similarities between them, as well as identifying the main issues related to the theme.

2. Methods – Horizon 2020 roadmap stresses the relevance of prefabrication in the wider frame of retrofit [3]. It can help indeed overcoming the issues connected to traditional retrofit, in terms of time, discomfort, construction, aesthetics and cost. In this context, external retrofit provides several advantages, as it requires no internal living space loss, minimum disruption, and condensation risk minimization. Prefabrication plays a primary role in retrofit, as it consents standardization in construction, a certain flexibility in architecture (mainly in terms of finishing) and allows the combination with other conventional retrofit options.

As prefabricated retrofit is a current issue, European projects, research works and architects have developed several projects, mainly focusing on residential context. The review of the state of the art shows several approaches in terms of prefabricated panels.

- Large modules: development of a complete prefabrication solution based on façade modules made of wood, mounted on-site on a timber substructure, in an additive retrofit strategy. Other concepts are based on the addition of large modules on aluminium profiles deriving from standard solutions commonly used for glazed façade [4] [5] [6]
- Small modules: development of small modules, completely prefabricated, with a steel substructure, cork, XPS insulation and aluminium finishing, still as part of an additive retrofit [7].
- Highly standardized small modules: a different approach was carried out developing smaller panels with a high level of standardisation, to be set on the existing façade in combination with other prefabricated panels [6].
- Self-standing steel modules: development of self-standing steel substructures, with steel frame modules covering two stories and providing addition of floor area to an existing building through the closing of balconies and loggias [6].

- The EASEE project provides a further development and application of a prefabricated system on existing residential buildings. It focuses on the envelope retrofitting of existing multi-storey and multi-owner buildings, through a TRM and EPS panels, installed with punctual anchors.

3. Results and Discussion – The majority of the projects analysed regards residential buildings, dating back to the period 1950s-1980s. Tertiary buildings retrofit is a well-documented theme, especially in case of curtain-walls renovation. Disparate solutions are available, mainly developed by façade-systems companies.

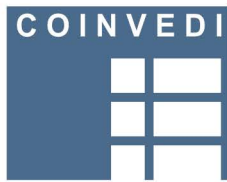
The main challenges are linked to design, fabrication, transport and installation: the classification of the projects has been shaped through those parameters, with a focus on residential retrofit. The majority of the projects involves addition retrofit, meaning the positioning of panels on the existing façade, but there are some cases regarding also partial or total replacement of the façade. The main issues are related to the presence of balconies, loggias or windows: in many cases, loggias are closed and transformed in living space, both for energy efficiency and for economical reasons. Some panels includes building services integration, mainly as ventilation ducts and solar systems (solar collectors or photovoltaics) [8].

Most of the projects presented does not include any follow-up, meaning that it is difficult to evaluate the effectiveness of the intervention in time. Several studies were carried out using numerical simulations: actual energy savings may be different from those estimated. Practical case studies are needed to help increase the level of confidence in potential retrofit benefits.

4. Conclusions - Building envelope represents a critical element to reach the 2050 decarbonisation goals, as it consists in the main part of the building thermal loads. The main targets connected to building envelopes regard the improvement of the energy performance, as well as its aesthetics, acoustic and lighting comfort, together with the quality of indoor environment [9]. Prefabrication in building retrofit is on its way to become a major tool to reach these goals. Several projects have been developed, and other are underway, both in terms of research projects and private initiatives. The classification of those projects is helping in identifying the main innovation fields to be further investigated. Some possible future developments are the thickness of the panel (linked to the use of innovative insulation materials), and the adaptation, in terms of finishing, dimensions and adjustments of the panel.

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ARCHITECTURAL SOLUTIONS TO IMPROVE THE VISUAL INTEGRATION OF BUILDINGS IN THE HISTORIC CENTER OF VALENCIA

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Keywords: *Color, visual impact, integration, urban center*

1. Introduction – This study is part of a research project aimed at defining strategies to improve the integration of architectures with visual impact in landscape, based on chromatic criteria. It exists an extensive literature regarding visual integration of infrastructure and industrial facilities in natural environment, but it is smaller regarding the visual integration of architecture in landscape [1], and scarce in urban settlements [2] and ancient city centres.

The main objective of the project is to find chromatic strategies to enhance the visual impact of disrupting buildings in the urban environment and assert different artistic possibilities to reduce the visual impact of such architectures. For this purpose, it has been performed a set of 10 photomontages with different colour and material solutions which make a "base stimulus" to be evaluated by observers. Some different visualisation media have been used: in-situ observations, images on computer screen [3], printed panels, images in a *Power Wall* by overhead projectors, and 360° surrounding images using *Oculus Rift Glasses* technology.

The subjective perception expressed by observers regarding the visual integration [4] will be related to different design variables to understand how these variables might help a better integration of architecture [5]. The aim is to have some guidance to facilitate the work of the architects when working in these buildings.

In this paper we explain the criteria used to design the 10 photomontages shown to observers (Images 1- 4). To cover a wide range of stimulus, we have developed different integration solutions, some of them are contrasting, some harmonic and some mimetic, depending on the level of similarity with the surroundings. Attending to the *design attributes* of the images (both shape and colour attributes), a initial "objective classification" of the impact of every solution has been settled, to assure that the range of different stimulus is wide enough for the statistic sample.

2. Methods –

We have formalized a checklist with 31 questions that contain the *design attributes* considered to initially evaluate the level of similarity or difference between the building solution and its surroundings. This initial classification can be said to be *objective*, as it is based on verifiable and measurable criteria. A group of 5 architects, experts in color research, have valued every *design attribute* with a likert scale. The answers of all of them are statistically consistent enough to assure an *objective initial integration value* for every proposal (table 1).

This objective classification will be compared with the *subjective integration value* perceived by the observers when answering a test. Not necessary the most similar solution with the surroundings has to be the most integrated solution in opinion of the observers, as many other subjective considerations could come into play: an improvement of the environmental quality of the surroundings with a more challenging solution than the actual state, although not linked with the surroundings very much, for instance.

Design attributes

Related with the formal composition

1. Formal attributes related with the typology
2. Formal attributes related with the aesthetic language
3. Formal attributes related with the local culture
4. Formal attributes related with the essential elements of the image

Related with the color composition

5. Color attributes related with the colorimetric characteristics
6. Color attributes related with whole chromatic composition
7. Color attributes related with the number of colours and their extension

Table1. This is a resume of the contents of the test to settle the *objective initial integration value*

3. Results and Discussion – The *objective initial integration value* show a strong coherence with the *subjective integration value* expressed by the observers in their test. Nevertheless, this coincidence is better for those photomontages considered integrated in the environment (mimetic images) and for those considered contrasted (contrasting images). Divergence in results is wider in those photomontages which have some characteristic in common with the urban landscape but do not seek for a disappearance (harmonic images). The use of vegetation in the facade sharpens the discrepancy between those observers in favour and opposed with the rate of integration.



Image 1. Actual condition.



Image 2. Mimetic Photomontage.



Image 3. Harmonic Photomontage.



Image 4. Contrasting Photomontage.

4. Conclusions - *Objective indicators* in relation to colour and shape contrast/ harmony with the surroundings are a first step to approach the problem of the architectural integration, and correctly fit with the *subjective evaluation* of the observers in most of the cases. Nevertheless, the architectural integration relies on many other subjective facts that actually disperse the results in some middle situations. There exist proposals which are challenging, abstract (not figurative), with vegetation or with other design resources, which are sometimes considered worthy by observers. There exist visual integration strategies which are not based on colour matching or a perfect mimesis and could result in an alternative artistic solution for architectures with impact on urban landscape.

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EVALUATION OF THE IMPACT OF THE RETROFITTING SOLUTION ON THE ACOUSTIC AND THERMAL PERFORMANCE OF FLOORS

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Keywords: *Refurbishment and Maintenance; Structural Retrofitting; Acoustic performance; Thermal insulation*

1. Introduction –Building renovation projects deal with many aspects of construction performance, including energetic and acoustic properties, accessibility, and structural reinforcement. Four aspects must be taken into account in building rehabilitation: proportionality, flexibility, no-deterioration and transversality. Proportionality implies that the costs and complexity of execution may be related to the level of improvement. Flexibility involves proportionality; according to flexibility criterion, a building must approach its best performance but it can be exempted from new construction regulations as its improvement depends on the current situation. No-deterioration is closely related to transversality. Pursuing no-deterioration, we must study the relations between aspects affecting habitability, in order to choose a viable solution [1]. Structural reinforcement is not usually considered in terms of transversality in building renovation, in spite of the fact it can change thermal and acoustic performance. This work studies the impact of solutions for floor structural retrofitting on its acoustic and thermal insulation, according to Spanish standards, with the aim of recalling the importance of comparative study of properties in rehabilitation works [2].

2. Methods –The work compares three common solutions to increase the load-bearing capacity of floors. In Spain, old building floor structures usually consist on one way slabs with wood, concrete or steel joists and arched lightened ceramic or concrete pieces [3]. As the goal of this work is to compare the retrofitting solutions, a one way slab with concrete joists and ceramic arches has been chosen. The retrofitting solutions that have been considered are: 7 cm conventional concrete screed on top of the original floor, 7 cm lightweight concrete on top of the original floor and retrofitting under the joists with steel or carbon plates. The three considered methods can effectively increase the load bearing-capacity. Retrofitting with steel or carbon plates does not affect the clearance height, but it cannot improve the thermo-acoustic performance of the floor. The study has been focused on section enlargement of floors. Conventional concrete screeds raises the structure stiffness, but with a considerable increase in dead load; lightweight concrete screeds contribute to strengthen with a smaller increase in dead load. Regardless the structural contribution of each solution, as there is no choice but to do what is structurally acceptable, the two retrofitting schemes have been compared in terms of acoustic and thermal behaviour.

Computer-based tools have been used for the analysis of acoustic properties of floor solutions. The first one of them was specifically created to analyse the building to compliance of Spanish regulation CTE DB-HR [3]; this program accepts only one layer of floor, with the possibility of adding a floating floor, and the main layer is described in terms of its density. The other one is the educational version of CYPECAD-MEP, which is widely used for building projects. It allows the designer to add layers with differing properties to the traditional floor structure, It uses the formulas included in UNE-12354 [4], and can be used following european or local regulations. The thermal properties have been calculated with CYPECAD-MEP and with a spreadsheet following the method proposed in UNE-EN ISO 6946 [5].

3. Results and Discussion –The results of the section enlargement techniques are presented (table 1), compared to the original properties of the floor, which are supposed to be the same as the properties with an steel or carbon plate retrofitting. The results show the capacity of both retrofitting schemes to fulfil the acoustic requirements when a floating floor is installed. The differences between computer programs are of no high significance, in spite of the generalization of layers made by the DB-HR tool.

The thermal properties reveal little difference between solutions. The thermal transmittance value (U-value) decreases when additional layers are included, but concrete is not a good thermal insulator. Installing floating floor is an effective way to improve the thermal performance. For extreme climates, more insulation is needed according to CTE [3], such as a thicker layer between the screed and the laminated floor.

The results are presented with a colour coding that is being increasingly used in renovation projects. It comes from energy ratings, and its goal is to include a gradation, accepting the non-fulfilment of the regulation in rehabilitation works. This is related to the flexibility concept.

analysis	tool	property	constructive solution						spanish regulation limit
			unreinforced floor / plate retrofitting system		lightweight concrete screed (1800 kg/m3)		conventional concrete screed (2400 kg/m3)		
			glued floor	floating floor	glued floor	floating floor	glued floor	floating floor	
ACOUSTIC	CYPECAD-MEP	impact noise	73	64	69	59	67	57	≤ 65 dB
	DB-HR tool		75	64	71	60	69	58	
	CYPECAD-MEP	airborne noise	51	49	54	53	54	55	≥ 50 dBA
	DB-HR tool		48	48	52	53	53	55	
THERMAL	CYPECAD-MEP	thermal transmittance U	1,46	1,09	1,36	1,06	1,41	1,10	1,2 W/m²·K (For climatic zones A,B,C)
	UNE-EN ISO 6946		1,58	1,20	1,45	1,13	1,52	1,17	
			D _{NTA} ≥ 50 dBA; L _{NTW} ≤ 65 dB / U ≤ 1,2 W/m²·K						
			D _{NTA} : 45-49 dBA; L _{NTW} : 66-70 dB / U: 1,1-1,45 W/m²·K						
			D _{NTA} : 40-45 dBA; L _{NTW} : 70-75 dB / U: 1,46-1,6 W/m²·K						
			D _{NTA} < 40 dBA; L _{NTW} > 6,75 dB / U > 1,6 W/m²·K						

Table 1. Results of acoustic and thermal performance

4. Conclusions – The thermo-acoustic performance of several retrofitting solutions for floor structures has been studied. Solutions are compared following the principles of flexibility and transversality, and considering the Spanish regulation limits. If there are no geometrical limitations, the use of concrete screeds on top of the original floor can lead to a better acoustic performance. The studied solutions have very similar thermal behaviour. The choice of lightweight concrete may be bounded to structural reasons; according to flexibility the differences between common and lightweight concrete are not too relevant. Despite this, more research is needed as the acoustic properties of lightweight concrete can be underestimated by those programs lacking technical specifications of the product. The installation of floating floors has a positive impact on all the considered properties of the solutions, regardless the retrofitting scheme.

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III INTERNATIONAL CONGRESS ON CONSTRUCTION AND BUILDING RESEARCH (COINVEDI)

TCOI

PLANNING FOR BUILDING CONSTRUCTION MANAGEMENT: IMPLEMENTING LAST PLANNER THROUGH BUSINESS PROCESS MANAGEMENT

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Keywords: *Last Planner system; LPS; Business Process Management; BPM*

1. Introduction – The construction projects executions are characterized by its complexity, uncertainty, variability and dynamism due to the one-of-a-kind nature of projects, site production, and temporary multi-organization [1-3]. These characteristics turn the current traditional planning models into mere initial assumptions which subsequently will be adjusted [4, 5]. In this environment, it is impossible to make a reliable detailed plan far in advance following the initial schedule of how much work can be carried out by a crew [6]. Considering this, one of the main emerging approaches in management theory of construction projects is the Last Planner System (hereinafter LPS) [6, 7]. This tool based on Lean Construction philosophy [8] promotes a new form of production management that allows an active management of variability by identifying and eliminating the root cause of the problems that cause uncertainty through collaborative planning, performing collaborative constraint analysis, and learning from plan failures [9]. Although LPS has reported satisfactory results from its implementation on construction projects in several countries there are some difficulties and barriers for its implementation [10]. One of the main barriers detected is the lack of information management tools to support the Last Planner process [11]. Consequently, to overcome this technological gap is proposed the use of the Business Process Management paradigm (hereinafter BPM) [12, 13] to model and automate the LPS methodology in order to facilitate its implementation and expand the use in the industry.

2. Methods – In this paper it has been done an analysis of LPS, specifically in the phase of short-term planning, i.e. the Weekly Work Plan (hereinafter WWP) where is decided the specific work that will be done during the week [14]. Then, it has been applied the BPM strategy for the modelling and the automation of a WWP framework.

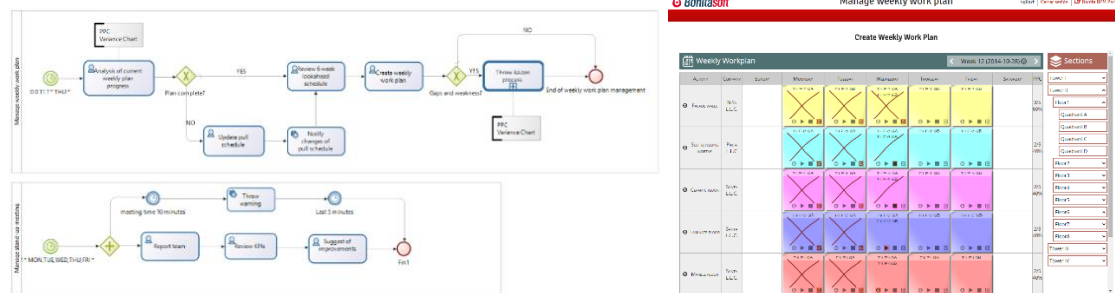


Figure 1. BPMN model of WWP (left) and screenshot of WWP interface (right).

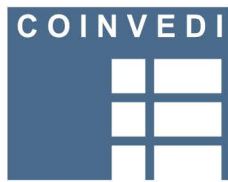
This has been made through the open source business process management suite (hereinafter BPMS) Bonita BPM. To design the interface WWP it has been used a sticky's screen, that allows with drag and drop operations the control of the applications in friendly way. Finally, in the WWP has been defined a use case of a construction process, to validate the usefulness and utility of the proposal.

3. Results and Discussion – To validate the proposal from the point of view of usability and usefulness, some tests and a benchmarking meeting were carried out with participants of the companies Acciona, Urbana de Exteriores, 3AG Gestión y Construcción y Aglodelta, Tecnicalia 24 and Moa, S.L. First, a meeting of benchmarking was organised to talk about current site management practices. Then, they tested the prototype. And finally, a meeting of benchmarking was convened to discuss the prototype in terms of usability and benefits of implementation where all participants highlighted the intuitive navigation and the high profits in efficiency and productivity of this integrated system of Last Planner.

4. Conclusions – The creation of this framework within BPM approach will provide technological support to the WWP as a phase of LPS, promoting its use and guiding the process to avoid erroneous implementation, achieving efficiently in the weekly and daily meetings reliable commitments, measuring the percentage of compliance with the commitments of the period through the percent plan complete (hereinafter PPC) and acting on the causes of non-compliance (variance code).

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Q-BIM. QUALITY AND ASSURANCE CONTROL FOR CONSTRUCTION PROJECTS ON A BIM ENVIROMENT. AN ANALYSIS OF THE STRENGTHS AND WEAKNESSES OF THE CURRENT SOFTWARE

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Keywords: *BIM; Quality; Building; Management*

1. Introduction- Software for collaborative working as Building Information Modelling (BIM), which enhances the coordination between multidisciplinary teams throughout the Building Design and Execution process [1][2], has appeared in the Construction Industry recently. This methodology covers and manages the total building lifecycle information, simulating and updating digital representations for all construction stages, functioning, demolition and recycling.

Quality Management is one of the deeply involved disciplines throughout the development of a project. It is essential to guarantee professional standards in Construction Industry, by establishing owner and user's rights. Globalization is a reality in a world where International competitiveness has become increasingly important. In this scenario, organizations should be capable of fulfilling the quality of their products and services [3][4][5].

Therefore, the development of BIM based software to improve Quality Management is an essential part of the framework in order to accomplish collaborative work successfully. It is called Quality BIM or Q-BIM and defined as set of tools to collect information about Assurance and Quality Control within an exchange information model.

2. Methods – The aim of this study is mostly to analyse and determine the strengths and weaknesses of the various Q-BIM based software already on the market. To this end, the following steps are completed:

Firstly, the statutory duties of the Project manager/Architect and Project Execution Manager, both representing the owner, are defined as stated by “Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación [6] and “Código Técnico de la Edificación “[7]. Additionally, PMBOK® Guide (Project Management Body of Knowledge Guide)[8], an internationally recognised standard of good practice for quality in construction, is also considered.

A good practice task list for construction is drawn up from the documents studied. This list would include the necessary good practice tasks, grouped by various control categories, to ensure the quality of the construction.

Concurrently, a search for BIM based software, which were offering Quality Control functions, is carried out in the market. This research would be aimed to determine the specific strengths and weaknesses of the regarding software, according to the good practice task list. The tools analyzed are Altra CDO, QGest and GestProject.

Finally, conclusions are drawn from the whole analysis, highlighting the aspects that are still unresolved by the current software.

3. Results and Discussion – From the study of the documents, a good practice task list for control of construction in building projects is established. The categorising lists would be grouped according to control type and documental requirements in order to monitor each stage of the control process. The following table presents a summary of this list (table 1).

Type of control	Good Practice	Document
Control of construction units	Verification of readiness for construction	Certificate verifying readiness for construction.
	Verification of Construction staking and surveying	Assessment Report for construction staking
	Verification of proper execution of construction units	Work performance control sheet
		Audit report
		Incident report
	Verification of Proper Ending of construction units	Reception control Log
Control of supplies	Verification of documentary quality requirements of supplies in accordance with the project specifications	Documentary requirement sheet
		Record book for submitted documents
	Verification of stockpiles with the specifications laid down in the design	Audit record
	Verification of supplies on worksite with the specifications laid down in the design	Audit record

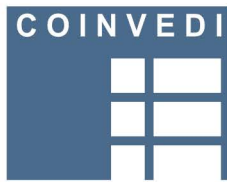
Table 1: Summary of good practice list for control of construction in building projects

Regarding Q-BIM based software, the study found that the main issue to be considered was that most of the software only offered quality control functions during project design stage: compliance with codes and clash detection, but not during construction stages. The only exception found among the existing software used Revit's datasheet to integrate the results of the tests controlling the resistance of the concrete into the model [9], therefore, it can not be considered a specific Q-BIM software.

4. Conclusions – Although the study is not completed, it seems to suggest a lack of specific software in the market: the one which would allow integrate quality control during the construction of projects designed in BIM environment.

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**PLANIFICATION, CONTROL AND MONITORING OF A PROFESSIONAL
SERVICE OF ENGINEERING BUILDING A MODEL OF QUALITY MANAGEMENT
IN ACCORDANCE TO ISO 9001**

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Keywords: *building engineer; quality management system; ISO 9001*

1. Introduction – The Quality Management applied to organizations formed by technicians dedicated to providing services in the building process is an unexploited area, having a low level of implementation of Systems Quality Management in these professional groups, among which we find the Engineering Building.

The difficulty in deciding the implementation of Systems Quality Management may have its origin in several causes. One cause may be the difficulty to interpret and adapt to the way of working the requirements of the standards or reference models used, such as the model defined in the standard UNE-EN ISO 9001:2008 [1]. Another cause could be do not have a practical, simple and customized guide to suit the technician requirements, that meets the requirements of standards or reference models and identify the activities to be performed, thus facilitating the development of services provided guidance and leaving no room for misinterpretation of the requirements [3-5].

Undertaking research, the results arouse the interest of these technicians in the area of quality, and it can help the implementation of this type of organizational systems in their organizations in order to improve their work and achieve greater efficiency and effectiveness.

This paper proposes an original documentation self-developed, related to the planning, control and monitoring of professional work commissioned within a System Model Quality Management, whose implementation aims to improve the results and increase the customer satisfaction.

2. Methods – The documentation is part of the work carried on research developed during the years 2012-2014 [2] which was drawn up documenting a model for quality management according to ISO 9001 applicable to the professional development of the Engineering Building.

For the study, primary and secondary sources have been used. Regarding secondary sources, a thorough review and analysis of the contents of various published references and the reference standard UNE-EN ISO 9001:2008 have been conducted, making a consistent interpretation of the requirements for the application to the type of services provided in the Engineering Building. The regulations affecting professional services and other related literature with relevant character have also been reviewed.

We have opted for a practical system of tabs and formats as instructions of working, general and specific, describing the tasks and records required by the System of Quality Management.

To validate the model and its documentation a qualitative methodology has been used for collecting primary information namely the realization of a dynamic group composed of experts in the subject matter of the investigation (focus group).

3. Results and Discussion – The model validation for Quality Management has resulted, among others documents, into documents in order to plan and to develop the processes needed for the service before implementation (requirement 7.1 ISO 9001) and identify the state it is, performing, supervising control and monitoring it (requirement 7.5 ISO 9001) [1]. For that, it used the formats F/PE and F/CS respectively.

The format F/PE, “custom planning and monitoring” (table 1), is generated prior to their implementation, in order to structure the bases that are necessary for the development and application.

Logo or company name	Custom planning and monitoring			F/PE			
				Version			
				Page N° referenced to the total			
Custom code		Supply code		Customer code		Work code	

Table 1. Header format F/PE “Custom planning and monitoring”

In order to know the phase in which the services are, their status and their evolution, the format F/CS, “state control of the services requested” (table 2) has been created. This format is useful to identify at any time the situation where a service is regarding its implementation, measurement and monitoring, and it can see, among other things, if it has fulfilled the programmed activities, if these have been successful, if nonconformity has been detected or if there have been complaints.

Logo or company name	State control of the services requested			F/CS			
				Version			
				Page N° referenced to the total			
Application date:							

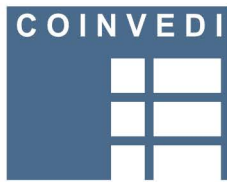
Table 2. Header format F/PE “State control of the services requested”

4. Conclusions – The formats which are the documents related to the planning, control and monitoring of professional work commissioned, are a useful tool applicable to the development of the professional activity of the Engineering Building in the world of quality and continuous improvement, meeting in the form and content to the needs of these technicians.

This documentation is prepared as a useful guide that leads the technician in planning, control and monitoring of their professional work, indicating the steps to follow in developing their activity, avoiding omissions and improvisations out of time and covering extraordinary activities that contribute to the provision of services more comprehensive and effective, adaptable to the specific activity of different organizations or independent professionals who are part of the Engineering Building services.

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EARNED VALUE METHOD USED IN PROJECT MANAGEMENT IN SECTOR BUILDING IN SPAIN

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Keywords: *Earned Value; Cost-Time; Management; Edification.*

1. Introduction –

The fact that Earned value method (EVM) is a tool to accurately know the actual state in which a Project is [1], the main objective of this research was to analyze the effectiveness of the EVM in the execution of projects in Spanish edification as a tool to improve management of those projects, so you can detect early deviations that may appear [2]. It aims to prove that their use is appropriate in the execution of projects in Spanish edification.

2. Methods – This study has focused on checking:

- If there is an improvement in cost control throughout the execution of the edification project.
- If that produces a better fit within the initial programmed budget.
- If there is an improvement in the execution of the edification project while using EVM.

This research aims to improve the present process management of Spanish edification projects, proposing a series of measures to be taken in controlling and implement the projects of construction in our country. It has been found that the use of EVM is suitable in the execution of Spanish edification projects.

Studying the main objective of this research has resulted in the emergence of other specific objectives, typical of the sector in which this research is developed.

These objectives are:

- To identify methodological changes that current methods of planning and management of edification projects may suffer as EVM method is being implemented.
- To identify activities in edification projects that may produce deviations of the initial planning.
- To suggest improvements in current edification projects planning -in order to avoid deviations that may usually occur. To achieve this goal, the rate Time-Expense in building projects will be determined.
- To know which type of resources could delay or thrust project implementation and to determine how they appear. For this you would have to determine the time-cost relationship in the activities of edification projects.

3. Results and Discussion – Results obtained during this investigation are shown in the following tables.

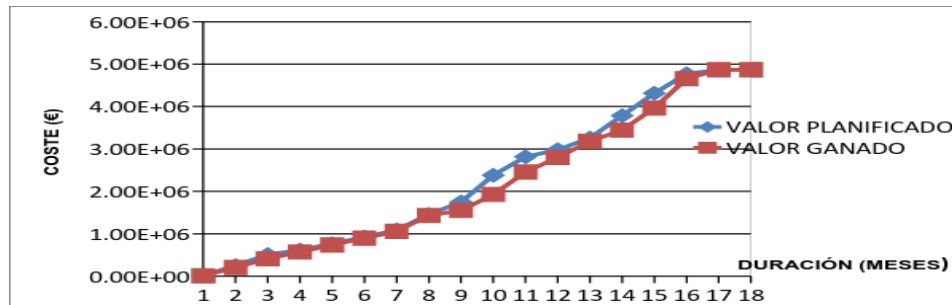


Figure 1. Planned evolution of expense and revenue values. (Own production)

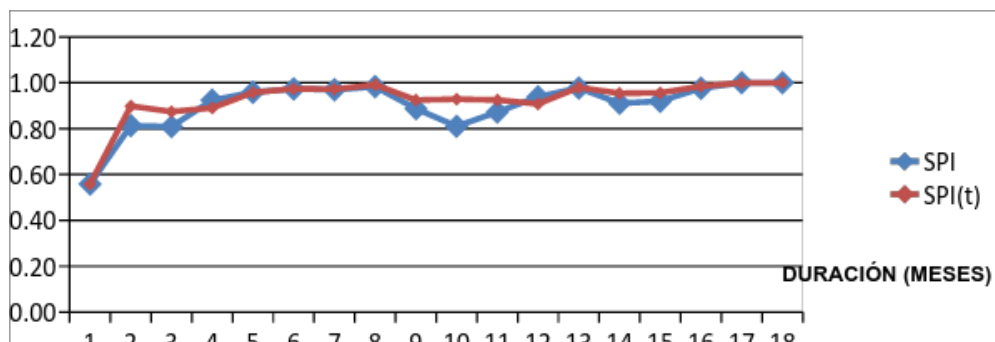


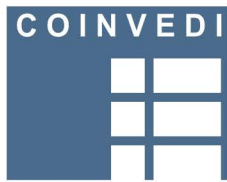
Figure 2. Evolution of time efficiency index. (Own production)

4. Conclusions – This research has allowed to develop a model to be apply the EVM techniques in edification work in Spain -since currently there is no model for implementing the EVM methods in the edification sector of our country.

Also it has identified the advantages and disadvantages of usage of EVM in the field of the construction in Spain.

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INTEGRATED PROJECT DELIVERY (IPD) ASSISTED BY BIM FOR SUSTAINABLE DESIGN SOLUTIONS

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Keywords: *Collaboration Engineering, Integrated Project Delivery, Intelligent Computer Agents, Virtual Design and Construction*

1. Introduction – Over the past decade we have seen rapid movements in the UK, USA, Australia and the European Construction Industries to offer alternatives to the traditional design-bid-build contract procurement system. The core to these new systems are built around collaboration, trust and an integrating computer models, in an attempt to move away from the often adversarial contract conditions thereby giving clients of construction services greater value. The paper outlines first research focused on creating a decision support environment that actively supports collaboration during decision making and problem solving. It then moves to current field research where active projects that are applying the processes of Integrated Project Delivery (IPD) within the “Big-Room” environment are studied. The significance of Virtual Design and Integrated Project Delivery will be discussed in the context of improved collaboration on the construction project.

Virtual Design and Construction (VDC) is a collaborative, integrated process that considers both design and construction using a 3D BIM models in combination with schedule data (4D) and cost estimating data (5D) (fig1), a virtual object is created even before construction starts. As such, it serves as a shared knowledge resource for information about a facility thereby forming a reliable basis for decisions during its lifecycle from project inception onwards to facility management. Model, schedule and cost (GSA.2011) have to be coordinated from the beginning. For best results it is essential that VDC and BIM are implemented from the beginning of a construction project in order to increase the quality of the object, the organization, and the process, during the building life cycle. An important basic requirement for the model based work method is a sufficient amount of information from the very start of a project. In particular, the criteria and constraints of the various contributors need to be articulated and discussed as the model builds. For the approach to work effectively it is essential to include the experience of construction managers and contractors to maximize project benefits from the execution experience. Indeed in the USA construction firms are leading the delivery of IPD. The result is a win-win situation for all members of the team. Furthermore, the building owner has security in terms of cost and schedule as well as optimized operation. During this phase the 3D, 4D or 5D models with a level of detail appropriate for execution are created.

2. Methods – The author's investigation measured the views of practitioners in the main building professions; Architecture, Engineering and Construction Management before proposing the decision support system. The processes and interactions that Architects, Engineers and Construction Managers (AEC) use when making key project decisions were studied. Research data was collected from 54 companies in the USA and 39 in the United Kingdom. Scenarios of typical design and production problems were used to measure the differences in making key decisions in the traditional method of project delivery (design-bid-build) compared to a system where there was a high incidence of collaborative decision making; such as Design-Build. Results were compared between the three participating groups (AEC) so that the consensus view could be obtained. Participants were asked to define the processes they used when working to find solutions to three specific problems associated with a typical reinforced concrete office building. The problems posed were related to making decisions regarding: (i) The foundation system; (ii) The suspended floor

system; (iii) The enclosure system. The survey was designed to collect information related to four areas: 1). To Ascertain the problem solving processes traditionally used by the three main groups under investigation together with their interactions. 2) To Discover the constraints each group imposed on others, and determines how those constraints affect other groups. 3) To Learn the requirements of architects, engineers and contractors to the greater levels of collaboration under consideration; what do the practitioners want? 4) To Find out the features that architects, engineers and contractors would like in any re-designed framework that enhanced collaboration. The second phase of this investigation measures the current state of AEC collaboration that is in progress on various projects in California through IPD strategies.

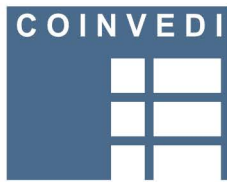
3. Results and Discussion – The results are conclusive that in comparison to the present process of construction development all participants would like greater levels of collaboration to review and resolve design and construction problems and find the best solution. This is required at much earlier stages of the project than currently happens. It was found that for all six-production problems significant increases in collaboration were called for by all three domains; architect, engineer and construction manager. However the perception of present levels of interaction differed with domain. Decision or choice that had to be made by the design team where first analyzed and tabulated. Developing a design solution in each of these areas then generate criteria and constraint, which influence problem solving of other participant domains. Further analysis of the findings resulted in identifying those areas, which set constraints for problem solving by the construction manager. By indicating each major area in this way gives a good indication of the level of collaboration that should be taking place. To achieve the performance improvements outlined, the starting point is to create an environment where greater collaboration between the main parties to the project team can be practiced. Because of the wide range of criteria to be satisfied by the participating groups an agent assist environment is desirable. The research demonstrates that such an environment can be built that assists an AEC collaborating team in their search for alternative solutions which satisfy the criteria and constraints imposed by a client's project requirements. The computer environment explored is extendable to include all project participants whose input to the design process is desirable. The problem-solving domain of construction management is represented in such an environment. The results of the work is a conceptual model; a definition of the contractors' construction management computer agents and a specification based on scenarios of how these agents would interact with design agents.

4. Conclusions - The results of the author's earlier work in Intelligent Computer Agents (Jones 1998) are linked to present day VDC. In this way a collaborative team has the tools and information to interrogate and solve many of the cost, constructability, time, quality, sustainability, environmental, safety, etc. issues before construction commences, and continue that monitoring throughout the construction process. At the end of the project all captured information can be organized and passed to the facility operations team. The development in the near future as follows: (i) BIM tools (3D, 4D and 5D ...) with integrated construction management function will spread wider; (ii) New professional roles, like the one of a BIM manager, will become more and more important; (iii) Suppliers will be more integrated into the processes of the construction industry (like it is already happening in the automobile industry); (iv) The application of BIM in the field of modular construction and pre-manufacture will advance this kind of construction; (v) More and more building owners and government agencies will insist on BIM and virtual design tools as part of the contract; (vi) Contract and remuneration terms will be impacted by BIM; (vi) Greater standardization will find its way into the construction industry

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CITIZEN CONSULTATION IN PUBLIC SPACES' PROJECT MANAGEMENT. THE CASE STUDY OF AHMED BEY PLACE CONSTANTINE

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Keywords: *citizen consultation, public space, project management*

1. Introduction: The extremely rapid development of cities and the growth of traffic have long restricted the design of public spaces to a primarily functional approach, to the detriment of local life and the urban environment [1], this is the case in Algerian cities particularly in the city of Constantine which benefits, since the second millennium of special attention from new urban strategies. All converge to a single goal: to give back to this city its rank in the eastern Algeria and the whole country.

In this context, various programs have been set for the development of the city such as the Project of Modernization of the Metropolis of Constantine to get the city in the tune of the world, relying on its own identity by the urban project contribution which aims to improve neighborhoods better life, particularly in certain municipalities and even in the center of Constantine in the context of sustainable development that requires participation at the various project stakeholders and in particular projects of public spaces.

The project is designed to revitalize the located area in the heart of the city of Constantine. Place Ahmed Bey fully fulfills its role as real living space and assembly. It generates great vitality.

To this effect, the aim of this survey consists to how to identify the communication in a given project in progress. Thought a poll on the field in order to get implement an approach/cooperation communication model in project management.

2. Methods: The approach is the method of qualitative and quantitative approach from a case study which is the project of "Revitalization and Urban Regeneration The Town Center Constantine Lot: Ahmed Bey Place". Structured interviews and semi-directive and a poll radiation at the center of Constantine, this poll is composed of closed type questions. The latter is subjected fifty individuals age and different sex. The author proposes to meet a specific shape and a limited number of answer choices in order to show the importance of their participation and how it can help in decision, to put tools and communication means of citizen consultation in the project management.

3. Results and Discussion: The identification of the communication of project stakeholders of "Revitalization and Urban Regeneration The Town Center Constantine Lot: Ahmed Bey Constantine " showed us that communication between the project owner and other project stakeholders (project supervision, realization enterprising) appears with meetings scheduled at the site.

Nevertheless, the flow of work was disrupted for various reasons; the most significant is the mismanagement of the preliminary study of the project. Indeed, the local authority (the land owner) has not paid on time the expropriation of the owners of kiosks within existing space. Yet this issue was raised during the study during several meetings organized within the organism.

The poll survey showed that 50% of respondents have heard of this project by the population itself (Figure 1). Indeed, information is poorly disseminated by the project managers. We

note the lack of communication with the population. Thus, the poll showed that the authorities did not ask the opinion of the population on how to redesign the public space in question.

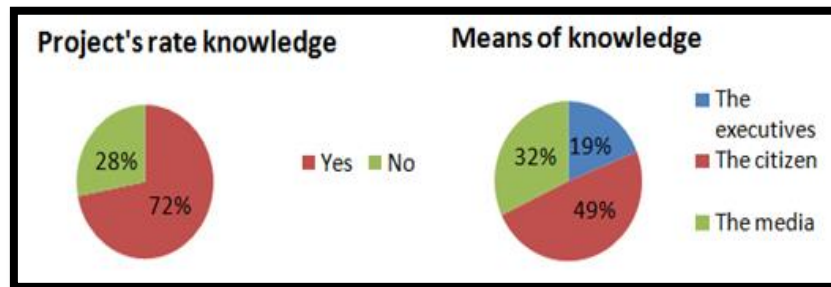


Figure 01: Project intention of citizen

This result confirms that the citizens are not integrated into the decision making process and in the assembly of the project. Addition to this, the lack of local of associations who could play an important role and could be heard.

4. Conclusions: This study aims to implement an intervention proposal for the project Revitalization and Urban Regeneration of the City center of Constantine lot: "Ahmed Bey." The architectural project is a citizen action, and shows the importance of citizen consultation. The work of the architect shared with project owners and users is the heart of the city life. Indeed, to solve the problem between the project owner and the citizen, a set up of an open consultative approach, scalable is essential in management project through various tools and means.

Finally, we quote the words of "Aminata KONE" (General Secretary of the Trade Union Confederation of Families): « The consultation is a tool as it gives power to the inhabitants, that of being associated with the preparation and development of projects. I believe that the projects we followed pursue this is strong guiding idea, Search for new conditions for a new citizenship in order to build together the common reference values favorable to ownership by the occupants.» [2]

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OVERVIEW AND ANALYSIS OF STUDIES ON GENDER CAREER BARRIERS IN THE CONSTRUCTION INDUSTRY ACROSS 14 YEARS

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Keywords: *Career Barriers; Construction industry; Discrimination; Gender*

1. Introduction – Although women have greatly advanced in the world of work, progress has been very slow in the construction industry where “gender stubbornly remains a marker of division” [1]. This industry has long been a site of gender discrimination across cultures and nationalities, and women remain under-represented [2, 3]. In Spain, women’s presence in the construction sector is progressive but slow, barriers and inequalities in hiring conditions still exist, and there is horizontal and vertical segregation [4]. The construction industry presents a major challenge for women’s inclusion and equal opportunities. But for an improvement in the numbers of women employed in construction, it is necessary to identify and understand the potential barriers they must confront when trying to enter the industry and in their future career development.

Career barriers are viewed as obstacles preventing forward movement, they can be defined as “events or conditions, either within the person or in his/her environment, that make career progress difficult” [5]. In addition, they are said to enforce “the glass ceiling” where prejudices within the work place give rise to work practices that discriminate against women.

Many articles on career barriers faced by women in the construction industry have been previously published, but most of them do not offer a comprehensive and systematic literature review covering most countries. This article tries to fill in this gap. The specific goals of this paper are to identify the following variables related to previous research on the subject published from 2000 to 2014: construction professionals under study, countries where each study has been implemented, research methodologies used, relevant journals and most important career barriers.

2. Methods – In order to review empirical studies on career barriers in the construction literature, a preliminary search was carried out in various online databases (Science Citation Index, Social Science Citation Index, Scopus, Association of Researchers in Construction Management (ARCOM), Redalyc and Google Scholar). Combinations of several keywords were tried to search for publications such as: “architects”, “career barriers”, “discrimination”, “gender”, “construction industry”, “engineers” and “women”. This preliminary search resulted in a broad selection of a large number of works that included empirical, theoretical and conceptual articles, unpublished dissertations, books, magazine articles, conference papers and official documents. In order to separate empirical studies from the larger pool the following selection criteria was established: the research is written either in English or in Spanish language and is empirical in nature. Finally, the study covers papers published over the past 14 years, that is from 2000 until 2014. It was also decided to select refereed articles from journals and conferences, as these articles have gone through the peer review process and therefore achieved an acceptable quality. A total of 56 works were found addressing the subject and fulfilling the required criteria.

3. Results and Discussion – Participants under study have usually been professional women such as architects, civil engineers, building engineers, quantity surveyors, technical professionals in general, or senior managers in small construction firms. The situation of women construction workers has also been analysed. Most studies consider only women in

their samples, but some also include perceptions from male subordinates, colleagues, superiors and/or employers. Furthermore, some authors analyse perceptions of career counsellors working at education institutions, and trade unions and employers' associations.

Great Britain is the country where most empirical research has been implemented, but other countries with significant number of studies are the USA, Australia and Canada, followed by Bangladesh, India, Malaysia, Nigeria, Palestine, Singapore, South Africa, Thailand, Turkey and Spain. International comparisons have been carried out between Great Britain and Spain, Great Britain and Australia, Thailand and Bangladesh and several European countries.

Most studies are qualitative in nature, and use in depth face to face or telephone interviews, and/or focus groups for data collection. But a few quantitative articles using survey questionnaires to collect information, as well as "multimethod" research, have also been identified. Studies included in this review are cross-sectional in nature, leading to a bias in static analysis. Sample size is also quite dispersed, with samples ranging from 7 up to 1.290 women participants.

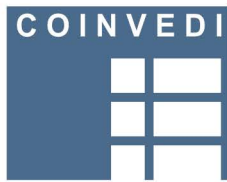
Studies have been published in four types of journals with different scope. There are journals related to sociology such as "Work, Employment and Society" and "Sociology" and journals focused on gender and feminist issues like "Feminismos", "Journal of International Women Studies", and "Gender, Work and Organization". But technical journals closely related to the construction sector and engineering have been extremely prolific, with "Construction Management and Economics" publishing 11 papers, and "Revista de la Construcción", "Journal of Management and Engineering", "Building and Environment" and "Engineering, Construction and Architectural Management" being also relevant. Last, the field of education is also identified with "International Journal of Construction Education and Research" and "Journal of Professional Issues in Engineering Education and Practice".

As regards career barriers pointed out in the literature, the most noted are difficulties in balancing work and family life followed by gender stereotyping (Table 1). Furthermore, the lack of professionalism in human resource management, since promotion, tasks assignment, recruitment and selection, monetary compensation and performance assessment discriminate against women. Difficult working conditions and a sexist culture are also outlined in many studies, followed by harassment and lack of respect. Finally, not being part of formal and informal social networks and women themselves are identified as barriers for women's career development.

CAREER BARRIERS	NUMBER OF STUDIES
- Work-family conflict	24
- Gender stereotypes	24
- Promotion	19
- Task assignment	19
- Working conditions	18
- Sexist culture	17
- Recruitment and selection	17
- Harassment and lack of respect	15
- Monetary compensation	11
- Performance assessment	8
- Social networks	7
- Women themselves	7

Table 1. Identified Gender Career Barriers Source: Personal compilation.

4. Conclusions and reflections – According to our literature review, career barriers confronted by women in construction are still a real problem that has been thoroughly studied in many countries across the last 14 years. Due to the few references focused on the Spanish case, we conclude that our country is not very sensitive to the issue and lags



behind. The reason for this might be the false and blind idea that gender equality has already been achieved. This study is vital to new researchers in aiding them to obtain a wider perspective of career barriers faced by women in the construction industry all over the world. We hope it will motivate further studies on the subject.

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AN APPLICATION OF THE HEDONIC PRICES MODEL TO THE SECOND-HAND HOUSING MARKET IN ALICANTE

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Keywords: *Regression, hedonic models, second-hand housing selling prices, Alicante.*

1. Introduction –The aim of this paper is to analyse the influence that the characteristics of second-hand housing located in high collective buildings in three areas of the city of Alicante have on their selling price. For this purpose hedonic methodology, which is based on the idea that the utility provided by a house derives from the characteristics it possesses, has been used. Zietz and Sirmans (2008, p. 318) suggest that hedonic regression analysis is usually used to identify the marginal effect of a set of features on the price of housing. That multitude of features, which are present in heterogeneous goods such as a house, can affect its value, and hedonic methodology is used to estimate the contribution of the same, (Sirmans, Macpherson, & Zietz, 2005, p. 3).

Hedonic pricing methodology has been used prior to the housing market in automobiles, various authors¹ highlight the work of Court (1939) for incorporating improvements to the methodology of analysis. In the housing market, the first application of hedonic pricing methodology is in Ridker and Henning works (1967), being the first who tried the determinants of home values, with particular reference to environmental issues, as air pollution in a particular area (Tabales Nunez, 2007, p. 237). However, it was not until the work of Rosen (1974) when a unified treatment of the theoretical model of embedded markets underlying the hedonic price model is provided, becoming generally accepted as the paradigm of the hedonic approach (Nunez Tabales, 2007, p 138; García Pozo, 2007, p 57). It is therefore the seminal work of Rosen (McGreal & Taltavull of La Paz, 2013, p. 2025), which marked a turning point and it is since his work, when applications of the methodology of hedonic prices occur.

2. Methods – The literature that deals with the study of prices using hedonic methodology, shows how they have had in mind a large number of variables that define characteristics of the good that is analysed. Sirmans, and Zietz Macpherson (2005, p. 9-11), made a comprehensive summary of these peculiarities which have been classified into eight categories based on structural, internal, external characteristics as well as the natural environment or location of the neighbourhood environment, the resulting environment utilities, market factors and financial issues.

This paper focuses on the type of second-hand housing located in high collective buildings and it is based on a sample of 199 houses of which both external and internal characteristics have been obtained.

All data collected come from the website idealista.com and the virtual Land Office. As shown in Table 1, on average it is homes located over the fourth floor, over 30 years old, with 3 bedrooms, close to 100 m² floor area, and priced at approximately 80,000 euros.

¹ Reference on this author may be found in the works of for example (Sirmans, Macpherson, & Zietz, 2005, p. 6; García Pozo, 2007, p. 55; Núñez Tabales, 2007, p. 137)

Variable	Minimun	Maximum	Average	Standard deviation
Floors (number)	1,00	16,00	4,46	2,44
Age (years)	6	65	32,33	17,09
Bedrooms (number)	1,00	4,00	3,04	0,66
Built floor area (m ²)	53,00	185,00	99,81	22,81
Price (Euros)	25000,00	230000,00	79832,71	42768,05
N=199				

Table 1 Quantitative variables

The objective is to analyse the impact of the characteristics of second-hand housing in the advertised sale price. Given the heterogeneity present in buildings, hedonic methodology is used as the most coherent, and the model shown in equation (1) is considered, using an ordinary least squares regression and the stepwise method for selecting variables, this introduces or removes them based on statistical criteria (Alvarez C., 1995, p. 111-112).

$$P = \beta_0 + \sum_{i=1}^n \beta_i * X_i + \mu \quad (1)$$

3. Results and Discussion- Results indicate that the model meets minimum levels of robustness and significance in the estimated parameters which makes it acceptable for inference. From the results, it appears that the greatest impact on the advertised sale price has been obtained for the construction area, followed by the presence of kitchen and elevator, having been obtained in the last two cases a similar impact on the estimated parameters. The other variables show, in absolute value, a similar effect on the selling price.

4. Conclusions - There are many characteristics that can influence the selling price of a home, in this paper we have evaluated some of them. The results obtained are in line with those achieved in other studies and suggest that the built area, the presence of a lift and the availability of an independent kitchen are the features that have a greater positive impact on the advertised sale price of second-hand homes located in high collective buildings in three areas of the city of Alicante.

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TEMPORARY STRUCTURES: LEGAL VACUUM. DEFINITION OF REQUIREMENTS FOR INSTALLATION AND REMOVAL

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Keywords: *Temporary Structures, Legal Vacuum, Normative.*

1. Introduction - This research deals with the terms of use and establishment of temporary structures like awnings, in relation to the currently required parameters for installation, assembly and disassembly. This research will highlight the serious legal vacuum which directly affects the execution of this type of constructions linked to the safety of people who use it. This causes that this large industry, which is settled in this situation of legal ambiguity, is not able to innovate.

The importance of this construction and industry sector is evident. According to the National Association of Awnings and Mobile Structures (Asociación Nacional de Empresarios de Carpas y Estructuras Móviles) (ASPEC) [1] the Mobile Structures and Textile Architecture Sector (awnings, aluminum tensed structures, big tops, removable platforms, stages, internal and external fittings, etc.) estimates a turnover of over 700 million euros in Spain. ASPEC underlines that with an influx of public between 21 and 36 million in the roaming sector and over 18 million in the semi roaming these architectural establishments are the second public places after supermarkets and malls.

In Spain there is a legal vacuum in what refers to installation, assembly, industrialization or regulation and standardization of this sector belonging structures. The Law on Construction Planning (Ley de Ordenación de la Edificación) (LOE) or the Technical Building Code (Código Técnico de la Edificación) (CTE) excludes temporary structures of its scope, leaving aside the temporary removable buildings, while the above NBE-CPI / 96, now repealed, defined the term "building" in a more ambiguous way, but allowing to include these structures. The European Union establishes a technical standard called EN 13782: 2005 Temporary structures - Tents -Safety [2]. The Spanish law has collected it through the not binding UNEEN 13782: 2007 law. It does not define the requirements for installation, assembly or disassembly, which causes a clear lack on the control quality and execution processes. In countries like France [3] and Germany [4], this control process is obligatory for the most of these structures. These establishments have in most cases a public use and local governments establish by themselves installation permits or conditions needed. The main objective of the research is to analyze through a comparative analysis of 40 different cities the national requirements needed at present, achieving:

- Conclusions about the comparative requirements of the 40 cases studied.
- Set points of common requirement in all cases and establish and agree on the necessary requirements to give public administration a clear, consistent and concise tool to regulate this type of constructions.
- Relate the requirements to establish in advance of a new obligatory regulatory framework.

2. Methods - This research study was carried out collecting the necessary technical requirements for the temporary establishment of tents and temporary structures in a total of 50 Spanish cities. The enquiry was done by direct contact with municipal technicians, by collecting the web documentation provided and the provisions of the bylaws in which the subjects of study

were contemplated. The purpose of the survey, as referred to above is made, it is to obtain an empirical reality sample of the sector regulations which establish common standards and differences between the administrations consulted.

The legal aspects taken into account are especially referring to what kind of documentation is required, what information should be provided by the owner of the structures and what individual or entity have to act as a guarantor of the documentation above is correct and truthful. The results of the exhaustive survey of the documentation required by the 40 local governments is outlined by a comparative analysis.

3. Results and Discussion - The comparative analysis concludes that at present in Spain the setting of this type of constructions (execution, assembly, disassembly, quality control, execution control, durability, etc.) are not regulated neither clearly nor accurately. In the absence of clear implementation rules, these local governments set requirements that do not conform to the use or characteristics of the structure whose documentation is required to establish conditions of installation. Due to the lack of a clear and effective rules, the local administrations and technical offices have not clearly established the requirements to apply to this type of establishments, assuming a clear risk to people.

It is concluded that in the requirements requested exists a clear mismatch, inconsistency and serious heterogeneity demonstrating the difficulty that governments have to regularize this construction sector. This is motivated by a vacuum of specific regulations, highlighting the urgent need for the definition of a national policy framework that establishes the execution conditions, maintenance, quality and dismantling control, specific regulations appropriate to the specific requirements of removable temporary structures, and to ultimately serve as a stimulant for innovation processes in these complex building systems.

4. Conclusion - It is proposed, a normalization of the sector in relation to the establishment and installation of these structures which should be considered as the basis on which to build the ideal regulatory environment that this profession urgently needs. We understand that this issue is extremely important due to the great accident record in the sector, the large current boom in the use of such interventions, their widespread use in mass events and the direct involvement with the safety of people.

The drafting of common rules applicable throughout the territory, to standardize the requirements and to rectify the lack of clarity and precision that exists today is necessary. The lack of specific regulation on this matter leads to a decrease in the efficiency and usefulness of the checks carried out by municipal corporations. Because if there are no clear requirements, it is difficult to control them or determine whether the requirements are met. In conclusion, the necessary innovation in this type of architecture is to provide it with a regulatory framework with which work in a common and regulated way, stablishing, clearly and concisely, minimum standards for assembly, disassembly, maintenance, safety and use of temporary structures.

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THE NEW SOCIO-ECONOMIC CONTEXT AS A DRIVER OF INNOVATION IN PROPERTY DEVELOPMENT

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Keywords: *Building; Innovation; Operations; Development*

1. Introduction – The development of property projects in the current economic context, caused by the financial crisis which began in 2007 and by the economic downturn that it triggered, requires a high amount of innovation and effort by the private sector (RREEF Research, 2010).

There is no question that for the world's real estate market the events of recent years represented the greatest crisis since the 1930s and had a devastating impact on the real estate and construction industry (Kroszner & Shiller, 2011).

Moreover, the importance of real estate industry is clear taking into account its capital-intensive activity and displays particularly high levels of tangible investment. In 2010 it employed 2.0% of the non-financial business economy workforce in Europe and generated 3.9% of the total non-financial business economy (NACE, 2013).

In this scenario, there is a clear need for the construction and real estate organizations to incorporate innovations in the development value chain (Figure 1) such as project management, operations, technology and business models (Calderón, 2001). This may provide the success in this new context.

+ Higher Project Activities

- Lower Project Activities

Land Provision	Land Planning	Urbanization	Construction	Asset Management

+ Public sector leadership

+ Private Sector Leadership

Figure 1 Real Estate Value Chain ¹⁾

1) Public entities usually play an active role at the initial stages of projects where the risk is more acute and private companies are not adequately incentivized

Source: (Roig and Soriano, 2015).

In view of the above, this paper analyses the new innovative trends in property development taking account that real estate projects have a positive effect on societies as they attract economic activity and commercial development, and provide decent and affordable housing (Roig and Soriano, 2015). Therefore, it is important to design appropriate methods for developing real estate projects which cannot prosper with private initiative alone and which require public participation.

2. Methods – The methodology applied in the study is outlined below.

First, we review the global scientific literature on innovation in the real estate value chain, in particular with reference to the residential development.

Second, we compile data from successful Spanish developers, the National Stock Market Commission (hereinafter, CNMV), the Alternative Investment Market (hereinafter, MAB), as well as on-line information from Spanish Developers websites and interviews.

Finally, the study analyses the current situation of property developer's in real estate industry and identifies the main forms of value chain innovation such as operational or building management in the success cases. That is, a case study analysis of innovative developers is presented.

3. Results and Discussion – In this section business success in the real estate industry is explored during the financial crisis. On this basis it is concluded that construction and real estate sector is considered less intensive in research and development, innovation is a key success factor. Moreover, innovation is not only reflected in construction materials but also in key processes of the industry value chain such as the management of land purchase, land development, the assembling of the materials or the innovation in the sale process (Teece, 2010).

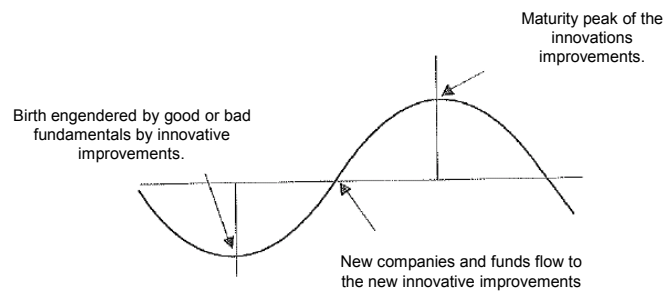


Figure 2. Innovation Life Cycle

James Montier (2003) introduced the Life Cycle of an Investment Style that can be adapted to the Innovation Life Cycle (Figure 2). Is in this spirit that Hewlett and Kaufmann (2008) suggested that property developers strategy should be adapted in accordance with socio-economic environment. New revolutionary business forms can be found in companies like Corp-Promotores, La Casa Por el Tejado or Activitas Inversión Inmobiliaria.

4. Conclusions - The present socio-economic context caused by the financial crisis have shown that there is a room for innovation in the property development industry that may lead to a key business success factor.

The new trends being introduced aim to make an effort to do things differently, in particular, aspects of the industry value chain. This results in an improvement of the adaptation of companies to the economic context, ending up in a better competitiveness and strengthens the capacity to generate profits.

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MHCP NICARAGUA: USE OF BIM IN INTERNATIONAL PROJECT MANAGEMENT

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Keywords: *Project; BIM; Management; International*

1. Introduction – The Project carried out by Acciona Engineering for the Ministry of Finance and Public Credit in Nicaragua (MHCP) arises from the need to create a new building complex which centralizes and modernizes the existing buildings of the Ministry. Currently, they have serious shortcomings in their infrastructure, services and functionality, which leads to high operating and maintenance costs.

Therefore, a new set of buildings has been designed. They will accommodate the different areas and services currently in use, and, at the same time, will be able to undertake the growth planned by the Ministry and its future needs.

In the project, prismatic volumes have been arranged over the ground level building working as a baseboard which runs throughout the complex as a "loop" that communicates all its uses. At the same time, it meets with the need of separating private from public areas. Different alternatives of restricted or public circulation routes for the users have been taken into account. The prisms, mainly allocated for private offices and open areas of the Ministry Departments and Divisions, take advantage of their location on the upper levels due to the views towards the main boulevards and the lake.

On the other hand, the "loop" hosts the public areas of the complex and all the retailing uses that serve the private areas, such as auditorium, cafeteria, etc.

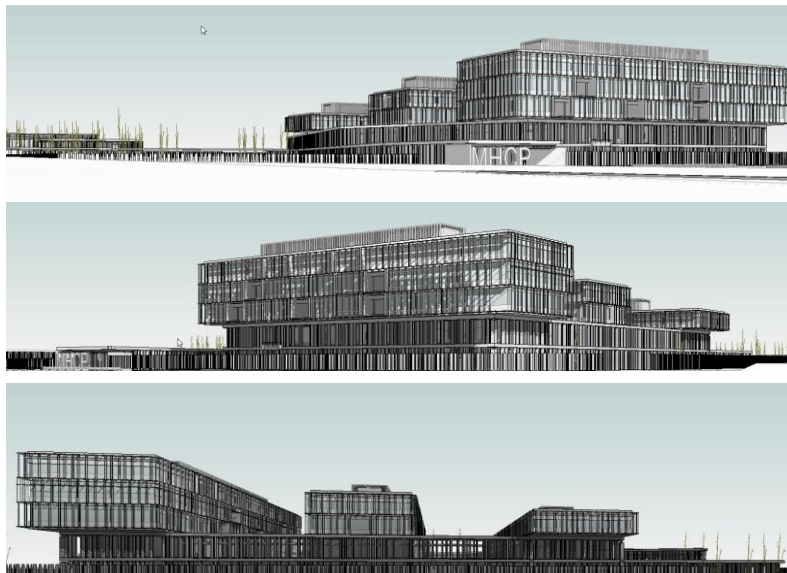


Figure 1 Concept designs

2. Methods – One of the most significant features of the work carried out by Acciona Engineering has been the use of **BIM methodology** (Building Information Modelling) applied to an **international working background** where some tasks were developed in Nicaragua and other in Spain.

BIM consists of a process focused on the development, use and transfer of digital information of a project. It is based on the generation of an informed and permanently stoked model where software interoperability and collaborative work allow the whole project to be stored in a single model.

The expansion of businesses related with engineering consultancies towards international settings, entails the imperative need of renovation. Therefore, it has become completely necessary to adopt new working methods and requirements of those countries where projects are to be developed; in this case Nicaragua. This is where BIM methodology comes into play, and an effective multidisciplinary work has to be developed by each member of the team.

3. Aims – From the point of view of project management in MHCP Nicaragua, the principal aim was to develop the project in a 3D environment reducing run-times as much as possible. The following aspects directly related with the application of this methodology, should mean the key of success along the drafting of the project.

- Assigning of specific roles:
 - o BIM Manager that from Madrid worked as a bridge of communication and information channel with Nicaragua.
 - o Project Manager responsible of the decisions that had to be taken related with the project.
- Communication and coordination between the different disciplines (Architecture, Structure and MEP) allowing anticipation of problems and possible interferences between them.
- Adaptation to the level of development, detail and project requirements.
- Planning and distribution of tasks according to real skills and dedication of each team member based on the requirements of each project state.
- Establishment of a clear criteria and work process', unambiguous, systematic, organized and planned.
- Ability to provide quick solutions to difficulties, adversities and vicissitudes when working in an international project.
- Management of models using links for each discipline, which are associated with a single and central model managed from Madrid.

4. Results – Collaborative work of the different agents involved in the project, a proper management of the information and an appropriate coordination of each activity and discipline have become the most important aspects of the project to focus on. The use of BIM not only improved the quality of the project, but also the design processes reduced run run-times, equipment and production costs up to 30% in comparison with traditional methods.

5. Conclusions and contributions – Taking into consideration that worldwide consultant companies are migrating to BIM project designs, the challenge of change must be assumed to keep being competitive. The conclusive results detailed above, confirms that this direction is the right one. It can therefore be said that although the initial investment requires a great economic effort in technology and training, the results exposed above makes it worth enough as it enables companies to have a preferential position when facing towards nowadays international competitive market.

THE PROJECT OWNER ASSISTANT: A NEW OPERATOR IN LARGE-SCALE PROJECT. THE CASE OF THE GRAND MOSQUE OF ALGIERS PROJECT

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Keywords: Building management, stakeholders, assistance in project management, grand project

1. Introduction – Algeria, The largest country in Africa, the Arab world, the Mediterranean and the tenth largest country in the world. Algeria covers an area of 2,381,741 km², its capital Algiers, occupies an important strategic position geopolitically in the African continent. This last decade, major projects initiated in this capital constitute the driving force of development and enhancement of the capital.

In Algeria, it is primarily the capital upgrading which polarizes the new investments; from the reconquest of the waterfront, to the redevelopment of some neighborhoods, passing by the structuring of the periphery, the lighting plan, the transport macro

meshing, the urban boulevard, the “agri parks” belt and other walks. The capital is living the pace of change in order to become around 2030, «Algiers world city» [1].

Indeed, the city of Algiers, as part of its strategic plan, has been chosen to be presented among the 25 largest cities in the world that have the potential to the highest development [2], it is also the 5th largest city of the future in the African continent after North Africa, Cairo (Egypt), Tunis (Tunisia) and Casablanca (Morocco) as reported by the US firm Price water house Coo (PWC) 'cities of opportunities» [3].



Figure 1 Case study: project of the Grand Mosque of Algiers. Source: Wikipedia.com

A great objective criterion which puts the city in competition is the existence of large structured and planned projects. And the project of the Grand Mosque of Algiers is the major pilot project at the present with a strong mobilization of public and private stakeholders to properly carry it.

In this sense, to meet the requirements of efficiency, management of mega projects in the urban framework is based on several pillars that fall within governance [4]. The fundamental elements of these pillars are: the administrative structure and its managerial instruments, managerial techniques and competent human resources (expertise [5] represented by foreign assistance in project ownership, which is often essential to help the project bearer and the project leader in their organization tasks in the process and coordination of actions to be undertaken in specific projects).

So, our research question is as follows: how the project owner assistant skills are the key success factors for the project bearer at the managerial, technical and decision making level?

The question is then a reflection about the involvement of the project owner assistant and his technical, managerial and decision-making skills as a new operator in the management of projects in Algeria.

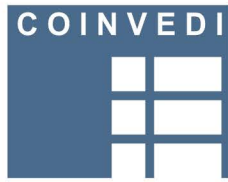
2. Methods – To conduct this research we opted for a qualitative- analysis [6] and the realization of afield survey throughout semi-directive interviews with the different actors of the Grand Mosque of Algiers project in order to draw a more complete picture as possible of our project process.

3. Results and Discussion – The results of our analyzes (in progress) will enable us to make a diagram of actors in the process of developing a major project which will be identified and defined: the role of the project owner assistance in terms of major project management and the opportunities the later offers for general management efficiency in specific projects such as our case study, drawing on “Project Management Fields” [7].

4. Conclusions - Our research focuses on the role of assistance to the contracting and the project owner assistance regarding the management side of work, in developing countries, to clarify what skills are key success factors for the project holder. The purpose of this study is to clarify the positioning and the contribution of the new operator in mounting a particular project in a developing context, therefore major projects meet the end their goal in terms of cost, deadlines and quality.

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CONTEMPORARY METHODOLOGY FOR INFRASTRUCTURE PROJECT MANAGEMENT, DISPUTE AVOIDANCE AND DELAY ANALYSIS

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Keywords: *Project Management; Record Keeping; Dispute avoidance; Delay*

1. Introduction – The delivery of an infrastructure construction project is a complex process, not a mere event. Delays to the completion of the project are often caused due to the large number of parties involved and the variation in the way these parties perceive important issues of the construction process. There are affecting factors such as weather or miscalculations that cannot be foreseen. Furthermore, changes to the scope of the works or the methods, which are carried out are, in most occasions, unavoidable. Therefore delay is, undoubtedly, an issue that affects, if not all, the majority of infrastructure projects.

Considering the high costs involved in a construction project, none of the involved parties wishes to be held responsible for and bear the extra costs and expenses caused by delay. The justification of cause and effect of delay events often comprises a major dispute issue in construction cases. Concordantly, the delay analysis is forming a significant element in the resolution of construction disputes. In such cases, the quality and quantity of available records will be crucial as well as the delay and disruption analysis itself [1]. Of course, the ultimate aim of the professionals involved in the construction industry would be the avoidance of disputes. However, if one seeks to avoid disputes, he should seek ways to predict them, by taking the necessary actions to avoid delays [2]. Therefore, the efficient and systematic recording, and the effective management of a construction project programme [3] may be essential elements of dispute prediction and avoidance in order to have a successful project.

The methods used for record keeping are mainly the site diary, reports, correspondence, progress meetings' minutes, drawings' updates, variation instructions and site photographs. The progress of works is usually presented and monitored by the contractor by updating the initial programme, which is in the form of Gantt charts. However as-built programmes may have uncertainties and inaccuracies, and there may be certain mistrust from the part of the receivers, including the courts, regarding the subjectivity of the information [4]. Additionally, many interested parties that need to take important decisions related to the project progress may find it hard to visualise the progress of the works as described by the programme's Gantt presentation, and obtain an accurate position and location from text-based illustrations of a traditional schedule [5].

At this point, the question that arises is whether there are any other options that could provide efficient and transparent record keeping, to increase the effectiveness in project management and decision making to avoid delay. Is there a framework that can increase the transparency of the construction process, and works progress of a project to a such level that disputes will be avoided, or in case there is a dispute, to have the actual facts presented in detail before the arbitrator or adjudicator and thus decreasing the duration and cost of the resolution procedure?

2. Methods – In this paper a contemporary methodology is proposed for efficient and transparent record keeping and sharing, to achieve more effective project management and decision making, delay and dispute avoidance, and cheaper dispute resolution. Modern technology tools are utilized to provide important and useful information, both spatial and descriptive, to a Geographical Information System (GIS) central server, which in turn provides reports regarding milestone issues related to the project works, as shown in Diagram 1. The tools that will comprise the proposed methodology are the following:

- i. Time lapse cameras placed in various positions of a project site, programmed so that by using time lapse photographs a short video of the works can be created. These videos represent the traditional “site diary and reporting”.
- ii. GPS and smartphone mobile technology so that the machinery presence and motion on site can be patterned. A similar approach can be used to document human resources presence.
- iii. 3D (or 4D) visual illustration of the milestone works progress using UAV and BIM technologies.
- iv. Direct comparison between the theoretical programmes of works as used in the traditional way of project works management by using 3D illustrations.
- v. High resolution satellite imagery for periodic works progress presentation.

3. Results and Discussion – This objective of this paper is twofold; it explores the causes of disruption and delay to infrastructure construction projects and the current methods for delay analysis and dispute resolution, and proposes a contemporary methodology, which is comprised by a GIS Server, as shown in Diagram 1, that will enable the collection of information from various sensors by means of modern technologies, and then generate reports regarding significant issues with regards to the project. This technique can provide an efficient, unbiased and transparent record collection and sharing the results to all interested parties within the framework of a project. This is a crucial element towards more effective project management and decision making for delay and dispute avoidance and, if needed, a more effective and cheaper dispute resolution procedure.

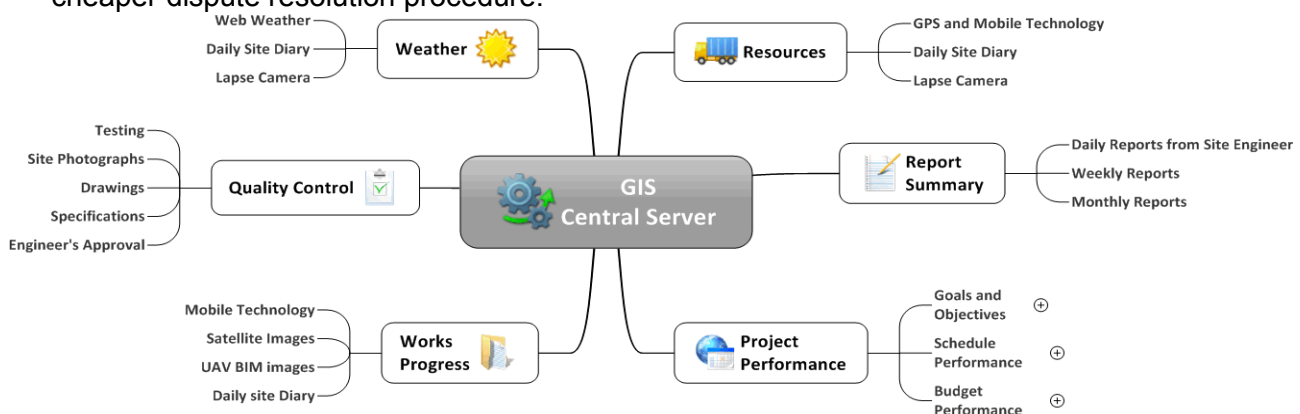


Diagram 1: Demonstration of the proposed instrument

4. Conclusions – The causes of disruption and delay to infrastructure construction projects are known but inevitable, and the current methods for delay analysis and dispute resolution are expensive and faced with suspiciousness. A contemporary methodology including the use of modern technologies is proposed for efficient and transparent record keeping and sharing for effective project management, delay and dispute avoidance and cheaper dispute resolution.

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III INTERNATIONAL CONGRESS ON CONSTRUCTION AND BUILDING RESEARCH (COINVEDI)

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HEALTH AND SAFETY IN BUILDING CONSTRUCTION

HEALTH AND SAFETY RISK ASSESSMENT METHODS IN BUILDING CONSTRUCTION: AN OUTSTANDING PROBLEM.

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Keywords: *Health and Safety; Risk Assessment; Construction Risk; Workplace.*

1. Introduction – This work has begun from fundamental concepts such as the right to live of people [1]. It has managed to materialize in the form of laws and social awareness regarding the magnitude representing the Health and Safety of people in workplace. This compendium leads us to act in the prevention line, researching about it [2], [3]. So that they make us understand that improving the Health and Safety starts from oneself and the need to share knowledge.

The large number of laws, methodologies and guidelines [4], [5] accompanying the assessment of risks in business, don't reflect a lack of safety culture that exists in today's society. In Europe, as in other parts of the world, the reduction of work accidents is an immediate social priority and, as a result, accident prevention and risk management is a crucial issue within the construction industry [6], [7], [8]. In other ways application different methodologies are been studying [9], [10], [11].

Diverse methodologies analyse work and environment, type of business, labour, workforce, location, etc., valuing independently, security risks, hygiene, ergonomics and social psychology within subjective ratings. These are the following methods to this research: INSHT, '*Instituto Nacional de Seguridad e Higiene en el Trabajo*' [12]; ANACT, '*Agence Nationale pour l'Amélioration des Conditions de Travail*' [13]; RNUR, '*Régie Nationale Des Usines Renault*' [14] and FINE, '*Mathematical evaluation for controlling hazards*' [15], [16]. The objective is an analysis of labour risk assessing methodologies and their comparison. Furthermore, identify a new proposal for risk assessment focus on edification. Results indicates disparity outcomes between the methods, that together with the evolution of technology and complexity of construction work requires the need for a new method based on the analysed, adapted to building works.

About this new methodology: The evaluation of preventive action (E_{pac}) is defined as the ratio between the level of preventive action (L_{pac}) used in the work and the absolute risk or initial risk of project (R_{ab}). This factor measures the relationship between the level of preventive action used in the work and the absolute risk defined in the Health and Safety Study of the Project Construction.

2. Methods – The methodology is a theoretical - analytical study with an innovative proposal. This paper discusses different methodologies of risk assessment in construction works. Four methods of risk evaluation have been selected based on the ability to better adapt to the characteristics of the construction sector: INSHT, ANACT, RNUR and FINE. These four methods have been applied to three building constructions (models) of different features: Model 1, detached house with garage; model 2, rehabilitation of an urban space on a street in the historic centre of Toledo; and model 3, state school for educational use. In each construction work, three high accident phases were analysed: structure, façades and roofs. The research studies 10 working risks, classified according to the technique used against that particular risk, that is: safety at work (4), industrial hygiene (2), ergonomics (2) and applied social-psychology (2). The figure 1 shows a graphical abstract.

3. Results and Discussion –

Results show that there are very significant differences in terms of risk types and levels of risk that each method is capable of signalling, depending on the type of work analysed. In common practice a risk assessment is carried out in the phase of adjustment to the regulation with the Health and Safety, by applying the INSHT. In the contracting phase, the construction company drafts the Health and Safety Plan using the same concepts and adapted to the media business. And in the implementation phase of the Health and Safety Plan without knowing a priori the factual conditions of the project, the contractor and the work itself is approved. Risk evaluation methods must incorporate and unify concepts of the building works, adapting to the complexity of organization and management of construction works.

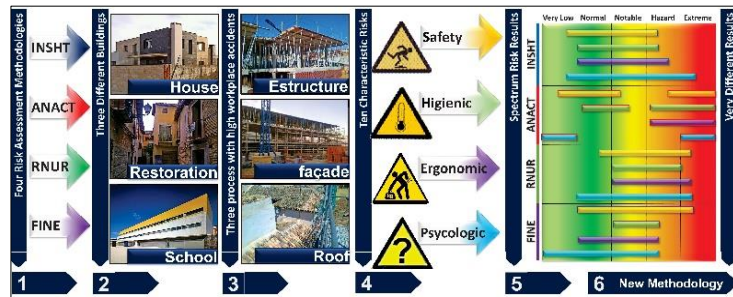


Figure 1. Graphical abstract.

This new evaluation methodology indicates the trend of risk depending on the security measures and sets the level of preventive action in each of the phases of the building. Figure 2 shows the new formula: Evaluation of the Preventive Action.

$$E_{pac} = \frac{L_{pac}}{R_{ab}} = \frac{\text{Preventive Action Level}}{\text{Project Initial Risk}}$$

Figure 2. Evaluation of the Preventive Action.

4. Conclusions - The new method considers the preventive action, allows the analysis of overall risk and partial risk, adapted to all kinds of businesses, within qualitative and quantitative parameters, and is adapted to the building works. Their implementation of the construction of a building of 78 homes in Toledo for 2016 is expected.

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RISK MANAGEMENT FRAMEWORK FOR INTERNATIONAL CONSTRUCTION JOINT VENTURES (ICJVs)

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Keywords: *Risk management, international construction, joint venture, risk measurement scale.*

1. Introduction – The construction industry is one of the most dynamic, risky, challenging, and rewarding fields [1]. So risk management is an imported part of the decision-making process in a construction company [1] and now widely accepted as a vital tool in the management of construction projects and even joint ventures. Risk management is about defining sources of uncertainty (risk identification), estimating the consequences of uncertain events/conditions (risk analysis), and finally generating response strategies in the light of expected outcomes [2]. A joint venture (often abbreviated JV) is a market entry mode formed between two or more parties to undertake economic activity together [3]. Construction companies are encouraged to enter foreign markets in the form of joint ventures and come up against a set of risks for joint venture process. The identification of risks is seemed to be important for success rate in joint ventures for construction companies. Researchers have found that a large number of ICJVs fail to achieve the goals and objectives that were originally established [4]. In developing countries -like Turkey- in particular the number of ICJVs that failed is significantly higher, >50%, as Beamish (2004) discovered in his study [5]. In this context the main objective of this paper is to develop a risk management framework for international construction joint ventures and to investigate the most important risk management measures for ICJVs.

2. Methods – The following methodology has been adopted to achieve the objective of this study:

- After an extensive literature review for the construct “risks for international construction joint ventures (ICJVs)” there were generated 42 variables in three categories namely internal, project specific and external. After that the generated framework was investigated with In-depth interviews and two focus group discussion.
- There were conducted face to face in-depth interviews with 3 Turkish construction industry professionals. The mean age was 35 and the work experience was at least 7-8 years. All of the respondents have worked in director position in an ICJV. Open-ended questions were mostly used and the interview was tape-recorded. Critical Incident technique was used for data-gathering from respondents.
- Focus group study was used as an additional source of data collection to provide “methodological triangulation”. In focus group studies the data need to be collected though group action on a topic determined by researcher, and also it comes from group interaction. Two of real focus groups were conducted in the scope of this research for validation the results. In real focus groups there is a moderated discussion, it should be a homogenous groups. The topic “risk management framework for international construction joint ventures” was discussed controversial, the main factors and sub-parameters were identified and interpreted.

3. Results and Discussion – After completing the focus group studies and in-depth interviews, both the literature review findings and the qualitative research results were analysed with content analysis technique. As a result 42 risk factors were identified under three main category (Figure 1), among these 42 items, 2 of them is generated during focus group discussions, 2 of them is generated during in-depth interviews and 38 of them are taken from previously developed scales. 42 items were coded under the three categories (internal, project-specific, and external) by two independent judges to predict the “coefficient

of agreement". Finally, the agreement percentage among these judges was analysed for the purpose of interrater reliability analysis. For this purpose Cohen's kappa value was calculated [6] [7] .



Figure 1. In the scope of these research developed risk measures for construction JV's

This study utilizes a combination of qualitative methods in-depth interviews, critical incident and longitudinal focus groups to collect data. It can be assumed that the study is strong by its instrumental validity and consultative validity for the construct "risks for international construction joint ventures" whereas triangulation method was used. Instrumental validity pertains when data are provided which match those "generated by an alternative procedure itself accepted as valid [8].

4. Conclusions –This paper has focused on the analysis of the different risk environments for an appropriate risk management framework for international construction joint ventures' success. By this study the proposed ICJVs' risk management framework include three main risk dimensions: internal risk factors, project-specific risk factors and external risk factors. Each dimension has its sub-items. Considering the internal risk factors "*Dispute*" was determined as the most significant risk element. Dispute means a conflict between two parents' JV Company. The participants decided though their own experiences that dispute would be a critical risk factor for construction joint ventures. On the other hand in the context of project-specific risk factors "*Delay of start and completion of the warranty period*" is the most important risk measure for management framework. This is because any delay in the warranty period cause cost overruns which is an important risk factor for project success. Finally by external risk factors "*Security problems at project site*" was predicted as the key risk element. Overall, it is a conclusion of this study that there are factors that a construction manager may observe at international construction joint venture inception that predict success.

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TOOLS FOR MANAGEMENT THE SAFETY ON SITE: “CRITERIA FOR DESIGN HEALTH AND SAFETY STUDIES” AND “CRITERIA FOR MANAGEMENT COORDINATION”

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Keywords: *Construction Safety; Coordination, Safety Studies, Management Tools*

1. Introduction –The new preventive vision born thirty years ago with the Law 31/95 Prevention of Occupational Risks, has its specific character in the construction sector in 1997 with the publication of Decree 1627/97. The new figures contained in this RD are the safety coordinator at the design stage and on site.

Since 1997 it there have been many publications to guide these functions and preparation of documents [1] [2]. However, we’ve detected a malfunction in the work of coordinating and design the safety studies [3]. He had not implemented generally a real prevention culture in the daily work of coordination and the design of safety and health studies. Still remaining doubts application functions as well as clear objectives of coordination and the need to document them [4].

Given the detected situation after studying existing guides, we consider necessary to introduce some specific, practical processes making a criterion to enhance the performance in terms of prevention and safety, and thereby improving the overall level prevention on site. The aim was to go beyond the technical criteria, connecting with the concrete processes to be performed by the technician either on site or at the design stage. Thus the guides are made a part of the theoretical framework that has its automatic application with specific integrate into the daily work of the technician in prevention activities.

2. Methods –The work was developed on two fronts. It began with safety coordination in the implementation phase, we thought topic requiring further support for the importance of the functions and dysfunctions that we detected that occurred at work [3]. To close the topic, addressing the full performance of the coach was full with performances technician draft stage in design the safety study.

1st Tool: Criteria for management the safety coordination.(Figure 1)

First step of the job was to study the existing criterias, looking that they established . condenses a practical and enjoyable means a sequence of activities to be performed by the safety coordination technician.

We try to distance the technician corrective functions [5], once the work started by linking it to work forecasting and study of the processes and site organization, which take precedence over the risks and problems of improvisation. It is the coordination redirect that preventive nature had not sufficiently developed



Figure 1

The guide provides actionable insight directly to the daily work, relating the actions and the documentation he needs. In this way it is structured to be done before, during and at the end of the execution. It includes what should be treated with different agents and administrations as well as the criteria for communication with each of them. Stands at emphasizing preventive marking given to acting coordinator, highlighting what to do and how to document it before the start of each work or work stages. The criteria are complemented by models of documents applicable for each of the actions of coordination as either phase of work, or meeting with agents, raised earlier in the guide.

Criteria for design health and safety studies (Figure 2) for building works deal with a similar format to the previous, to address the recommendations for the plan of these documents. It is essential work to be performed under the project will make the subsequent work of developing the security plan and coordination itself. Just as in the previous guide, it is complemented by annexes with examples and practical applications for the drafting of documents.



Figure 2

3. Results and Discussion—To ensure that they had a maximum exposure guidelines have been various efforts in several areas:

- A guide insert each magazine with national circulation truss to the entire group.
- Technical meetings for make public the publication of the criteria and the discussion of solutions and consulting doubt about it.
- A website (www.fundacionmussat.es) in which all the main documents of the guides are available, as well as all documentation referring to the guidelines for the effective conduct of proceedings. Such documentation is accessible and downloadable online.
- Actually we're working in a mobile application of the criteria of coordination, so that the technician has to work hand to manage aid coordination

4. Conclusions - The material provided is a new contribution, as a matter of practical application to those skilled safety on site in the day-to-day and preventive planning of the work, we think we have had an important impact and follow-up by this group. With initiatives like this are being made to increase the effectiveness of the activities in the field of prevention, which will help to improve safety conditions in the work and ultimately help to reduce accidents in the building sector.

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STUDY OF SAFETY AND HEALTH MANAGEMENT IN THE CONSTRUCTION SECTOR OF VALENCIA

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Keywords: *Safety, Management, Health, Construction*

1. Introduction

Construction sites are complex places of work and often unsafe for several reasons: its working condition outdoors, dependence on weather factors, the pace of work, the methods of execution, the high labor component and the high subcontracting (Pellicer-Armiñana 2003 [1]; Fuentes-Bargues et al. 2015 [2]).

The high rate of accidents makes construction works one of the most dangerous places to work, both Spanish level, European level (Ros-Serrano et al. 2013 [3]) and global level (Teo et al. 2005 [4]; Loosemore et al. 2007 [5]).

Many of the accidents in the construction sector are caused by errors of organization, planning and control (HSE 1988 [6]; López-González et al. 2012 [7]). Greater involvement of high company management and improvement of management are guidelines to achieve a reduction of the number of accidents (Mattila et al. 1994 [8]; Teo et al. 2005 [4]; Loosemore et al. 2007 [5]).

The aim of this paper is to study the current level of safety and health management in the construction sector in Valencia (Spain), from a survey conducted on a sample of technicians who have worked in different jobs in construction companies in recent years.

2. Methods

The method of this research is based on a survey of various aspects of health and safety management. This survey has been developed for a sample of technicians with experience in the construction sector in Valencia (Spain).

The study is divided into three blocks. The first block corresponds to general data of the participants, about their position in the company and about the characteristics of the company. The second section consists of questions about the organization of safety in the company and the third block corresponds to the safety and health management during the execution of the work.

3. Results and Discussion

The initial results obtained in this study are the following:

- The size of the company is a key factor for safety and health. The bigger size of the company has the bigger integration of preventive activities in enterprise policy.
- There is an important ignorance and in some situations is not available of the Authorized Business Registry (ABR, in Spanish: Registro de Empresas Autorizadas).

- The level of training in safety and health is commensurate with the size of the company.
- There is a high percentage of companies that do not develop on their own the required initial documentation of health and safety for starting a work. They usually hire the development of the documentation to external technicians or consultants.

4. Conclusions

Managing health and safety in construction companies is a key factor in preventing accidents on construction sites, and according to the preliminary results, smaller companies have severe problems.

As these type of companies are the largest number of companies in the sector and have the higher accident rates, the administrations should boost policies more effective on awareness and training in prevention of occupational hazards.

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EXPERIENCES AND RELATED TYPES OF JUDICIAL REPORTS ABOUT DAMAGE WORKERS ON CONSTRUCTION SITES

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Keywords: *Construction sites, Health and safety, Damage construction workers, Judicial reports*

1. Introduction – Accidents occurred on construction sites, cause or may cause, certain injury to workers or individuals related to the sector, which triggered from a legal point of view different processes where are involved in one way or another, several of the agents involved in the construction process.

At certain stages of the processes above, appears an expert work, which should combine the study of all the specific documentation of the case, with sufficient theory or normative knowledge and a clear awareness of the practice in the construction sector, that allows to determine and explain the necessary means, the causes of claims listed

This comprehensive study of real-life situations, will allow that expert work of the technicians concerned, get a clear idea of reference about real-life situations.

Therefore, based on such expert action effected develops exposure of a study of sufficient practical and real cases analyzed from 2009 to the present, with the intention of carrying out an approach to the existing reality that surrounds us, the target and studying real accidents in the sector through one sufficient number of case studies really happened.

This study aims, first of all a statement of the types of cases and agents affected and in second place, their relationship with the final results of the action and proposals which arise after their study.

2. Methods – Aims to firstly a previous study necessary understanding necessary to determine the phases in which divides criminal proceedings within the scope type construction and the need for expert evidence on the basis of each point in the criminal process.

In second place is a quantitative analysis on the cases studied on:

- Type of accident
- Type of construction
- Phase of work in which the accident happens
- Contractor / subcontractor
- Technical agents charged (ATI)
- Accused technical agents (ATA)
- No technical agents charged (ANTI)
- Accused no technical agents (ANTA)
- Type of accusation
- ATA condemned

- ANTI condemned

3. Results and Discussion – With the data obtained, we can determine the outcome of the action. Figure technique with highest percentage of accusation (Director de la Ejecución de la Obra (DEO) and no technical (contratista-principal contractor) inside of the construction site, are accused in a higher percentage compared to other figures.

Such penalties are seldom overcome the threshold of 24 months in prison, although quantifying economic compensation to meet is high.

It also allows us to determine the types of claim (falls at different height), together with the types and stages of most dangerous works (structures), to enable comparisons with other studies.

Also the results, offer us the type of contractor (subcontratista), suffering higher casualties.

Studied incidents present a completion of an acquittal or dismissal of the case by the Prosecutor's office.

4. Conclusions - With respect to personal injury, in the building and with the data obtained we can determine that the necessary actions must be aimed at the study and awareness of the responsibilities that affect the Director de Ejecución de la Obra execution of the work (DEO) and contractors.

Within the types of claims studied, at different heights and falls within the same, during the execution of spraying ceilings and decking floor slabs, are sources of accidents and must be treated with special attention to safe processes. Similarly, the presence of electric high lines must be always concerned from the beginning (estudio/estudio básico de seguridad y salud) to avoid sanctions of the technical agents.

In general it is recommended to include documentation in any danger included in Anexo II of the RD 1627/97 (work involving special risks), as reports of the ITSS and technicians from different communities security always referred to, and therefore the Prosecutor's office and various accusations.

Issued criminal penalties that have been studied, don't leave without freedom to the studied agents (technical and non-technical), provided that they have no background, but economic sanctions in case of fatal and serious accidents, make necessary an insurance compulsory for all participants in the construction process.

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INNOVATIONS IN THE MODERN BUILT ENVIRONMENT – OLD AND NEW STRUCTURAL FIRE SAFETY CONSIDERATIONS

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Keywords: Innovation; materials; structural systems; structural fire safety; fire testing.

1. Introduction – The use of innovative materials and optimized structural systems present challenges, as well as opportunities, to the modern built environment; the opportunity is related to a fundamentally better-optimised construction while the challenges lay in innovations not performing as expected. The work presented herein examines the aforesaid with particular attention in some of old and new fire safety considerations arising from these so-called innovations in the built environment.

To ensure that minimum standards of safety are maintained, practitioners and regulators must keep pace with the rapid developing built environment. However, there is frequently a time-lag between the introduction of a new structural material or system, and the wider construction industry to fully comprehend its full benefits and risks associated with its implementation. The work presented herein examines the introduction of optimized, high-performance concrete elements in the modern built environment. The combined use of carbon fibre reinforced polymer (CFRP) tendons and high performance concrete, yields low-weight prestressed elements with a reduced concrete cover and overall thickness; this gives excellent corrosion resistance, high stiffness and high fatigue strength. However, the performance of these elements in fire is not well known [REF] and must be better understood before they can be used with confidence in load-bearing applications where structural fire resistance is required.



Figure 1 – Application of CFRP prestressed concrete L-shaped beams for structural façade elements in Zurich, Switzerland [1].

2. Research Significance – A limited number of fire resistance tests on fibre reinforced polymer (FRP) reinforced or prestressed concrete elements have been reported in the literature (e.g. [2]). Despite the scarcity of work studying the fire behaviour of concrete structural elements incorporating FRP reinforcements, fundamental differences to traditionally reinforced concrete structural elements have been reported [3]. Three important failure mechanisms have been identified that may control the fire resistance (i.e. time-to-failure in a standard fire resistance test) of reinforced or prestressed concrete elements, namely:

- heat-induced explosive concrete spalling;
- thermo-mechanical bond degradation; and
- thermo-mechanically induced longitudinal splitting cracks.

3. Outcomes from a Comprehensive Experimental Study – Outcomes and thoughts from small-scale (for inspecting bond behaviour), medium-scale (for inspecting the occurrence of concrete spalling), and large-scale (for inspecting full structural behavior) tests were used in studies performed by the author [4]. A wide variety of experimental techniques were used for understanding the behavior of materials and structures at elevated temperatures and in fire.

Results show that the high propensity for explosive heat-induced spalling of concrete can result in a sudden failure of the structural system. When spalling is avoided, failure occurs by loss of anchorage, which is in turn governed by a combination between a degradation of the epoxy resin around the surface of the CFRP tendons and loss of concrete's confining action due heat-induced transversal forces generated by the CFRP tendons. While heat-induced behaviours observed during testing have been investigated in the past, the combined influence on the overall structural fire performance presents a massive challenge.

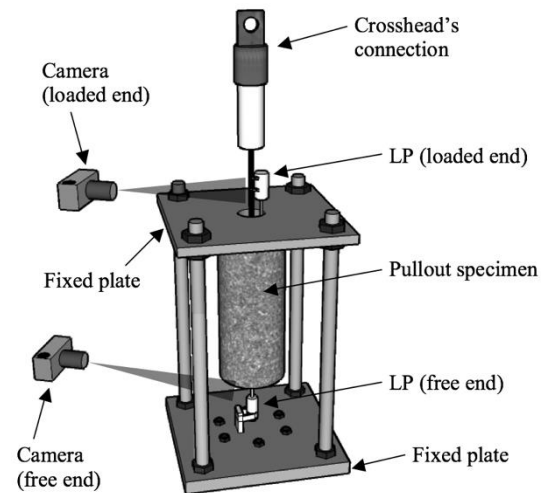


Figure 2 – Schematic of bond behavior tests [5].

4. Discussion – Findings from the extensive work presented herein evidenced that conventional fire safe design of structural concrete systems, conceived for traditional steel reinforced concrete structural elements, is not applicable for the design of highly optimized CFRP prestressed concrete elements, and most likely for similarly innovative structural elements. The high risk of heat-induced concrete spalling and the complexities associated with structural failure due to loss of bond strength capacity of pretensioned CFRP tendons, both of which are relevant to the behaviour of such novel structural elements during fire. This is an opportunity to develop fundamental and practical understanding for the behaviour of CFRP prestressed concrete structural elements during fire; and in doing so to provide designers with the 'practical' tools (rather simple than complex) to use structural fire safety considerations as a design generator rather than a constraint in the building design process.

5. Conclusions – The overarching recommendation is that future research and development around these novel structural elements (and similarly innovative) should not aim to simply comply with a required fire resistance rating (i.e. time-to-failure during a standard fire resistance test), but rather to 'understand' the full-scale fire behaviour of the structural systems during, and its relevance within the introduction in the modern build environment.

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STUDY AND ANALYSIS OF THE DUTIES AND RESPONSIBILITIES OF THE DEVELOPER REGARDING SAFETY MATTERS ON CONSTRUCTION SITES IN 22 COUNTRIES

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Keywords: *Coordination, Europe, health and safety, construction, Directive 92/57, Developer*

1. Introduction – There are a number of characteristics in the construction sector that are not found in other productive sectors which make industrialization of work processes complex and difficult. All this makes the risk in this sector very high and therefore the activity of construction is considered highly dangerous. At European level, construction is considered high risk, in fact, the Council of the European Communities, in its Resolution of 21st December 1987, selected construction as one of the three with most risk and instructed the Commission to produce a Directive [1] COMMUNITY DIRECTIVE 92/57 / EEC on the minimum health and safety requirements that should be applied during temporary or mobile construction works. which culminated in that identified as 92/57 EEC of 24th June 1992 relating to construction activity [2] COMMISSION OF EUROPEAN COMMUNITIES "Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions on the practical application of Directives 92/57 / EEC (temporary or mobile construction works) and 92/58 / EEC (signaling safety at work) on health and safety at work". Brussels, 6th November 2008. The framework of the Directive provides that owners should play a major role regarding management of prevention. However, in many situations, they lack the knowledge or skills needed, therefore making other actors participant and disassociating themselves from the role passed by the board, although this does not mean that they can evade their responsibilities.

2. Objectives and Methods – The study of the various transpositions of Directive 92/57 / EEC for each of the legal systems of the countries that make up the EU through the information provided by various European bodies such as the [3] European Agency for Health and Safety at Work or CEN - European Committee for Standardisation - <http://europe.osha.eu.int/index.php?lang=es> has provide us with, through their analysis, comparison and discussion, information on how to carry out the different duties of the developer as the agent of the construction process emanating from Directive 92/57 / EEC. On the other hand, this has allowed us to know the legal advantages and disadvantages of each one as well as reflect on the appropriateness of the development and implementation of a management methodology from an owner's approach, for construction works. This study has been conducted focused on a geographical context of 22 countries of which most of them belong to the EU (Germany, Austria, Belgium, Bulgaria, Croatia, Denmark, Spain, Finland, France , Greece, Holland, Ireland, Italy, Italy, Luxemburg, Norway, Poland, Portugal, United Kingdom, Romania, Sweden, Switzerland and Turkey). The transposition of the EU Directive has been



Figure 1

examined from a legal approach for each country on (see table 1); (obligations and responsibilities) [4] ESTEBAN, Jesus; Study on the integration of prevention in the drafting stages of projects. Doctoral thesis. 2011 for the figure of the developer.

REQUISITO		UNITED KINGDOM	IRLANDA
PROMOTOR	PREVENCIÓN DE ACCIDENTES	Notificaciones (del PD y PC). notificación de inicio de obra. PD - Principal Designer, responsable al coordinador de seguridad y salud en fase de elaboración de planos. * Tarea que es un diseñador en el contexto del CDM, se dice que es un diseñador si es responsable, para alguien que tiene capacidad para influir en el diseño de un proyecto, la gestión de la obra (Proyecto) (personal propio o contratista). * El diseñador es responsable de la fase de diseño tan pronto sea posible. * Colaborar. * Disponer de las herramientas, conocimientos y experiencia en caso de individuos y en caso de una organización la capacidad organizativa suficiente para coordinar y gestionar la elaboración de la fase de Prevención. * Coordinación técnica en la actividad de construcción relevante para el proyecto que se construye. * Integración dentro de la Construcción encargada de la gestión y control de obra (personal propio o contratista). PC - Principal Contractor, responsable a un coordinador de seguridad y salud en fase de ejecución de obras. * Colaborar. * Disponer de las herramientas, conocimientos y experiencia en caso de individuos y en caso de una organización la capacidad organizativa suficiente para desarrollar un función de manera efectiva en cualquier momento a la seguridad y salud.	Existen dos figuras clave en la gestión del Proyecto para la fase de diseño y de ejecución, ambas pueden designar un coordinador. PROJECT SUPERVISOR FOR THE DESIGN PROCESS (PSDP) * PROJECT SUPERVISOR FOR THE DESIGN PROCESS (PSDP) * El PSDP debe designar, antes o en el inicio del proceso de diseño, al PSCD debe designar antes del comienzo de las obras de construcción. PROJECT SUPERVISOR FOR THE DESIGN PROCESS (PSDP) * Se designa y coordina por escrito, antes del inicio de la etapa de construcción. * El PSDP asegura la coordinación del trabajo de los "designers" en todo el proyecto en materia de seguridad. * El PSDP debe designar, antes o en el inicio del proceso de diseño, al PSCD debe designar antes del comienzo de las obras de construcción. PROJECT SUPERVISOR FOR THE DESIGN PROCESS (PSDP) * Se designa y coordina por escrito, antes del inicio de la etapa de construcción. * El PSDP asegura la coordinación del trabajo de los "designers" en todo el proyecto en materia de seguridad. * El PSDP debe designar, antes o en el inicio del proceso de diseño, al PSCD debe designar antes del comienzo de las obras de construcción.
	PREVENCIÓN DE ACCIDENTES	PD y PC: Notificación por escrito, obligatoria en proyectos donde intervenga más de un contratista. F10: Notificación de inicio de proyecto para obras. * La notificación de inicio de proyecto para obras. * La notificación de inicio de proyecto para obras. * La notificación de inicio de proyecto para obras. PC: Pre-Construction Information, se realiza para todos los proyectos donde intervenga más de un contratista. * La notificación de inicio de proyecto para obras. * La notificación de inicio de proyecto para obras. * La notificación de inicio de proyecto para obras.	PRELIMINARY SAFETY AND HEALTH PLAN: Plan de Seguridad y Salud. * El PSDP debe preparar un archivo por escrito "Safety File" que contiene información de salud y seguridad relevante para tener en cuenta durante las obras de construcción. Se hará entrega al promotor al finalizar el proyecto. * El PSDP debe preparar un archivo por escrito "Safety File" que contiene información de salud y seguridad relevante para tener en cuenta durante las obras de construcción. Se hará entrega al promotor al finalizar el proyecto. * El PSDP debe preparar un archivo por escrito "Safety File" que contiene información de salud y seguridad relevante para tener en cuenta durante las obras de construcción. Se hará entrega al promotor al finalizar el proyecto.
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Table 2

Among the main obligations and responsibilities detected and analyzed for the figure of Developer, are those of appointing a qualified professional to carry out the supervision and control of safety measures. General aspects carried out in the methodological or logical phase were:

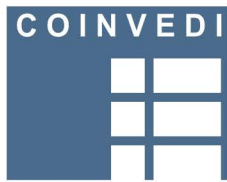
1. Study and analysis of the national legislation of each EU Member State, to determine to what extent the Directive was implemented, how it was done and fidelity to the guidelines set.
2. Comparative study of the main characteristics of each of the national laws to see commonalities between all of them.

3. Results and Discussion – With this study and dealing with its results we have sought to help in improving the integration process for risk prevention through the figure of "developer" as a fundamental element of the process and through a specific preventive management system that gives developers tools to set up better preventive controls in order to improve the figures for accidents in the construction industry throughout the construction process. Similarly we have tried to establish a series of organizational improvements in the area of Management and Preventive Planning on site; currently it is scarce and poor, which has emerged as one of the reasons that cause the most accidents in the construction industry.

4. Conclusions - The transposition models of the Directive in the EU countries and own regulations in other countries regarding the figure of the developer, may be seen as homogeneous in some cases and in others, there are differences that can open future lines of investigation with regards to an approach where the developer plays a role as the main agent regarding the conditions of risk prevention in the works. This study reveals a general lack of control and/or management that the developer makes in prevention of risks in their respective workplaces regarding occupational safety conditions, or in the design or implementation phase.

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practical application of Directives 92/57 / EEC (temporary or mobile construction works) and 92/58 / EEC (signalling safety at work) on health and safety at work ". Brussels, 6th November 2008.

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PROFILES RELATED OF FATAL ACCIDENTS IN BUILDING SECTOR 2008-2012

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Keywords: Accidents investigation; Workers profiles, Buildings sites, Fatal accidents

1. Introduction –The investigation of accidents is one of the most used by researchers [1], although at present has its detractors as it is are active system resources. The construction sector is generally divided into two types: building and civil engineering. It should be noted the difference between building, for example, an apartment building and a road. Processes, means, machinery and labor, are radically different, which will determine the risks and safety measures to be applied in each.

In the construction sector there are no investigations which separate beyond the two types described. The purpose of this investigation has been, since it started in 2008, studying how fatal labor accidents in the building sector, as well as the profile of the injured worker, in order to propose solutions to the dramatic problem posed by them because until now, accidents in building sector with technical building management was not analyzed independently of the whole of the building and the official statistics of the Ministry of Employment and Social Security sector concerned throughout the construction industry.

2. Methods –In the study an analysis of data obtained from the study of 210 accidents resulting in death in the period 2008-2012 in the building sector, in particular aspects such as is done, budget, outsourcing, legal, professional category, age, nationality and age of the victim; and the manner in which the accident occurred, the deviation that caused it and study of the causes that gave rise to it, using their codes of official studies by the Ministry of Employment and Social Security in order to validate data obtained with respect to the official data of Delta accident reporting system.

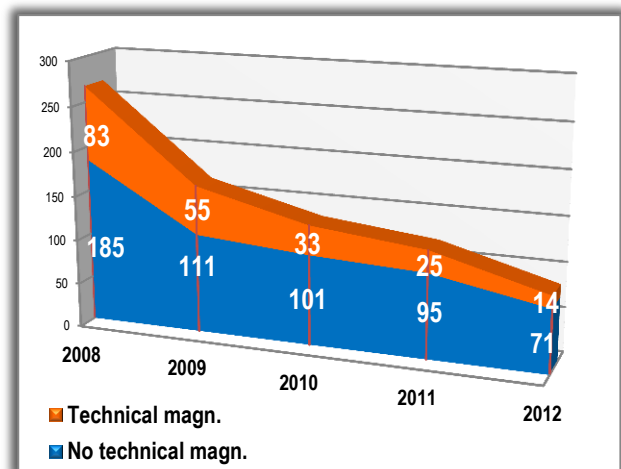


Figure 1

3. Results and Discussion –As example of the profiles related in the whole study we established:

- The new type “new tall building” has the highest accident rate, with 40% of all accidents objects of study. It seems every year a decrease in the accident rate in the construction of new residential floor (height and family), with the sharpest decline in single-family type (isolated and row), where in the past two years does not have posted no accident. Also, in the last three years there have been an increased number of accidents on the types of reform/rehabilitation of the building (height and dotacional). These data relate to the economic climate and changes in types due to market conditions in recent years
- Tuesday is the biggest day of accident. On the other days of the week an equitable distribution of accidents occurs

- Due to the small difference in accidents depending on whether the accident belonged to the principal contractor or a subcontractor, it can be said that this factor does not have a decisive influence on the fatal accident in the building sector, unlike what is concluded statistical analysis of all accidents that take into account accidents resulting in minor, serious, very serious and fatal injuries, that if you set the factor subcontracting accident, and where the profile of the deadly accident is totally overshadowed by the number of minor accidents
- In Figure 2, the age data of the injured are reflected. It shows that the age group of over 55 suffers more accidents, thirty two, followed by the age group 40 to 44 years with nine accidents and 45-49 years with twenty. Important fact that differentiates profile of fatal accidents from the resulting profile when all the accidents (minor, serious and fatal) is studied, where the trend is reversed and are under age 25 who are at the top (Figure 2)
- The highest percentage of fatal accidents in construction, almost 70% (69%), affecting officers, managers and builders, that is supposed staff holding qualification and responsibilities on site (Figure 3)

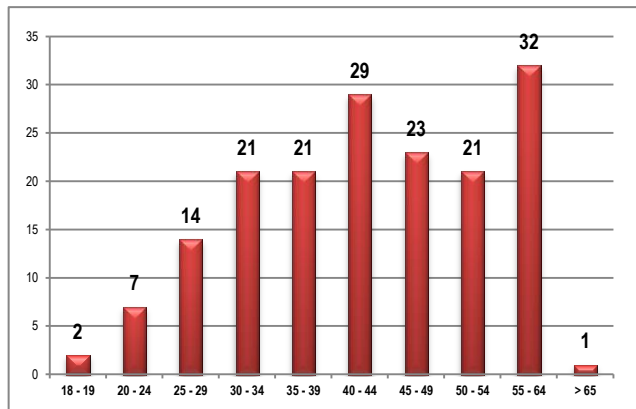


Figure 2

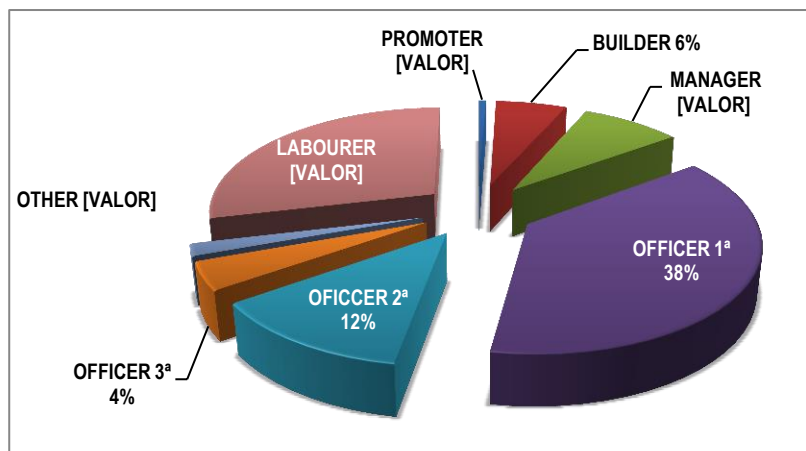


Figure 3

4. Conclusions - In conclusion we can say that should deeper into the disclosed of: the working procedures and the good practices of the trades involved in the execution of a building. We need to study the working processes to predict the risk, and this effort especially for all companies that concur on site.

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HEALTH AND SAFETY ELECTRONIC LOG BOOK APP

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Keywords: *Construction; Health & Safety; APP*

1. Introduction – The H&S electronic Log Book APP (*APP Libro de Incidencias Electrónico*) is the first professional APP to manage an Official document under the Spanish Construction H&S Legislation. The use of new Technology in the H&S field at the construction industrie helps to reduce accidents statistics and is a tool that provides a continuous H&S training to all agents involved in the construction industry.

The APP allows H&S Site Coordinators:

- produce Incidences, reports and minutes directly on the tablet device including pictures
- include signatures on site
- send the documents produce directly to agents involved

All information introduced can be usefully use to obtain statistical information on H&S works carried out on site and therefore, can be use to improve from a H&S point of view the construction systems and management.

The use of tablets on site gives H&S Technicians a useful tool maintain a continuous H&S training and support throughout their professional life.



2. Methods – The present H&S Tool is the result of more than 3 years of works in real construction projects. Two different companies (Gabinete Técnico de Prevención – H&S Management in construction sites and OPTIMIZA Process – Design of new technology) have joined their know-how in order to provide professional H&S tool. The Professional Bodies COAATM and CGATE have introduced this H&S tool to all technical members.

3. Results and Discussion – The results of the use of the H&S APP is the absence of accidents on site due to the immediate and continuous H&S information during the works. Are all agents involved in the construction working phase with the correct H&S training? Do we need to change or add more H&S Training at University?

4. Conclusions – The H&S APP is not only a H&S Tool for technicians, but it can also be use to continue the H&S education received, and the most important characteristic is proven reduce of accidents when using it.

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- [3] Consejo General de Arquitectura Técnica de España (CGATE)

RESIDENTIAL ENVIRONMENT QUALITY AND ITS REPERCUSSION ON HUMAN HEALTH. A PRELIMINARY APPROACH.

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Keywords: *Design; Environment; Quality; Health;*

1. Introduction – Over the last decade, research has shown how built environments affect humans on several domains, from behaviour to well-being. The interaction between human beings and their surroundings can be described from a human perception perspective. Through perception, human beings try to understand their surroundings. Depending on the environment's simplicity or complexity, users can experience a wide array of feelings such as confidence, relaxation, frustration or anxiety, depending on the way the information is processed [1]. A continuous exposure to complex information promotes the development of stress, which has been associated with human health issues. To avoid stress, a thorough design of the interior environment should be implemented [2].

Aspects of daily events such as friendship formation, or personal safety, can be improved by applying design features that enhance social interaction [3]. Orientation within built environments can potentially be frustrating or satisfactory depending on the layout and, therefore, the experience of a space from the user's perspective can be improved by design [4] [5].

Residential spaces exercise as strong influence in human behaviour and health as any other built environment [6]. Qualitative evaluations of environments have served as basis for previous studies but have also been proven insufficient to provide further knowledge on human-environment interactions. Quantitative evaluations of environments are needed to advance that knowledge [7].

Based on the hypothesis of the existence of a correlation between residential design patterns and the mental/emotional health conditions of their inhabitants, the objectives of the present research are to ascertain that correlation, to provide a tool to measure it quantitatively, and to identify what specific residential features influence the most.

2. Methods – The methodology comprises the following steps:

1. Measuring the quality of the residential environments by using the Housing Quality Indicators tool (HQI), developed by the United Kingdom Government.
2. Evaluating user's health. Anonymous data is collected about health and well-being of the residents by using the Short Form-36 Health Survey (SF-36), which provides two sets of results: Physical Component Score (PCS), and Mental Component Score (MCS).
3. Statistical analysis. The analysis proposed for this research is the regression. We intent to predict the behavior of a factor, the health of users ("Y", dependent variable or criterion), in reference to the residential environment quality ("X", predictor or independent variable). The formula would be as follows:

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

The value of the dependent variable Y is the user's health, measured by the SF-36 Health Survey. Since this survey provides two types of scores, PCS and MCS, there will be two separate regressions that will be analysed to verify the influence of the HQI on the physical and mental components of the user's health.

The value of the independent variable X will be the score obtained by using the Housing Quality Indicator (HQI).

3. Results and Discussion – This research is currently ongoing and there are not any results obtained yet. It is the goal of this research to evaluate further data so that the results can be more accurate in order to ascertain the correlation.

4. Conclusions – This thesis aims to provide a step ahead on residential design, to set a precedent for future researchers, and to establish the grounds for the building codes to improve toward a more human-centered design. The main contributions that are expected for this research are the following:

1. A more detailed knowledge of the impact of the residential spaces on human health.
2. A new tool for the evaluation of the quality of the interior spaces based on the HQI.
3. The development of a new rating system for residential spaces.
4. The basis for the building codes to reconsider their requirements in order to promote healthier environments.

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IMPLEMENTATION OF THE BIM METHODOLOGY FOR COMPLIANCE ON DELIVERING THE RISK&SAFETY INFORMATION TO THE WORKERS DURING THE BUILDING MAINTENANCE WORKS

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Key words: health and safety, BIM, facility management, information risk

1. Introduction

The study forms part of a doctoral thesis which tries to analyse the degree of compliance that the companies have during the building maintenance and operation phases in order to comply their duties of informing to the workers about the existing risks on the workplace (article 18, occupational health and safety Law, 1995) [1]. To do so, it has been compared the data obtained through the current methodology established in the workplace with data coming through of delivering this information using parameterized BIM methodology models over these operation and maintenance phases.

2. Methodology

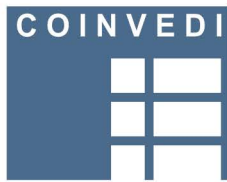
The study was performed in a real workplace which provides an "Occupational health and safety integrated management system" under the guideline OHSAS 18001 [2] and where the Facility Management tasks have been carried out through a subcontractor. It was studied and analysed how the safety risk information delivery is been performing and the relationship with the accidents and incidents or the possible legal non-compliance related to those non-compliances.

Likewise, it has been identified the building operational works and its risks associated, setting up the action priorities to be taken according to type of risk.

In the second phase, it proceeds to make the parameterized model of the workplace based on a level of development fitted for the use chased, on which the high risk maintenance works are identified (as per the identification performed at the beginning). Once these ones are identified, it proceeds to perform of safety work procedures which will be included in the BIM model. In such a way, when the worker has to perform the maintenance works, he will receive the safety work procedure just before starting the task, in a virtual environment, leaving a tracking information register delivered.

3. Results and Discussion

The study's results, under the implementation system phase, show that the manager's compliance over the safety risk information deliver to the workers is in 100% cases, practically. Besides, we are able to detect mistakes in the work procedures either due to the proper work procedure or to the worker. Once the building is parameterized [4], the control over the facilities is complete, reporting the information related to consumptions, performance, etc., very important and key for the owner.



4. Conclusions

Even though the doctoral thesis is not finished yet, on the study made, it can be extracted a progress of conclusions which will be completed once the whole building and facilities were modeled. Through the BIM implementation, an updated building and facilities information will be at disposal. This new technology, based on a virtual environments and collaborative work, allows us a building information control in real time. In this way, the worker, before starting every maintenance work, will have received the safety risk information related to those tasks as well as the safety work procedure to carry out on the building real status.

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ANALYSIS OF COMPLIANCE WITH ALL HEALTH AND SAFETY SMEs DUTIES ON CONSTRUCTION SECTOR**Segarra Cañameres, María ⁽¹⁾, Rodríguez Saiz, Angel ⁽²⁾, Esteban Gabriel, Jesús ⁽³⁾**

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Keywords: Health, Safety, Construction, SMEs, Safety Management

1. Introduction – Official statistics show general improvement within the preventative system of small and medium enterprises (SMEs) since in recent years there has been an increase in preventative resources, workforce presence and training, and in preventative activities in general. Nonetheless, SMEs seem to continue to have an unresolved issue in the field of Occupational Risk Prevention: the integration of workplace safety and health into their overall management, and especially, into their culture.

This makes it necessary to continue the advancement of preventative actions within businesses, so that said businesses consider integrating prevention into their productive units. This integration goes beyond mere compliance with the diverse documentary obligations that the management of this business area requires, and ought to be understood as the incorporation of prevention throughout the entire organizational structure and decision-making processes of a company. However, this qualitative leap can only be made if businesses comply with all their preventative obligations, as it does not make sense to talk about the further integration of prevention if not even the most basic of safety obligations, which are necessary to guarantee the protection of the worker, are being met.

Understanding the difficulties faced by Construction Sector SMEs in complying with preventative obligations, the base upon which other actions must rest, is the principle objective of this research paper.

2. Methods –The research method chosen was that of a survey since surveys are a resource used in qualitative research of processes, and because they facilitate the gathering of real and specific information regarding the studied indicators. In order to reinforce the quality of the results obtained and corroborate their validity, the technique of a focus group was also employed, which provided a qualitative bias that explained the phenomena studied and exposed the causes that produced them.

3. Specimen preparation – A survey of 60 questions that addressed all key aspects of the corporate duty to incorporate preventative obligations into their General Management System was proposed to 106 Construction Sector SMEs.

Once the surveys were completed, two workshops with experts and business professionals from the Construction Sector were organized, by way of the focus group technique, in order to ascertain the opinions of the stakeholders in the processes of the integration of prevention, to identify the circumstances which make the processes difficult and, as far as possible, to make proposals to better them.

In order to allow for the participation of all stakeholders in the processes of the integration of prevention, the first focus group was made up of heads of public organizations, bodies that specialize in prevention and representatives from businesses with experience in prevention. The second focus group was made up of Construction Sector SMEs, in their capacity as contractors and subcontractors in the process.

4. Results and Discussion – This research has revealed the degree of compliance with preventative obligations by Construction Sector SMEs and revealed how to identify the difficulties that arise during the integration of Occupational Risk Prevention into a business' General Management Systems.

From the indicators obtained during the experimental process, it can be noted that:

Only 42% of businesses consider it necessary to dedicate time to the development of preventative activities, and of those, 21% only dedicate between 1 and 5 hours a month. The other 58% of businesses either do not consider do not recognize the necessity of the development of preventative activities.

21% of businesses do not designate Preventative Resources to the construction work they take on or are unaware of the need for their designation and, of the 24% that indicate that they designate Preventative Resources to only some construction jobs, only 17% identified the designation with risks that required the presence of Preventative Resources. When asked to indicate who should allocate the presence of Preventative Resources, in 44% of cases the External Prevention Service was identified.

Another worrying statistic is that 36% of the businesses surveyed do not carry out Investigative Reports on Accidents and 23% said that they did not know if Reports were made or did not answer the question. Of the 42% that claim to comply with the Reports, it is significant that 50% do not know who carries them out.

41% of subcontractors have never participated in safety meetings with other subcontractors, while 33% of the subcontractors surveyed showed that they either have not received a Safety and Health Plan or have only received it in some cases. On top of this, in 25% of cases a Head of Safety and Health was never appointed to the construction job.

5. Conclusions – Prevention Strategies must not only focus on making informed and documented preventative recommendations on what needs to be done to comply with regulations, but must also integrate General Risk Prevention into the General Management System of businesses in order to guarantee workers' safety. The ultimate goal of this process of integration is to establish conduct guidelines and procedures for direct application, which will be an effective aid to Construction Sector Small and Medium Enterprises.

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EFFECTS OF FIRE POSITIONS ON THE BREAKING BEHAVIOUR OF POINT-SUPPORTED AND FRAME-SUPPORTED GLASS FACADES

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Keywords: *Glass facades; Fire performance; Fire position*

1. Introduction

Glass façade is extensively employed in skyscrapers, but due to brittleness it is always viewed as the weakest part of a building. In particular, when subjected to a fire, glass façades may easily break and fall out creating a new vent for fire spread and air entrance, which will significantly accelerate the fire development in a compartment. Thus, this is an important structural issue for fire safety. Some researchers have paid their attention to the thermal performance of large scale glass façades, focusing their works on different factors that can influence the glass breakage behavior. For example, Chow et al. [1] and Ni et al. [2] conducted full scale experiments to investigate the smoke effect on fire performance of glass. Shields et al. [3, 4] studied the effect of different kinds of glass (single and double glazing) on glass fallout behavior. Nevertheless, relatively little research has focused on the fire source influence. The limited works of fire effect on glass were generally concerning the thermal load of increasing severity [2, 4, 5]. In a real fire scenario, the fire may be ignited near the edge or centerline of glass pane, or directly infringing on the crucial fixing point of façades, as shown in Fig. 1. It is anticipated that the thermal performance of glass façades may differ significantly when the fire location changes. Therefore, it becomes necessary to investigate the influence of fire locations on the thermal performance of glass façades.

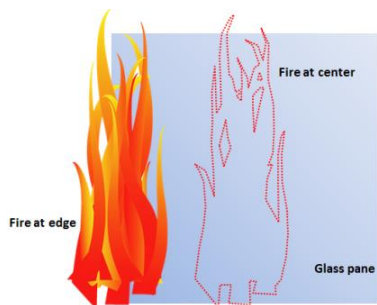


Figure 1 Glass pane subjected to fires at different locations.

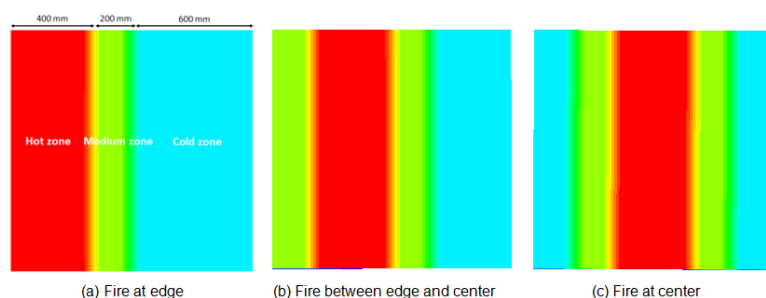


Figure 2 Three different thermal loading

2. Methods

The different glass thermal performances, resulting from fire location changing from the glass edge to center, are simulated using a self-developed finite element software in this work [6, 7]. The Coulomb-Mohr criterion and stress intensity factors (SIFs) based mixed-mode criterion are employed to predict the crack initiation and growth. Both frame supported and point supported glass panes, with a dimension of 1200×1200×6 mm³, are employed. The fire position changes from the edge to the center. The glass stress distributions, breaking time and initiation and propagation of crack are presented. Additionally, some relevant experimental results are also presented for comparison.

3. Results and Discussion

A total of nine cases were simulated, including three kinds of thermal loadings, as shown in Fig. 2. It is established that fire location has a notable influence on the thermal behavior of

glass. Frame supported glass façades are more prone breaking when fire is located in the center of pane. Meanwhile, if the fire is positioned near the fixing points, point supported glass façades will be more prone breaking. As a typical example of edge fire, the stress of frame and pointed supported glass façades are shown in Fig. 3. The maximum stress are locating around fixing points for point supported glass, and at the borderline between exposed and shaded areas for framing glass. Thus, these areas are more prone initiating the cracks, as shown in Fig. 3. Some experiments were also conducted as shown in Fig. 4. The critical heat flux and temperature difference are approximately 5 kW/m^2 and 90°C . The crack initiation and propagation fit well with numerical results.

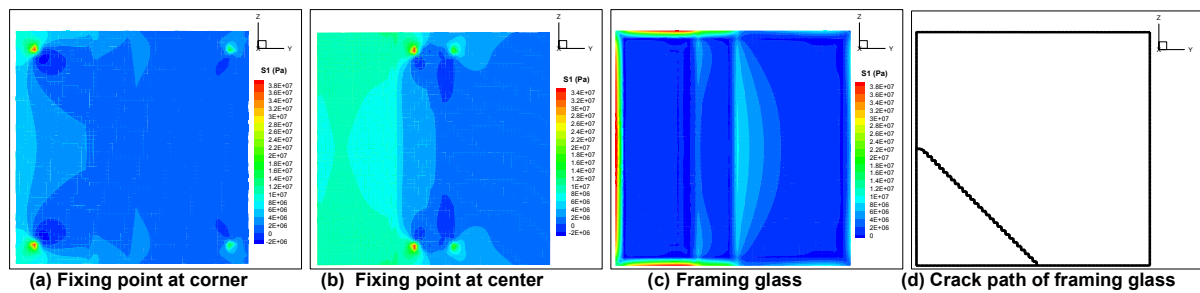


Figure 3 The distribution of principal stress and crack propagation (fire at the edge of glass pane)



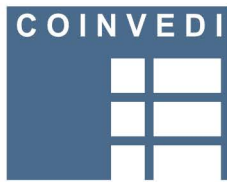
Figure 4 Full-scale experiments of point (left) and frame (right) supported glass façades (fire at the center of glass pane)

4. Conclusions

From the results, it is established that the fire location has a significant effect on the breaking behavior of glass façades. For frame supported glass, when the fire locates the center of glass pane, it shows relatively good fire resistance, but wherever the fire is, the maximum stress is always at the edge of glass pane which is the dangerous area for crack initiation. Meanwhile, point supported glass will have good fire performance when the fixing points are not in the hot zone, namely fire location, and the cracks are generally initiated from fixing points. The exceeding tensile stress is primary breakage reason for the both glass façades.

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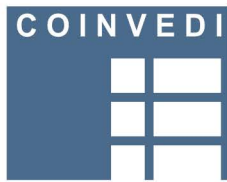
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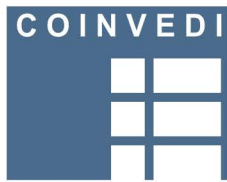
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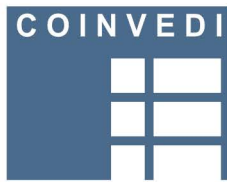
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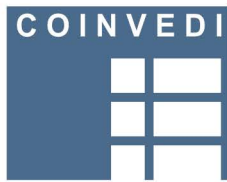
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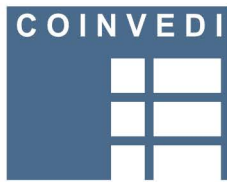
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