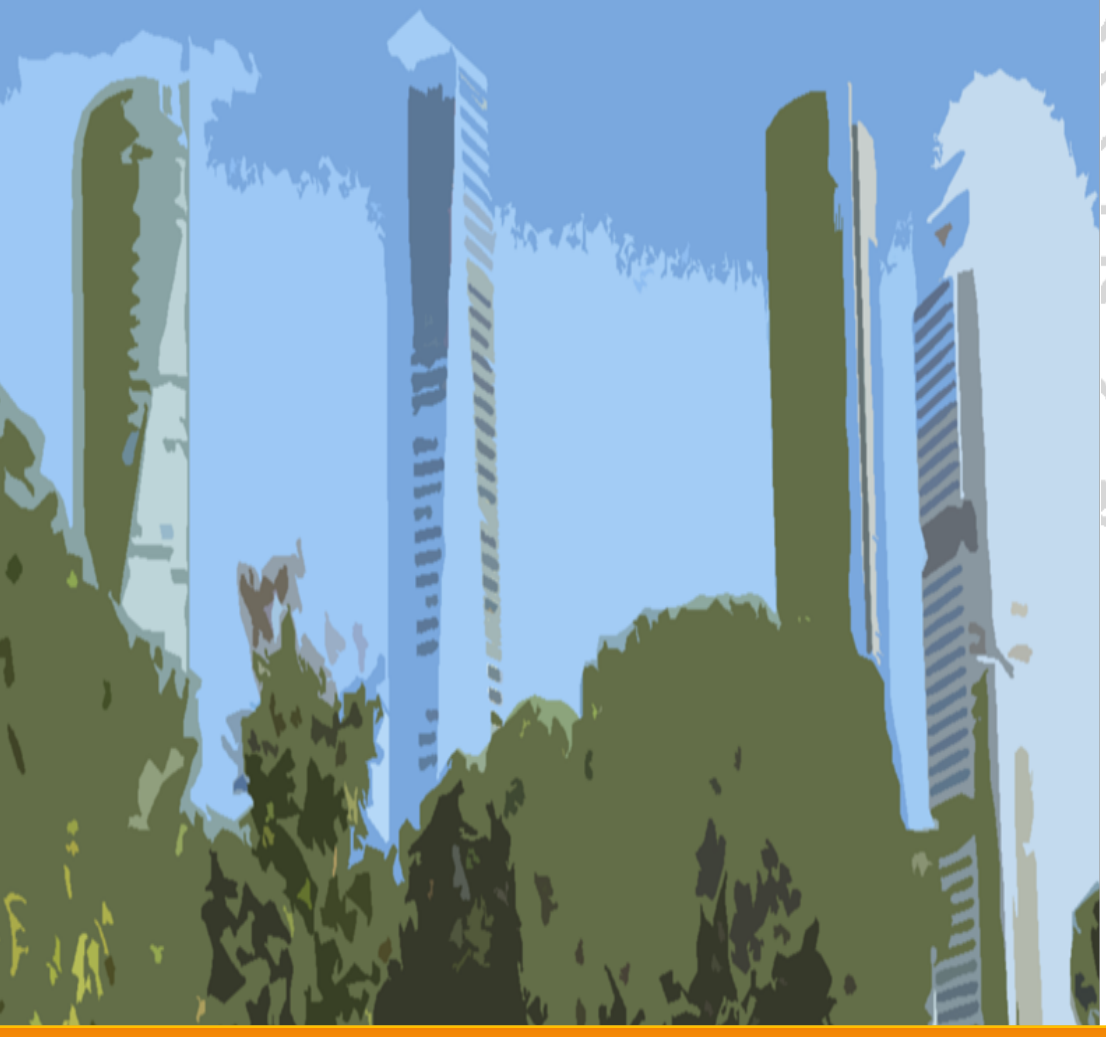
3RD BUILDING AND MANAGEMENT INTERNATIONAL CONFERENCE

3er CONGRESO INTERNACIONAL DE GESTIÓN EN EDIFICACIÓN

BUILDING & MANAGEMENT

BIMIC

INTERNATIONAL CONFERENCE



Madrid, 24-26 November

2021

PROCEEDINGS

ETSEM

UNIVERSIDAD POLITÉCNICA DE MADRID

Escuela Técnica Superior de Edificación

Universidad Politécnica de Madrid

Avda. Juan de Herrera, nº 6 - 28040 - Madrid

3rd BUILDING AND MANAGEMENT INTERNATIONAL CONFERENCE

3er CONGRESO INTERNACIONAL DE GESTIÓN EN EDIFICACIÓN

ESCUELA TÉCNICA SUPERIOR DE EDIFICACIÓN
Avenida Juan de Herrera, 6. 28040 – Madrid
Tel. 91 336 75 95 Fax: 91 336 76 44
Universidad Politécnica de Madrid

ISBN: 978-84-09-37217-1

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CONGRESO INTERNACIONAL DE GESTIÓN EN EDIFICACIÓN (BIMIC 2021)

24, 25 y 26 de noviembre de 2021

BIMIC nace con el **objetivo** de servir de plataforma a la difusión de los avances en el ámbito de la Gestión en la Edificación.

Pretendemos poner en contacto y establecer un nuevo vínculo entre aquellos profesionales interesados, por razón de su trabajo, en los aspectos específicos de la Gestión en la Edificación.

Gestionar es una actividad muy amplia que se desarrolla en áreas muy diversas. En el mundo de la edificación gestionamos las ideas, sus frutos que son los proyectos, los edificios resultantes y finalmente las actividades derivadas de su amortización.

El **programa BIMIC 2021** está estructurado en conferencias invitadas, mesas redondas, comunicaciones orales, posters y talleres sobre la base de diferentes áreas temáticas, tales como Gestión de Accesibilidad, Gestión y Seguridad en la Construcción, Gestión de Evaluación de Riesgos, Rehabilitación, Patología y Mantenimiento de Edificios, Eficiencia Energética, Innovación en la Construcción, Gestión de Planificación Urbana, Gestión de la Construcción de Edificios.

Y finalmente agradecer la inestimable colaboración de la Cátedra-Empresa Proiescón, INACOM Ingeniería Aplicada y el Grupo Erasmus+ GLOCAL, cuyo objetivo es la formación innovadora de los futuros ingenieros, que responde a los problemas de las ciudades contemporáneas.

El Comité Organizador

INTRODUCTION

BUILDING AND MANAGEMENT INTERNATIONAL CONFERENCE (BIMIC 2021)

November 24th, 25th and 26th, 2021

BIMIC Is born with the objetive of serving as a forum for the dissemination of advances in the field of Building Management.

We try to put in contact and establish a new link between professionals interested in the specific aspects of Building Management.

Managing is a very broad activity that takes place in very diverse areas. In the world of building we manage the ideas, their outcomes which are the projects, the resulting buildings and finally the activities derived from their buildings life cycle.

The **BIMIC 2021** program is structured in keynote lectures, round tables, lectures, posters and workshops based on different thematic areas, such as Accessibility Management, Construction Management and Safety, Risk Assessment Management, Rehabilitation, Pathology and Building Maintenance, Energy Efficiency, Construction Innovation, Urban Planning Management, Construction Management of buildings.

Finally, we want to thank our Main Sponsor, Chair-Company Proiescón, INACOM Ingeniería Aplicada and the Erasmus+ Group GLOCAL, whose mission is to provide innovative trainingvof future engineers responding to problems of contemporary cities.

The Organizing Committee

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FACILITIES AND BUILDING SERVICES MANAGEMENT

ANALYSIS OF QUALITATIVE RESEARCH TECHNIQUES IN ITS APPLICATION IN MAINTENANCE ENGINEERING OF LARGE FACILITIES AND INFRASTRUCTURES

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Keywords: *maintenance engineering; qualitative methods; reliability; energy efficiency; maintenance*

Abstract

Maintenance is one of the strategic activities in large buildings and facilities, as its service has an impact on the global operation, its availability, production stoppage or the service provided, as well as the life cycle of the facilities, civil works, equipment and machinery, which have an impact on the application time and on the economic balance of the company. Likewise, in its normal operation, its performance has an impact on energy efficiency and production reliability and quality. This activity, by its intrinsic nature, has a strong technical and, fundamentally, human component, where the levels of implicit knowledge (based on the maintenance technicians' own experience and which are not recorded) far exceed other departments in the company. The same analogies could be made for other professionals involved in historical rehabilitation, craftsmanship in construction, etc.

Maintenance actions, like any human activity, require levels of information and knowledge that define their effectiveness. Knowledge management, from a vision as a process, is integrated through the generation, transfer and use of knowledge within the company. [1]. There are two types of knowledge that are applied, implicit and explicit. Therefore, it is necessary to analyse the process of knowledge creation and transfer in organisations, identifying the knowledge resources available and how they are used to generate new knowledge. [2]. For this purpose, qualitative techniques have been used, which even from a more subjective basis help to address and understand the problem and its possible solution.

Maintenance can be defined in a Kantian approach. The Kantian systemic approach raises the possibility to study and understand any phenomenon, as it defines that any system is basically composed of three elements: people, artefacts, and environment.

[3]. Within this system, and as mentioned above, it is specifically proposed to address that transfer of knowledge which undoubtedly exists in the relationship between the three elements (Figure 1), and which is of great importance in the functions required of the users of maintenance services.

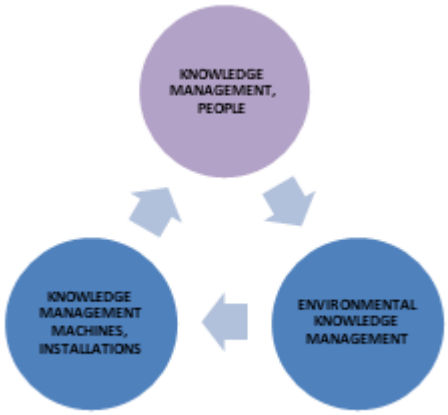


Figure 1: *Kantian approach to maintenance activity in relation to G.C. Source: own elaboration.*

Technical operators (figure 2) have the need to learn about the environment in which they work. Such environments in large industrial constructions (with large extensions, with a multitude of installations and thousands of machines in the case of industrial processes) entail a long period of training for these people, which is repeated with the arrival of a new professional in the maintenance organisation. Knowledge management processes are very difficult to measure and evaluate, requiring the use of qualitative research techniques to study these processes [4,5].



Figure 2. *Performance of maintenance actions based on operator experience on machinery in an industrial construction environment. Source: own elaboration.*

Quantitative research is dedicated to collecting, processing and analysing quantitative or numerical data on previously determined variables and studies the association or relationship between the variables that have been quantified (power, energy,

vibrations, thermal processes, etc.). An explanatory example of this is energy or maintenance audits, which are used in the overall maintenance research process.

This already gives it a connotation that goes beyond a mere list of data organised as a result; as these data, which are shown in a final report, are in full agreement with the variables that were stated from the beginning and the results obtained will provide a specific reality to which they are subjected. [6].

However, in industrial maintenance research there are many aspects that are difficult to measure or quantify and yet substantially affect its performance, such as human processes in knowledge management that affect how operational activities are carried out which, in turn, directly affect reliability, energy efficiency and maintainability and that can greatly affect the business. It is at this stage that the use of qualitative research methodologies can take over to complement or extend the research, building on the quantitative studies that mark the physical evidence of the research. [7-11].

Table 1 shows the different advantages and limitations of qualitative research observed in its use, which clarify the processes in which it can be used.

Table 1: *Summary of advantages and limitations observed in the experimental trials, in the maintenance population. Source: own elaboration.*

Research technique	Advantages of its use in industrial maintenance research	Disadvantages of its use in industrial maintenance research	Remarks
Quantitative techniques (Measurement of the physical variables that affect a phenomenon in the environment of the equipment and facilities)	• Required for the measurement of the essential variables in an investigation in a technical environment (temperature, voltage, current, power, time, vibration, etc.).	• Those inherent in the research design and the precision of the measuring equipment.	• It is complementary to qualitative techniques. • Equipment and instruments are needed for recording and quantification. • Variables in the environment of the equipment and facilities are detected and studied, not the human factor in their involvement.
Delphi Panel (Qualitative)	• Compilation of expert views. • It facilitates participation, allows time for reflection, is anonymous and avoids intra-group pressures.	• Excessive duration of the process, possible drop-outs, biased selection of participants.	• It is very useful, however, when resources are scarce, issues are complex, and expert opinion in a particular area is required.

Surveys/Tests (Quantitative)	• The data obtained thanks to this procedure allows for a rigorous treatment of the information and the calculation of statistical significance.	• The sample must be representative of the population of interest. • The information obtained is conditioned by the formulation of the questions and the veracity of the answers.	• It can be used to reach larger populations and is cheaper than interviews.
Semi-structured individual interview (Qualitative)	• It marks a flow of information that provides it with content. • It allows you to go deeper into an idea that may be relevant, asking new questions. • It is the social actors themselves who provide the data relating to their behaviours. • Enables researcher interaction.	• The interviewee will give us the image he/she has of things, what he/she thinks they are, through all his/her subjective load.	• Useful when what we are really interested in collecting is the subjective view of the social actors, especially when we want to explore the different points of view "representative" of the different positions that may exist around the subject under investigation.
Questionnaire (Quantitative/ Qualitative)	• It allows for more open-ended information to be collected, as the respondent judgement, on the subject under discussion. • Cheaper than individual interviews. • Allow to be sent to a wider sample.	• The information obtained is conditioned by the formulation of the questions and the veracity of the answers. • The processing of information is more complex than in tests.	
Focus groups (Qualitative)	• It brings together a group of people, who are a structural sample with their own characteristics, which at this point constitutes the group dimension. • With symmetrical relations between the participants, we achieve the coupling of speech and the social reproduction of discourse. • Opinions can be sought, questions can be asked, questionnaires can be used, cases can be discussed, points of view can be exchanged, and various aspects can be assessed.	• It is costly because of the logistics involved. • Highly trained personnel in the subject matter are needed.	• The selection of the number of groups is based on structural rather than statistical criteria.

Technique Observation (Qualitative)	• It helps to carry out an adequate approach to the problem to be studied. • It allows for an overall formulation of the research. • The researcher is introduced into the context and environment of the phenomenon to be addressed, giving a clearer and more accurate view of the phenomenon.	• You must have full authorisation from the researcher in the area of the company being studied, which is sometimes difficult to obtain.	• In industrial maintenance, it helps to get inside the contour of the phenomenon and the operational movements that take place.
Case studies (Qualitative)	• The behaviour of people or organisations in the company in the phenomenon under study is measured and recorded. • Seeks to illustrate, represent, expand, or generalise a theoretical framework.	• Tendency to generalise conclusions	• Used by many researchers as a pre-experimental design method.
Theory-based (Qualitative)	• Generating theory from data collected in natural contexts. • Their findings are theoretical formulations of reality. • The outcome of a grounded theory study is presented as a process, or some of its elements such as the strategies.	• There is no fixed sample. • It ends when theoretical saturation is reached, not being defined at the beginning of the research.	• Useful for the development of new theories or procedures. • There are various computer programmes for the processing of qualitative information.

Acknowledgements

This work has been conducted within the framework of the CONDAP project "Digital skills for workplace mentors in construction sector apprenticeships" funded by the European Commission within the Key Action 2: Cooperation for innovation and the exchange of good practices, reference number 2018-1-UK01-KA202-048122.

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PROPOSALS FOR FOLDING ROOFS FOR THE RESCUE OF URBAN SPACES

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Keywords: *transformable architecture; folding roofs; prototype design; construction details*

Abstract

The following approach was developed to solve in this research, in this case the geometric adequacy of light roofs in urban rescue spaces such as parks within the city of Poza Rica, Veracruz, these foundations were designed in a methodological based on adaptive systems, analyzed in the first stages of this work and that are specifically referred to the methods of finding the forms. The methodology to obtain them includes bibliographic-descriptive and experimental activities.

Subsequently, the geometry of the models that can be simulated with software and perform a second-order analysis is developed, so that this type of structures can be placed within the field of lightweight roofs. Since they require unique mechanisms in the connections.

Finally, obtaining the necessary parameters, we will seek to propose and define approximations or results of previous studies, performing comparative analysis of prototypes, in order to demonstrate the feasibility of the proposal. We will experiment with scale models of different materials in order to select the ideal material that will provide the greatest benefits.

To have an idea of how to design this type of structures, a recommendation of the expert in the field of lightweight roofs is considered (Figure 1), in which we can observe that Dr. H. Berger, provides a series of approximate parameters to find the steps of the design of a lightweight structure, this table will serve as a reference to elaborate the development of the constructive proposal of the system and to elaborate the design methodology of a tensioned folded system. [3] [2]

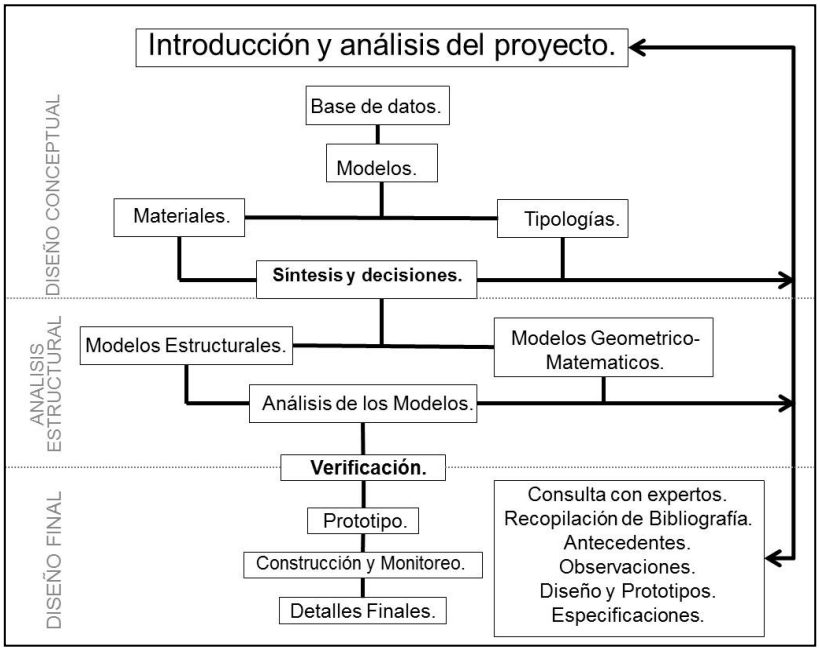


Figure 1: *Development of the conceptual scheme of the design procedure of a tensioned folded system, based on the scheme of Dr. H. Berger, Source: Own scheme based on Light Structures, (1996) Morales, C.C (2017).*

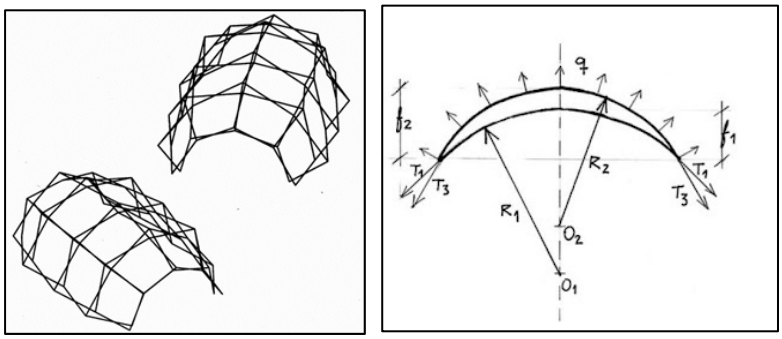
The spatial disorder, the lack of criteria in the management of public and urban spaces, as well as the lack of conservation culture in the population are some aspects that have contributed to the deterioration of the facilities of the parks in Poza Rica, for this study we will analyze the rescue of Cuauhtémoc Park, one of the main parks of the city, one of the causes of the abandonment of the population towards this park was the lack of adequate infrastructure to develop activities in this place, therefore we intend to create such infrastructure to meet the needs of the surrounding population.

In order to provide a modern public space that offers users of all ages with the possibility of developing functions that promote respect for the population, social coexistence and various outdoor activities, the need arises to rehabilitate and remodel the existing park located in the Manuel Avila Camacho neighborhood.

The project does not intend to replace the current activities of the place, but to complement them and improve their functioning to provide greater comfort and safety with green areas covered totally or partially, as well as the necessary vegetation to generate a pleasant microclimate for the users.

So this research focuses on generating constructive models that help to generate a lightweight roof for urban spaces, so it is a priority in our present work the design of lightweight roofs, its characteristic of this system lies in the design of an optimal

constructive connection for its manufacture, the method in which these theses were conducted refers to experimental investigations (Figure 2, 3), to unroll different types of lightweight roofs." [3] [4] [2] [5] [8]



Figures 2, 3: *Project of a deployable cover with blades to cover a single-family swimming pool 11 x 7 m. Seville, Spain. Dr. Felix Escrig. Source: (Escrig 2012), (Sánchez 1992).*

Once the construction typologies to be implemented in the project were assigned, experimental practices were carried out in the faculty of architecture to understand the design and construction execution of this type of light roofs, so that later the elements of the construction system of the roofs will be analyzed. [2] [9] [10] [10] [11].

Subsequently, the structure was built inside the faculty for the rescue of common areas for the students. This experimental roof was created with a steel tube 4 meters high and a diameter of 60 cm, with a 40 gauge; for the central post that will support the entire structure. For the 8 arms, we specified 4" steel tubes with a length of 4.50 meters with a central carcass for the union of the intermediate arms that generate the deployment. These arms 8 intermediate arms are steel tubes of 4" cedula 40 with 1.25 meters long, along the arms beams were placed welded poles to create a system of tensioned beams so that its centroid was further away and support the tractions that would be had, (figure 4, 5, 6) was placed an architectural shadow mesh of 90% which makes it protected from solar inclemency of the place. [2] [12] [13]



Figures 4, 5, 6: *Construction of folding Umbrella scale 1:1. Source: Morales, C.C (2017)*

The second model was then made to scale 1:1, the geometric translations necessary for this larger scale exercise are elaborated with a specialized software called Wintess 3, and the result of the patterns were 64 sections which were printed in the necessary scale on paper, to be joined with glue to obtain the shape, this to later make the shadow mesh 13 m long and wide, 3" steel tubes were placed with a 40 medula with varied heights since they would be articulated to plates attached to the ground, to tighten the posts were placed straps for load of 1 ½" wide that helped to pull the entire structure and support the load, (figure 7, 8) for this practical exercise helped the entire manufacturing process to include it in the rehabilitation project of the park. [3] [14] [15] [16]



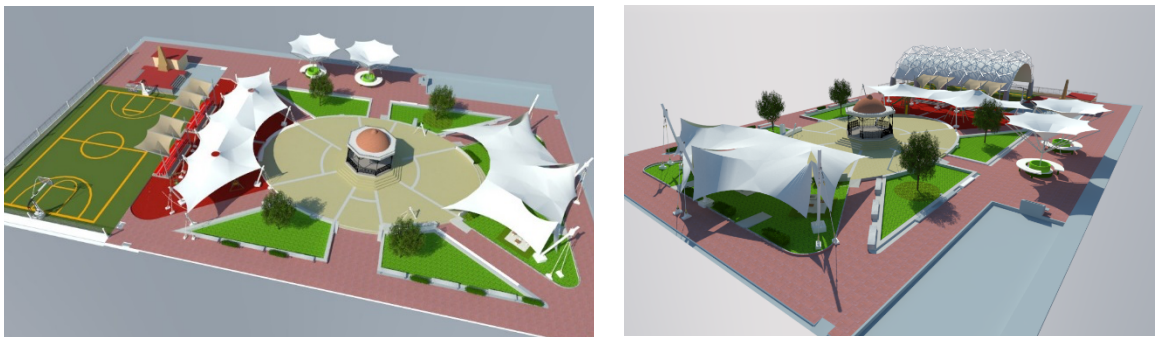
Figures 7, 8: *Construction of the tensile structure scale 1:1. Source: Morales, C.C (2017)*

The proposed canopies for Cuauhtémoc Park are intended to be aesthetically pleasing and fulfill their function of providing shade from the sun and giving a new image to the city. For this project, two tensile canopies supported by articulated posts and windbreaks anchored to the ground are proposed. The first one, which will be placed over the playground area, will cover 330 m² and the second one, which will be placed over the children's playground area, will cover 271 m². The transformable roof will cover the sports court with a covered area of 560 m² and the two umbrella-shaped roofs that together cover 120 m², for a total of 1,281 m² inside Cuauhtémoc Park.

Within the architectural context of Cuauhtémoc Park, there are important spaces that bring together the population for recreational use, which is occupied by all types of users regardless of age who require a fresh space that can be used at any time of the day, which is why the light, transformable roofs are proposed. The following illustrations show a hypothetical before and after of Cuauhtémoc Park (Figure 9- 16). Consequently, it fulfills the purpose of rescuing parks within the city.



Figures 9 – 14: *Technological design applications to a Cuauhtémoc park rehabilitation project. Source: Morales, C.C (2017)*



Figures 15, 16: *Cuauhtémoc Park rehabilitation project. Source: Morales, C.C (2017).*

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DEPENDENCE AND LINKAGE OF THE ROOFING WORK ISSUES WITH RESPECT TO THE PROJECT

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Keywords: *design; quality; verification; construction*

Abstract

Design supervision is not very common in Spain – it is usually only carried out for structural aspects. Technical Control Bodies often carry out risk assessments in foundations and structures for insurance purposes, but comparable assessments are rare for building envelopes.

Roofs are a problematic component in buildings, given to their exposure to environmental factors. These factors (rain, wind, snow, as well as extreme and variable temperatures, biological agents, etc.) demand excellent from a project's design and quality from its execution, if a long service life is to be expected.

The analysis of problems in buildings is a good way of gathering feedback on our technical knowledge and learning from failures while trying to minimise repair costs – especially considering that this is one of the sectors with the highest economic impact in many countries [1]. A macro-research on building anomalies in Spain shows that roofs, as well as façades, are the target of the highest number of complaints for damages in the courts of law [2]. However, it is often the case that roofs are not checked regularly during their service life, despite the fact that a simple visual inspection is easily carried out and could stop small problems from turning into more serious damages [3].

Design supervision, as well as good quality control in roof construction, is a very convenient and effective way of getting ahead of any such problems and reducing their associated economic impact [4].

This research has focused on the supervision work in roofs and, specifically, on pitched roofs, based on the instructions found in the documents of construction projects in a series of buildings. Design management and construction management can be understood in various ways and design supervision is certainly an activity that can prevent problems that might otherwise occur during the construction phase due to omissions or errors in the description, drawings, or measurements forming part of the design documents.

To understand the incidence of such problems – and the improvements such supervision might bring about – the construction phase of two sets of buildings was analysed: buildings that included roof design supervision and buildings that did not. To systematise quality control in the construction of this element (pitched roofs), over thirty indicators were evaluated and grouped according to their location: tail-ends with the perimeter, gutters, roof plans, other singularities, etc.

To obtain the data for this study it was necessary to find entities whose archives contained construction designs and inspections produced during inspections. The conditions set to acquire such a data source were:

- *That the information be reliable and organised in formal records.*
- *That written information exists about each site visit.*
- *That the process had been carried out by specialised personnel.*
- *That, to the extent possible, photographic material exist and depict the defects found.*
- *That in some of the cases design supervision had been carried out.*

It was soon realised that these conditions could not all be met by the internal notes taken by construction companies, nor by work books in which Site Managers write their instructions. However, the conditions were indeed set by Building Quality Control Entities, and the authors of this research approached them in turn.

As in the case of medical studies, and based on the above, two samples were collected: a sample related to the question at hand (projects with prior design supervision of their roofs) and another sample (control and comparison set, consisting of projects without design supervision).

The execution process was examined through around thirty indicators of various types, such as: *'incorrect placement of lap joints or connections between tiles', 'ventilation tiles absent or incorrectly placed', 'tiles in different rows are placed adjacent to another, without any space between them', 'the slope percentage of the roof plans is inadequate for the type of tile', 'there is an inadequate tail-end between the lateral edge of the roof plans with the adjacent perimeter walls', 'insufficient overlap between pieces*, etc.



Figure 1:
Process of execution of a pitched roof (safety aspects are not taken into account)

It was possible to measure and quantify the results through the application of the concept of 'quality index by volume of problems' [5], analysing different aspects. The results of the implementation of improvement procedures, aimed at reducing construction defects, could be accounted thus. The formula used is:

$$I_{VP} = \frac{Npd}{Nwa}$$

Where:

I_{VP} = Quality index by volume of problems
N_{pd} = Number of problems detected
N_{wa} = Number of works analysed

Applying this formula to this research, we obtain:

- I_{VP} in works with no prior design supervision $I_{VP}(NDS)= 7,91$
- I_{VP} in works with prior design supervision $I_{VP}(WDS)= 3,85$
- I_{VP} in the total set of works analysed $I_{VP}(TWA)= 5,85$

Based on the obtained results, it was found that the works that did include a prior supervision of the respective design documents, and in which designers had the opportunity to improve instructions based on this review process, had significantly fewer construction issues. As such, it is found that this methodology of prior review of technical prescriptions is an adequate system for the minimisation of the number of importance of problems that may arise during the execution phase.

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REAL ESTATE MARKET: SMART RENAISSANCE

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Keywords: *real estate market; smart cities; architecture; COVID 19 pandemic*

Abstract

In the years of crisis following the Real Estate boom, the change appreciated in architecture studies was remarkable. Architects, technical architects, engineers, testing and quality companies, developers, builders, site managers, operators of different trades and, in general, facilities, materials and Real Estate companies were forced, in the last twelve years, to change business focus on other goals. This crisis even had an impact on university studies, and private architecture schools created during the boom suffered from enrollment losses. The new graduates sought professional opportunity outside the national panorama.

In this research we will contribute, through a real case study and in collaboration with the University and with Real Estate companies, with new conclusions because the Architecture sector assumes twists and turns, as well as speeds fluctuating and cyclical developments.

The latest crisis that occurred in our sector in 2007, as well as the pandemic due to COVID 19 has affected several disciplines, deriving professionals and teachers in the creation of new teaching methods or means of working in diverse teams, opening up research fields of new forms of building and urban development. It did not only affect the employment and the hiring of new architects but to the generation of housing and the promotion of it. This crisis also had repercussions on university studies because the private Architecture Schools born during the boom suffered numerous enrollment losses and new graduates had to seek professional opportunities outside the national scene.

This study highlights the hypothesis of boom and bust cycles in the Real Estate sector that is observed to be repeated every seven years and thus the crisis in the sector of 2007 lasted until 2014 when architects and construction finally saw the light again until 2021, a year that has clearly been affected by the pandemic (due to COVID 19) that occurred in 2020, foreseeing a negative decline again in 2022 and a positive one in 2028 and so on.

The present research also presents how the so-called applied intelligence, artificial intelligence and the application of IOT are not understood without the emotional intelligence of the human being and that is why the concept of the Smart Renaissance is presented here for the first time, which will be the that balances the understanding of the behavior of the human being within the operation of the machinery of the intelligent city or Smart City.

It also has the participation of university teaching professors and experts in the Real Estate Market, as well as builders who have survived with their companies the Real Estate crisis of 2007 and the pandemic due to COVID 19 of 2020.

The object focuses on the study of cycles as well as the search for the ideal of improvement in the treatment of the Real Estate concept in the coming years. Other data on the demand of Youth [1], the employment situation [2], the immigration factor [3] and the increase in physical and intellectual disability [4] also caused by the aging of the population, will give us clues about how innovate in the way of understanding architecture and the Real Estate sector.

This research analyzes the time lapses under a hypothesis established periodically, and it even supports the unexpected events that have affected over the years as COVID 19. The method combines and crosses the conclusive data of the time lapses with those provided by the experts in the field and the statistics shown in reliable international databases on inter-annual variation such as EUROSTAT and national ones such as the Bank of Spain and the EPDATA application.

Thus, we cannot avoid looking at the past and trying to understand it in order to understand it and thus discard the useless factors that have to meet new requests and demands through cutting-edge technologies. Owen's own experience reveals the difficulty of translating a theoretical model into an architectural and urban reality when in 1825 he implanted his ideal of a city in Harmony, Indiana. His initiative fails and he falls into poverty [5] and [6]. There are basic factors that dictate that a city is intelligent insofar as it responds to the needs that are demanded here and today, but this we must bear in mind that this premise is out of date and, according to the timeless advance of technologies and networks, that the citizens' understanding of the use of these technologies depends a lot on the culture in which we live.

Some of the solutions and recommendations that we arrived at in the Real Estate study and in relation to the ideal and intelligent city of the present are the following:

- Society has to raise a current debate in multidisciplinary and not mono-disciplinary teams in order to investigate these concepts and offer a response to the city of the present that serves the city of the future. Actions from the University: through the modification of the current Urban Planning [7] curricula such as Undergraduate or Postgraduate, the creation of practical multidisciplinary teams from the University field and the study of the application of applied emotional and artificial intelligences.
- The preparation of the university student, not only of the architect, as a person prepared to understand said humanistic and technical multi-disciplinarity:

economy, history, sociology, anthropology, law, politics, topography, environment, sustainability, construction and urban planning.

- Technology at the service of the human being and not the other way around, since virtual dependence makes the relationship with the real context move to another term from which our understanding escapes [8].
- Put the focus on markets that refer to the health and improvement of the quality of life of the elderly, since the accelerated aging of the population becomes eminent in the northern hemisphere.
- Architecture Schools in this year 2021 have experienced an increase in applications since there are two cycles of 7 years in decline which have reduced the student rate to 20% in 14 years.

The preparation of the individual as a citizen in the face of a new crisis that is yet to come and that will last another seven years (from 2022 to 2028). The analyzes and results presented here predict a line of smooth growth until mid-2022 (probably May) and from here on the decline that we will accuse in 2023 to 2028. By crossing these data with the theory of Henry George, it is appreciated that a good moment to invest in the Real Estate market as physical entities was in the recovery period from January 2018 to May 2019. The hypothesis proposed here about the seven-year cycles will lead us to again glimpse a positive rebound that will start from 2029 to 2036 and so on.

Table 1: *Hypothesis raised here about the 7-year cycle in relation to Henry George's Theory. Source: article author*



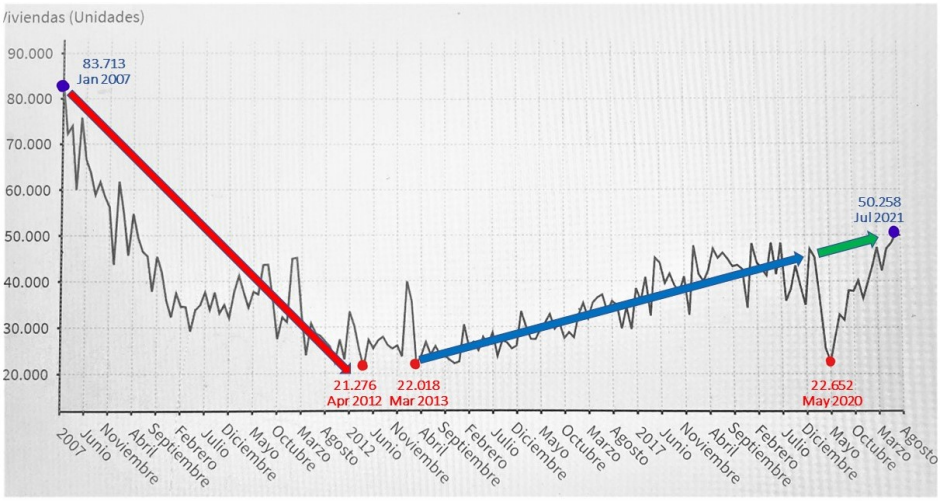


Figure 1: *Graph of property sales in Spain since 2007 and the end of the Real Estate Bubble until July 2021. Key dates and lines of crisis and growth highlighted by the author of the research. Source of the graph: Epdata.es and: on it and in color: key dates, lines as contributions by the author*

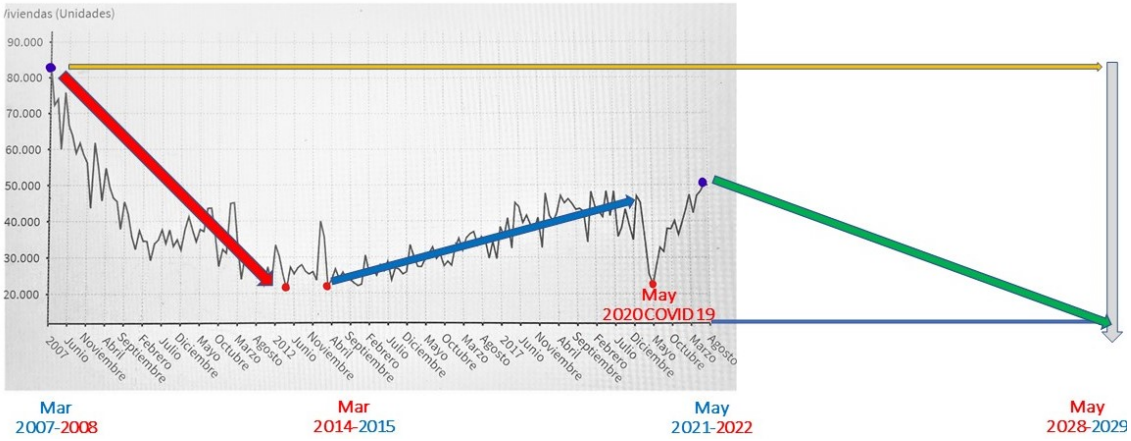


Figure 2: *Forecast based on Table 7 on the graph of home sales in Spain since 2007 and the end of the Real Estate Bubble until July 2021. Key dates in the lower line every 7 years according to the Hypothesis of cycles of the author of the research and lines of future crises and growth highlighted in color. Source of the graph: Epdata.es and: on it and in color: key dates, lines as contributions by the author*

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INNOVATION IN BUILDING ENGINEERING

ALKALINE ACTIVATED MATERIALS AND HYBRID CEMENT: A BRIEF APPROACH

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Keywords: *alkali-activated materials; hybrid materials; life cycle assessment (LCA); durability; abrasive wear*

Abstract

Portland cements (PC) have been the most used binder in concrete for decades. However, their production consumes resources and generates environmental degradation since cement production is one of the largest sources of CO_2 (5-7% of global anthropogenic CO_2 emissions).

One way to mitigate these adverse effects is the development of construction materials as an alternative to PC, whose manufacture does not emit polluting gases and results in appreciable energy savings. Among these alternative materials, those coming from alkaline activation of industrial by-products can be highlighted, such as blast furnace slag and/or fly ash, called alkaline activated materials (AAM). These materials have aroused great interest due to the following reasons: they exhibit good mechanical performance from a very early age; the manufacturing of AAM is aligned with the principles of the circular economy using industrial waste; they offer similar or even better durability than that offered by PCs, for example, against attack by sulfates and acids, chlorides, among others.

Besides, working with alkaline solutions limits the workability of this type of materials in the construction sector. For this reason, the search continues for alternatives to PC that respect the environment and offer technological viability. Along these lines, a recent research line has opened whose object of study are the so-called hybrid materials (HM).

The main characteristics that define HM are their composition, with low content of PC (20-30%) and one that is high in mineral additions (70-80%) such as fly ash, blast furnace slag or natural pozzolans. These compositional characteristics allow the mixture to be set in the presence of only water, although the addition of a low content of solid alkaline activator powder improves the mechanical properties of the mortar at an early age. Regarding the mechanical properties offered by hybrid cements, the mechanical resistance values obtained in these systems are comparable to those offered by PC.

On the other hand, from the point of view of durability, wear and/or abrasion resistances of construction materials are of great interest. The wear behavior is important for understanding problems such as the wear of surfaces (floors or slabs), or surface problems due to percussion, scratching and attrition from automobiles and heavy trucks [1-2].

Clearly HM can be presented as an alternative to PC and a parallel solution to AAMs. HM can represent a very significant advance in the immediate future of construction materials that respect the environment due to the use of residues, good mechanical properties, durability, and manageability. However, the questions we now ask ourselves are: what happens from a life cycle point of view? Are alkaline cements beneficial from an environmental point of view? Where do HM stand with respect to PC and AAMs?

Thus, to determine if the use of waste mineral in AAM and HM is environmentally friendly, their production processes must be analyzed. A deep understanding of mass and energy flows in cement production systems will help to optimize these mortars. In this regard, life cycle assessment (LCA) has been extensively recognized as a tool to evaluate environmental impacts and identify the reduction opportunities to produce environmentally improved investments.

In order to determine if the mechanical properties of hybrid and alkali-activated mortars are indeed comparable to those from Portland Cements (PC), this paper first examines the compressive strength and porosity of an AAM case study from slag and two HM systems, both from slag and fly ash (Figure 1a).

Their wear behavior was compared to Portland cements. Reciprocating wear tests and rolling wear Böhme tests were carried out for pastes and mortars, respectively. Wear tracks in the pastes were analyzed through opto-digital microscopy and electron microscopy (SEM). In the mortars, the mechanical resistance was measured to understand different behaviors (Figure 1b).

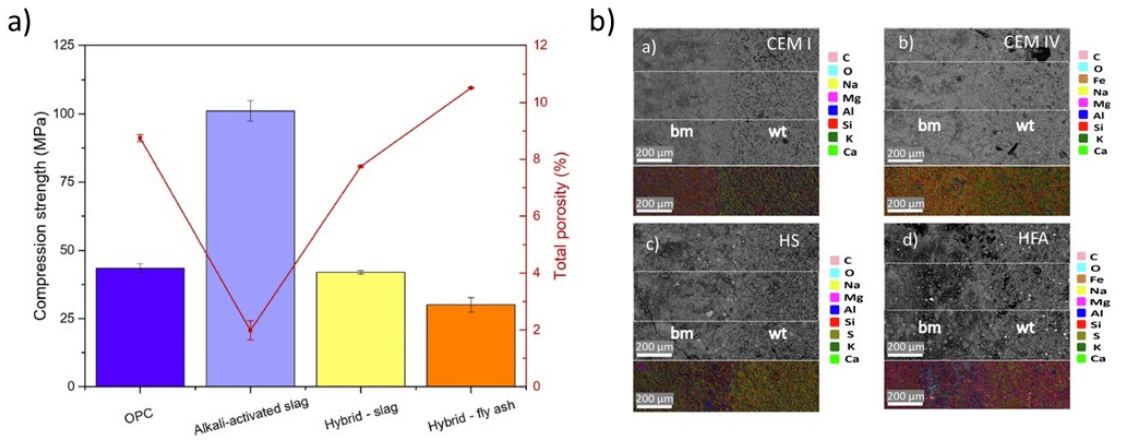


Figure 1: a) *Compression strength and total porosity for all mortars evaluated; b) SEM compositional maps in the interface base material (bm) and wear track (wt) in the different systems evaluated (CEM I, CEM IV, HS and HFA).*

Moreover, since very little is known about their environmental impacts in terms on water use and carbon footprint, they were calculated through the Life Cycle Assessment methodology and compared to those of PC. Results revealed that the assessed AAM and two HM case studies obtained mechanical properties comparable to those for PC. The AAM obtained 406.02 kg CO_2/m^3 while for the hybrids the carbon footprints were 253.26 kg CO_2/m^3 (HM from slag) and 253.27 kg CO_2/m^3 (HM from fly ash), proving that partial or total substitution of cement by waste in mortars reduces the carbon footprint of OPC more than 100% [3]. In terms on water footprint, more than a 40% reduction in water use is obtained if HM are used instead of PC supporting the idea that HM achieve good balance between carbon footprint and water use reductions (Figure 2).

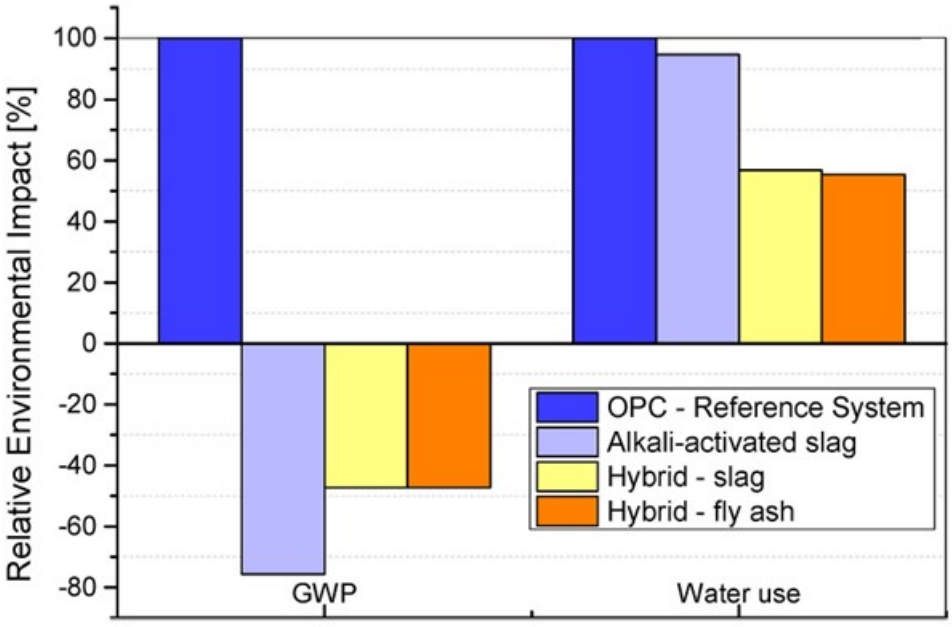


Figure 2: *Relative environmental profile (%) of the case studies.*

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TOWARDS NET ZERO CARBON TEMPORARY BOX

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Keywords: *carbon footprint; temporary box; embodied carbon; construction site*

Abstract

The construction sector, in order to comply with the Roadmap 2050 [1] and European Green Deal [2] targets, is called upon to be increasingly explicit in its support for climate action. The biggest challenge is the implementation of zero carbon emissions for buildings, both new and existing. Achieving zero carbon emissions will require us to transform the way we design, construct and operate buildings of all types and sizes [3]. So, It is no longer enough the control of energy and environmental impacts of the operating stage of a building, but it is necessary to analyze the budget of resources, throughout the entirelife-cycle (from cradle to grave), carrying out assessments also in terms of embodied energy and carbon. This approach should be used irrespective of the type of construction and the expected service life. However, despite this growing need, embodied carbon is still largely ignored by regulators and the market.

The paper shows the evolution of a funded research project that studied the strategies to improve the energy and environmental performance of logistics services (site cabins), in order to reduce carbon footprint of the construction site [4]. Some studies has shown, that the construction phase represents 3 to 9 % of the total impacts [5].

In this paper, "temporary box" refers to prefabricated modular construction used mainly in construction sites (office and site accommodation), but not only there, in order to allow a more or less long permanence of people.

Although there has been a growing need to promote good environmental practices on the construction site, in order to reduce the embodied energy [6] [7] attributable to the construction phase, "relatively little information is provided on the design and operation of construction site offices which are indispensable facilities for almost every building and construction project" [8]. Yet the operating cost of these construction site temporary office buildings, especially in hot and arid climates, can have a major impact on the environment in terms of embodied energy and carbon. [9] In recent years, more and more of these temporary prefabricated structures used for construction sites are being used in other contexts.

The concept of office space is changing in many ways. Aspects like space, costs, mobility, frequent needs for modification, are transforming the traditional office into something more transient and temporary.

In this context, temporary office boxes must be studied from a twofold point of view: not only as essential elements of the building site, generating energy and environmental impacts during the construction phase (thus in relation to the life cycle of a building), but also in relation to their own life cycle, as they are increasingly used in contexts other than the building site, for more or less temporary uses.

It becomes essential to design temporary office blocks and their aggregation in order to limit their carbon footprint, regardless of their expected lifespan, also considering that the actual lifespan may be different from the initial forecasts and especially that these structures may be reused in other contexts. To this end, they should also be designed for possible and desirable reuse.

The research analyses temporary prefabricated structures in relation to the environmental impacts they generate throughout their life cycle, considering that this also affects the life cycle of the building, where temporary structures are used during the construction phase of the building itself, as logistical services for the construction site (intersection between the life cycle of the temporary box and the life cycle of the building).

In fact, the energy efficiency of prefabricated temporary structures for the construction site has been identified as the strategy that can have the strongest impact on CO2 emissions caused by the construction phase, as it has the greatest potential for reduction [10] (precisely because of the poor quality of these structures).

The research methodology starts from a critical analysis of the intrinsic construction characteristics of the temporary prefabricated structures usually used in construction sites, with respect to both the operational and the embodied carbon, to arrive at the definition of design strategies to optimise their energy and environmental performance.

Traditional “temporary box” are prefabricated elements, shaped as a parallelepiped, made of metal modular structures, easily stackable. The structure is made up of vertical and horizontal metal elements, cold rolled sections, galvanized and bolted, representing the container skeleton. The buffers are made of self-supporting, modular sandwich panels, with an external support in waved galvanized sheet metal, resulting in greater mechanical strength. The minimum thickness is generally 40 mm. Even the roof is made up of sandwich panels, while the floor is in waterproof particleboard, with an inner coating in single PVC sheet [4].

The research was structured according to the following phases:

- Step 1 - Identifying the type of carbon emissions in the different phases of the life cycle of temporary boxes

- Step 2 - Analysis of energy performance and operational carbon in traditional temporary boxes
- Step 3 - Checking the implementation of adequate measures to control the embodied carbon in the different life cycle phases
- Step 4 - Definition of goals and design strategies to reduce the carbon footprint of temporary boxes.

In the first phase, the different life cycle phases affecting in terms of carbon emissions of temporary boxes have been defined.

From the analysis of operational energy (Step 2) it is clear that temporary boxes have inadequate energy performance, especially when compared to current legislative standards. The control of energy consumption and comfort is entrusted to a thin layer of thermal insulation (often insufficient) and to heat pumps for summer and/or winter air conditioning. As a result, these temporary structures, in addition to having considerable impacts in terms of energy and operational carbon, are in most cases unable to guarantee adequate conditions of thermo-hygrometric comfort for workers, especially in summer.

In the third step, the carbon emissions associated with the three life cycle phases (before use, use, post use) were analysed. The assessment was made through a set of indicators that allowed to highlight critical points.

A critical analysis of the usual methods of construction and aggregation of traditional temporary boxes highlights the complete absence of strategies to reduce carbon emissions associated with the different phases of the life cycle of these structures. In particular, no specific actions have been implemented to reduce embodied carbon in the pre-use and post-use (end-of-life) phases.

The final phase (Step 4) involved the definition of goals and design strategies to reduce the carbon footprint of temporary boxes (table 2).
Implementable strategies to reduce operational carbon are classified as:

- Passive design to reduce heating demand
- Passive design to reduce cooling demand
- Passive design to reduce lighting consumption
- Active design to reduce non-renewable primary energy demand

These strategies involve a structured approach on two different levels:

- Optimisation of the intrinsic construction characteristics of temporary box
- Optimisation of spatial and aggregative configurations.

A critical point is that traditional temporary boxes are generally the same in any context. The intrinsic construction characteristics and spatial and aggregative configurations do not take into account the location and different climatic conditions, in contrast not only with the current legislative framework (which provides for different minimum

requirements in relation to different climate zones), but also with the most basic principles of bioclimatic architecture.

All envelope components must been designed not only to optimise the primary energy demand during the operational phase, but also to minimise upfront carbon associated to before-use phase.

The temporary box used in the past mainly in construction site, but today increasingly used in other contexts and with different uses, is a product widespread on the International Market for so long, with characteristics that have been nearly unchanged over time. A critical analysis of the usual methods of construction and aggregation of traditional temporary boxes highlights the complete absence of strategies to reduce carbon emissions associated with the different phases of the life cycle of these structures.

It is believed that this kind of structure, even if it is temporary, should be considered effectively as a "building", and should therefore be designed according to a whole-life embodied carbon approach.

In this direction, the design strategies provided aim to implement a net zero carbon temporary box.

Table 1: *Goals and design strategies to implement a net zero carbon temporary box*

Goals	Design approach	Evaluation indicators	Design strategies	Optimisation of intrinsic construction characteristics	Optimisation of spatial and/or aggregative configurations
Minimising upfront carbon		Raw materials supply and Manufacturing	Recycling of used monoblocs with additional envelope panels	■	■
			Maximize use of Recycled / Reused materials and componets	■	
		Materials transport	Use of materials manufactured within 800km of the project site	■	
			Optimise material weight	■	
		Eco-compatibility of materials	Use of low carbon embodied materials	■	
		Amount of material	Use less material	■	
		Waste management	Use of used structures and components, which could be easily assembled and reused	■	
Minimising operational carbon	Passive design to reduce heating demand	Thermal insulation	Use of low conductivity materials	■	
		Solar heat gain	Positioning and sizing of transparent openings	■	■
		Shape ratio S/V	Optimize shape ratio to reduce heating demand.		■
	Passive design to reduce cooling demand	Thermal Inerzia	Use of low diffusivity materials	■	■
		Solar gain control on opaque components	Use of high reflectance materials for surface finishes	■	■
			Optimise exposure and position to take advantage of shadows cast by existing buildings/structures		■
					■

		Solar gain control on transparent components	Use of shading systems and/or solar control glazing	■	■
		Natural ventilation	Shape and openings aligns with the annual prevailing wind		■
			Provision of cross-ventilated openings to utilize natural ventilation		■
	Passive design to reduce lighting energy consumption	Daylighting	Optimum window area for daylighting		■
			Positioning and sizing of transparent openings	■	■
	Active design to reduce non-renewable primary energy demand	HVAC System	Use of high Efficiency HVAC System	■	
		Lighting System	Use of efficient Lighting System	■	
		Renewable sources	integration of renewable sources in building components	■	■
Minimising embodied carbon		Demolition / Recycling and Waste management	All elements must be easily removable and reusable	■	■

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STUDY OF THE PHYSICAL-MECHANICAL CHARACTERISTICS OF PLASTER WITH PADDLE BALL RESIDUES

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Keywords: *gypsum; paddle ball residues; shore; physical-mechanical characteristics*

Abstract

It is widely estimated that Spain's annual usage of 'paddle tennis' balls equals roughly 300 million balls. This results in close to 200 metric tons of discarded balls, presenting a considerable recycling challenge.

Paddle balls are difficult to recycle because they are manufactured with a 100% natural rubber core with certain chemical additives added plus epoxy resin then covered with a 70% nylon-30% acrylic yellow felt. All these ingredients have a long-life cycle, taking decades to disappear in any local landfills.

Today's ecological mindset is do not create products that produce undesirable waste, all in the goal of the circular economy to minimize waste as far as possible.

It is this reasoning that has inspired this study. The goal is how to best re-utilize this undesirable waste in a manner that other products will benefit from its characteristics in a positive manner for the circular economy.

To start we will consider the use of inexpensive resources such as those found in nature in quantity, e.g., plaster of Paris and gypsum, to mix with the waste product resulting from all these discarded paddle balls.

Plaster in the construction industry is mostly used - on a broad scale - for the finishing of interiors and prefab plaster units. Thus, the concept of reusing all this paddle ball waste, were lab analysis and research into its practical use on construction industry sites to yield positive results, makes a lot of sense.

The property of natural rubber contains a plastic that is difficult to recycle and is virtually impossible to reuse in any manufacturing process. Our thinking is to reintroduce this waste, however, into a low-cost manufacturing process that employs only mechanical transformation by crushing/shredding/pulverizing.

Should this result be positive, our project will involve adding this product to many different interior finishes on the construction site as well as to prefabricated plaster sheets or other plaster products.

In order to do these separate studies will be required for each of the ingredients listed in the second paragraph. The study of each component, adjusted for specific percentages as well as exact size counts and mix proportions, will enable us to attest the accuracy of this concept. We will also be able to compare the physical and mechanical properties using this municipal pelletization mix from paddle ball waste and plaster.

Should the result of our findings be encouraging it will be necessary to extend this research to study the most practical and inexpensive manner in which large volumes of paddle ball refuse can be retrieved for use.

The target is to end up with a product that improves sustainable building materials.

First, by reusing waste to avoid it occupying a municipal landfill or other dump site as the life cycle of paddle-ball waste is long. So, we pose ourselves the question whether this waste can be reused as a thermal additive to help buildings reduce their energy costs. We bear in mind the environment above all else, so we look towards nature and its natural resources to see if we can take advantage of this paddle-ball waste.

What we are driving at here is “the study of new plaster composites using industrial waste from paddle balls”.

By studying the physics, stress, chemical, mechanical, and thermal properties of these composites using assay norms approved by UNE [1], [2], the Spanish Association for Standardization (La Asociación Española de Normalización). We expect the results of these exhaustive tests to indicate possibly new applications for plaster composites and laminates using this waste.

We will not ignore environmental impact as we forge ahead thinking in terms of the circular economy where a reduction in natural resources will be offset by the benefit of reusing this discarded paddle-ball waste.

Several studies have studied mixing plaster with waste products [3], [4] or additions [5], [6] but none has employed paddle balls. As the game of paddle gains popularity with Spain’s favourable climate there will be more and more waste and the problem will only grow year on year. By substituting a significant part of plastering use with paddle-ball waste we will be helping the environment due to the fact plaster manufacture consumes high levels of CO^2.

The end goal we seek is to use paddle-ball waste as a plaster composite in the construction industry to improve sustained development, to recycle waste with a long-life cycle, and to boost the circular economy.

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STUDY OF THE MECHANICAL BEHAVIOR OF STAINLESS STEEL REINFORCEMENTS, DEPENDING ON THEIR DEGREE OF CORROSION

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Keywords: *reinforcement; corrosion; ductility; reinforcement; equivalent steel*

Abstract

Corrosion of reinforcement is one of the main problems in reinforced concrete structures worldwide [1], and chloride attack is the most common problem, caused by airborne salt, de-icing salt and/or chloride-contaminated aggregates. Corrosion affects the tensile behavior of steel bars. It decreases the cross-sectional area and thus the load-bearing capacity of the bars. In addition, it induces a non-uniform reduction in the cross-sectional area along the length of the bars, thus decreasing the deformation capacity of the bars, which can affect the durability and cause premature failure of reinforced concrete structures, leading to safety problems and economic losses [2-4].

There are a number of alternatives for the protection of carbon steel reinforcement against corrosion, one promising option is the use of stainless steel, which has a higher corrosion resistance than carbon steel [5-6].

In this work, the mechanical behavior of stainless steel reinforcement was experimentally evaluated in comparison with the mechanical behavior of carbon steel reinforcement. For this purpose, 15 duplex stainless steel rebar of low alloy EN 1.4482 (AISI 2001) and 15 carbon steel rebar B 500 SD, both 16 mm in diameter, were subjected to tensile tests with different degrees of corrosion, which were corroded in an accelerated manner in a previous stage and where the presence of chloride ion was the triggering factor of the corrosion, in order to study the effect of corrosion on their mechanical properties and their ductility based on the concept of equivalent steel (Figure 1).



***Figure 1**: Steels used. a) Low alloy duplex stainless steels; b) Carbon steels B 500 SD*

From the results obtained, it was possible to observe a significant decrease in terms of ductility of carbon steels with respect to stainless steels. The parameters studied on the basis of the equivalent steel concept decreased as corrosion increased, so that the use of ductility criteria is efficient for analyzing steel reinforcements with corrosion problems. It was also possible to verify that the influence of corrosion in stainless steels is much lower than in carbon steels, complying with the minimum values established in the European regulations for reinforced concrete structures (CM-90, EC2 and EHE) (Figure 2).

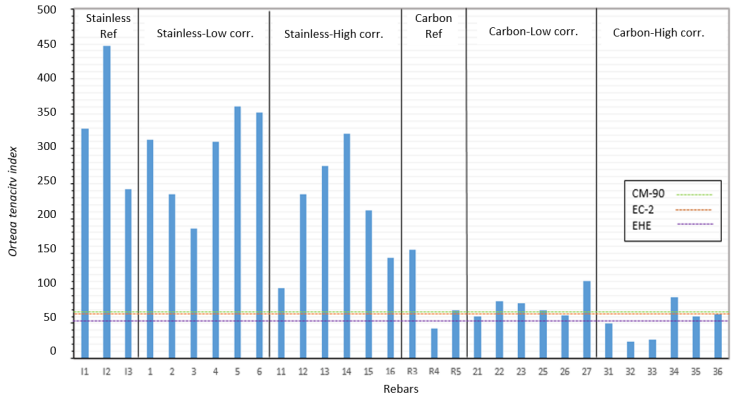


***Figure 2**: Comparison of the values obtained in the Ortega tenacity index, with the different European regulations*

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STUDY OF THE EVALUATION OF THE MECHANICAL CHARACTERISTICS OF A ROCK SOIL USING DOWN HOLE PROCEDURES

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Keywords: *down hole; SPT; geology; geotechnical engineering*

Abstract

This experimental work deals with soil characterisation, the first step for any engineering work. Reference is made to a real case, a road development project in the village of Scaletta Zanclea in the province of Messina. Following a terrible flood, the road connecting the upper part of the village with the cemetery and the football field was damaged due to the detachment and collapse of the debris covers with the formation of mud flows and, locally, the occurrence of overturning and sliding of some concrete structures. The restoration project starts from the geotechnical characterisation of the soil, the methods used and the results obtained are analysed and compared to arrive at the geotechnical parameters that can be used for the design (Figure 1).



Figure 1: *a) Regional technical map of the region of Sicily, (Source: Regione Sicilia [1]); b) Scaletta Zanclea after the flood of 1 October 2009, (Source: ANSA [2])*

Given the importance of the project, soil characterisation was carried out using different types of tests in order to obtain the most accurate results possible, even in such a rugged terrain. In fact, each test has different potential and limits.

In particular, the Standard Penetration Test (SPT) can be performed on all types of soils with the necessary precautions, but for the case study, given the use of the Raymond sampler, it was used only to characterise the first few metres of material, or the superficial detrital layer. There are several reasons for this: to test the deeper layers, which are characterised by the presence of phyllites, it would be necessary to replace the standard sampler with a conical sampler. This would increase costs and time, but would not be justified by the discontinuous results obtained, which would be strongly influenced by the equipment used and the application methods employed.

The soil layer immediately below was analysed by laboratory tests on undisturbed samples, which allows obtaining the soil parameters according to the Hoek-Brown theory and deriving the Mohr-Coulomb parameters by superposition between the two different failure criteria.

Finally, two down hole tests (DH) were performed using both the direct and interval methods. These tests, thanks to the determination of the velocity profiles of the compressional P and shear S seismic waves with the depth varies, allow the seismic characterisation of the area and the determination of the elastic parameters of the soil. The down hole tests provide continuous results for the entire depth analysed and are very reliable tests given the extensive scientific literature on which they are based. Moreover, Italian regulations require the determination of the equivalent shear wave velocity in the first 30 m, $V_{S,30}$, to define the design seismic action, dividing the soils into different categories according to the values obtained, so this parameter is calculated for each test with the two methods.

The results show how a proper soil characterisation can lead to fundamental information for the correct design of engineering works. Moreover, it can be seen how different types of tests can coexist within a well-executed research campaign to have test-specific and redundant results in case of possible hazards or doubts.

In fact, it was found that the surface layer of debris not only lacks the right homogeneity to be used as a design resource, but can even constitute a hazard after further flooding. For this reason, the first step of the intervention to settle the area should be the removal of the rubble material, which is considered unsafe due to the excessive heterogeneity of the response to the SPT test. Furthermore, as the results of the DH and SPT tests show, the point chosen for the test is decisive for the results of the rubble layer properties obtained. The subsequent layers, on the other hand, were characterised without any problems or surprises until the geological parameters were obtained. These parameters can also be corrected for safety and in accordance with geotechnical theory.

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PROPOSAL OF A METHODOLOGY FOR PHOTOGRAMMETRIC AND THERMOGRAPHIC SURVEYS OF EXISTING BUILDINGS WITH DRONES

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Keywords: *drone; photogrammetry; infrared thermography; BIM; BEM*

Abstract

The interest in studying the energy performance of existing buildings has been growing, making it advantageous to integrate the building's information into BIM and/or BEM models [1]. For a convenient analysis of an existing building ("as-is"), it is possible to collect data of its 3D geometric characteristics and measure the thermal conditions of the building's envelope in order to perform an energy analysis [2], [3].

With the increasing use of technologies to study buildings, the use of UAS/drones to capture building data has become a popular method [2], as it provides advantages regarding reduced human effort, low cost, and easy access to locations that might otherwise be inaccessible [4], [5]. Moreover, with the evolution of infrared (IR) sensors to make them smaller, it is possible to integrate them on drones. IR data can be used to study building behaviour and pathologies since different temperatures on the building's surface are noticeable [5].

Even though existing methodologies focus on fusing RGB and IR images, normally integrating the IR data with the 3D geometry, in a process that can later be integrated into BIM models [6], they fail to achieve the advantages of doing this procedure with UASs [5]. In their 2018 literature review about the use of UASs for building's inspection, Rakha and Gorodetsky do not acknowledge the exclusive use of drones to integrate the building's thermal data into BIM models nor a standard approach for similar processes with the non-exclusive use of UASs, making it a research gap [5].

A systematic literature review was conducted to identify articles featuring the exclusive use of drones, in addition to the integration of photogrammetric and thermographic data with BIM models for later qualitative or quantitative analysis. The articles were assessed to find how many followed the line of thought of using RGB and IR data

acquired with a drone and integrating it with BIM. It was found that only two articles ([7], [8]) followed the envisioned process thoroughly, which also included the interest in building energy analysis; however, they do not use drones alone but also laser scanners. Figures 1(a) and 1(b) summarise the process:

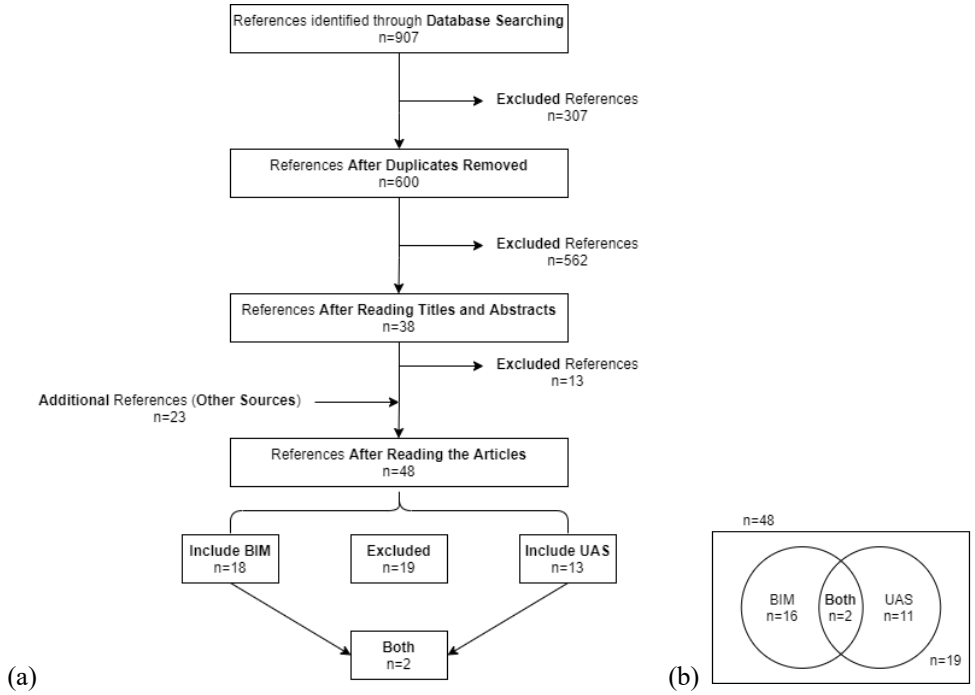


***Figure 1**: References obtainment process, based on PRISMA 2009 diagram flow* [9] *(a) and Venn Diagram of the final step of the process (b)*

In this paper, the authors identify and address a knowledge gap concerning methodologies for drone-exclusive photogrammetric and thermographic surveys and propose a framework for this purpose (see Figure 2).

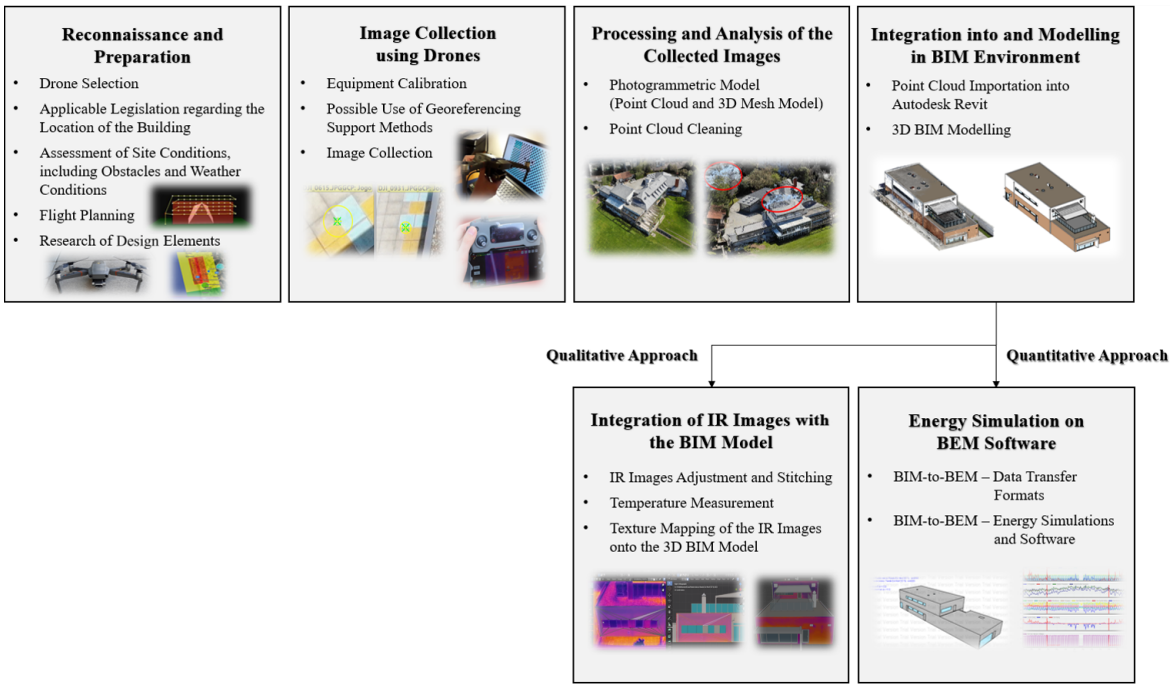


Figure 2: *Methodology for UAS-exclusive photogrammetric and thermographic surveys of existing buildings [images from the authors' collection]*

The proposal follows a continuous workflow starting from the preparation of the surveys, the images collection and the data processing using proper software so that a 3D BIM model can be built afterwards. After these steps, two approach scenarios are proposed: a qualitative approach, where the IR images are added to the BIM model to display thermography sensitive anomalies directly on its surfaces; and a quantitative approach, where the data acquired is used for energy simulations on BEM software.

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OPTIMIZATION APPROACHES FOR STANDARD REPAIRS IN A CONCRETE ELEMENT

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Keywords: *optimization; repairs; concrete; cost estimation; seismic design*

Abstract

This study investigates the optimization approaches for standard repairs in a concrete element. the most significant information for decision-makers would be the cost to retrofit a building. The objective is to provide fertile ground for the decision-makers with accurate information when deciding whether to mitigate or to permit the building to remain as built. In order to achieve such an important goal, an excellent knowledge of knowing about repair and retrofit costs are needed. Indeed, evaluation of repair and retrofit costs play a pivotal role in the future of concrete structures.

A methodology tests a method of multi-objective optimization to find a group of proper solutions in repairing damaged concrete sections, each of the solution vectors has a series of certain characteristics that affect the decision-making process. and for automatic optimize and cost estimation of common elements will be developed by MATLAB programming, which is useful for decision making in performance-based design. The study indicates that after extreme cracking in the building, what are the optional ways to repair and reinforce the construction. In addition, it shows what type of repairing is much better than the other ones.

All the coefficients can be changed if necessary to make alternative configurations if needed as the present study is not about reaching specific solutions for a single building but to propose and test a method to help the decision-maker find proper answers to repair a damaged building. As the results in chapter four have shown, there will be a set of Pareto optimal answers satisfying the objectives of the problem.

With a weighted sum method, the problem has been reduced mathematically into a single-objective optimization problem so a series of optimal answers sorted by their weighted normalized values could be proposed. As the answers seem applicable in the given situation, and objectives are satisfied into the desired degree, the weighted sum multi-objective optimization method seems to have been working in this case. The

decision-maker can, of course, make additional or alternative configuration in the process.

The real plan is used from Kermansha City in Iran. The concrete removal methods, surface preparation methods, coating material, and reinforcement materials brought in the concrete repair guide “ACI 546R-04, And Federal Emergency Management Agency (FEMA) was published FEMA 273 and FEMA 274 as two guidelines for seismic rehabilitation of buildings. After that, FEMA 356 entitled of “Pre-standard for Seismic Rehabilitation” were released based on FEMA 273 and 274. It was intended to be used as a relevant source for professional designs, code officials, and building owners to undertake the seismic rehabilitation of structures.

The analysis results have been presented and discussed. All the numbers, including weights, constraints, and coefficients, could be changed if needed. The purpose of this study is not to offer a series of solutions for a specific building but to propose an optimization approach to reach the best solutions possible in a situation. All the charts and tables representing the results including Pareto fronts are presented.

MIX PROPORTIONING OF ULTRA-HIGH-PERFORMANCE CONCRETE THROUGH USE OF PACKING MODELS

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Keywords: *packing models; concrete; addition; nano addition; ultra-high-performance concrete*

Abstract

Ultra-high-performance concrete (UHPC) and ultra-high-performance fiber reinforced concrete (UHPFRC) concrete are increasingly used in architectural design due to their better mechanical properties and longer durability. The greater compressive and flexural strength, in addition to its greater ductility, allows geometries with larger dimensions, lower weight and more slender both in façades and structural elements. Thus, allowing lower consumption of materials. Moreover, due to its lower porosity and closer network porosity, concrete with longer durability than conventional concrete is achieved, obtaining an increase in its life span, improving efficiency and causing less environmental impact.

In the 1990s, Ultra-High Performance Concrete (UHPC) was designed using packing models [1]. The evolution of admixtures (superplasticisers, viscosity modifying agents) made it possible to produce Self-Compacting Concrete (SCC). Fibres with high adhesion to concrete such as vinyl acetate fibres (PVA) are used. As well as metallic fibres with curvatures to improve pull-out, obtaining compressive strengths of 150 MPa. In the first decade of the 20th century, the development of UHPC concretes and the use of steel fibres, smooth or curved, with diameters of less than 0.12 mm and high tensile strength (up to 3400 MPa) increased, calling these concretes Ultra-High Performance Fibre Reinforced Concrete (UHPFRC), consolidating the nanoscale packing models. In the second decade of the 20th century, there was an increase in studies referring to the hydration processes of the cementitious matrix to nano particles [2].

Therefore, in this paper, an attempt is made to balance the maximum compactness obtained through packing models with the optimum ratio between the materials from the point of view of their hydration mechanics.

The packing models are divided into two main groups: continuous and discrete models. These last ones are based on obtaining an adequate simulation of the packing of the particles up to nanometric size. This type of modelling includes the interaction between the particles by means of the loosening and wall coefficients, allowing the simulation of the virtual and real compactness of these particles. Moreover, a relationship between both compactness is achieved, through the compaction index, which can simulate the energy of compaction that the particles experience in their placement in the mould. The use of latest generation additives allows these models to be implemented with a/c ratios even of 0.18. However, the premise of maximum packing as a basic pillar for the production of UHPC should be studied together with certain considerations regarding the hydration processes of the nano-additions. In addition, the effectiveness of nano-additions in the properties of fresh and hardened state of concrete, according to their percentage in the mixture, should be studied. An adequate ratio and proportion of these additions can lead to better results, even with lower compactness.

To obtain a denser structure, additions of silica fume (SF), nanosilica (nSi), filler (FILL) and metakaolin (MK) were used, combined in different mixes. This allowed a skeleton to be configured at a size of less than 25 nm. Figure 1 shows the particle size measured with laser diffraction of the most important additions used and of the cement, CEM I 52.5 R.

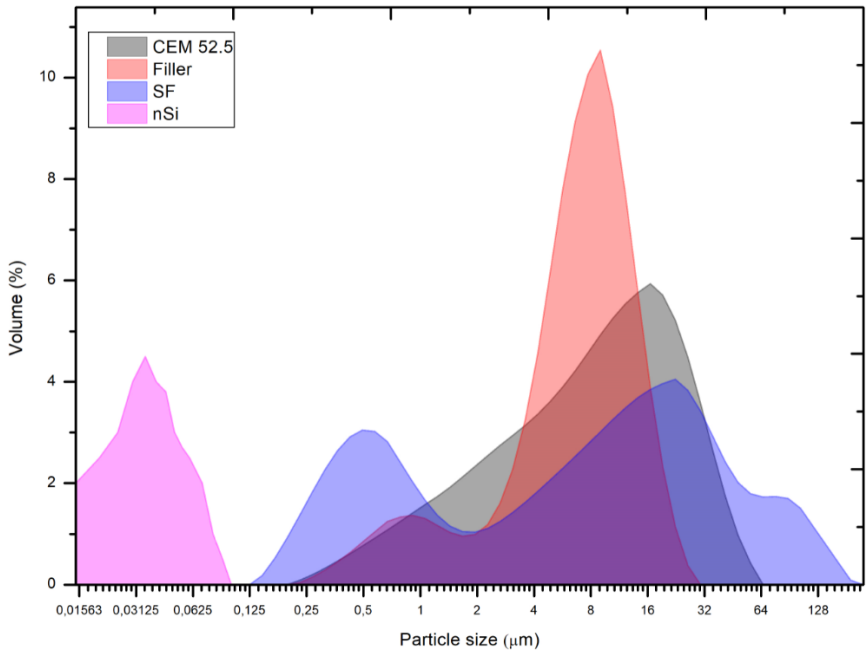


***Figure 1**. % Additions volume.*

In the design of the granular skeleton, two siliceous aggregates were used, with sizes S_3 (0.5-1.6 mm) and S_1 (0-0.5 mm), whose granulometry is shown in Figure 2. The experimental compactnesses, dry compactness, *ci* of these aggregates were determined with a compaction index of *K=9*, establishing values of $c_{S3}=0.57$; $c_{S1}=0.56$. The method

used is the one indicated in the LPC test nº 61 [3] with the variation by vibration indicated by T. Sedran [4].By means of the MEC, the maximum compactnesses reached were analysed according to the percentage of each aggregate. The highest compactness was obtained in the mixture of S_3-S_1 aggregates with 60% of S_3 aggregate, obtaining a compactness $\phi_{S3\text{-}S1}=0.70$.

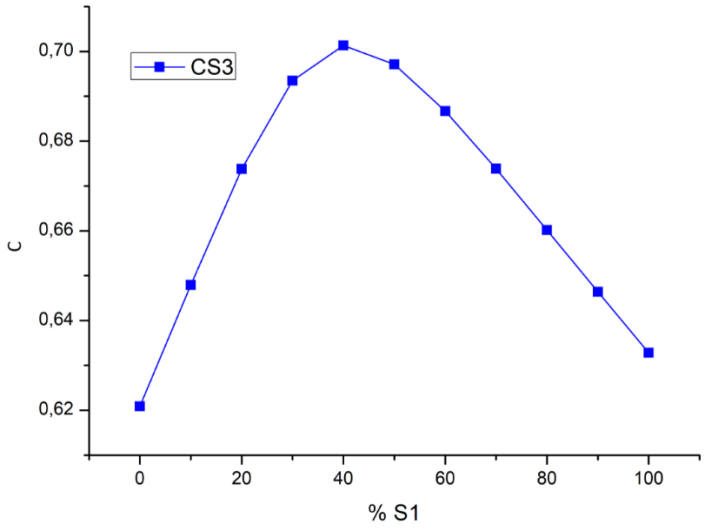


***Figure 2**. Aggregate compactness S3-S1.*

Twelve designs were established with S_3 and S_1 sands and with a maximum of 3 additions. The percentage by volume of cement was set at 35.2%-44.2%. The compaction index is set at *K=6.45*, which is somewhat lower than the wet compaction and close to the value of *K=7* used in self-compacting concretes [4]. The highest compactness is obtained with the use of three additions with a value of $\phi=0.7899$. Table 1 shows the % by volume of the components of each mix, as well as the compaction index and compactness achieved. In three mixes, *Dramix®, OL 13/.20* metallic fibres with a length of 13 mm and a thickness of 0.20 mm were used, with a tensile strength of 2750N/mm^2, usually used in high performance concretes [5]. This addition leads to a minimal adjustment in the rest of the parameters. The *w/c* ratios used were 0.18-0.19.

***Table 1**. Components of each mixture, compaction index and compactness.*

Mix	1	2	3	4	5	6	7	8	9	10	11	12
ϕ	0.7750	0.7750	0.7750	0.7750	0.7899	0.7899	0.7890	0.7870	0.7899	0.7881	0.7762	0.7762
K	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45	6.45
Aggreg 1 S_3	27.2	27.2	27.2	26.6	20.7	20.7	20.7	20.6	20.3	21.5	18.3	17.9
Aggreg 3 S_1	18.1	18.1	18.1	17.7	13.8	13.8	13.8	13.8	13.6	14.3	12.2	12.0
Cement	28.0	28.0	28.0	27.4	33.2	33.2	33.2	33.2	32.5	33.2	33.4	32.7
Fíller	3.2	3.2	3.2	3.1	3.2	3.2	3.2	4.5	3.1		0.0	0.0

Sílica F	3.2	3.2	3.2	3.1	3.2	3.2	3.3	3.1	3.1	3.1	11.6	11.4
Metakaolín										3.1		
nSi					2.5	2.5	2.4	1.5	2	1.5		
Air	2	2	2	2	2	2	2	2	2	2	2	2
Water	16	16	16	16	19	19	19	19	19	19	20	20
Additive SP	2.3	2.3	2.3	2	2.3	2.3	2.3	2.3	2	2.3	2	2
Fiber				2					2			2

The results obtained for compressive strength in cubic specimen are shown below. For mixes 1-3 with two additions, same cement content and compactness, an average strength at 7 days of 83 MPa and a deviation of 3.45 MPa is obtained. The same dosage, mix 4, but with 2% by volume of fibre obtained a value of 107 MPa. At 28 days the average strength obtained is 119 MPa with a higher deviation of 4.42 MPa. With fibre, a result of 136 MPa is obtained. Mixes 5-8, 10 are made with the same % of cement, higher than that used in mixes 1-3, and three additions. Mix 10 is the only one containing metakaolin and no filler. It can be seen that due to the higher reactivity of this addition, higher compressive strength values are obtained with respect to mixes containing filler and higher compactness. Mix 9, with fibre, exceeds 150 MPa at 90 days, UHPC concrete values. Mixes 11 and 12 have a higher cement content, but a lower compactness, obtaining the highest values of 160.8 MPa at 90 days, using a single addition. In this mix, a flexural strength test was carried out according to EN 14651, obtaining a value of 24 MPa, the limit of proportionality LOP.

Table 2. *Compressive strength at 7, 28 and 90 days*

Mixture	ϕ	R7 cub (MPa)	R28 cub (MPa)	R90 cub (MPa)
1	0.7750	81.3	117.0	
2	0.7750	80.1	124.6	126.0
3	0.7750	86.6	116.9	
4	0.7750	106.7	136.4	149.1
5	0.7899	89.7	91.7	131.0
6	0.7899	83.0	97.3	106.0
7	0.7890	93.7	121.7	
8	0.7870	96.8	101.5	
9	0.7899	112.7	142.8	154.4
10	0.7881	89.3	121.1	
11	0.7762	79.4	111.3	130.7
12	0.7762	110.7	148.8	160.8

Figure 3 compares the compressive strength at 7 and 28 days with respect to the compactness obtained. At 7 and 28 days, there is a directly proportional relationship

between the compressive strength and compactness. However, this trend is reversed with the results at 90 days, indicating that the effect of nanoadditions on strength must be taken into account in compressible packing models, where the emphasis is on obtaining a higher compactness in order to achieve a higher strength.

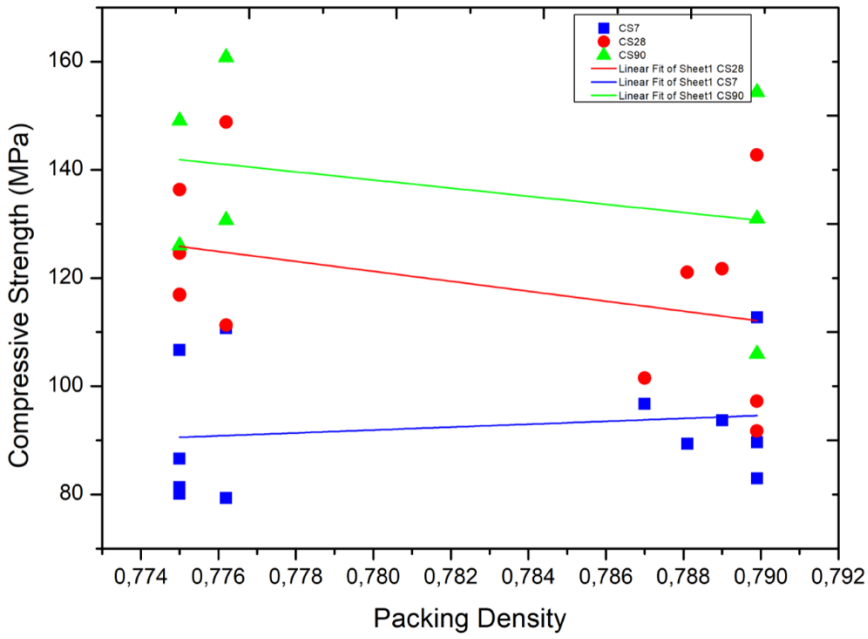


Figure 3. *Compressive strength results according to compactness*

The results obtained in this work, where the compactness design was carried out maintaining fixed percentages of certain nano-additions, varying the rest of the granular components, Compressive strength higher than 160 N/mm2 and flexural strength higher than 24 N/mm2 were obtained at of 90 days of concrete age, confirming the effectiveness of the hydration process on the properties of the concrete in combination with the compaction of the mix proportioning.

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MECHANICAL CHARACTERIZATION OF GYPSUM MORTARS WITH WASTE FROM THE AUTOMOTIVE SECTOR

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Keywords: *plaster; waste; recycling; building; circular economy*

Abstract

The construction sector is one of the main sectors generating greater environmental impacts. In this sense, the European Commission is forcing the sector to implement alternative measures and strategies to tackle this situation and bring the sector to a circular economy. One of the adopted measures is the use of recycled materials to produce construction materials and products. In this sense, many research works have been conducted analyzing the incorporation of different waste categories in gypsum products. In this sense, the main objective of this research is to characterize new gypsum-based materials that incorporate waste from the automotive sector. For this, waste from the production of cars has been used, containing a mixture of polyurethane foam, cardboard, and fiberglass (PCF) through different size scales. A total of 41 gypsum samples were made incorporating up to 11% of waste addition. These samples were tested according to the density, superficial hardness, mechanical resistance, and thermal behavior. Results show that it is possible to incorporate up to 11% of waste overpassing the minimum strength values established by the regulations. In addition, the lightness of the material and its compression and flexion behavior improved considerably compared to the reference values. Finally, the use of the automotive waste analyzed can be used in the manufacture of gypsum mortars for construction, reducing the consumption of natural resources and, at the same time, recovering an industrial waste that is otherwise difficult to recycle.

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INFLUENCE OF THE PERCENTAGE OF SUBSTITUTION OF AGGREGATES IN RECYCLED CONCRETE

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Keywords: *Circular economy; sustainability; construction waste; recycled aggregate concrete; recycled aggregate*

Abstract

The history of the use of demolition and construction waste (CDW) as aggregates to make concrete with recycled aggregates (RAC) began after World War II, reusing the enormous amount of rubble generated as a result of the bombings in cities, mainly in the UK and Germany [1]. From the beginning it was found that RAC has higher water absorption, lower mechanical resistance, similar resistance to freeze-thaw and lower drying shrinkage than concrete with natural aggregate (NAC) [2]. Extensive research was conducted from 1945 to 1985 aimed at obtaining the physical and mechanical properties of RAC and it was not until the late 20th century that it began to be used in prestressed beams for important spans. Currently, the emphasis has been placed on the study of the durability and improvement of the quality of recycled aggregates. Due to the enormous international interest in protecting the environment and achieving sustainable development, the number of published research in the last 20 years has grown enormously (figure 1) [3].

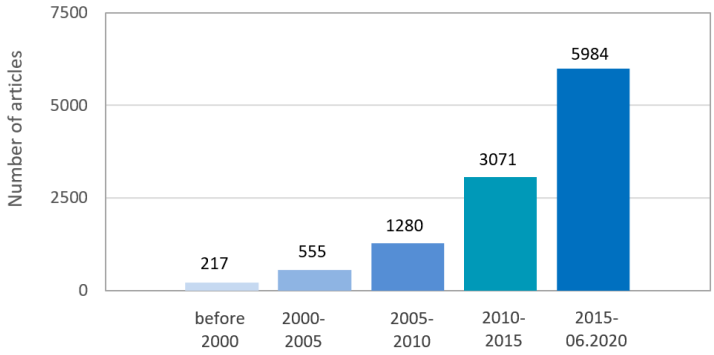


Figure 1: *The increasing number of articles on the topic "recycled aggregate concrete. (Source: web of science)*

The reuse of industrial waste incorporating it in the preparation of mortars and concrete is a necessary step for the sustainability of the construction sector and for the incorporation of the circular economy within this productive sector. In this context, the manufacture of concrete with aggregates from construction and demolition waste (RCD) of concrete structures (recycled aggregates) constitutes a way of achieving efficient use of the waste generated in demolitions.

Hardened concrete is a composite material of three phases: aggregates, cement paste and the interfacial transition zone (ITZ). During the mixing of the concrete, the coarse aggregate is mixed with the cement paste. The size of the coarse aggregate (usually between 10 and 20 mm in diameter) is several orders of magnitude greater than that of the cement grains (usually between 1 and 100 microns), so the surface of the coarse aggregate can be considered as a "wall" for cement grains, which with different sizes and shapes cannot easily contact the surface of the coarse aggregate. In this way, gaps are generated in the area adjacent to the surface of the coarse aggregate that are filled with small particles or molecules such as cement grains, air and water. This phenomenon is known as the "wall effect" [4] and involves a zone that surrounds the coarse aggregate with a thickness of a few tens of µm (ITZ). Due to the enormous amount of small grains and hollows, the resistance of this area is always lower than the resistance of the rest of the cement mortar. There is no clear dividing line between the ITZ and the rest of the mortar, however, the ITZ can be defined by the distribution of porosity or with microhardness tests.

The RCA has two ITZs, the ITZ corresponding to the mortar that adheres to the gravel to be recycled and is incorporated into the concrete and the new ITZ that is generated by mixing the recycled aggregate with the paste to generate the new concrete. For this reason, the porosity of RCA is usually greater than that of NCA and its resistances are usually lower. Following the chain theory that breaks at the weakest link, the presence of two ITZs makes the RCA less resistant than the NCA.

The ITZ also explains why the mixture of cement paste and gravel, both materials with a marked linear behavior, gives rise to a compound with a non-linear behavior. Indeed,

ITZ causes the presence of microcracks between the paste and the gravel wall, even in the absence of load, which progress in size when loads are applied to the concrete and give rise to an increasingly less rigid behavior, losing linearity (Figure 2).

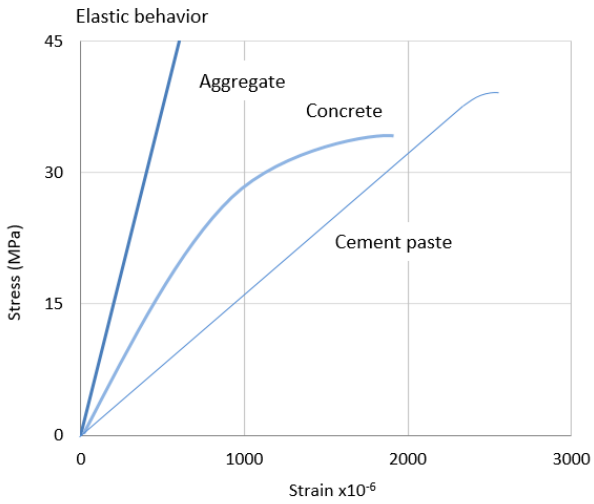


Figure 2: *Compressive behavior of gravel, cement paste and concrete.*

Table 1 shows the variation in the results obtained for four mechanical properties as a function of the percentage of substitution of aggregates. The table has been adapted from the information obtained from [4]. The number in brackets indicates the reference number analyzed to obtain the percentage decrease in the mechanical property analyzed (upper number).

Table 1: *Evolution of the mechanical properties in a RAC as a function of the percentage of substitution of aggregates*

	0%	**20%**	**25%**	**50%**	**100%**
Compressive strength (%)	100	96 [14]	96 [13]	92 [25]	86 [37]
Modulus of elasticity by compression (%)	100	----	96 [11]	85 [13]	77 [22]
Flexural strength (%)	100	----	98 [11]	94 [11]	89 [14]
Tensile strength (%)	100	93 [9]	95 [10]	93 [21]	84 [28]

The analysis of the table allows to indicate that all the analyzed properties experience a progressive decrease when the percentage of substitution of the aggregate increases. However, except for the modulus of elasticity of concrete under compression, the decrease, even at 100% replacement percentages, is not too high a value. The above values allow to obtain a first approximation to predict what quality of "base concrete" should be had to reach a certain value for the mechanical properties of table 1 when the

substitution of the amount of aggregate indicated in the table is carried out. For example, if a compressive strength of 25 MPa is desired when a 100% substitution of natural aggregate for recycled aggregate is made, one must start from a natural aggregate concrete with a compressive strength of 29 MPa.

In this work, a study has been carried out on the influence of the percentage of substitution of natural aggregate by recycled aggregate on the mechanical properties of concrete. The results show that it is possible to substitute 100% natural aggregate for recycled aggregate.

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INDUSTRIAL APPLICATIONS OF PIEZOELECTRIC EFFECT

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Keywords: *piezoelectric; transducter; energy harvesting*

Abstract

In dielectrics without a center of symmetry, the action of a mechanical stress can produce a dipole moment known as the piezoelectric effect. The reverse effect also occurs: Under the action of an electric field, the crystal can expand or contract. This effect occurs in all crystals that do not have a center of symmetry when, under the action of a mechanical stress, there is a displacement of the charged particles and the dipole moment is produced.

The phenomenon was discovered in 1880 by brothers Jaques and Pierre Curie, who demonstrated that when certain crystals such as tourmaline, quartz, topaz, and Rochelle salt are subjected to mechanical stress, an electric charge is generated whose voltage is proportional to the stress exerted. In 1881, Gabriel Lippmann confirmed the reverse phenomenon: when an electric field is applied, a mechanical stress is produced that is proportional to the applied voltage. In 1882, the Curie brothers found that the effect discovered by Lippmann had the same conversion coefficient as the direct effect.

In 1893 Kelvin developed theoretical models to explain the piezoelectric effect, and in 1910 Voigt published the equations with tensors that apply to piezoelectric materials. In 1940 Manson extended Kelvin's model by applying it to the deformation of glass.

The piezoelectric effect is described by the following constitutive equation:

$$[D_i] = [\varepsilon_{ij}][E_j] + [d_{in}][T_n]$$

Where D is the electric flux density, E is the electric field vector, ϵ is the permittivity of the medium, T is the voltage vector, and d is the piezoelectric constant.

It took several decades from the discovery of the piezoelectric effect to its first industrial applications. The first application was during World War I, when Langevin developed a

piezoelectric transducer that could detect ultrasonic signals from submarines, enabling their detection.

During World War II, individual research groups from the United States, Japan, and the Soviet Union working on improving capacitor materials discovered that metal materials made by sintering metal oxide powders had dielectric constants up to 100 times higher than conventional crystals. Moreover, these materials (ferroelectric materials) could be fabricated in such a way that their piezoelectric properties were enhanced. This led to an enormous boom in the research and development of piezoelectric devices.

In 1945, the commercialization of piezoelectric materials began when it was discovered that barium titanate had a very high piezoelectric constant and could be easily manufactured.

The development of this technology spread throughout the world, but was clearly dominated by groups in the United States who secured a leadership position by obtaining important patents.

At the same time, several companies and universities in Japan formed the Barium Titanate Application Research Committee Association in 1951 with the goal of studying these materials and finding new business areas for them. From 1965, these efforts led to Japan becoming a leader in this field of knowledge at all levels, from scientific to commercial.

In 1969, a large piezoelectric activity was discovered in the polymer polyvinylidene fluoride (PVDF). This was the beginning of a very important line of work and research on the use of polymers in devices such as microphones, hydrophones and detectors of electromagnetic radiation.

Since then, the work dedicated to the study of these materials and the search for new applications and business fields has increased almost constantly at the international level. Currently, the interest in these materials is very high, since the widespread use of systems based on the piezoelectric effect will lead to reduced consumption of non-renewable energy.

Currently, monocrystalline piezoelectric materials are still being developed, but the most commonly used piezoelectric materials are polycrystalline ceramic materials and polymers. These materials acquire piezoelectric character after being subjected to artificial polarization. The most commonly used piezoelectric ceramic is lead zirconate titanate (PZT). The most developed piezoelectric polymer is polyvinylidene fluoride (PVDF) polymer. The combination of a piezoelectric ceramic and a passive polymer can form a composite material that can be used to develop new piezoelectrics that offer

significant advantages over conventional piezoelectric ceramics and piezoelectric polymers.

Depending on the piezoelectric material used, applications requiring highly variable stiffness are possible. Piezoceramics are used as actuators due to their high modulus of elasticity, which facilitates mechanical coupling with the structure. Piezopolymer materials are used as sensors due to their low elastic modulus and impart minimal stiffness to the structure.

The following are some current applications of piezoelectric materials in the fields of electronics, mechanical engineering, construction, and biomedicine.

Currently, the most common application in electrical engineering is piezoelectric actuators, which are devices that produce motion when an electric field is applied to a piezoelectric material [1]. Actuators based on this effect have been on the market for 40 years and have brought unprecedented advances in precision positioning. For example, devices have been developed that convert mechanical energy into electrical energy that can be stored and used to power low-consumption electronic systems such as those used in computers and wireless sensor networks (energy harvesting) [2].

In engineering and construction, work is being done on their use on highways to use the energy generated for lighting, and on roads to power traffic lights [3].

Piezoelectric materials have been embedded in composite materials to dampen vibrations or detect an impact, such as in vehicle airbags, where the material detects the force of the impact and sends an electrical signal that activates the airbag.

Piezoelectric paints were made using ceramic powder based on lead zirconate titanate as the pigment and epoxy resin as the binder. The mixture is applied to a surface, cures, polarizes at room temperature and serves as a sensor for vibrations and acoustic emissions.

In biomedical engineering, it is known that the average energy consumption of a human is $1{,}07 \cdot 10^7$ J, with most of the energy being converted to heat and motion. It is possible to implement systems that collect the biomechanical energy generated by the human body and convert it into electrical energy to power electronic circuits with low consumption.

In this sense, they have been used to power electronic devices implanted in or attached to the human body. In such situations, it is desirable for the devices to be completely autonomous, as batteries are difficult to replace. A successful example of this type of

application is the sensing of energy generated by the human body for applications such as heart pulse detection to estimate a person's heart rate [4].

Energy harvesting systems based on piezoelectric sensors on the soles of shoes have been proposed, so that electrical energy is generated at each step by the mechanical tension generated by the shoe soles. Shenck and Paradiso [5] placed a polyvinylidene fluoride (PVDF) film in the midfoot area and a lead zirconium titanate (PZT) sensor in the heel area. In the first case, they obtained an average power of 1.3 mW while walking at a frequency of 0.9 Hz. In the second case, they obtained a power of 8.4 mW while walking at a similar frequency.

In another application, the straps of the backpack were replaced with those made of PVDF. The force generated between the backpack and the person wearing it generates a voltage that can produce a power of 45.6 mW [6].

As a conclusion, it can be said that piezoelectric materials have undergone a continuous development since their first application in the First World War and nowadays they can be found in all fields of technology and industry. Moreover, the widespread use of systems based on the piezoelectric effect will lead to reduced consumption of non-renewable energy.

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GRAPHENE OXIDE AS AN ADDITIVE TO ENHANCE THE PERFORMANCE OF CEMENT MORTARS

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Abstract

Nanomaterials have received an increased evolution in the field of civil engineering, as their incorporation can effectively modify the mechanical and chemical properties of cementitious composites. graphene oxide (GO) has aroused the interests of researchers as an effective Nano-reinforcement for cementitious composites because is a wonderful nanomaterial as it reforms the cement composite ranging from the atomic scale to macroscale and improves the mechanical properties, durability and other multifunctional behaviour. the present work aims to combine GO nanoparticles with ordinary Portland cement (OPC) mortar, evaluating possible improvements on their mechanical properties, durability and ultimately coming up with an ideal and effective concentration of graphene oxide for future concrete applications. so, mortars were performed with two water/cement ratios which are 0.5 and 0.35 (without and with superplasticizer, respectively), GO were added with different percentages of 0.0005, 0.005 and 0.05% by weight of cement, and the standard sand was 3 parts by part of cement. the results show that the workability decreases as increasing the content of GO with the second ratio 0.35, superplasticizer was necessary to maintain the same flow for all samples, firstly prismatic specimens of dimensions 160x40x40 mm^3 were performed and subjected to electrical resistivity, compressive and flexural strength tests at the ages from 2 until 90 days. results revealed that significant improvements in both side mechanical and durability properties were provide. In case of electrical resistivity test it was found that in each mix, resistivity value increased with increase in curing time and in some case with increasing in percentage of GO. The optimal flexural strength increases were obtained with samples doped with 0.05% of GO dosage, with

improvements of 12.26, 23.58, and 22.20% after 7, 28, and 90 days, respectively, compared with samples without GO. moreover, the optimal compressive strength was achieved with dosage's samples of 0.005%, for which the corresponding increases were 4.10, 6.36 and 6.13%, after 7, 28 and 90 days, respectively, compared with control sample. And cylindrical specimens of dimensions 150x75 mm^3 were performed and subjected to the durability test such as Chloride penetration test and water-accessible porosity test. Chloride penetration test on the selected mortar samples shows that the migration of chloride ions slows down with the addition of GO in cement mortar when compared to the control sample, and the water-accessible porosity test showed porosity decline by 18.71, and 26.89, for 0.05% GO and 0,0005% GO+SP in comparison to Control sample, respectively. And regarding the chemical characteristics, the addition of GO apparently accelerates cement hydration reactions and enhance the mechanical strength, as mentioned in the results part, the amount of C-S-H gel increased by increasing the percentages of GO. an improvement in electrical resistivity and other chemical properties are also associated with the incorporation of GO. based on the experimental results, it seems that all samples reinforced with GO showed improvements in mechanical properties and durability compared to the control samples. and samples containing both, GO and superplasticizer showed better results than both, control samples, and samples that just contains GO, because superplasticizer helps GO to better dispersion.

EFFECTS OF CORROSION ON THE TENSILE STRENGTH OF STEEL REBARS

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Keywords: *tensile strength; stainless-steel; carbon-steel; corrosion; breaking tests*

Abstract

Steel is one of the materials with the widest field of application in construction, including that of concrete reinforcement. Steel reinforcing bars are used in concrete construction to enhance tensile strength, complementing concrete's excellent compressive properties.

The assessment of the strength of reinforced concrete structures depends mainly on the properties of the materials they are made of and the conditions to which they are subjected. Rebars corrosion can be considered one of the main causes of the deterioration of the mechanical characteristics of the material, affecting his behavior at the service limit state and the ultimate limit state and causing dangerous degradation phenomena or in more serious cases, structural failure.

Corrosion involves, in addition to the loss of bearing capacity following the reduction of the resistant section of the element, also other damages, such as the internal stresses in the concrete produced by the corrosion of the reinforcements, whose oxides, expanding, cause cracking and detachment of the concrete covers. It is necessary to consider that the so-called stainless steels do not rust exclusively under certain conditions, therefore the use and application of these materials must be verified on a case-by-case basis, both with respect to current building regulations, and with respect to surface finishes and the desired resistance to corrosion.

The aim of this investigation is to experimentally analyze the effects of corrosion on mechanical properties of steel rebars. To investigate the impact of corrosion on its mechanical properties, tensile tests were conducted on the corroded rebars, and the mechanical performance characteristics were examined. The results produced from the tests help understand the corrosion behavior and its effect on mechanical properties of corroded rebars, which can be used to predict mechanical behavior in structures.

The tests were made on steel rebars subjected to an accelerated corrosion procedure and the results obtained were compared with those proceeding from new rebars with the same geometry. The axial tensile strength tests were repeated with both stainless-steel bars and carbon-steel bars, obtaining the necessary data for the analysis and allowing the comparison between the two materials.

Experiments consisted of a tensile test on corroded and non-corroded stainless steel and carbon steel reinforcement bars, analyzed to determine the different response to the applied stresses. Sixteen specimens were used for the tensile test. Where the new stainless steel rebars provides the reference data for the analysis. All bars are corrugated, type B400SD and Ø16 mm diameter.

The effects of corrosion degree on tensile strength of the two types of corroded steel fibers were investigated. The tensile test is performed to examine the deformation and strength behavior of a material subjected to tensile loading. During the tensile test the specimen is stretched to failure, measuring the strength and deformation of the material.

The bars used in the tests had previously been subjected to an accelerated corrosion process by impressed anodic current applied to the reinforcement embedded in concrete. The amount of steel lost in the corrosion process is evaluated by the difference in weight between new and corroded bars, which implies a loss in mass and volume. The loss of mass gave a better approximation of residual cross-section than the loss of diameter measured with caliper because the irregularities reduced the precision of residual cross-section measurement. Due to the irregularity of the corroded rebars, the weight loss of the steel bar was also used to calculate the diameter loss. The specimens were named, weighed and the initial length was measured.

The state of deformation of a uniaxial element clearly depends on the magnitude of the internal forces that develop within the element, as well as on the constituent material. Within certain limits it is possible to describe with a good approximation the response to stresses of the steel rebars examined by studying the elastic behavior.

With the tensile test the characteristic values of resistance and deformation of metallic materials are determined. The task of the test is to determine the characteristic values in a reliable and reproducible way and to obtain international comparability. The uniaxial tensile test is used to determine the characteristic values of the yield point, tensile strength, and deformation. In the laboratory, the specimens were subjected to the experimental tensile rupture test. In the tensile test a test piece is subjected to a gradually increasing load until it breaks.

Due to the tensile stress, the rebar under examination undergoes a certain elongation, which will be measured after breaking by making the two pieces of the rebar perfectly match. Simultaneously with the elongation, the specimen undergoes a decrease in its transversal dimensions. This decrease manifests itself with the development of heat, which derives from the transformation of the deformation work to which the crystalline

structure of the material is subjected during the test. The test is carried out to identify the characteristics of resistance, deformability, and elasticity of a material.



Figure 1: *Carbon steel bar after breaking test.*

All the results obtained from the tests were the basis for calculating the failure graphs, the limit stress and yield values of each of the rebars. The graphic resulting from the experimental data alone must be corrected according to some precautions. The initial part of the graph presents some irregularities due to the settling of the bar in the clamp. Thanks to the measurements of the lengths before and after the tensile test, the elongation is calculated, and the value of the deformation is determined through the calculation. On the basis of this value, the graph, which keeps the same trend, is adjusted to the correct deformation values.

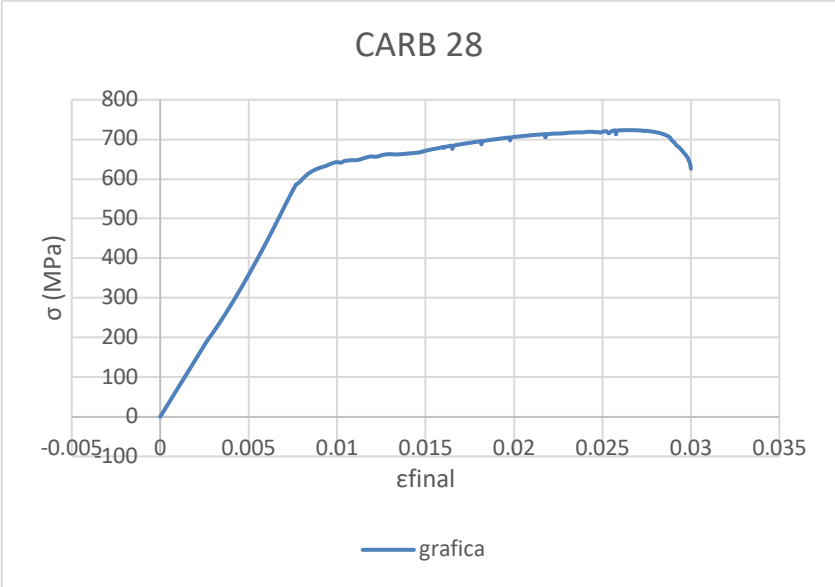


Figure 2: *Final graphic resulting from the tensile test, after adjustments.*

From the observation of the data, it is clearly noticeable that the degree of corrosion strongly affected the mechanical properties of the steel, particularly the ultimate stress and strain. A reduction of the ultimate elongation appeared to be the major effect of corrosion.

The comparison between the results shows how the corrosion clearly affects the resistance properties of the steel with the loss of ductility. As the corrosion degree increased, both the tensile strength and elongation of the two types of corroded steel fibers decreased. In addition to weight loss, local section loss is the main reason for further degradation of the mechanical properties of steel fibers because the reacting surface is smaller.

From the stress-strain curves of corroded steel bars, it was observed that both strength and deformation capacities decreased with corrosion.

Table 1: *Resulting data for each rebar.*

Barra	F_{max} (kN)	f_y (MPa)	f_{max} (MPa)	ε_y	ε_{max}	A_{max}	A_u	f_{max}/f_y
CARB28	113,746	656,144	723,419	0,011	0,027	14,702	17,165	1,103
CARB29	110,420	586,831	646,444	0,014	0,033	16,416	19,134	1,102
CARB30	111,017	618,120	710,043	0,014	0,053	30,842	33,372	1,149
CARB38	111,703	642,322	713,513	0,017	0,058	33,446	38,132	1,111
CARB39	115,591	666,180	738,227	0,015	0,060	36,162	41,599	1,108
CARB40	113,746	622,658	723,419	0,020	0,044	14,702	17,165	1,105
INOX9	165,926	1008,353	1278,526	0,023	0,278	303,390	312,947	1,268
INOX17	152,608	985,954	1185,106	0,021	0,251	260,441	278,614	1,202
INOX18	149,653	963,238	1169,080	0,021	0,223	225,883	233,153	1,214
INOX19	161,148	994,847	1203,488	0,022	0,243	254,174	261,806	1,210
INOX20	144,127	862,888	1057,863	0,020	0,217	198,223	210,787	1,226
REF-INOX1	172,558	604,855	858,231	0,019	0,335	243,272	250,820	1,419
REF-INOX2	173,116	656,759	861,009	0,021	0,330	242,907	255,374	1,311
REF-INOX3	171,022	640,521	850,595	0,022	0,334	241,422	250,741	1,328
REF-INOX4	175,652	637,063	873,623	0,021	0,333	244,506	266,314	1,371
REF-INOX5	178,124	683,080	885,918	0,021	0,321	243,836	254,639	1,297

From the analysis of the test results, some of the conclusions that can be drawn includes the fact that corrosion of steel reinforcement reduces the tensile strength of steel reinforcement and impairs the bonding between steel reinforcement and concrete. In this way corrosion reduces the flexural capacity of steel-reinforced concrete and this reduction is primarily due to the reduction of the tensile strength and bond.

It is therefore important considering that steel reinforcements should be protected from environments and substances that can produce corrosion such as humidity and chlorides.

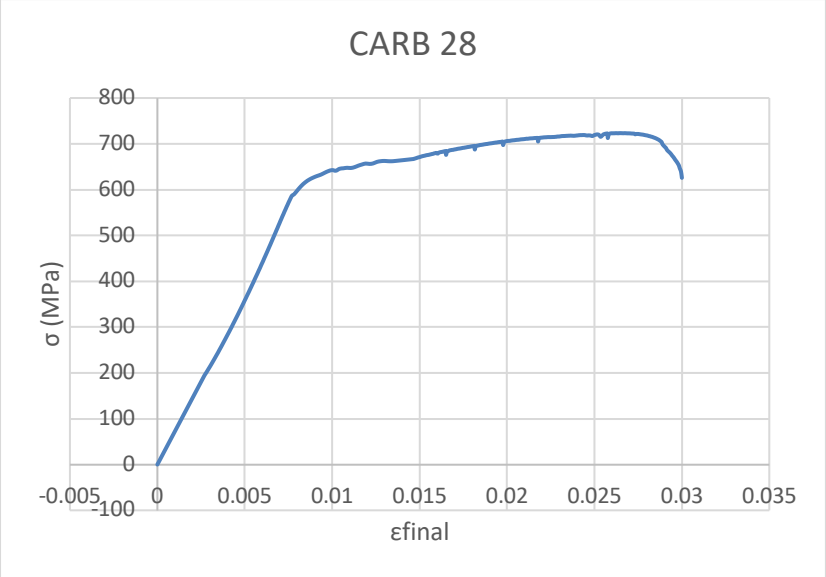




Figure 3: *Final graphic and breaking of a corroded carbon-steel bar.*

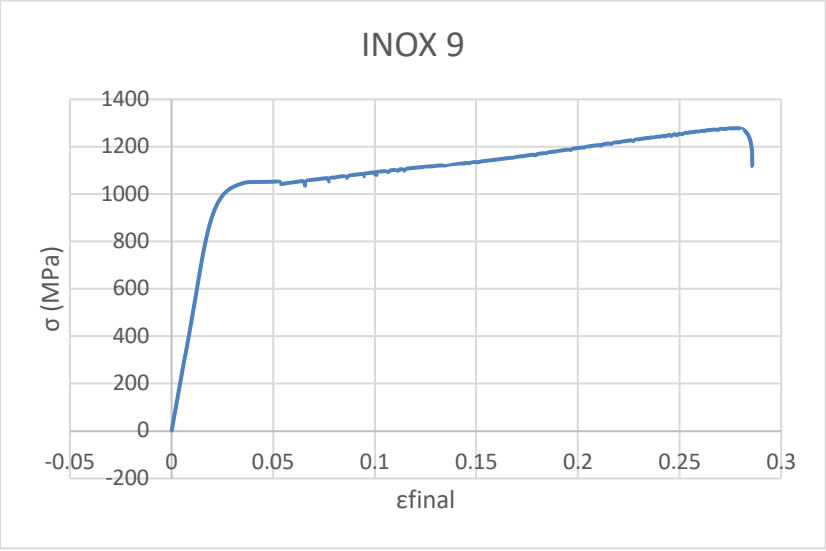
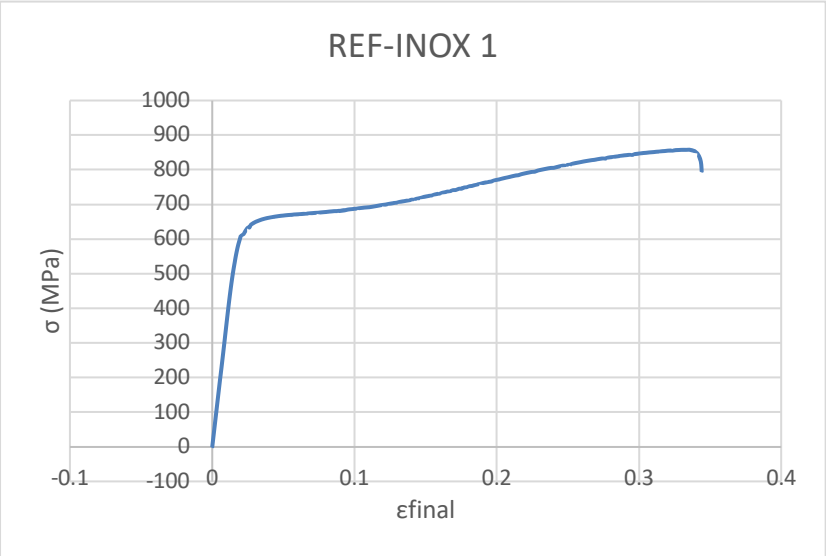




Figure 4: *Final graphic and breaking of a corroded stainless-steel bar.*



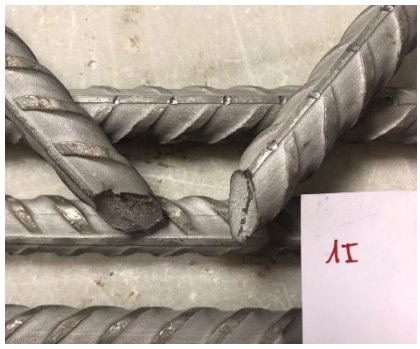


Figure 5: *Final graphic and breaking of a stainless-steel bar.*

EFFECTIVENESS OF ADDED COMMERCIAL CORROSION INHIBITORS IN MORTAR TESTS WITH 2% CL- RELATED TO THE WEIGHT OF CEMENT IN MIXING WATER

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Keywords: *corrosion; inhibitors; linear polarization resistance (LPR); corrosion density; electrochemical impedance spectroscopy (EIS); equivalent circuit*

Abstract

Concrete is a protective medium in which reinforcing steel is embedded. It is a heterogeneous material with porous structure. It has the property of protecting steel against corrosion in a stable and durable way [1]. This protection is twofold in nature: First, it is a physical barrier between the steel and the external environment. Second, the water that fills the pores due to hydration reactions is saturated in Ca(OH)2 and contains ions such as Na^+, K^+ and SO_4^-, which place its pH between 12.5 and 13.5, depending on the type of cement used [2, 3]. This high pH and in presence of atmospheric oxygen, favors the formation of a stable oxide film, leading to the passivation of the reinforcements [1, 2, 3, 4]. However, when sufficient amount of chloride ions (from de-icing salts or seawater) penetrates through the concrete surface and reaches the reinforcement, or when pH of the pore solution drops to low values due to upon carbonation, the protective film is destroyed and reinforcing steel depassivates [2, 4, 5, 6, 7].

Breakdown of the passive film as a consequence of these aggressive agents at the level of the reinforcement produces corrosion and causes the reduction of the properties of reinforced concrete, which can be associated with a decrease in the time of the useful life of the structures [5]. Reduction of the structure service time has associated economic costs derived from the temporary or total loss of use, the cost of repairs and monitoring, as well as an increase in the carbon footprint of the material [8]. The appearance of corrosion in steel leads to a higher incidence of detachment, delamination and structural element failures [1, 8, 9].

To avoid or reduce the impact of this problem, several methods have been investigated and applied. Some examples are: epoxy-type protective coatings for steel [10], organic and inorganic inhibitors [4, 11, 12, 13, 14], cathodic protection etc. Inhibitors in reinforced concrete are widely used because their low cost and easy way to apply [4, 11, 15]. These are considered chemical substances that delay the onset of corrosion or decrease its propagation speed without adverse effects on the mechanical properties of concrete [16, 17, 18].

This investigation is about the efficacy of three inhibitors added in mortar specimens with 2% Cl^- in relation to the weight of cement in mixing water. Inhibitors formulated based on different active principles have been chosen: Alkoxy Silane, mixture of Alkylsilanes and Mineral Organ based on water. Electrochemical behavior of steel was investigated by the linear polarization resistance (LPR) and electrochemical impedance spectroscopy (EIS) technique.

Inhibitors were studied as a repair treatment. It was necessary to implement a method to initiate the corrosion process of the steel bars in the mortar. 2% Cl^- by weight of cement was added to the mixing water. In each test piece, two working electrodes were inserted in the sides and a graphite auxiliary or counter electrode in the middle. In order to eliminate the reducing concentration effect of the most volatile components of the sample on the surface of the steel, they have been added to the mortar mix.

Table 1 shows the results of steels at the same specimen after 544 days of LPR analysis. Order of measurement has been maintained to evaluate the effect of the electric field applied on the other steel. The results obtained for corrosion density (I_{corr}) reflect that, after 544 days, one steel from each specimen with study product is in a passive state ($I_{corr} < 0.1\,\mu A/cm^2$) as a consequence of add the product in the kneading. All specimen steels with inhibitors corrode at a slower rate than benchmarks. The remaining percentage of the test piece steels with study products shows (I_{corr}) results within the limits that represent a low corrosion state ($0.1 < I_{corr} < 0.5\,\mu A/cm^2$). Alkoxy Silane inhibitor achieves better performance and places its corrosion density within the negligible corrosion limit values. Furthermore, the probability of active corrosion processes is considered low in both steels ($E_{corr} > -200\,mV$). However, once it is ensured that the products are homogeneously distributed within the specimens, the difference in I_{corr} is not significant.

Table 1: *Electrochemical parameters after 544 days.*

GROUP	Steel	Ecorr (mV)	Rp (kΩ·cm²)	Icorr (µA/cm²)
Reference	1	-583	26,25	0,99
	2	-855	29,16	0,89
Alcoxy Silane	1	-75	2347,04	0,01
	2	-198	131,76	0,20
Alkylsilanes	1	-133	1615,19	0,02
	2	-472	72,24	0,36
Mineral Organ	1	-483	533,60	0,05
	2	-619	85,39	0,30

If it is guaranteed inhibitor products are within the mix: Performance of material is better than the reference in all cases. Products keep the corrosion density at negligible values. If the evolution of corrosion density is observed, the steel with the Alkoxy Silane product remains almost stable from the moment the specimen was manufactured. However, Alkylsilane and Mineral Organ, only after 150 days tends to negligible values of Icorr. Once the distribution of the product within the specimen is guaranteed, the formation of the passive layer is faster with Alkoxy Silane inhibitor than with the other products. In addition, it is confirmed that the inhibitor Alkoxy Silane and Alkylsilane work as anodic inhibitors because they reduce the thermodynamics and kinetics of the process. The probability of corrosion is low with both products. This inhibitor effect indicates that it favors the oxidation reaction of iron to give oxides with a higher degree of oxidation, more stable in alkaline medium, which block the transport of Fe^{2+} ions to the electrolyte. Thus, the speed of the anodic process is reduced, taking the corrosion potential of the steel to less electronegative values. Thus, it favors the formation of a protective film on the steel with greater resistance to corrosion. This seems to confirm that products have differentiated interaction mechanisms with the matrix that modify both the deadlines for action and the final results.

After breaking the specimens and cleaning the reference steel, it was possible to observe that pitting has occurred in one case. In the other steel, deterioration in the form of flaking is observed. Also, it is possible to observe that the oxide stains are smaller in the steels without pickling with the Alkoxy Silane and Alkylsilane product. However, once the pickling has been carried out, the steels with Alkoxy Silane and Mineral Organ do not present any pitting, which confirms the presence of the homogeneous protective layer created on the surface of the steel independent of the mechanism used by the inhibitor. Only stains are observed due to cleaning products. Small pit was observed in one steel with Alkylsilane inhibitor. In the other steel, deterioration in the form of flaking is observed, as in the reference. This is the reason why active corrosion results were obtained after performing the electrochemical

measurements. It seems that the concentration of this inhibitor used is not sufficient to avoid superficial damage when there is 2% Cl ion within the structure. Despite having pitting, the inhibitors manage to stabilize corrosion at low corrosion values. It should be taken into account that the problem with this type of anodic inhibitor is that if they are present in little or insufficient quantity, the cathodic process is stimulated without the anodic one being canceled; thereby increasing the risk of localized pitting corrosion, faster than in the absence of inhibitor [1, 17].

To conclude, it is confirmed that after 544 days, all inhibitors reduce Icorr. However, there are significant differences. Alkoxy Silane turns out to be the most effective at the age studied. Adding the inhibitors has shown that the concentration proposed by the manufacturer does not always ensure the arrival of the Alkylsilane product on the surface of the steel in the proper way. The used concentration of this inhibitor is not sufficient to avoid superficial damages.

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EFFECT OF NANOSILICA ON SUSTAINABLE AND DURABLE ADDITIONS: METAKAOLIN AND BLAST FURNACE SLAG

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Keywords: *metakaolin; nanosilica; C-S-H gel; C-A-S-H gel; Friedel's sal; chlorides*

Abstract

This study analyses the chloride binding capacity and the formation of calcium silicate hydrate (C-S-H) and calcium aluminium silicate hydrate (C-A-S-H) gels in aqueous calcium hydroxide and sodium chloride phases with the addition of metakaolin (MK), blast furnace slag (EAH) and nanosilica (A200). A key method to improve the durability of cement-based materials is to minimize the penetration of external chlorides and to increase the binding capacity of the Cl- ion to the concrete in order to delay their penetration. In general, clinker hydration products, such as calcium silicate gels (C-S-H) and hydrated calcium aluminium silicate gels (C-A-S-H), as well as phases formed by the hydration of aluminates and/or reactions by pozzolanic additions, such as metakaolin or blast furnace slag, have a strong capacity to bind chloride ions in their structure, as is observed in the case of the formation of Friedel's and Kuzel salts. The formation of these salts represents a feasible tool for the restriction of chloride ingress [1-3].

For the chemical analysis of MK and EHA, the X-ray fluorescence technique was used. MetaMax® (MK) is a highly reactive metakaolin produced by thermal activation of high purity kaolin, with a mean particle size of 3.2 µm and a specific surface area of 12.56 m2/g. The SiO2 and Al2O3 contents are 52.4 wt.% and 44.9 wt.%, respectively. The (EHA) is obtained from a steel mill in the north of the country, product of the pig iron from the smelting of steel at more than 1500 °C, it was processed by mechanical means until obtaining an average particle size of 45 µm and a specific surface of 1.77 m2/g, the contents of silica and aluminium determined by chemical analysis were 34.1 % by weight and 10.50 % by weight, respectively. AEROSIL 200 (A200) manufactured by Evonik®, is a pyrogenic hydrophilic nanosilica with a specific surface area of 200 ± 25 m2/g and a purity of ≥ 99.8%, with a mean primary particle diameter of 12 nm. Calcium hydroxide manufactured by SCHARLAU® with a purity > 95.0 wt.% and sodium chloride manufactured by LABKEM® with a purity ≥ 99.9 wt.% were also used.

Eight mixtures were prepared, starting with the gel-forming ability of EHA and MK combined with $Ca(OH)_2$ and 250 ml of distilled water, then incorporating nanosilica to observe the possible change in the structures observed in the previous samples, and finally incorporating chloride in all the previous combinations. The chloride concentration was 0.5 M for the mixtures including cl, which is similar to seawater. As a starting point a 4 to 1 ratio of MK and A200 is established for the initial mixtures, then the Ca/Si and Al/Si ratios are calculated for all samples. The compositions prepared without cement to avoid its contribution to the formation of C-S-H gel and Friedel salt. The prepared suspensions were stirred constantly for 7 days, filtered and dried at 100 °C for 24 hours. The dried powders were characterized by differential thermal analysis and thermogravimetry (DTA-TG), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and total and free chlorides previously extracted by chemical methods were determined by potentiometric titration with $AgNO_3$.

The results obtained showed that the additions of MK and EHA have a high capacity to form chloride ionic bonds, i.e. Friedel salt, which is more significant when looking at the results free of A200. This is more significant when looking at the results free of A200. The amount of Friedel salt was determined by DTA in two ranges 230-380ºC and 260-360ºC is found when using EHA as an addition alone or combined with A200 in comparison to MK. Compared with the FTIR analysis, the Friedel salt formation is mainly observed in the combinations with MK, this could be confirmed by deconvolution in the 750 and 800 cm-1 range. In XRD the opposite of FTIR is observed, the presence of Friedel salt is higher when EHA is used. While in the potentiometric results, the quantification of the combined chlorides where Friedel's salt is present is higher when MK alone is used, but the combination with A200 and EHA shows a better behaviour than the rest of the combinations.

The free mixtures of A200, EHACl and MKCl, favoured the chemical bonding of chlorides through the formation of the Friedel salt. In addition, it had a higher tendency to form a C-A-S-H gel than a C-S-H gel. In mixtures containing A200, due to its high specific surface area, it prevented MK and EHA from reacting with chlorides with the same intensity, preventing the chemical bonding of chlorides and the formation of Friedel's salt. The C-A-S-H and C-S-H gels formed in the A200-containing mixtures contained less physisorbed chlorides compared to the non-nanosilica-containing mixtures.

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CATHODIC PROTECTION IN CONCRETE BY ANODES ZINC PLATES ADHERED

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Keywords: *concrete; reinforcement; cathodic protection; galvanic anode*

Abstract

The deterioration of reinforced concrete structures (RCS) can be produced by mechanical, physical and chemical causes, being the durability problems due to the corrosion of the reinforcement, the main cause of reduction of their service life [1,2]. It is estimated that the cost to repair reinforced concrete structures is approximately $ 200 per square meter of exposed surface. In the United States alone, the annual direct cost of corrosion in highway bridges is approximately $ 8.3 billion, including maintenance, repair, replacement and capital cost, with indirect costs multiplying by 10, taking account for traffic delays and lost productivity [3,4].

Corrosion in reinforced concrete can be produced by the carbonation of the concrete, by the presence of chlorides or by the combination of both, these being the factors that trigger the process and transfer the reinforcement to the passive state, in which the rate of corrosion is not very significant, in the active state, in which corrosion affects the durability of the element [5]. But in addition to the triggering factors, the presence of oxygen and moisture is necessary for corrosion to develop, these factors controlling the rate of the process [6]. For decades, the effects that corrosion produces in reinforced concrete structures have been investigated: loss of reinforcement section, accumulation of corrosion products at the steel / concrete interface, cracking and delamination of the concrete covering, due to tensions generated by the higher specific volume of corrosion products than that of the base metal, and loss of adhesion between concrete and steel [7-9]. At present there are numerous investigations that simulate and experimentally validate the corrosive corrosion behavior of the reinforcements embedded in the reinforced concrete and in which they investigate the influence of different parameters on the corrosion rate, such as: the quality of the concrete, the concentration of chlorides, the coating and the cracking process [10,11].

The corrosion of reinforcement of concrete structures is an electrochemical type process, this means that the process can be stopped or minimized by acting on any of the sub-processes that compose it:

- Stopping the anode process
- Stopping the cathodic process
- Stopping the electrolyte charge between anode and cathode

In recent years, various electrochemical rehabilitation techniques have been developed to stop corrosion processes. The most widely used procedures have been Electrochemical Realkalisation (ERA) and Electrochemical Chloride Removal (ECR) [12]. These procedures should be considered as preventive, since they have been shown to be incapable of stopping corrosion when the corrosion products generated constitute a considerable volume [13]. Cathodic Protection (CP), however, has been demonstrated as a technique capable of stopping an already initiated corrosion, regardless of the level of corrosion existing in the steel. The three procedures have the same way of application, the circulation of an electric current between the reinforcement (which acts as a cathode) and an external anode. This means that the reinforcement must be short-circuited and must be electrically connected to the anode. Table 1 shows the most relevant characteristics of these procedures.

Table 1: *Characteristics of electrochemical rehabilitation treatments.*

	ERA	**ECR**	**CP**
Protective objective	Passivating environment	Passivating environment	Protection potential
Duration of polarisation	Temporary (3-14 days)	Temporary (up to ten weeks)	Permanent
Current densities (Steel)	1 - 2 (A/m^2)	1 - 2 (A/m^2)	10 - 20 (mA/m^2)
Current densities (Concrete)	0.8 - 2 (A/m^2)	0.8 - 2 (A/m^2)	3 - 20 (mA/m^2)

When a PC system is put into operation, the following conditions are created:

- Fall of the electric potential of the reinforcement to more negative values
- Generation of hydroxyl ions around the reinforcement (cathode)
- Migration of chloride ions from the reinforcement to the outer anode

PC has been recognized since 1981 by the Federal Highway Administration (FHWA) as the only rehabilitation technique that has been able to stop the progression of a reinforcement corrosion, regardless of the amount of chloride ions present in the medium.

PC has been used since the 1920s in buried metal structures such as oil and gas pipelines; since the 1940s in metal structures in contact with seawater such as offshore structures; from the 1960s to buried structures of reinforced and prestressed concrete such as aqueducts; and in the 1970s it began to be used in reinforced concrete aerial structures.

PC can be realized through the use of anode currents or with sacrificial anodes. The use of sacrificial anodes is a highly interesting alternative due to its greater ease of execution.

The anodes formed by adhered zinc sheets are applied directly to a prepared concrete surface, generally using a hydrogel as an adhesive, resulting in a very competitive technical and commercial system due to its good results and its ease of execution.

In this work, the suitability of using MAPEI MAPESHIELD E25 zinc laminar bonded anodes for the cathodic protection of reinforced concrete structures has been verified regardless of the chloride content present and the state of previous corrosion of the reinforcements.

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CARBONATION EVALUATION IN MORTAR AND CONCRETE BY THYMOL BLUE PH-INDICATOR

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Keywords: *phenolphthalein; thymol blue; carbonation testing; health hazards*

Abstract

Phenolphthalein is the most used pH indicator in the study of mortar and concrete carbonation. The transition range goes from pH=8.2 (colourless) to pH=10 (purple). This change means that it is well-suited for application in carbonation studies in building materials made with Portland cement. Therefore, phenolphthalein is still the most widely used pH indicator in Spain to determine the carbonation depth of mortars and concretes exposed to an XC environment in accordance with the Spanish Structural Code, which contains the technical regulations for concrete and steel structures (Royal Decree 470/2021, 29th June, 2021) [1].

Despite being the most suitable indicator for the durability studies mentioned above, the use of phenolphthalein without applying the necessary protective measures entails some health risks. Phenolphthalein use could be limited to some cases because of the risks for the health and safety of consumers. Some health hazards have promoted its classification as: carcinogenic (C), suspected to be mutagenic (M) and suspected to be toxic to reproduction (R). Consequently, other pH indicators are being evaluated to replace the phenolphthalein use in some construction laboratories and in field durability studies performed in building and civil works.

Reinforced concrete carbonation is one of the main deterioration processes of this construction material, which can occur in built-up areas. Steel reinforcement, which remains passive due to the high pH of the concrete pore solution, can corrode when the pH drops below 8. Accordingly, this deleterious process must be considered in the design of reinforced concrete structures exposed to carbon dioxide environments (XC). In addition, the atmospheric concentration is increasing (Figure 1), so, for reasons of adaptation to climate change, it should also be considered.

Carbonation reactions, i. e. reactions between atmospheric carbon dioxide and calcium hydroxide and other alkaline phases of the cementitious materials, are well known and reported widely in the literature [4].

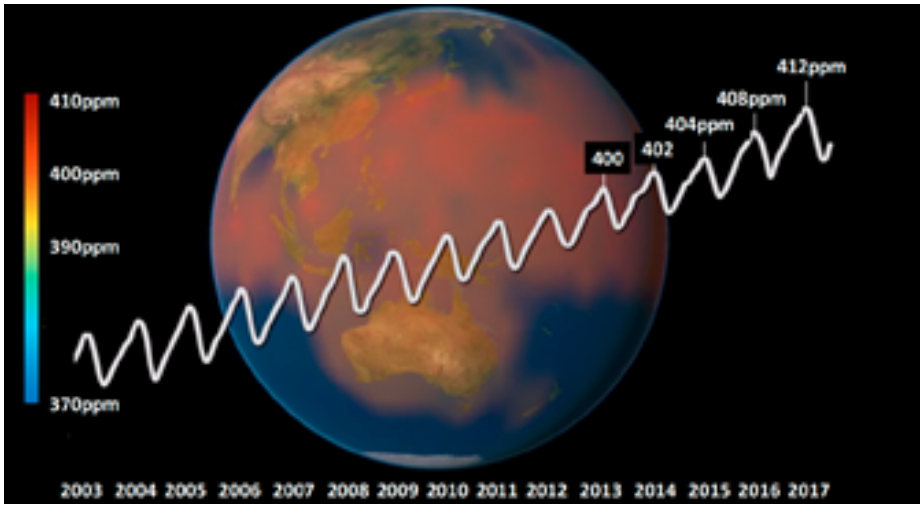


Figure 1: *Evolution of carbon dioxide concentration in the atmosphere with the time [3]*

As discussed above, the pH indicator commonly used to determine the carbonation depth in mortars and concretes, phenolphthalein, has recently been identified as a substance of high concern due to its classification as a category 1B carcinogen in the European Regulation (EC) No. 1272/2008 [5]. By contrast, thymol blue is used as a pH indicator in many applications without any health risk. This indicator, below pH 8.0 is yellow, and above pH 9.6 is blue, so it may be a good candidate to replace phenolphthalein, among other indicators [6].

The purpose of this study is to evaluate the feasibility of using thymol blue to replace phenolphthalein in the determination of the depth of carbonation.

In this study, three commercial cements named CEM I 52.5 R-SR 3, CEM II/A-S 42.5 N and CEM III/B 32.5 N-LH/SR) according to the European standard UNE-EN 197-1:2011 were tested [7]. These cements contain 0%, 14.4% and 62.2% of blast-furnace slag, respectively.

Chemical properties were performed according to the European standard UNE-EN 196-2:2014 [8] and the standardized mortars were prepared with distilled water and CEN sand standardized according to European standard UNE-EN 196-1:2018 [9].

Carbonation tests were performed by exposing the mortars to a natural atmosphere, sheltered from rain (indoor environment conditions), according to UNE-EN 12390-10:2019 [10] (CO_2 concentration: 0.035 ± 0.005 %, temperature: 20 ± 2 ºC and relative humidity: 65 ± 5 %).

Figure 2 shows the carbonation results measured with thymol blue and phenolphthalein on mortars carbonated for two years under natural indoor conditions (0.03% CO_2). Individual measurements of carbonation depth on the specimens ranged from 1.6 to 8.4 mm depending on the curing conditions, mortar dosage and pH indicator. The mean value for each specimen ranged from 1.8 to 8.1 mm (Figure 2).

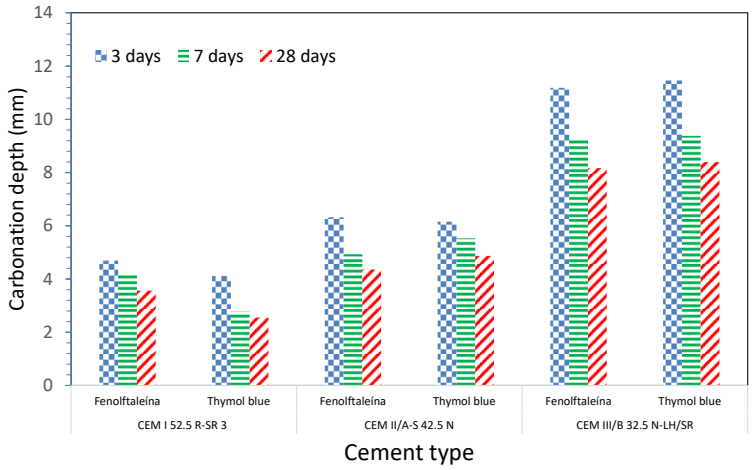


Figure 2: *Carbonation depth in natural conditions (indoor environment) after two years of natural exposure measured with thymol blue and phenolphthalein*

Carbonation coefficients calculated from measurements performed with thymol blue or phenolphthalein in mortars with CEM II/A-S 42.5 N and CEM III/B 32.5 N-LH/SR are very similar, and slightly higher than those of mortars made with CEM II/A-S 42.5 N in the case of using thymol blue (Figure 3). On the other hand, in the case of mortars made with CEM I 52.5 R-SR 3, the results obtained with phenolphthalein were slightly higher than those obtained with thymol blue.

Equation (1) shows the correlation ($r^2 = 0.95$) between the carbonation depth measured with thymol blue ($X_{thymol\ blue}$) and phenolphthalein ($X_{phenolphthalein}$).

$$X_{\text{azul de timol}}\,(\text{mm}) = 0{,}9952 \times X_{\text{fenolftaleína}}\,(\text{mm}) \qquad (1)$$

where $X_{thymol\ blue}$ is the carbonation depth measured with thymol blue and $X_{phenolphthalein}$ is the carbonation depth obtained with phenolphthalein.

Based on the results of this study, it can be considered that both pH indicators, phenolphthalein, and thymol blue, perform adequately in measuring the carbonation

depth of cement-based materials with and without mineral additions. By using thymol blue, a slightly lower carbonation depth in mortars made with CEM I 52.5 R-SR 3 than by using phenolphthalein was obtained. However, the difference was only about 0.3 to 0.7 mm. By contrast, better results were obtained with blast-furnace slag mortars, where the differences were in the range of 0-0.3 mm (CEM II/A-S 42.5 N) and 0-0.1 mm (CEM III/B 32.5 N-LH/SR). By utilizing phenolphthalein, a lighter carbonation front was always obtained, especially in the case of mortars made with blast-furnace slag.

Finally, the effect of the curing conditions on the natural carbonation have been observed. Accordingly, the greatest difference in carbonation depth results was found between the different curing times. Such difference was about 0-5 mm (CEM I 52.5 R-SR 3), 1 mm (CEM II/A-S 42.5 N) and 1.5 mm (CEM III/B 32.5 N-LH/SR) between 3 days and 28 days of curing. Furthermore, no significant differences were found when using phenolphthalein or thymol blue as pH indicator regarding to the study of the effect of the curing time.

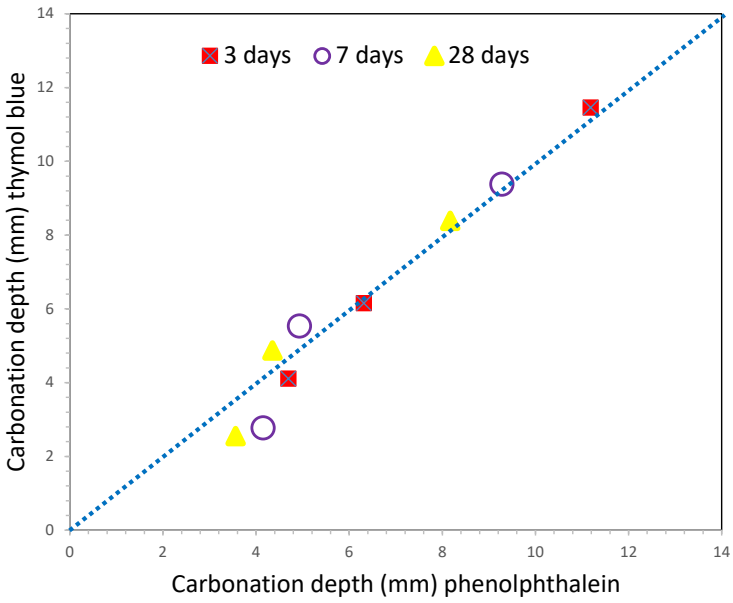


Figure 3: *Comparison between the depth of carbonation measured after two years of natural carbonation with thymol blue and phenolphthalein*

This paper has discussed the results obtained on Portland cement mortars subjected to natural carbonation for two years. The carbonation front was measured with both phenolphthalein and thymol blue. In conclusion, it has been found that there is a good correlation between both testing procedures. Therefore, it is considered that thymol blue could be safely used for the determination of the carbonation front of Portland cement-based materials, as a substitute for phenolphthalein.

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AUGMENTED REALITY FOR THE SEMANTIC ENRICHMENT OF BIM MODELS: TOWARDS THE DEVELOPMENT OF INTERFACES FOR ONSITE USE

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Keywords: *building information modelling; natural user interfaces; integrated projects; virtual reality; augmented reality*

Abstract

The potential of the combination of Building Information Modelling (BIM) and Augmented Reality (AR) interfaces has shown favourable outcomes on different applications among the Architecture, Engineering, Construction and Operations (AECO) sector. Also, despite the gradual adoption of BIM, there is a need for more integrative and attuned interfaces that may harness the different academic backgrounds, profiles, and tacit knowledge of the actors of the AECO sector. As several stakeholders are actively involved in the project development [1], the complexity of construction works and the sheer amount of teams and disciplines from design to operation stages substantiates the requirement for effective communication and integration strategies.

The design and subsequent realization of a building rely on constant critical input from the various disciplines resulting in a network of decisions supported by information [2]. However, the diversity of today's demands relies on a series of most often not communicating systems. Thus, the articulation of information and data communication between the actors of the AECO sector is key to a more effective response. Integration as a work methodology for the disciplinary articulation between the actors in the development of the project and the construction process should embrace all parties involved from the designers, the owner (or representative), managers, and the future end-users and trade crews - an "integrated vision of the building by all the specialties, the Integrated Project" [3]. As such, the vision of an integrated project assumes increased significance when targeting more democratic interfaces for the permeability of BIM across the actors of the AECO sector.

Similarly to other relevant industry segments, the AECO sector faces more competitive and complex projects [4], [5] with continuously shorter budgets and due dates, highly demanding quality assurance and monitoring needs resulting in added costs and pressures. Additionally, the AECO is recognized for its low productivity [6], which may lead to digitalization to pursue more performance and accuracy among the processes, minimizing costs and streamlining production. Throughout the uptake of BIM, a paradigm shift for the industry [7], [8], inevitable clashes with more traditional and sectorial-embedded approaches are anticipated. Indeed, trade crews and many industry stakeholders still lack the knowledge to take full advantage of BIM-related technologies and methodology, for instance, in the operations phase [9] or real-time communication amongst project teams [10]. Conversely, research on Natural User Interfaces (NUIs) has provided innovative approaches to democratize practice and access to technology, attending to various user profiles and knowledge backgrounds. Head-mounted displays (HMDs) (e.g., HoloLens [11], HTC VIVE [12], Oculus Quest 2 [13]), motion and gesture tracking devices (e.g., Project Kinect for Azure [14], Leap Motion [15], Myo [16]), pen-based, touch and multitouch detection on handheld devices and voice recognition (e.g., Microsoft's Cortana [17], Apple's Siri [18]) comprise the myriad of solutions within NUIs [19].

The present study implements the concept of a Natural BIM Interface (NBI) initially presented by Dinis et al. [20], which regards the integration of BIM within a framework to enable instant expertise and direct access to project information. In a broader sense, NBIs comprise a set of processes and devices that, through the reuse of actions common to other contexts, enable accessibility to BIM, maximizing the ratio between performance and effort. As BIM authoring tools comprise systems designed to handle specific tasks, usually holding many features, and not meant for short-term and momentary usage, these are usually meant for the long run and frequently require more time for users to adapt [21]. Furthermore, higher cognitive load is patent in some BIM tools, making them unsuitable to be used by the variety of stakeholders involved in construction project teams. NBIs aim to increase the permeability of construction information through BIM, consequently adapted to the various layers and demands of AECO teams.

This work presents a framework and preliminary development steps of an NBI based on AR technology for the semantic enrichment of BIM models. In detail, the interface provides more natural ways to access BIM information, even for users without previous experience or knowledge regarding BIM tools. Preliminary laboratory tests were conducted to assess the feasibility of using voice and gesture interactions through the HoloLens 2 HMD to attach semantic data to physical objects further converted to BIM information.

This study aims to contribute to developing a set of BIM-based tools that prevent the exclusion of sectors of construction projects teams less familiar with BIM methodologies and provide innovative approaches to enhance access to BIM information and collaboration.

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CONSTRUCTION 4.0 AND ITS IMPACT ON PRODUCTION

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Keywords: *artificial intelligence; crack detection; construction 4.0; durability of concrete; productivity*

Abstract

Detection of cracks in reinforced concrete is essential to maintain the durability of concrete structures, so as for a good damage assessment during its useful life. Currently, many reinforced concrete structures do not present maintenance plans and, consequently may exhibit risks to people and the population where they are located. The way in which the inspection is implemented today carries a great risk to the inspectors, many damages occur at high altitude, hard to reach areas, and even some damages occur in areas with no human access. This diagnosis exercise normally takes long time in a traditional way, using manual instruments like taking pictures to evaluate the damage of every structure reviewed, so the use of new Construction 4.0 technologies such as artificial intelligence to help analyse the big data captured in a diagnosis job will significantly help to improve the productivity to give a quick answer to accelerate the decision making of reinforcement, repair or rehabilitation of the infrastructure that we need to solve.

This research talks about a methodology based on the premise of state-of-the-art in artificial intelligence applied to crack detection. This study shows that there are new and better ways to perform inspection on reinforced concrete structures.

MANAGEMENT AND SAFETY IN BUILDING

APPLICATION AND GRAPHIC INTERPRETATION OF THE OCCUPATIONAL RISK ASSESSMENT METHOD "LEVEL OF PREVENTIVE ACTION"

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Keywords: *risk assessment; construction; graphic results; preventive action*

Abstract

As an introduction, there are many investigations that incorporate the safety climate due to the uncertainty generated by human behavior in risk prevention [1], being necessary to assess the risk from the joint aspects of safety, hygiene, ergonomics and psychosociology [2]. To fight against occupational accidents, it is mandatory to integrate risk prevention in all phases of business action [3], implementing an occupational risk prevention plan that uses risk assessment as a tool, to carry out preventive planning and to be able to fight against work accidents.

The Level of Preventive Action (*Lpac*) is an occupational risk assessment methodology adapted to building works [4-6], adjusted to their "special" complexity. Its implementation is based on a mathematical formulation developed from the method of William T. Fine [7]. The mathematical expression (1) that defines the *Lpac* based on the evaluation parameters of each of the environments and their interpretation according to the degree of correction (by direct or indirect relationship), is:

$$Lpac = (R_{ab}) \cdot \left(\frac{R_r \cdot B_r \cdot E}{E_c \cdot P_i \cdot L_s}\right) \quad (1)$$

Rab being the absolute risk identified by the probability and consequences parameters, *Rr* the relative risk, *Br* the border risk, *E* the degree of exposure, *Ec* the economic capacity, *Pi* the participatory interest and *Ls* the level of satisfaction. Considering the factor of constructive reality, which contemplates the risks associated with the complexity of the work units, their location and interdependence [8]; the economic response factor of the contractor with the direct execution of the construction systems and means of prevention [9]; and the social factor with the participative interest and emotional state of the workers [10]. These factors therefore include the documentary

environment [11], the constructive environment [12] and the social environment as fundamental elements associated with the execution of a work [13].

As an objective, this work proposes the implementation of the Preventive Action Level risk assessment methodology in three construction sites and in three countries, Brazil, Spain, and Portugal (Figure 1); covering different phases of the work execution. Procedures for its implementation and obtaining results are proposed, in order to establish the effectiveness of the methodology in the detection and prevention of risks. From the results obtained, we proceed to the elaboration of all the possible graphs and their subsequent interpretations; obtaining very visual information so that the results can be easily interpreted.



a) *b)* *c)*

Figure 1. *Implemented in three construction sites, a) Brazil, b) Spain and c) Portugal.*

With respect to the methodological procedure, a risk assessment is developed through a series of well-defined and systematic steps with the aim of resulting in a complete identification and analysis of the risks of the activities that are being or will be carried out. Through this process, it is also possible to identify adequate measures to eliminate and/or mitigate the events considered [14]. The first step was the exhaustive description of the construction processes of the three evaluated projects, which were carried out in an observational way and through the analysis of the projects. Once these processes were understood, an identification of all hazards and risks was carried out through the analysis of the Health and Safety Plans provided by the construction companies, field observations and interviews with workers and site managers.

Regarding results, the wide variety of graphical results shows the different ways of evaluating risks, work environments and the different techniques to combat risk, in a particular or general way. All this allows to establish with great success and with great approximation to reality, the amount of preventive action control that is required to achieve that the Preventive Action Level is optimal. For a better interpretation of the results, the method establishes certain controls of the preventive action based on the value obtained and some color codes (table 1).

Table 1: Preventive action controls.

Colour Code	Category of preventive action control.
	Values between 0% and 4%, optimal control of preventive action.
	Values between> 4% and 12%, adequate control of preventive action.
	Values between> 12% and 20%, plus preventive action control.
	Values between> 21% and 36%, greater control of preventive action.
	Values between> 36% and 60%, intensive control of preventive action.
	Values between> 60%, exhaustive control of preventive action.

It should be noted that the methodology of the Level of Preventive Action has a great sensitivity to identify situations that require immediate preventive actions. In decision making, preventive action involves improving any of the observation environments. For this, it is important to communicate and establish training strategies for workers so that they know how to improve prevention environments. Some of the graphic results of the investigation are shown (figure 2).

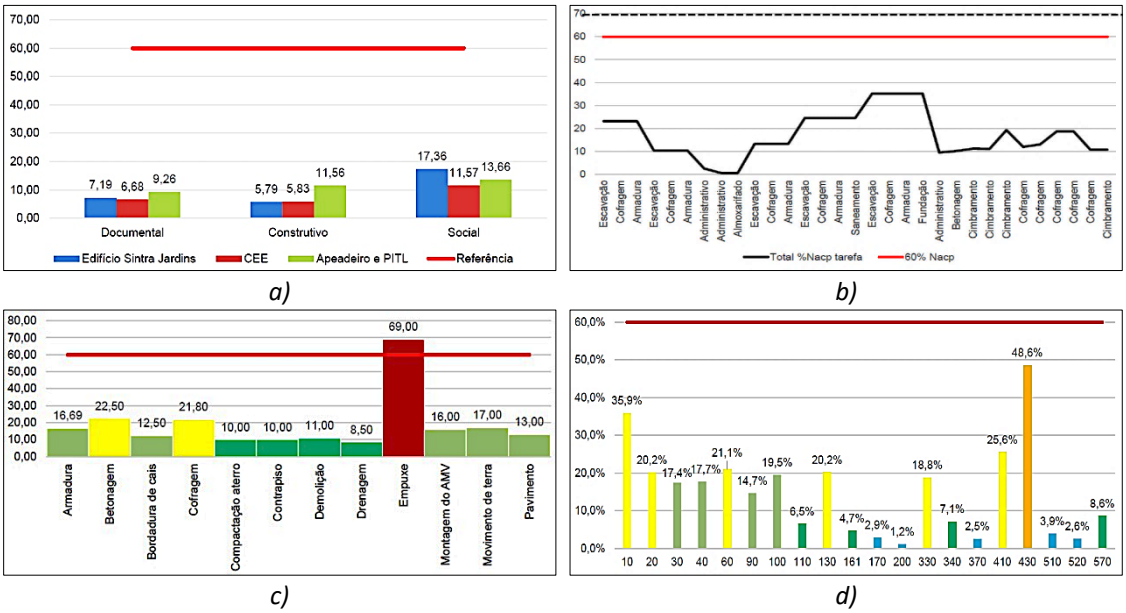


Figure 2. Different graphic results of the investigation: a) Average values of documentary, constructive and social environments; b) Average value of the Level of Preventive Action in the work of Brazil; c) Level of Preventive Action for construction systems in the work of Portugal; d) Level of Preventive Action for risk-fighting techniques in the work of Spain.

As a conclusion, not only is the design of the building, the construction systems, and the security elements to be used during the construction process important, but the emotional state and the levels of participation in matters of safety imply relevant degrees of correction in the construction process. It is essential to learn to observe construction, not only from a technical-constructive point of view, but it is crucial to observe and analyze the interest shown by the worker regarding their participation in health and safety individually or collectively, and their behavior based on the mood; and how it affects constructive development. A wide spectrum of results can be generated from many graphics that can be obtained, among which are those related to the total

"level of preventive action" and its corresponding parameters with respect to the construction system; risk preventive action in construction systems; evaluation by techniques to combat risk; personal, social, and environmental perception of workers; and the evaluation of preventive action in preventive environments.

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THE IMPORTANCE OF THE PREVENTION OF PSYCHOSOCIAL RISK AND DRUG ADDICTION AMONG SPANISH CONSTRUCTION SECTOR WORKERS

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Keywords: *psychosocial risk; construction sector; Spain; European Agency for Safety and Health at Work; drug addiction*

Abstract

A clear shift may be observed in the prevailing prevention paradigm, an increasingly greater importance being attached to psychosocial risks in all production sectors, they are having previously gone unnoticed. This change has been driven by the European Agency for Safety and Health at Work [1] itself. Which together with the various editions of the European Survey of Enterprises on New and Emerging Risks (hereafter, ESENER), has carried out an extensive study into the management of risks concerning health and safety in European places of work, which devotes a specific section amongst the four blocks of which it is composed to psychosocial risks. Likewise, it consigns another block to workers' participation in health and safety practices, this being the employer's legal obligation, and the fact that they have an increasing impact on the correct inclusion of health and safety in the workplace. So much so that three editions of this macro study have now been carried out, the most recent of which [2] featured the participation of 45,420 companies from all of the production sectors in the 33 countries included, among them the European Union member states.

These actions are complemented, in the case of Spain, by campaigns to prevent and raise awareness about the importance of psychosocial risks in the workplace, implemented by the Spanish Institute of Health and Safety at Work (INSST for its acronym in Spanish), such as the 2014-2015 campaign concerning stress management, within the framework of the European campaign for "safe and healthy places of work" [1] [3].

Both this kind of psychosocial risk, and the participation of workers in health and safety practices, take on greater relevance if we focus upon the construction sector, which features a high rate of accidents at work [4] and, due to the fact that the associated workplaces are mobile, does not usually feature such established prevention measures

as companies with permanent places of work [5]. Furthermore, there are factors which mean that this production sector has characteristics which are dissimilar to the rest, with a special context that is rooted in traditional construction practices and processes, which in the specific case of Spain, makes it a "refuge sector" receiving workers from any other sector, without previous experience, since it has no entry requirements, making it difficult to correctly incorporate a "collective preventive culture" amongst all of the players involved in constructive-preventive processes, in addition to the language barrier between workers, since it is a sector with high levels of immigrant workers [6]. Another factor to be taken into account, is the sector's real need to become more professional, so as to be able to compete with the other production sectors and with the aim of reducing the high rate of accidents at work in the sector [7], as well as the high level of substance use during the working day which ends up leading to accidents in which consumption is involved [8]. A huge difference that exists with regard to alcohol and substance consumption during the working day in the case of Europe compared to the case of Spain is that Europe has raised workers' awareness concerning the prevention of addictions, as the ESENER-3 states.

To this end (the study the psychosocial risks present in the Construction Sector in Spain, as well as their consequences on workers, in conjunction with drug addiction and substance use to which this group is exposed), a quantitative study of the indicators of the study is carried out based on the surveys that were carried out on 250 workers in the Construction Sector of Castile-Leon, in conjunction with the sample of the Construction Labor Foundation of 1,547 workers in the sector, as in the case of ESENER with the surveys of 2,266 construction companies in Spain, to be able to extract the results of both studies and compare them, whilst focusing upon Spain's profile.

The results obtained show the importance of preventing these psychosocial risks, with worrying data concerning the level of stress among workers, along with the workers' legal obligation to participate in health and safety matters, which only a low percentage of companies in the sector fulfil. On top of this, the alarming consumption of substances use during the working day and its involvement in workplace accidents must also be considered.

In conclusion, a clear lack of integration of this type of psychosocial risks in the workplace assessments is detected and that companies must be provided with the resources to prevent them, in addition to carrying out awareness campaigns and training actions to raise awareness about the dangers of consuming substances during the working day.

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THE DESIGN OF PUBLIC POLICIES: AN OPPORTUNITY FOR HEALTH AND SAFETY IN CONSTRUCTION

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Keywords: *safety; prevention; construction; policy*

Abstract

Health and safety, both generally and particularly in the construction sector speaking, is a complex phenomenon that involves a multitude of agents and is projected on a wide sector of our society and our economy. There is no single definition for the concept of "public policy", although an academic consensus has been reached about which it includes the setting of objectives, actions and decisions carried out by a government initiative to solve the problems that, in a moment, are a priority for that government and its citizens. [1] [2] [3] [4] The formulation of public policies implies the monitoring of an assessed and objective process, which passes through the identification and definition of a problem, the formulation of alternatives, the adoption and implementation of one of the alternatives and the evaluation of the results. [5] [1] Despite this, the confrontation of these problems through public policies does not finish consolidating as an option.

To support this affirmation, the fundamental concepts of the design of public policies as a technique for solving complex problems will be analyzed, specially mentioning the essential stage: the definition of the problem, the current situation of public policies on prevention and under construction will also be illustrated.

The methodology used will consist of an analysis of both the existing bibliography [5] [6] [3] [7] [8] [9] [10] and the legal framework for prevention management in construction, adding a comparative analysis of the main enunciative instruments of public policies in ORP in Spain. [11] [12] [13] [14]

The conclusions will try to contribute and justify the need for interventions to improve safety and health in construction to take the form of public policies. They are the following:

Although health and safety in construction is clearly a field in which action should be taken through public policies, there is no research that addresses concrete solutions to the preventive problems of the sector from the point of view of public policy design, and more specifically:

- The prevention approach from public policies is more theoretical than real, and limited exclusively to the general field of prevention, not specifically reaching the construction sector. The "most political" instruments such as the Spanish Strategy or Action Plans lack some essential elements of any public policy, such as objective systems for evaluating results or making the value chains of the different interventions explicit.

- Almost all of the academic production on public policies on occupational risk prevention focuses on road safety and public health, which seem to be - due to their irradiation over the whole of society - the first fields of ORP where it is being used in a "natural" way to the formulation of public policies. It is precisely this approach from public policies that is lacking in the investigations and proposals analyzed for the construction sector, because, although safety and health in construction clearly constitutes a public policy, apparently it has not been treated as such.

- The definition of the problem (and specifically the participation of all those involved in it) is a critical process within the formulation of public policies. And in connection with this, the detection of training needs can be a good field of inspiration for the detection of needs in the process of defining the problem of a public policy, as this is one of the main stages in knowledge management and continues after decades suffering from certain defects –which are also those of preventive public policies-. In this way, it would be possible to explore whether similar solutions could be taken to the identity of the problems, especially those aimed at the agents involved (beyond exclusively following the criteria of the organizations), but always on the basis of quantitative tools and assessment systems of evaluation. It is also worth noting that, in terms of detecting training needs, the most commonly used research methods are descriptive, qualitative and empirical: questionnaires (always), occasionally adding discussion groups (less), and interviews. Although they are not often proposed, many authors warn about the lack of quantitative approaches to the phenomenon of the detection of needs or the management of training in general.

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TEN ISSUES RELATED TO WORKER EXPOSURE TO HAND-ARM VIBRATIONS

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Keywords: *prevention; safety; hand-arm vibration*

Abstract

The increasing use of machines and tools able to transmit vibrations raised the need to regulate this exposure to guarantee workers' safety and health. For this reason, in the last years, a significant effort to control and prevent this type of risk has been developed in the European Union and Spain in particular.

The evaluation of the human body's exposure to vibrations can be carried out in accordance with what is specified in the international standards (ISO - International Organization for Standardization). The ISO 2631 standard [1] addresses the problem of whole-body vibration, while the ISO 5349 standards address the hand-arm vibration (HAV) system. The ISO 5349-1 standard establishes the general requirements for this type of exposure [2]. ISO 5349-2 [3] guides the measurement and evaluation of hand-arm transmitted vibrations. The mechanical fixation of accelerometers is covered by ISO 5348 standard [4].

The Spanish legislation (*Real Decreto-ley* 1311/2005, November 4, [5], transposition of the Directive 2002/44 / EC of the European Parliament and the Council, of June 25, 2002) establishes the minimum provisions for workers protection against the risks of exposure to mechanical vibrations in this country. This legislation defines the minimum health and safety requirements relating to the exposure of workers to risks arising from physical agents (vibrations) [6].

There are many reasons for assessing hand-arm vibrations, with the measurements of accelerations produced and emitted by the equipment. The assessment of hand-arm vibration by measuring the produced accelerations has been the method used by most

studies. It is indicated by the regulations to quantify the severity of vibration and assess the risk of exposure [7].

However, since the 1960s, research has suggested that measuring vibration energy absorption (VEA) can provide more relevant information than measuring acceleration when deciding on the risk of suffering disorders by exposure to vibrations. There is some correlation between VEA and white finger syndrome (VWF) [8]. Numerous studies have been carried out to relate VEA and VWF [9]. However, an important task is still to be undertaken, such as the relationship between VEA and the frequency at which it occurs [10] or the part of the hand-arm system where it occurs [11]. As a result of previous studies, it has been found that the procedure outlined by the ISO 5349-1 can underestimate the effect produced by high-frequency vibrations on problems caused in the fingers [7].

In a report published by EU-OSHA [12], exposure to HAV was identified as an emerging risk due, among other factors, to the growth in the number of European workers exposed to this risk. It is estimated that in 2015 20% of workers in the European Union were exposed to vibrations.

When the use of the tool is prolonged, it causes different disorders that can affect the blood circulation, nerves, bones, joints, muscles and connective tissues of the hand and forearm, collectively known as Hand-Arm Vibration Syndrome (HAVS). HAV is often associated with workers in industries with vibration exposures such as construction, agriculture, welding, or forestry.

Hand-arm vibration syndrome (HAVS) can lead to a condition known as VWF or “Raynaud’s syndrome” caused by a dysregulation in the peripheral vascular response to cold and “tingling and numbness of the fingers”, identified as disorders in the sense of touch [13]. It can also cause lack of sensation and mobility related to carpal tunnel syndrome, skeletal disorders, bone arthritis in the wrist and elbow or calcification of tendon attachments in the elbow and muscle disorders such as muscle weakness, loss of grip strength and pain in the hands and arms [14]. Injuries depend on several factors, including mainly the intensity and duration of exposure to vibration, the type of work performed, and the tool used [15]. Studies have shown that VWF is fundamentally related to the use of tools where the middle frequencies (25 - 250 Hz) dominate [16]. In the domain of low frequencies (≤ 25 Hz), there are very few cases that have produced VWF [17].

It is possible to act on the magnitude of the vibrations and the exposure time to reduce the effects of the vibration. In addition, it is possible to intervene on the emitter focus, the propagation medium and the receiver.

This communication has been addressed to two complementary lines: i) a critical review has been made of the regulations that regulate this type of risk, and ii) a study has been carried out of various existing works in the web of science related to activities that involve a risk hand-arm vibration. Comparison of the existing regulations with the data

obtained in experimental work shows that there are still many issues that the current regulations have not been able to analyze.

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SAFETY GUARDRAILS' STANDARDS – A CRITICAL ANALYSIS

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Keywords: *safety; fall height: collective protections; temporary edge protection systems; impact load*

Abstract

For decades, accidents due to falls from height have represented a high percentage of the total of those that occurred in the construction Sector.

The preventive strategy against the risk of falling from height prioritizes the order of action according to the following stages:

- Elimination of risks at the source.
- Limit the fall from height by means of collective protections.
- Use of personal protective equipment.

Temporal edge protection systems (TEPS), also called safety rails, are an effective measure to prevent the risk of falling from height because they prevent the risk at the source, preventing the worker from falling. Therefore, they are systems that are prioritized at the first level of the order of action [1].

TEPS are governed by rules and regulations that specify the geometric and mechanical requirements that they must meet in order for them to carry out their mission. In Europe, regulation comes hand in hand with EN standards, while in the United States, OSHA standards serve as the regulatory framework for these systems. The EN 13374 [2] standard classifies TEPS into three classes (A, B and C), depending on the inclination of

the work surface and the fall height of the person to be protected (Figure 1). The EN 13374 standard indicates the requirements, in geometric and mechanical terms, that the TEPS must exceed depending on the class to which they belong. Class A systems, which are the most widely used, can only be used when the angle of inclination of the work surface is less than 10^0.

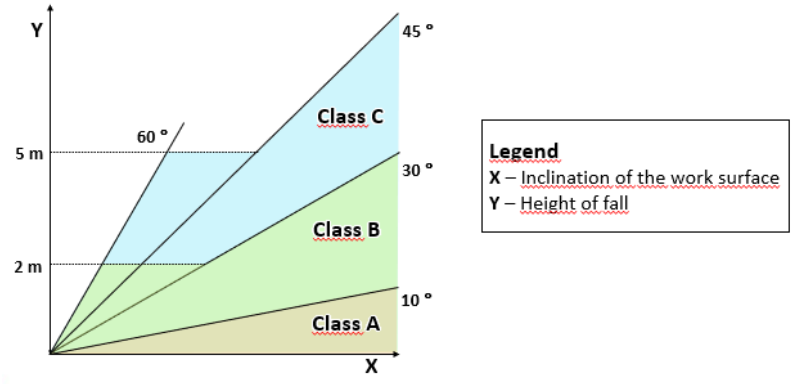


***Figure 1**. Classification of TEPS according to the standard EN-13374.*

In any case, a TEPS must be designed to prevent the fall of a worker who, walking quickly parallel to the protection, trips and hits against it. This roughly assumes that a TEPS must be able to absorb the impact of a 90 kg mass moving at a speed of 2 m/s, which is equivalent to a kinetic energy of 180 J. According to the above, a TEPS receives loads dynamic in nature, applied in the form of impact. However, both the OSHA standards [3] and the EN standards specify, for the validation of these systems, the surpassing of certain requirements that are based on the application of static loads (in Europe for class A systems) and the verification of the maximum displacements produced. It must be assumed that exceeding these requirements produces effects equivalent to the maximum impact that a system in service can experience or at least leads to a more unfavorable situation. In addition, the specifications of both regulatory bodies differ enormously, despite being written to fulfill the same mission.

In this work, a critical review of both standards has been carried out and analytical and experimental studies related to the mechanical behavior of TEPS have been analyzed, the results obtained have allowed to reach the following conclusions:

- Comparison of the EN and OSHA standards has made it possible to verify that the criteria established by both documents differ enormously in some cases, especially in relation to the classification of TEPS and in the evaluation carried out by the EN standard against limit states of service (scroll check). The latter

means that certain systems with railing formed by wooden boards comfortably comply with the specifications of the OSHA standard and yet do not exceed those of the EN standard.

- The tests carried out on systems made up of steel tube railings, wooden boards or high-density polyethylene systems allowed to verify that when the tested systems exceed the requirements of EN and OSHA standards, they are also capable of overcoming the impact of a spheroconic bag with energy at the moment of impact of 180 J. This supposes the calibration of the requirements established by both standards.
- The experimental analysis of the bending behavior of steel tubes of circular and square sections has allowed to verify that the classification of sections of Eurocode 3 (EC-3) [4] is on the side of insecurity for the tubes analyzed, because according to EC- 3 the sections of these tubes would be class 1 and yet in the tests they do not plasticize, but they buckle.
- With the use of strain gauges in wooden railings, it has been possible to verify that there is a similarity between the static deformation of the boards and the deformation under impact load, which means that the Rayleigh Hypothesis can be used to analytically calculate the impact effect about these items. The static deformation has been obtained analytically while the deformation under impact load has been obtained experimentally.
- The statistical analysis of the breaking stresses of wooden boards used as safety rails has shown that when the adjustment of the EN 12811-3 standard [5] is used to obtain the characteristic value of the breaking stress from the values obtained experimentally, the deduced value is well below the values obtained in the tests, due to the penalty produced by the dispersion of the breaking stress values of the wood in bending. In addition, the transformation of the data distribution to a logarithmic-normal distribution, suggested by the standard, can lead to obtaining values of characteristic resistance lower than those that would be achieved by working with the untransformed data.

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MINIMUM CONTENT: ASBESTOS EXPOSURE WORKING PLAN

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Keywords: *asbestos; construction; Royal Decree 396/2006; UNE 2014 standard; asbestos working plan*

Abstract

First of all, for jobs with risks of exposure to asbestos, a distinction must be made between:

- **Single work plan** of a general nature: provided that 100 m^2 of asbestos or Asbestos Materials (MCA for its acronym in Spanish) is not exceeded, or that the limit of 24 hours of duration of the work is not exceeded.
- **Specific plan**: all those works in which the assumptions established for the single plan are exceeded).

Once this division has been made (although their intrinsic characteristics may suffer slight variations between the different autonomous communities of the national territory), it is urgent to establish the minimum content that this work plan must contain, which is why, it is resorted to what is stated in article 11 of Royal Decree 396/2006 [1], in conjunction with the approach of the Junta of Castile-Leon [2] and the UNE Standard [3], which is summarized in the following list (Table 1).

Table 1: *Content of the asbestos plan of the Junta of Castile-Leon. Source: own elaboration.*

0. Identification data	
Title of the plan and modality (specific, unique of a general or successive nature), identification of the company, registration number in the Register of companies with Asbestos Risk (RERA for its acronym in Spanish), and identification of the promoter and contractor company.	
1. Nature of the work and place of completion	
Description of the task (removal of roofs, pipes, etc.), specifications of the type of activity (demolition, rehabilitation, maintenance, etc.), type of material to be intervened (friable or non-friable), form of presentation of the material (plates, pipes, etc.), condition or state of the material (deterioration), dimensions (surface, length, volume), location of the place (address and location plan and photographs).	
2. Start date and expected duration	

Start date, estimated duration of work and protocol of breaks.
3. Workers
Nominal relationship (name and surname, DNI, Social Security number, professional category, trade, experience), training (based on the UNE 171370: 2014 Standard [3], modality, initial or periodic training and recycling), health surveillance and information.
4. Working procedure. Measures to prevent fibre generation
Preparation of the work area (delimitation and signaling), sequence of operations to be developed and final cleaning.
5. Characteristics of equipment used for decontamination
Decontamination unit (minimum 3 compartments) and procedure for entering and leaving the workplace.
6. Personal Protective Equipment (EPI for its acronym in Spanish)
Respiratory tract protective equipment (FFP3), chemical protective clothing (type 5), watertight boots (classification II) and waterproof protective gloves.
7. Measures taken for the protection of persons working in or near the site
Signage (delimitation and access restrictions), isolation of the work area and cleaning of the work area.
8. Waste disposal
Disposal procedure (storage on site and packaging) and removal by carrier and authorized manager (carrier's RERA and authorization).
9. Preventive resources
Identification (appointment and acceptance), accreditation and training (asbestos training and basic level of prevention) and estimated time of presence of the preventive resource.
10. Evaluation and control of the work environment
Evaluation of the working procedure, environmental measurement and control strategy and recommended method (INSHT).
11. Procedure for consulting workers' representatives
Consultation and participation.
12. Attached documentation in Annex
Asbestos worker training, medical fitness, Occupational Risk-Prevention training, etc.

This represents a radical difference, within the construction sector, with the health and safety plan, whose minimum contents are not included in Royal Decree 1627/1997 [4].

Once the plan has been drawn up and the preventive measures for the execution of the works have been implemented, the disposal and transport of asbestos waste comes into play. For disposal, Royal Decree 1481/2001 [5], which regulates the disposal of waste by means of an authorized landfill deposit, is taken into account; as well as the transport part, always through an authorized waste manager [6].

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FIRE BEHAVIOUR OF LIGHTWEIGHT CEMENT ECO-PRECASTS WITH VEHICLE ROOF WASTES

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Keywords: *lightweight mortar; eco-blocks; recycled mortar; polyurethane matrix waste; non-combustibility test.*

Abstract

Our purpose is to produce a precast lightweight cement structure with polymeric industrial waste from shredded recycled vehicle roofs, which is fire resistant.

To obtain it, precast fire-resistant mortar blocks have been made using industrial waste of polymeric origin from recycled vehicle roofs.

The precast products manufactured are composed of the following raw materials:

- Cement: The cement used is type CEM I 52.5 R. according to standard UNE-EN 197-1.
- Aggregate: The aggregates used in the production of the mortars follow the standard EN 13139, using particles smaller than 4 mm and with a sand with rounded and slightly angular shapes, typical of natural granular aggregates.
- Shredded waste with polyurethane matrix: Polyurethane waste from recycled vehicle roofs has been used, with an apparent density of 92.5 Kg/m^3 and a real density of 1681 Kg/m^3.
- Additives: two different types of additives (non-ionic surfactants, hydrophobic/hydrophilic composition) have been used to modify the chemical

properties of the components. This means an improvement in the hydration of the cement because they reduce the amount of water needed in the dosages and improve its properties. A percentage of additives of 1% in relation to the weight of the cement has been used. The use of this type of additives changes the components of the precast cement as it helps to maintain its mechanical resistance, thus obtaining recycled materials with structural capacities, but at the same time, with a low density compared to conventional lightweight mortars.

The aggregates have been replaced by the shredded roof wastes from the automobile industry in different quantities. A cement/aggregate dosage of 1/6 by weight has been used, considering the aggregate as the addition of sand plus polymeric waste.

The additives added modify the chemical properties improving the hydration of the cement as well as mechanical properties. Two different additives have been added to each dosage: one very hydrophilic and one slightly hydrophilic to study their influence.

Different dosages have been carried out in order to measure their properties both in the fresh and hardened state. The dosages are listed below:

1. Substitution of 50% of the aggregate by polymeric waste, and a hydrophilic unit 3 EO (very hydrophilic) in relation to the weight of the cement.

2. Substitution of 100% of the aggregate by polymeric waste, and a hydrophilic unit 3 EO (very hydrophilic) in relation to the weight of the cement.

3. 50% substitution of the aggregate by polymeric waste, and a hydrophilic unit 10 EO (low hydrophilic) in relation to the weight of the cement.

4. Substitution of 100% of the aggregates by polymeric waste and a hydrophilic unit 10 EO (low hydrophilic) in relation to the weight of the cement.

The results of the fresh and hardened properties are described in Table 1 and Table 2.

Dosages	Density (kg/m^3)	Shore hardness (Shore C)	Flexural strength (MPa)	Compressive strength (MPa)
1	1667	81.3	5.38	13.27
2	873	46.7	2.52	4.05
3	1250	84.5	2.85	5.13
4	763	57.1	1.62	3.71

Table 1: Properties in the fresh and hardened state

Dosages	Water absorption due to capillarity ($Kg/m^2 \cdot min^{0,5}$)	Mortar classification	Absorption
1	4.24	W0	12.2
2	9.95	W0	48.6
3	7.15	W0	24.2
4	11.35	W0	59.5

Table 2: Properties in the fresh and hardened state

By adding waste, a decrease in density has been achieved, which is lower the more aggregate is replaced by the polymeric waste. These densities are lower than those of reference precast products currently on the market, with the consequent savings in the base structure, as well as an improvement in workability when it comes to placing them on site. The mechanical strength obtained is enough to consider these materials as structural eco blocks.

Large-sized blocks have been manufactured with the mixtures described above, so that they can be placed on site as precast products. The dosages described in Table 3 were carried out.

Dosages	Cement (kg)	Aggregate (kg)	Polymer waste (kg)	Water (kg)	Additive (g)
1	6.67	20	1.12	5.63	66
2	5	-	1.62	5.10	50
3	3.75	12.3	0.63	2.73	38
4	3.75	-	1.25	3.60	38

Table 3: Block dosages

The mixtures in the table above (Table 3) have been tested to the "Non-combustibility test" defined in the standard UNE EN-ISO 1182. The results obtained are shown in Table 4.

Dosages	Oven temperature increase (Δt) (°C)	Persistence of the inflammation (tf) (s)	Loss of mass (Δm) (%)
1	41.6	368	10.72
2	48.5	1072	32.31
3	29.2	517	14.24
4	81.3	745	38.17

Table 4: Results obtained in the non-combustibility test

These eco-precast mortar have a lower thermal conductivity as waste is incorporated, which greatly favours the thermal insulation of the final product, as well as a good behaviour against temperature and against fire, measured in terms thermogravimetry and non-combustibility (reaction to fire).

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FINDING CRITICAL PATHS IN PLANIFICATION PROBLEMS USING OPEN ACCESS SOFTWARE

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Keywords: *planning; programming; implementation; method; graph; activity; duration; arrow; ligature; slack*

Abstract

To achieve any objective, whether at the personal level or at the company level, it is necessary to carry out a planning, which defines what are the procedures to be followed and establishes an ordering among the different activities to be completed. Effective planification solutions also allow us to ensure a correct allocation of resources, which in addition will lead to a reduction in the total final cost of the project. Therefore, what is intended with every planification scheme is the achievement of a certain objective in the most efficient way among different possibilities (Taha, 2012).

Establishing a plan amounts to provide a sequence of activities that can be inter-dependent among each other. Once the planification has been decided and evaluated, a time span has to be assigned to each process or activity, as well as the dates that indicate the moment in which each activity must begin or end. This is what is called programming, which has as its final objective to provide a duration and an indicative date of end of project (Hillier & Lieberman, 2006).

Planning is defined as the action of sequencing the activities that make up a project, establishing the order that they must follow in a work, and what or what are the relationships between these activities (Westreicher, 2020). On the other hand, scheduling is defined as the process of establishing the times and dates of the plan previously elaborated, to determine the total duration of the project (Terrazas Pastor, 2011).

It is true that, in certain cases, despite having carried out a correct planning and programming of the tasks, the established deadlines are not always met. That is why it is essential to have at hand a schedule and a contingency plan that allows to relativize

the progress of the project to be able to compare the point where you are with the point where you should be. To be able to make the corresponding adjustments in the scheduled plan in the case of perceiving that there is a delay in the development of the project. Such adjustments may either be the contracting of a greater number of resources for future activities or assuming the cost that may arise from the delay in completion. These decisions are always taken with the goal of carrying out the project in the most efficient way possible in terms of time and cost (Romero López, 1997).

In planning theory, Critical Path Problems are used to obtain the schedule of a planning that minimizes the overall execution time and costs by finding a "critical path" that defines the ordering of activities during project execution. These problems are based on calculating the total duration of the project, as well as on obtaining information about all the times of each activity along the project. In order to do that, there is a variety of methods that solve this type of problems thanks to a proper usage of certain computer software, which are not free for the general public. In this contribution we propose two different ways to solve Critical Path Problems with access-free software. We provide two spreadsheet implementations in order to solve these problems.

The practical usefulness of our implementation relies in the fact that planification problems are usually solved either "by hand" or by acquiring the aforementioned, licensed software that are not free. Our two implementations allow to solve planification problems using a simple spreadsheet (Calc or Excel, for example) to which many students in universities and companies in Spain have access.

Planning problems are represented by graphs. Nodes can represent events and links activities, or vice versa. In order to find the optimal path along the graphs, first of all, there are several methods, among which we considered three, namely: the Critical Path Method (CPM), the Maximum Route Method and the Roy Method (due to the French mathematician Bernard Roy). These three methods allow the resolution of small planification problems by hand. The CPM calculates the longest path of planned activities over the graph that connects the starting activity with the endpoint of the project. The Maximum Route Method solves the problem as a linear programming problem over the network, yielding the total duration of the project. The Roy Method uses the dual representation of the graph, in which nodes represent activities and links stand for events, and finds the critical path over that network representation.

Our contribution consists of a toolbox formed by two spreadsheets that we developed for solving Critical Path Problems using Excel, although our implementation is valid for OpenOffice versions and the like. The first spreadsheet is based on the graph representation of the CPM method. The resolution of the problem consists of posing it as if it were a linear programming problem, specifically a Maximum Route problem. The second spreadsheet uses Roy's methodology and implements the algorithm in a way that allows to determine critical paths automatically by simply entering planning timings and dependencies.

Once the problem to solve is defined in the spreadsheet, we have implemented the CPM method and the Roy Method in order to find the critical path. Our spreadsheet implementations can be easily understood using a small example, consisting of a few activities of a particular planning problem. However, our implementation is flexible and can be easily modified by the user so that larger planification problems can be solved as well. Our spreadsheet implementations were made available to free usage by the general public.

Overall, in our contribution we provide a toolbox to solve generic planning problems in companies, through free access software. Two different methodologies were implemented: the first one (the Maximum Route Method) is faster, but less informative, so it could be used to quickly know what the total duration of the project will be. In this way, decisions could be made such as when it is convenient to start the project to be able to finish it before a certain moment. That is, it could be used as a preliminary calculation, prior to the realization of a more detailed programming.

On the other hand, the Roy Method provides all the information about every activity and about the project as well, specifying the time span for every activity and the optimal sequence or sequences. In addition, although its implementation was based on a graph that represents the activities as nodes, this does not mean that it cannot be used also in the case in which the graph represents the activities as arrows, since the information provided by both graphs is the same.

Finally, both methods are useful if adjustments are to be made during the execution of the project, since if the duration of any specific activity were to change, one simply has to update that duration data in the Excel spreadsheet and the calculation of the new route would be done again automatically.

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SUSTAINABILITY AND ENVIRONMENT

ANALYSIS OF AIR QUALITY BY VENTILATION IN HOUSE IN THE FRAMEWORK OF THE COVID-19 PANDEMIC: THE CASE OF SPAIN

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Keywords: *ventilation; indoor air quality; COVID-19; aerosols; Spain.*

Abstract

An efficient living, work or study environment is a fundamental requirement for building occupants to either live healthy or work productively. Thus, improving indoor air quality can be very important to increase productivity, and, moreover, to avoid the spread of the virus [1]. To reduce the likelihood of transmission via air, the WHO recommends a natural ventilation rate of at the least 60 liters per second and per person, and at least 6 air changes per hour [2, 3]. In light of the carried literature review, some questions can be raised: what are the regulations in Spain and Europe in matter of ventilation parameters? Are indoor environments up to the task of adopting the imposed, yet hopefully transitory, "new way of life"? Can they be considered safe in terms of preventing contagion, safeguarding public health? And also, have them proper ventilation system, according to the new demands in times of pandemic?

Due to the importance of ventilation in times of pandemic, this research focuses on the effectiveness of air change in homes, checking whether the corresponding values agree with the new requirements and directives established by laws, to contain spreading contagion [4, 5]. The methodology used for the air quality analysis consists of calculating flow rates and R/h of ventilation adopted indoors in Europe and Spain, considering the amount CO_2 emitted per person in the framework of the newly issued directives of COVID-19. To verify that the indoor ventilation is still adequate to the new requirements, the existing regulations at the European level are analyzed in comparison to the Spanish regulations regarding the minimum measurements indoors. This aspect is crucial because the increase of CO_2 concentration indoors, where people's breathing and related

activities account for a greater share due to the confinement, would imply an insufficient air exchange, raising the risk of SARS-CoV-2 contagion [6-9].

The analysis, next provided, shows the statistical results arisen from comparing the ventilation parameters, taking into account ten types of selected dwellings (Fig. 1). Summary tables and graphs are presented, showing whether the current regulations meet the new criteria established during the COVID-19 pandemic, including the relationship between Italian, Spanish, and European regulations.

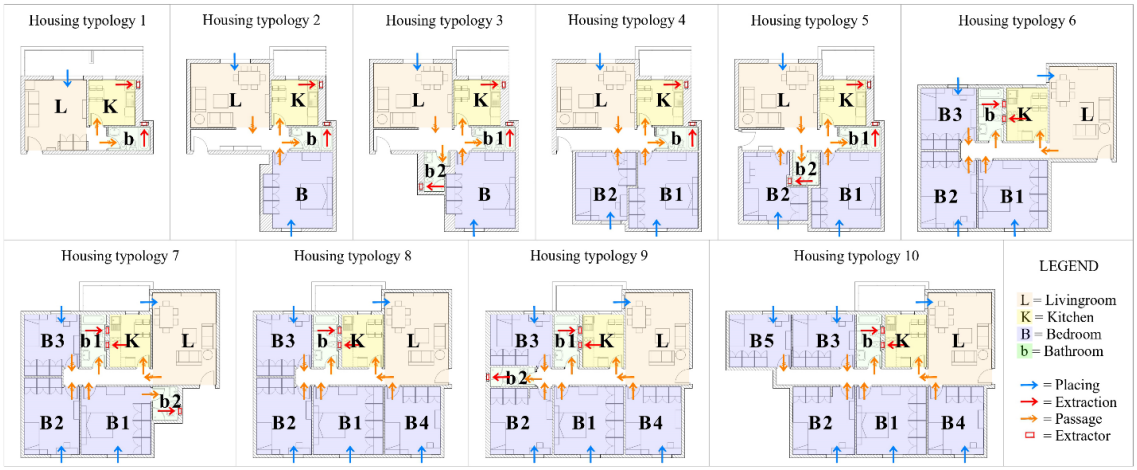


Figure 1: *Typology of dwellings to be studied.*

The results, shown in Fig.2, indicates that the Italian legislation is more restrictive than the Spanish one, obtaining the maximum difference in flows for house typology 2 and 3, with a percentage difference between the adopted regulations of 81%. In addition, in both regulations, it is observed that the most significant gap in the increase in ventilation is obtained between housing typologies 5 and 6, that is, when passing from two to three bedrooms. The recommended ventilation for times of pandemic is higher than that established in both legislations.

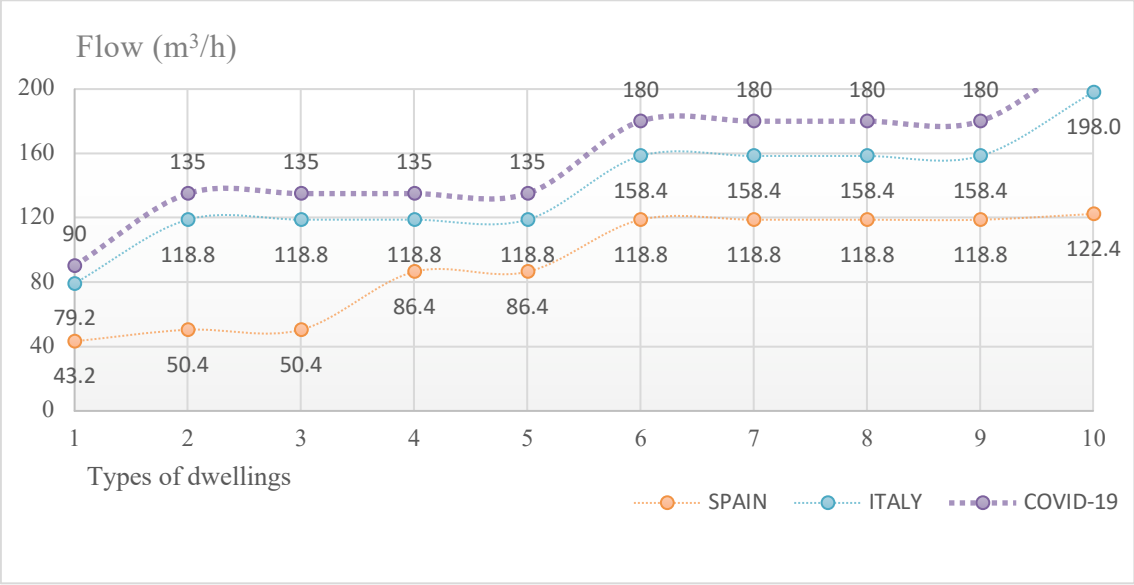


Figure 2: *Ventilation in the ten types of dwellings adopted, according to Spanish and Italian regulations.*

The one-way analysis of variance (ANOVA) showed that the Spanish and Italian regulations have significant differences in the ventilation flow data, being F (4, 493) = 12.59, for p <0.005. The null hypothesis expressing similar ventilation is rejected because the F value is greater than the critical value.

Comparative analysis between the regulations on ACH and the COVID-19 directives, according to the European standard EN 16798 (Fig.3) and the data on the minimum square footage for houses and bedrooms.

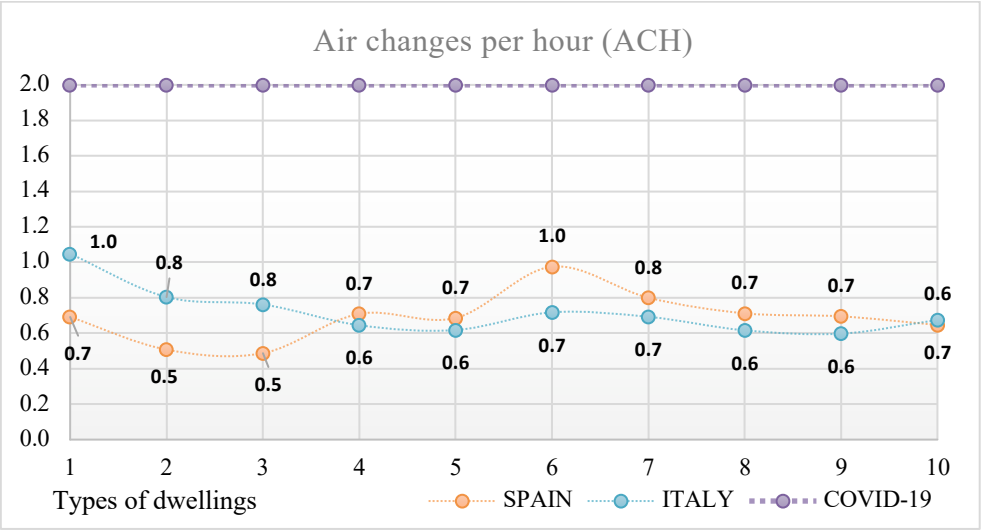


Figure 3: *Calculation of air changes per hour in the ten types of dwellings according to Spanish and Italian regulations.*

The highest data in the ventilation flow table were chosen as optimal. ACH was then calculated considering the height of the room(s), for the Spanish (2.5 m) and the Italian (2.7 m) cases. The ACH results turn out to be lower compared to the Covid-19 guidelines that establish a minimum of 2 ACH according to the government of Spain.

This analysis is done with the criteria established by European regulation, Spanish guidelines, and recommendations against the COVID-19 regarding CO_2 concentration (Table 1).

Table 1: *Comparison of CO2 concentration results by the different regulations*

CO_2 concentration				
CTE HS 3	Spanish recommendation for Covid-19	EN 16798-2 (Rooms) **Δ**CO_2 In-Out	EN-16798-2 (Living rooms) **Δ**CO_2 In-Out	UNE EN-171330-2 **Δ**CO_2 In-Out
Spain	Spain	Europe	Europe	Europe
ppm	ppm	ppm	ppm	ppm
900	500	380	550	500

The Spanish regulations present very restrictive CO_2 concentrations in the interior, being this of 900 ppm, provided that the annual accumulated CO_2 that exceeds 1,600 ppm is less than 500,000 ppm•h. But according to the recommendation guide in times of COVID, it is suggested that the concentration is not greater than 500 ppm. However, the European regulations EN-16798-2 and EN-171330-2 present limit values depending on the internal concentration compared to the external one, having a maximum difference of approximately 550 ppm (depending on the category). It can be seen that they are very different criteria that should be unified for the dimensioning of ventilation in homes and the improvement of people's well-being.

In light of the growing evidence of the risks of airborne transmission of the SARS-COV-2 virus, a need to reconsider the parameters established by law to ventilate spaces in residential buildings arisen.

Natural ventilation is an affordable and sustainable method to achieve this goal, but it presents discrepancies in the calculation variables. We have shown that for Italy, the air flows required in the applicable regulations are more restrictive than in Spain, especially for larger houses. Significant differences in this sense have been observed for all types of considered housing solutions, except number 1, which is the one with the smallest surface area. However, the ventilation flow established by the Spanish regulations presents better results than the Italian ones, since an air flow of 12.5 l/s per person is foresees for the former case.

The ventilation flows indicated by different standards are insufficient to comply with the number of air changes per hour recommended by WHO and, consequently, with decreasing levels of indoor CO_2 concentration. Therefore, it would be appropriate to increase the minimum health measures in terms of inner ventilation, considering that it

is a space where we spend more hours than before, as there are no laws that currently establish optimal measures that guarantee to avoid contagion via aerosol sprays.

As a result of this study, the need has arisen to update the legislation on ventilation, since the criteria established long ago are not currently adequate to avoid contagion by aerosols indoors. Under the proposed new paradigm, the air is supplied to building occupants for breathing, not for heating or cooling. For this reason, future efforts are also necessary to expand this research, in the general framework of natural and forced ventilation systems, comprehending other factors such as occupation, activity, weather conditions, energy efficiency, etc.

It should be noted that the obtained results are based on simplified assumptions, without taking into account many influencing factors such as temperature, humidity, evaporation of droplets, etc. Yet, this research can be considered a first step to understand the criteria required for ventilation in residential buildings to address the prevention of the transmission of infectious diseases

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THE EFFECTS OF A GREEN WALL ON THE INDOOR THERMAL COMFORT IN BUILDINGS AND ON OUTDOOR ENVIRONMENT: A CASE STUDY IN MEDITERRANEAN AREA

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Keywords: *green façade; computational fluid dynamic simulation; indoor thermal comfort; outdoor environment; ENVI-met*

Abstract

The energy consumption of buildings and the associated CO2 emissions are causing an increase in global average temperatures of the planet. The average annual temperature is rising and increasingly intense adverse weather phenomena are more frequent. The temperature increase in dense built-up urban areas may be much greater and this implies long lasting heat waves in summer along with all the negative impacts on the health of the city residents. Therefore, urban microclimate is being modified and an urgent need for action in relation to climate-change adaptation is necessary.

Greened building facades can offer remarkable thermal benefits as reduced solar heat gain through the vegetation canopy and conversion of absorbed solar heat to latent heat by evapotranspiration, resulting in the reduction of outer surface temperature and re-emitted longwave radiation. As a consequence, and depending on the construction

features, green facades can decrease the internal temperature and reduce indoor energy use in buildings.

This paper wants to evaluate the effectiveness of a green façade as a strategy for the improvement of indoor and outdoor thermal comfort, which is the main goal of the "BETA" Intradepartmental Project at the University of Catania (Italy). To this purpose, a micro-scale analysis of two lightweight prefabricated modules with insulated sandwich panels located at the University Campus of Catania is carried out by means of validated CFD simulations in ENVI-met.

The CFD analysis is carried out for preliminary assessing the thermal behavior induced by a vertical greenery system realized using the Trachelospermum jasminoides plant species, which will be installed in the next months on the west-oriented wall of one of the two prefabricated modules. The simulation outcomes highlighted a rough reduction of 4.0°C and 2.0°C in the peak of outer and inner surface temperatures and a decrement of 2.0°C in indoor air temperature. In the hottest hours during sunny day, a decrease in internal air temperature of about 1.0°C is achieved. Further investigations are planned to monitor the effectiveness of the green façade on the real test room for an entire year.

SUSTAINABILITY ANALYSIS OF THE CALLE 30 TUNNELS IN MADRID AND ITS SURROUNDINGS AFTER 15 YEARS OF SERVICE LIFE

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Keywords: *sustainability; MIVES method; tunnels; construction materials; Calle 30*

Abstract

The city of Madrid is the largest city in Spain and the fourth largest city in the European Union [1]. Madrid is surrounded by three ring roads, being the Calle 30 the busiest one, with an average daily traffic about 200,000 vehicles/day [2] and a length of 32 km [3]. This motorway was built between the years 1970 and 1990 and its renovation was carried out from 2004 to 2007. The main objectives of this renovation were to improve the service level of the road, reduce the accident rate, improve the environmental and social factors of the area, and reduce the barrier effect that the road entailed to the surrounding districts in the South-West sector [4].

In order to achieve these goals, the Calle 30 tunnels were built and the Parque Madrid Río was created in the South-West sector of the ring road [2, 4, 5]. This renovation brought important benefits to the traffic fluency, the creation of a large green area, the recovery of the ecosystems of the Manzanares River and a significant transformation of the surroundings.

The aim of this study was to analyse this transformation from the point of view of the sustainability 15 years after its construction. Changes in the area were studied considering relevant aspects related to sustainability, such as economic, environmental and social factors.

This analysis was performed by means of the MIVES method, a multicriteria tool which combines quantitative and qualitative factors, building a holistic decision tree with three levels (requirements, criteria and indicators) to obtain a single and non-dimensional sustainability index [6]. These requirements, criteria and indicators were evaluated by means of value functions, which transform the qualitative variables into quantitative ones. These value functions were evaluated by experts [7]. Also, these experts weight each requirement, criteria and indicator in order to determine its relevance in the global analysis.

In order to assess the economic, environmental and social impacts of the renovation of the South-West Sector of the Calle 30, three alternatives were analysed in this work: non-buried Calle 30 (previous layout, before the construction of the tunnels and the Parque Madrid Río), buried Calle 30 with conventional materials (present situation) and buried Calle 30 with improved materials (present situation using high-performance materials). The last alternative was included to evaluate the influence of the construction materials applied in the construction of the infrastructure and its service life.

The economic criteria studied in the analysis involved the direct costs of the alternatives (construction, maintenance and dismantling) and the indirect benefits brought by the renovation (real state market development, cultural boost and tourism increase). Non-quality costs were also considered. In order to evaluate these criteria, it was assumed that maintaining the previous layout of the road, would not have required any construction costs; and regarding the conventional materials, it was stated that they are cheaper and do not require highly specialized labour force, but they will require higher maintenance operations in the future. Also, it was verified that the burial of the South-West sector of the Calle 30 brought indirect benefits to the surrounding area [8–10].

Regarding the environmental criteria, some of the indicators studied were related to the energy and material consumption during the construction, maintenance and exploitation of the infrastructure. These indicators were focused on differentiating the use of conventional and improved materials. It must be noticed that the dosage of improved materials is different from the conventional ones, as they require higher amount of cement (400-500 kg/m^3), lower water to cement rates (less than 0.3), they include additives and additions and the size of their aggregates are carefully studied [11, 12]. Also, roads are an important source of noise and air pollution [13, 14], so emissions and noise generated during construction, maintenance and exploitation were included in the analysis. In addition, as one of the main goals of the renovation was to connect the fluvial system of the Manzanares River to the urban landscape of the city [13, 15] and recover the ecosystem of the river, some criteria and indicators were included to analyse these aspects.

The social criteria and indicators evaluate the impact of the works on the users and inhabitants of the surrounding areas during the construction of the tunnels and the exploitation of the infrastructure. Equally, social criteria and indicators have been

selected considering the direct effects (health and safety, pollution and accident rate) and the indirect ones (traffic fluency, accessibility and travel times) [16]. It was also considered that the construction of the tunnels removed the barrier effect in the South-West sector of the Calle 30 and the creation of the Parque Madrid Río enhanced leisure and cultural activities in the area, and the comfort and accessibility for users and residents. It should be highlighted that these indicators are directly dependent on the design of the infrastructure, but not on the materials used.

The conclusions of the analysis showed that the construction of the tunnels meant a significant improvement of the sustainability (Sustainability Index 3.43 before and 6.26 after the burial of the South-West sector of the Calle 30) and that the use of improved materials would have slightly raised this index. It is also important to notice that the materials used to build the tunnels only affect some of the economic and environmental indicators, as most of the social indicators depend only on the design of the structure and not on the materials used during construction.

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MULTICRITERIA APPROACH TO SUSTAINABLE DESIGN

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Keywords: *green buildings; sustainable design; thermal and energy performance; embodied carbon; costs*

Abstract

The construction sector is now called upon to confront with increasingly high-performance and sustainable buildings. In response to the energy crisis and the worsening environmental conditions, green buildings have emerged [1], resulting in the introduction of innovative building technologies and the rediscovery of ancient techniques based on the use of natural materials.

To ensure a good response to multiple requirements, it is important to apply a multi-criteria design approach, which allows the designer to analyze, evaluate, choose, and summarize the parameters to be given more relevance in order to ensure the best quality of the building. A conscious use of green materials and technologies also avoid the risk of greenwashing, which is very common today (both at the product and building level) [2].

This contribution aims to investigate the performance of different green building solutions (based on the use of bio-based materials as raw earth, timber, and natural fibers) and to compare them with those of technological solutions commonly adopted in contemporary construction.

The methodology adopted in the investigation provides for the realization of a multi-criteria analysis in which thermal, energy performances, indoor comfort conditions, and environmental and economic costs associated with these technologies are assessed (social sustainability is detected but will be evaluated elsewhere). A dynamic multi-criteria energy analysis was conducted on a case study model in a mild temperate climate area (Csa - Koppen classification) implementing numerical simulations [3].

The conclusions highlight how complex it is to identify a single building type and constructive system solution that optimizes all the performance criteria chosen. It is appropriate, for a proper building and envelope design, to adopt a multi-criteria design approach which consider the criteria which want to be maximized, based on various factors that affect the design (local climate, building type, geometry, and orientation of the building, etc.).

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INFLUENCE OF THE POSITION OF INSULATION ON THE THERMAL BEHAVIOR OF FLAT ROOFS IN MADRID

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Keywords: *roofing insulation; experimental research; sensor installation; full-scale modules*

Abstract

The roof of a building is almost always the most exposed part of the building. Pitched roofs and flat roofs suffer especially rain and solar radiation –but also other less frequent atmospheric phenomena, such as snow– so they require continuous maintenance and frequent renovations. A particular case of these roofs, the flat roof, is common in most residential buildings in Madrid. For several decades these roofs have been used to cover traditional and new buildings in the area. They are even more common today due, as they enable locating all new building facilities with ease. These roofs often have insufficient or ineffective insulation, for various reasons.

One of the objectives of this work is the study of the thermal behavior of two of the most common systems of contemporary flat roofs in the Madrid area. On the one hand, the so-called traditional roof, and, on the other, the inverted flat roof, with the dual objective of using them both in new construction and in the renovation of existing roofs, adapting them to current energy requirements. The traditional roof is a common covering system in new construction, characterized by the position of the insulation, on the inside of the building skin, below the waterproofing layer; contrary to that, the position of the insulation in an inverted roof is on the outside, under a heavy protection and above the waterproofing, serving as its protection.

This research starts from the hypothesis that the theoretical energy behavior of these roofs frequently presents differences with the real behavior, due, among other issues, to the greater exposure of the insulation in the inverted roof, in which the rainwater filters up to the waterproofing system.

In order to have data on the real behavior of these flat roofs, three experimental modules of 3mx3mx3m each have been built at the UPM-Montegancedo campus. 5 of the 6 faces os these modules are adiabatic, in order to control heat exchanges with the outside through the deck only. To obtain these adiabatic faces, about 60 cm of insulation

was used, so transmittance can be considered close to 0. The assembly of the modules was carried out with the support of the SIREIN+ project (Sistema integral de Rehabilitación energética - Comprehensive Energy Rehabilitation System).



***Figure 1**, Experimental modules assembly phase in Campus UPM-Montegancedo*

These modules were specifically designed and instrumented to test the characterization of different roof solutions. In regard to this paper, two solutions were built, refurbishing a minimally insulated roof: one with a traditional roof, and the other with an inverted roof. The goal of this approach was to establish a comparison between the two. The theoretical transmittance values for both solutions were similar –with a minimal difference– to simplify the comparison. Values adopted were improved over those established by CTE DB HE-1, 2019.

Two representative sections of each of the solutions described are sketched below.

Traditional flat roof

U total 0,22 W/m2k.

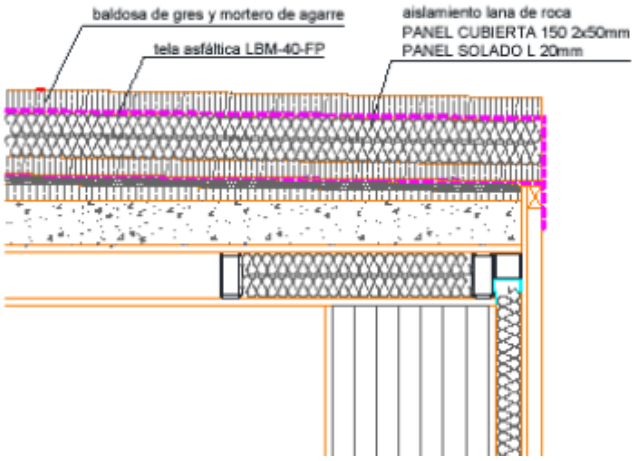


***Figure 2**, Traditional flat roof experimental module. Construction section.*

Inverted flat roof

U total 0,21 W/m2k.

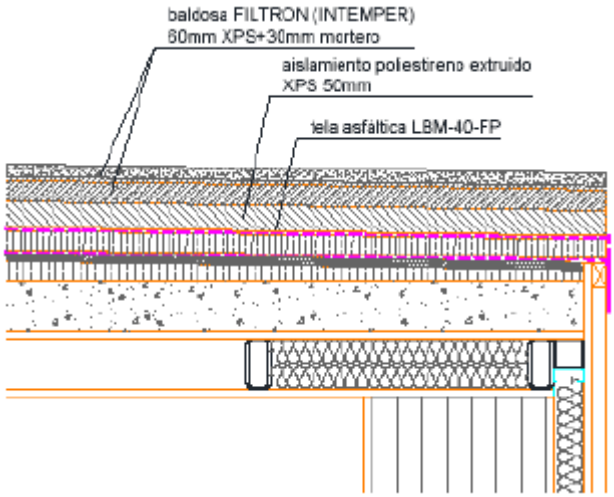


***Figure 3**, Inverted flat roof experimental module. Construction section.*

The main objective of the designed experimentation plan was the analysis of the heat flow, including the measurement of the temperature in each of the layers that make up the various systems. For this end, several thermocouples have been placed in the most representative points, as shown in the following figure.



***Figure 4**, Position of the external thermocouples in the inverted flat roof experimental module.*

The energy provided by the indoor air conditioning system, in terms of consumption, has also been recorded in order to know the real demand for each of the two roof

solutions. The data thrown by the instrumentation system were collected with a frequency of one minute, obtaining several graphs of the daily behavior.

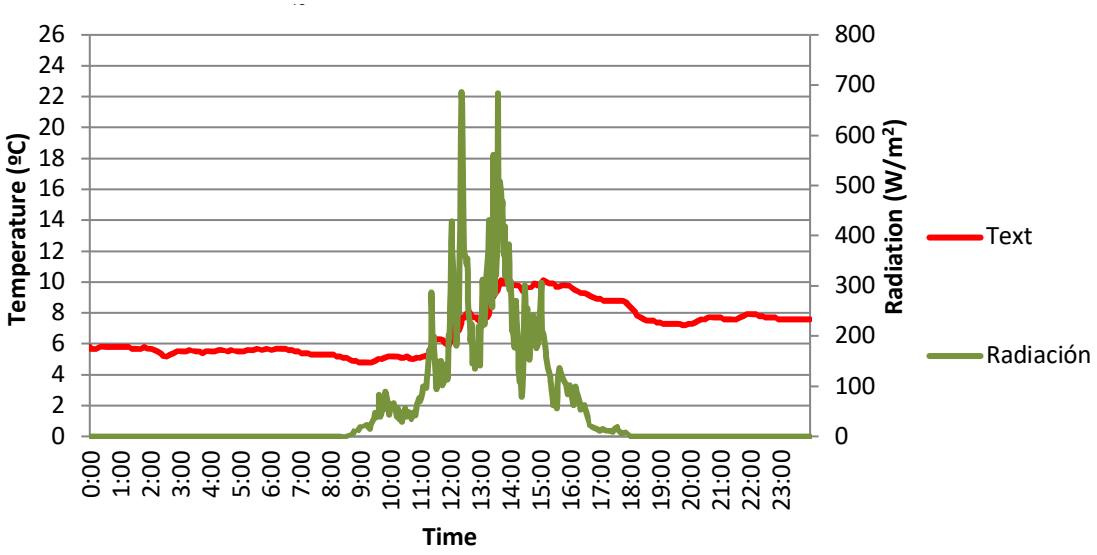
From a theoretical point of view, a simulation of the two prototypes proposed with a CFD software (DesignBuilder) was carried out, selecting and analyzing the parameters of reduction of energy demand –and, consequently, of consumption–.

The results obtained have been contrasted with previous theoretical values. Comparison between the results obtained in the traditional and in the inverted roof allows advancing provisional conclusions of great interest. The first could be that this type of small-size modules enable quantifying real –and not theoretical– improvement that these energy refurbishments entail on a minimally insulated base roof. These results can also be extrapolated to new construction case studies.

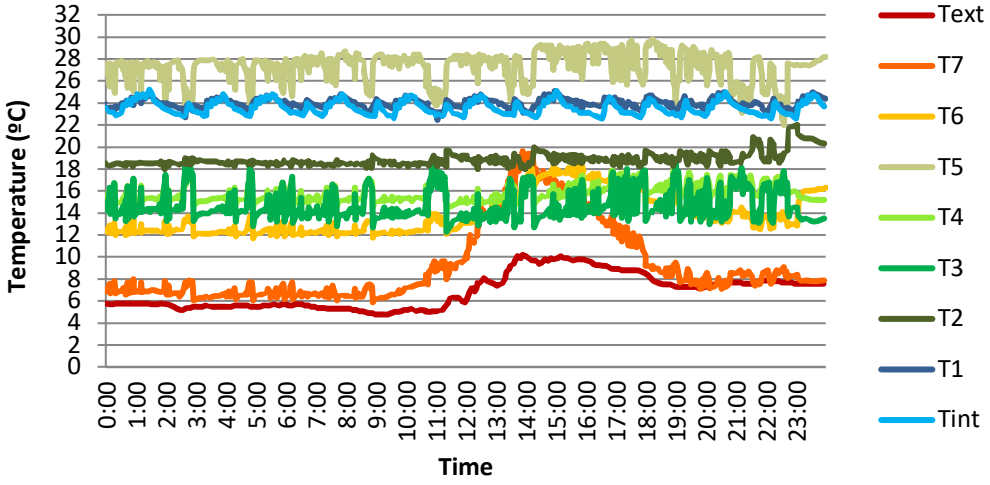
The energy simulation carried out shows that the reduction in energy demand is very important and similar in both roof solutions, traditional and inverted. These results are, as has been said, for the energy rehabilitation of a minimally insulated base roof. In the case of heating, a reduction of 45% is obtained; in refrigeration the reduction is of the order of 40%; combining both solutions, the reduction in the annual demand of energy is approximately 43%.

In addition, small modules allow to know the influence of various climatic phenomena, that are very complex to implement in digital models. Thus, this initial phase of the research has proven –though this is not conclusive and has not been studied in depth–, that traditional roofing obtains the greatest savings in consumption on rainy days and winter temperatures. Under these conditions, reductions in consumption of more than 18% were observed, what proves that the insulation was working optimally, protected by the waterproofing sheet. However, the traditional roof does not offer that many advantages in the days of higher radiation, obtaining less savings in consumption than the inverted roof.

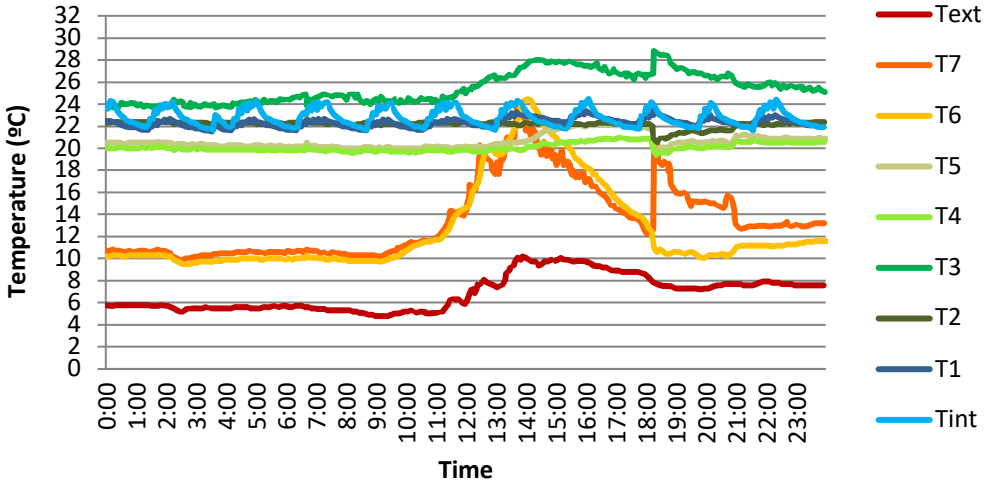
As an example, the graphs of the results of a rainy day in winter –and, consequently, with low solar radiation– are attached. Data of the consumption of the autonomous air conditioning units placed inside the modules are also included.



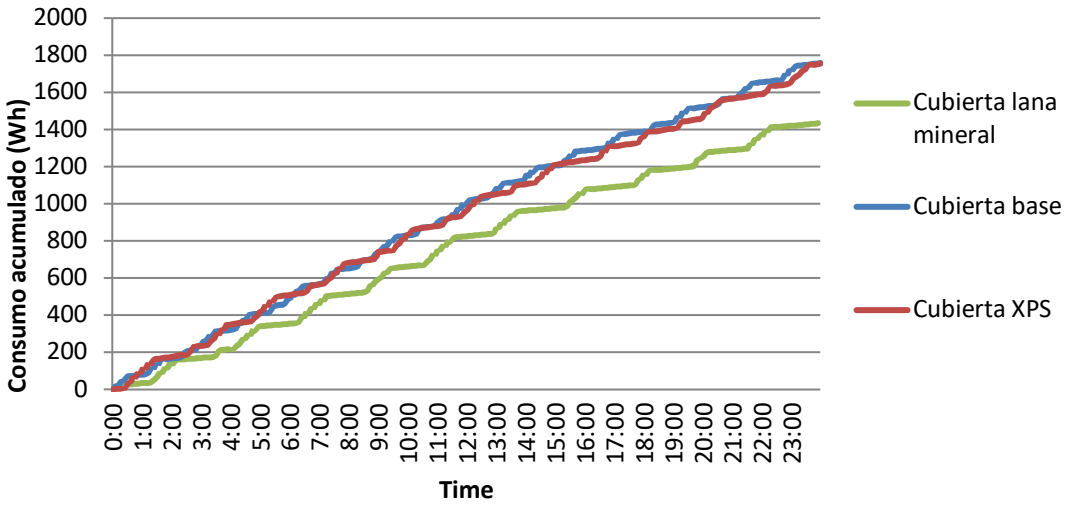
***Graph 1**, Outside temperature and radiation.*



***Graph 2**. Temperatures. Inverted roof.(Ins. XPS)*



***Graph 3**. Temperatures. Traditional roof. (Ins. Rockwool).*



***Graph 4**. Accumulated consumption.*

HOUSEHOLD ELECTRICITY MANAGEMENT SYSTEMS TO OBTAIN OPTIMIZED BILLS: THE CASE OF SMART PLUGS

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Keywords: *household; electricity; management; optimization; bill*

Abstract

In various European countries, and in our case in Spain, the companies called distributors perform all the services related to the electricity supply (they distribute the energy to homes, maintain the network, install the connections and meters, collect the readings, etc.) but they don't sell the energy directly to consumers, but rather to companies called traders, which are the ones that sell it to those consumers. These marketers are of two types: reference and free market.

In this study, we will focus on the PVPC with fluctuating prices according to the time slot, which exists in Spain at the date of writing of this study a single 2.0TD access rate, with two possible terms of contracted power and three terms of energy consumed.

For the calculation of the user charge in terms of the contracted power term, generally the most expensive peak hours correspond to between 8.00 and 0.00 hours from Monday to Friday and their off-peak hours from 0.00 to 8.00 on weekdays and all day in weekend or national holidays.

On the other hand, for the calculation of the user charge the energy term, which measures the effective consumption, the price can vary depending on whether the consumption has taken place at peak, flat or valley hours, with the peak being the highest.

Table 1: *Hourly discrimination on working days rate 2.0TD (Spain 2021)*

Time discrimination Peninsula, Balearic Islands and Canary Islands		
Top	Off-peak	Down time
Monday to Friday 10:00 – 14:00 18:00 - 22:00	Monday to Friday 8:00 – 10:00 14:00 - 18:00 22:00 - 00:00	Monday to Friday 00:00-8:00 All Saturday, Sunday and national holidays.

If we stick to those factors that depend directly on the consumer, these are fundamentally: i) choosing the most advantageous supply contract or other supply systems (mixed or even self-consumption); ii) choosing the most efficient electrical consumption elements (electrical appliances, light points, hot water production, etc.); iii) improving the energy efficiency of the house from the construction point of view; vi) efficient use of consumer items [1].

In this study, we will start from the following premises: i) the consumer has a supply contract with hourly discrimination; ii) as the casuistry is very varied, the consumption elements are not the object of analysis; iii) when trying to avoid investments in construction elements, the improvement of energy efficiency in this sense is not considered; vi) Regarding the efficient use of consumer items, it is intended to apply technologies that are very economical and entail significant savings without excessive loss of comfort.

The choice of technologies with regard to the efficient use of consumer items must comply with the premises of being very economical, based on the detection and control of consumption and cheaper hours, and entail significant savings without excessive loss of comfort.

Following these conditions, the following technologies have been detected: hardware (smart plugs, switches and control centers), software-applications (for PCs, apps, etc.) with control functions, meters and intelligent monitoring.

In this sense, smart plugs offer a very economical solution that has already been considered in several previous studies [2] [3] [4], and that can even be applied exclusively to household appliances with higher consumption.

The methodology followed focuses on detecting existing technologies, selecting the most appropriate and applying it to a practical case, to later carry out, on the results of these, an analysis and discussion and later the corresponding conclusions.



Figure 1: *Diagram of the technology and the chosen system (own source)*

The chosen house has approximately 100 useful m2, and an interior distribution that includes a hall, living room-dining room, a master bedroom, two bedrooms, a kitchen, balcony, hallway and two bathrooms. Regarding the technical data for contracting the supply, the aforementioned rate is 2.0 TD with contracted power of 4.6 Kw. Table 2 shows the existing consumption elements in the home and their estimated powers, and in which the smart plug was installed, following the criterion that only elements of high use or / and high power are analyzed, and whose use can be adapted to an intermittent or changing schedule.

Table 2: *Consumption elements in the dwelling selected as a test bench and their powers*

CONSUMER ELEMENTS	Nº	Average consumption estimated in% with respect to the total of all electrical appliances	ESTIMATED POWER IN kW	Smart plug installation YES / NO
			Between 1000 and 2500 kW	
Air conditioning (centralized with thermostat)	1	-	Between 900 and 2000 kW	No (use depends on ambient temperature)
Fridge	1	18	Between 250 and 350 kW	No (Permanent)
TV	3	-	Between 150 and 400 kW	No (in hours of leisure and little consumption)
Microwave	1	7	Between 150 and 1500 kW	Yes
Vitroceramic	1	15	Between 900 and 2000 kW	Yes
Oven	1	9	Between 1200 and 2200 kW	Yes
Washing machine	1	12	Between 1500 and 2200 kW	Yes
Dishwasher	1	6	Between 1500 and 2200 kW	Yes
Toaster	1	-	Between 550 and 1000 kW	No (very punctual use and according to need)
Computer	2	-	Between 250 and 350 kW	No (little consumes use according to need)

The choice of plug types followed the criterion of always considering the cheapest ones offered by the market that met the requirements of scheduling hours of use and sending consumption information via Wi-Fi remotely for monitoring on mobile devices with an app. free control. After the appropriate analysis, the choice was the TP-link tapo p110 plug with its own free app, highly valued in Google Play. The total cost of the entire system, excluding the mobile device (telephone) or Wi-Fi, was 90 euros. To verify that the programmed times are correct, “RedOS” was used, which is the free application of the Spanish Electricity Network with a section for consumers where it is possible to check the price of electricity every hour.

In Figure 3 you can see during the first week (A without smart plugs) and during the second (B with smart plugs installed) the time in minutes that each selected consumer item used and how much time of the total it was top, off-peak or down time. In this sense, it must be said that in some cases the reduction in top hours was not very significant because due to the user's needs, this disconnected the programming to power the plug and be able to use the point of consumption. However, even though this reduction is not very high, a significant impact on the final price to be paid by the user

is seen as a whole, with possible reductions in the consumption part of the set of these selected elements of close to 30%, if we apply tariffs of access (tolls + charges) 2.0TD.

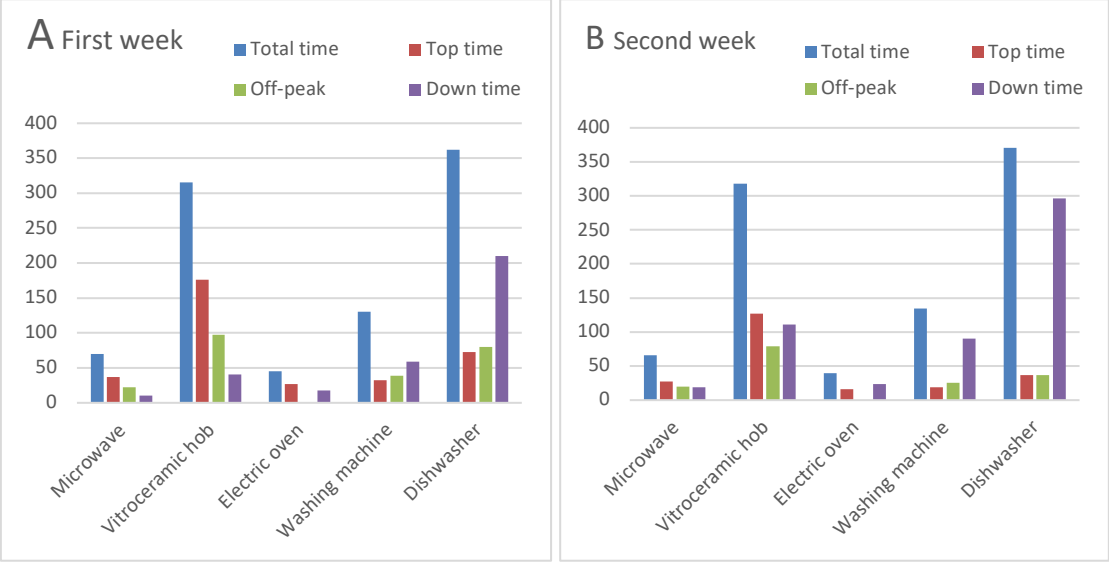


Figure 2: *A (first week) and B (second week). Time in minutes in which each selected consumer item was used and how much of the total was top, off-peak, or down time. (own source)*

Conclusions

The main conclusion lies in the fact that, with a minimum investment and a simple installation to be carried out by the user, as is the one used, significant savings can be achieved in the electricity bill with a contracted rate based on hourly discrimination. However, the problem of the high price of electricity continues to exist even during the off-peak hours, an issue that is not resolved by this technology, since less consumption isn't observed by producing changes in user habits that make it more austere in their behavior, without prejudice to certain emotional discomfort of the user and not being able to predict whether in the short, medium, or long time they would continue to use the system by the said user.

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ENERGY EFFICIENCY AND INDOOR AIR QUALITY ANALYSIS OF AN EDUCATIONAL BUILDING

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Keywords: *ventilation; indoor comfort; energy efficiency; educational building*

Abstract

Climate change is currently considered a very serious environmental problem that affects all parts of the planet.

In the construction sector, we can contribute to solving this climate problem by practicing sustainable construction, developing buildings that take into account the environmental impact at all stages: design, construction process, life of use, maintenance, demolition phase and waste management. And during the period of building use, occupants can use efficient facilities, including renewable energy sources, to contribute to sustainable development [1]-[3].

In addition, this type of construction provides a higher level of comfort to users in a more efficient way, consuming less energy and economic resources.

Thermal and acoustic comfort, lighting and air quality are considered the most important aspects to preserve occupants' comfort. Among them, the level of indoor air quality is a very important factor as it conditions the state of health, effectiveness, work performance and comfort in people. In the global pandemic situation in which we find ourselves, this aspect has become more relevant than the others.

A higher rate of natural ventilation can ensure a good level of air quality, eliminating pollutants and providing clean and healthy air. However, it is not an efficient solution, as it is not conducive to thermal and acoustic comfort in the building, and at the same time causes greater energy loss, especially in areas with extreme climates.

All these justifications are the reasons that support the realization of this project, which studies the conditions of thermal comfort and indoor air quality of the various spaces of the library of the ETSEM to improve and provide a comfortable study space in all aspects.

The methodology used in the work consists of the following steps:

- Analyze the meteorological data from AEMET for the year 2018 to determine the predominant wind direction, wind speed, average temperature and relative humidity for each month. This first step is essential in order to start the outdoor CFD analysis calculation.
- Make the geometry of the building in the Design Builder program to be able to execute the modeling of the project. Based on this model, all the simulations and analyses of interest will be carried out.
- Perform the exterior CFD analysis to determine the incoming air velocities through the openings. At this stage, the predominant direction and velocity obtained in the first step are entered to start the calculation of the residual equations. In this way, the actual external velocities can be known in order to be able to work more accurately on the internal conditions.
- Perform the interior CFD analysis with the results obtained from the previous point, to determine the interior space conditions such as air velocity, air age, PMV and PPD indices.
- Analyze the ventilation and comfort performance, comparing it with the limit values required by the regulations.
- Perform HVAC simulations to see the energy demand of the building.
- Propose improvement proposals with active and passive solutions to improve both thermal comfort and indoor air quality aspects.
- Perform CFD and HVAC simulations with the improvement measures.
- Analyze the results obtained with the incorporation of corrective measures and compare with the results obtained from the original building to quantify the savings and improvements achieved.

By performing several simulations of the actual building with the Design Builder program, information about the energy demand and its air quality status is obtained. Studying the results obtained from the different simulations, it has been detected that the PMV and PPD values are not in the range of optimal values.

After the analysis of the obtained results, strategies have been proposed with solutions that act actively and passively to improve and optimize the comfort indexes, also complying with the natural ventilation requirements demanded due to the global pandemic situation. These include the improvement of the building envelope with a ventilated façade; the replacement of windows with others of better category; and the incorporation of a mechanical ventilation system with heat recovery [4].

Finally, the aim is to check the improvements achieved with the proposed solutions by comparing them with the initial model. As can be seen, there is a great energy saving,

since the consumption destined to the air conditioning system is lower. Especially in the winter season, it can be seen that there is a 65.5% reduction in heating. The comfort indexes: PMV and PPD have also improved with the incorporation of the corrective measures. The air quality [5],[6] is guaranteed and the thermal sensation is better for the occupants, since the incoming air flow is controlled and also preheated by the heat exchanger in winter. The improvement strategies in the month of December have worked better with respect to air age, since in the initial model there is insufficient flow for the studied area. With the incorporation of mechanical ventilation in the roof of the enclosure, the air stagnation in the inlet area, where the air is not easily renewed with natural ventilation, has been improved.

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ECOLOGICAL PLASTERBOARD WITH LADLE FURNACE SLAG

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Keywords: *plasterboard; ladle furnace slag; thermal behaviour; fire reaction; sustainability*

Abstract

This work shows an investigation in which plasterboard are designed, with the addition of ladle furnace slag, generated in the steel manufacturing process in the Secondary Metallurgy.

The properties of gypsum mortars manufactured with the addition of ladle furnace slag have been characterized, with progressive substitutions of the conglomerate by the waste of 20%, 40%, 60% and 80%. The physical and mechanical properties have been studied, both in the fresh and hardened state, to verify that all the mixtures fulfil with the minimum parameters required by the applicable European regulations, as well as their behavior and reaction to fire.[1]

The following "Table 1" shows the values of the tests for the physical characteristics analyzed for each of the dosages used for the manufacture of the eco-prefabricated products.

Table 1: *Physical properties of plasterboard with laddle furnace slag.*

Results of Physical Properties						
	Sample	Flexural Resistance (N)	Water Absorption (%)	Flexural Resistance after Water Absorption Test (N)	Hadness Impact Resistance (mm)	Hadness Shore (C)
Ref.	PB0	447	27,4	406	11,0	94
PB+ LF	PBS20	340	19,6	303	12,3	92
	PBS40	260	20,1	210	14,4	90
	PBS60	120	22,0	77	20,2	87
	PBS80	92	30,0	67	1,1	35

The results show that the inclusion of ladle furnace slag produces a reduction in the flexural resistance values of more than 50% in the additions with the highest amount of aggregate residue. As for the hardness values, a slight reduction is seen, while the impact resistance and water absorption values are considerably improved, with the exception of the sample with the highest percentage of slag used.

Commercial gypsum boards with dimensions of 300x400x15 mm have been manufactured from mortars with the addition of ladle furnace slag, studying their properties for their use as construction material in different work units, analyzing the mechanical resistance, thermal conductivity and fire resistance [2].

Regarding the results obtained, it is concluded that the progressive incorporation of ladle furnace slag in the mixtures for the elaboration of the precast products as shown in “Table 2”, causes a significant variation in thermal conductivity and in the heat transfer coefficient, producing a greater compaction and a lower thermal insulation, in comparison with the reference sample [3].

Table 2: *Results of the fire reaction test for plasterboards with ladle furnace slag.*

Fire Reaction Results					
Sample	PB0	PBS20	PBS40	PBS60	PBS80
J = Heat Flow (W)	1,35	2,75	3,05	3,22	3,43
Λ=Thermal Conductivity (W/mºC)	49.2	144,4	175,9	162,8	195,0
Heat Transference Coefficient by Wall-Air Convection (W/m²ºC)	2.76	8,79	9,07	11,24	12,01
U = Thermal Transmission Coefficient or Total Conductance of Losses (W/m²ºC)	1,26	2,95	3,10	3,25	3,51

The results obtained in Gross Heat of Combustion PCS test indicate that the sample with the worst performance is PBS80, registering an average value of PCS = -0.538 MJ/kg, which is a correct result, since negative values indicate that an endothermic reaction was produced during the combustion of the material, as is the case we are analyzing. According to the applicable regulations, materials with negative PCS will be referenced with a value equal to zero, this being classified as Class A1, an aspect to be taken into account for the classification of precast products.

However, the addition of ladle furnace slag in the plasterboards, causes a substantial improvement in the response to fire and heat rise as shown in the following "Table 3", observing a reduction in the mass loss values presented by the samples [4].

Table 3: *Fire reaction results after non-combustibility test.*

Non-Combustibility Results				
	Muestra	Δ Oven Temperature (ºC)	Persistence of Inflammation (s)	Loss of Mass (%)
Sample	PB0	4,1	<5	25,1
PB + LF	PBS20	3,8	<5	21,4
	PBS40	3,4	<5	19,2
	PBS60	2,4	<5	17,5
	PBS80	2,2	<5	12,3

The values of % mass loss obtained show "Figure 1" a substantial improvement in relation to the reference sample of up to 50%, with this increase happening progressively as the amount of residue used in the dosage increases, contributing important values in terms of the behavior of these products in their reaction to fire.

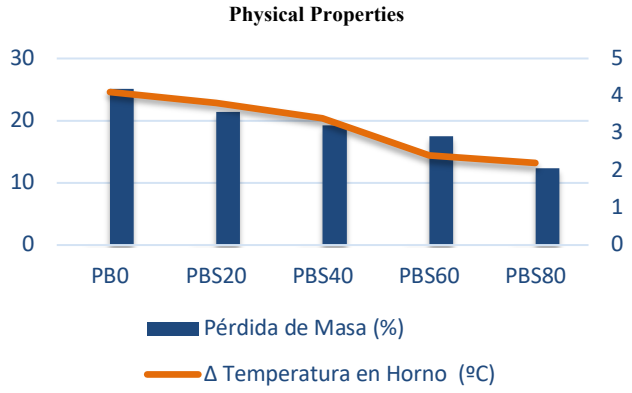


Figure 1*. Physical properties non-combustibility.*

The use of this waste in substitution of a natural resource such as gypsum, in one of the most used products in construction, entails a series of environmental and economic benefits, since analyzing the processes of extraction, elaboration and handling of the raw materials and residues generated, a reduction in the values of environmental and landscape impact is observed.

By using ladle furnace slag as a raw material, the energy costs associated with traditional manufacturing processes are decreased, reducing the volume of this material, lowering the costs of extraction of raw materials and the costs for its further processing, achieving significant environmental benefits, since it would reduce the dependence on natural resources, the energy costs for their extraction and processing and reduce the emission of polluting gases, with the consequent positive balance in favour of the circular economy of waste and sustainable development.

Therefore, it can be affirmed that the use of these new materials in construction is possible, providing significant advantages for the execution of partitions with aggressive thermal requirements and betting on a circular economy encouraging the sustainability of the planet.

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CONSTRUYE 2020+. AN ADAPTED SYSTEM AND ACCREDITATION SCHEME ON GREEN SKILLS WITHIN THE CONSTRUCTION SECTOR

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Keywords: *construction; vocational training; green skills; new standards; blended training*

Abstract

1. Introduction and objectives.

The objective of Construye 2020+ project - Horizon 2020 programme. H2020-EE-2017-CSA-PPI. EE-14 Construction Skills. Agreement number 785019 - is to support the construction sector in its transition towards a sustainable, competitive and efficient sector by developing an updated training and eco-skills accreditation scheme.

One of the main concepts behind the Construye 2020+ project is the challenge to address the skills needs in the construction sector and to provide workers in the sector with up-to-date training. This training will enable them to have the basis to perform their tasks aiming to carry out appropriate energy refurbishment works, which will result in a lower energy demand of the building. Moreover, it will contribute to achieving the European targets set for the sector.

The aim of the training is to train blue-collar and middle management workers in energy efficiency, renewable energies and nearly zero energy buildings.

This updating of skills seeks continuous improvement as well as recognition, through digital tools and open training resources, and collaborative tools for work procedures (BIM and LEAN). The role of training, in this sense, is key to be able to implement in the workplace all the knowledge acquired in a way that complies with the standards required at national and European level.

The training actions are on the Moodle platform, which is free and responsive, adapting to computer environments and mobile devices, through its app. Finally, the learning methodology has been modified with the introduction of the Ontologic flip teaching theory. According to Fidalgo-Blanco [1], this methodology allows assimilation of content understood as a process of internalisation of knowledge and would take place outside the classroom, in class the teacher would guide a process of socialisation in which knowledge would be exchanged creating a collective learning environment.

One of the activities that the project Call required was the development of a skills certification proposal. The scheme developed by Construye 2020+, name Green Tag proceeding, links the *Green tag* to the knowledge, skills and responsibility and autonomy defined in the eight training actions. Nevertheless, it is important to highlight that this *recognition system* has been created out of the formal competences recognition or accreditation system used by the public organisms in Spain (procedures for accreditation of professional competencies established in Royal Decree 1224 / 2009, of July 17, of recognition of the professional competences acquired through work experience, modified by Royal Decree 143/2021, of March 9).

2. Methodology

This paper focuses on the updating of training methodology from the 6 training actions from Build Up Skills initiative.

According to the methodology used in the 9 training actions developed in the Build Up Skills II project [2] was designed so that theory and practice would form an indivisible whole, i.e., regardless of the distribution of training hours, the contents were always approached taking into account both perspectives, so that the practical methodology follows the principles, procedures and modalities of the theoretical one. This facilitates the student's application of what he/she has learned to the reality and work context in which he/she will use what he/she has learned. In general, the methodology is based on the following principles:

- Expository clarity.
- Referring to an experience in a work context.
- Pointing out the importance of the regulations in force.
- Observation of safety requirements.

The substantial change in the methodology updated by the Construye 2020+ project is the modality, adapting the contents and didactic programming to a blended modality, in which the theoretical concepts would be studied online, maintaining the face-to-face nature for the competences to be acquired in a practical way.

3. Results

3.1 Basic features of Construye 2020+ training actions

Construye 2020+ project proposes the development of a training plan and an accreditation system that values the green skills.

In terms of competences to be developed, the training purpose has been the improvement of green skills.

The target audience for the training are blue-collar workers and mid-level professionals, such as bricklayers, fitters, installers or foremen and site managers. The aim is to have a wide spectrum in terms of professionalisation and qualification.

Depending on their nature, it will be more or less appropriate to establish a certain degree of interactivity and to define the time and place in which they will be addressed. The courses offer training about regulations and legislation, explanation basic sustainable construction terms through practical cases.

3.2 Learning methodology

The most attractive learning methodology for the project's group of experts is Ontological Flip Teaching due to: Its dynamism when presenting the theory. By transferring this theoretical content outside the classroom, it encourages the generation of short videos and alternative forms of presentation that capture the students attention.

According to the Laboratorio de Educación y Nuevas Tecnologías research group at the University of La Laguna [3], interactivity must be one of the basic characteristics of digital teaching materials for the "school of the 21st century".

Taking this into consideration, it would be necessary to determine, for each of the typologies, the three dimensions in which the theory, documentation, exercises and course activities would be classified:

- Dimension 1 - What to do at home;
- Dimension 2 - What to do in class; and
- Dimension 3 - What materials to generate by the students.

Despite this differentiation, these are simply adaptations of the same course and even students with and without office skills can share course and classroom. Only a number of adaptations would have to be made according to the needs of each of the groups.

3.3 Teaching methodology

They are blended courses:

- On-line: the student connects to the Moodle platform, where the theoretical contents of the course are available, supported by images, videos, digital animations and practical exercises.
- Face-to-face workshop: where the student will attend the training centre to carry out practical exercises on the installation of thermal insulation in buildings.

The course as a whole is integrated in the Moodle platform, where each didactic unit is made up of three parts:



Figure 1. Parts of each unit: At home, Classroom, Create

3.4 Evaluation assessment

To get the courses certificate, students must pass each of the course parts.

“At home" (on-line training) includes a test at the end of each didactic unit. It can be taken as many times as the student wishes. Despite its compulsory nature, the marks obtained do not contribute to the final mark. A final exam, with a combination of questions come from every didactic unit. The exam will be passed with 60% correct answers.

“Create" includes online and practical exercises in which students must put their knowledge into practice. This is a compulsory part in which it is also necessary to achieve 60% of correct answers to pass.

“In the classroom” includes face-to-face practices, in accordance with the course programme. The student must attend the training centre to carry out practical exercises and projects associated with the theoretical content of the course. These practices will be evaluated by the teacher through an observation grid, communicating the evaluation criteria to the students. The minimum mark to pass this block will be 70%.

3.5 Accreditation scheme in green skills: the Green tag system

The Green tag system (figure 2) is a tool to show the learning acquired through training (Construye 2020+ courses) or work experience. Nevertheless, it is important to highlight that this *recognition system* has been created out of the formal competences recognition or accreditation system used by the public organisms in Spain.

The competence recognition system is another collaborative result of Construye 2020+ project. The basis of the system are the learning outcomes defined in the courses developed and updated in the project.

The scheme developed throughout this document includes three categories of recognition that correspond to the levels of training provided in Construye2020+ project:

- Basic technical knowledge in sustainable construction: the worker knows the most significant aspects of energy efficiency in the building and identifies the influence of his/her tasks related to the energy performance of the building.
- Intermediate technical knowledge in sustainable construction: the worker relates the behaviour of buildings according to the work units to be executed. He/she identifies execution errors, especially critical elements (e.g. thermal bridges or installations).
- Advanced technical knowledge and skills in sustainable construction (Build Up Skills training courses updating): the worker executes the tasks of his/her trade with an energy efficiency perspective:
    - Geothermal works.
    - Aluminium and PVC carpentry.
    - Thermal insulation.
    - Biomass systems.
    - Heating and hot water systems.
    - Profitability of energy efficiency in buildings

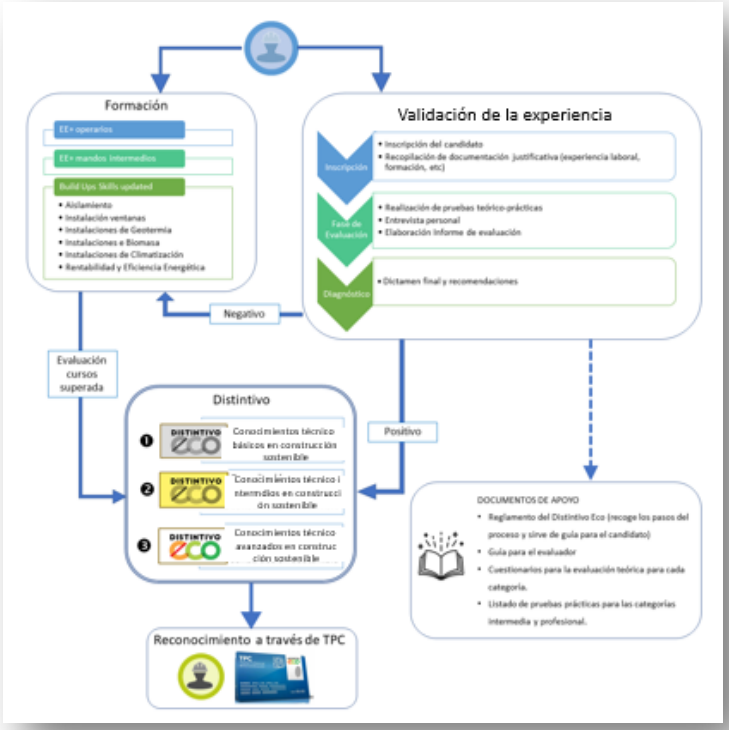


Figure 2 Green tag system

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BEHAVIOR OF COMPANIES IN THE CONSTRUCTION SECTOR IN ECUADOR TOWARDS THE MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE

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Keywords: *circular economy; construction and demolition waste; building management; Ecuador*

Abstract

The transformation of the construction sector in search of greater sustainability is an inevitable fact, which has been driving construction companies towards more sustainable management in recent decades by incorporating circular economy criteria in the building process. In this sense, it is necessary to promote initiatives that promote a lower environmental impact and an improvement in the management of construction and demolition waste (CDW). And is that, for the most part, the waste generated in construction can be transformed for reuse, thus prolonging its useful life and reducing the environmental impact caused by its accumulation in landfills in large cities.

Within the international scene, the most economically developed countries have been pioneers in the implementation of more efficient CDW management models. In Europe, approximately more than 30% of the solid waste generated comes from the construction industry (according to Eurostat sources, 2018). This has led to measures derived from the European Green Pact, which promotes the incorporation of the 3R principle: Reduce-Recycle-Recycle, in construction, works carried out within the framework of the Union. And it is that these models of waste management can suppose reuse of a large number of raw materials used on-site, which would otherwise be discarded following a linear economy model. Of the nearly 820 million tons of CDW generated in European countries in 2017, some nations such as the Netherlands or Germany have achieved high recycling rates, achieving almost zero landfills.

However, this situation differs greatly from the reality of Latin American countries, where there is great disparity as to what to do with CDWs and how to manage their reuse. For this reason, several researchers have tried to develop models to improve CDW management in different Latin American countries and incorporate circular economy criteria similar to those in Europe.

To contextualize the problem of CDW in Latin America, some data derived from consulted studies are presented. In Mexico in 2007, before the crisis, about 3,000 to 4,000 tons of CDW were generated per day. In Colombia, according to the District Secretary for Planning and Environment of Bogotá, there is a per capita of two tons of construction waste per year. In Chile, in 2009, about 5,821 tons of CDW were produced, which corresponds to 34.4% of the total Urban Solid Waste (MSW). Finally, as a consequence of the increase in Brazilian construction activity, Brazil has experienced a 1.7% growth in the generation of MSW between 2014 and 2015.

This research work focuses on knowing the context of CDW management in Ecuador. Currently, no known study has determined what are the procedures for the management of these CDWs and that reveals the activities that construction companies in the country carry out to face this challenge. However, the construction sector occupies a position of great importance within the Ecuadorian industry, which can be seen reflected in the historical growth in the number of buildings made in Ecuador between 2000 and 2019 shown in Figure 1. This figure has been prepared according to data from the National Institute of Statistics and Censuses (INEC) with the information generated from the Decentralized Autonomous Governments (GAD) of 214 municipalities.

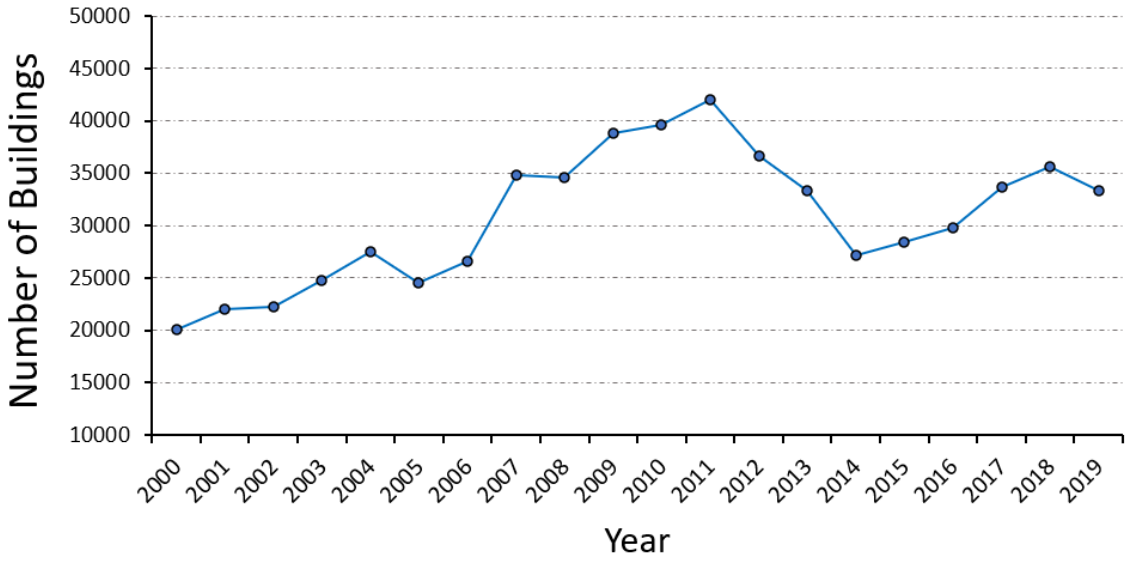


Figure 1. *Historical growth in the number of buildings built in Ecuador between 2000 and 2019.*

This research seeks to know the opinion of workers in the construction sector in Ecuador about the practices and behaviors that their companies maintain towards the management and recycling of RCD. To achieve this objective, the survey technique is

used. A web questionnaire has been designed, administered through the *Microsoft Forms* platform, following a non-probabilistic sampling strategy - specifically, the snowball method has been used, by asking the respondents to disseminate the questionnaire among their work contacts. A sample of 118 participants has been reached, workers in the nation's construction companies. However, web surveys have an abandonment rate or break-off, that is, subjects who initiate the questionnaire response, but leave the process without finishing. In this case, the breakoff rate was 15.25%. Therefore, out of 118 participants who have started the survey, 100 have gone on to complete all the questions. For the analysis of the results that were carried out, the 18 incomplete questionnaires were excluded.

Thus, for example, results have been obtained about the degree of planning that companies in Ecuador present in terms of RCD management in the design phase and the execution phase, as shown in Figure 2.

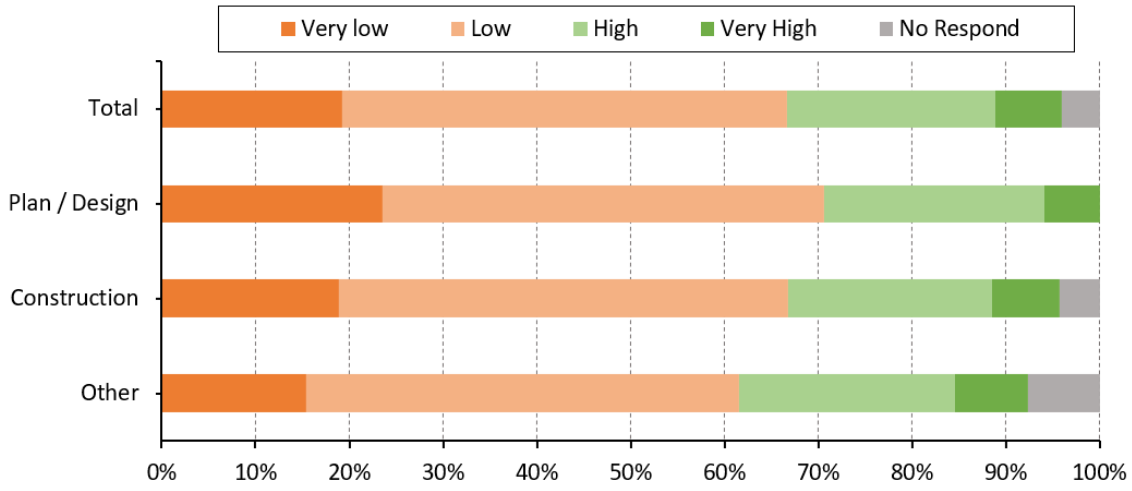


Figure 2. *Degree of design/construction planning for waste reduction.*

As can be seen in Figure 2, the degree of planning observed by workers does not vary significantly according to the activity in which their company is engaged. 66.2% (n = 65) of all workers consider that it is planned to a very low or low degree. When analyzing this opinion according to business activity, in none of them is it observed that this percentage falls below 60%, the highest being that of companies dedicated to planning and design, where 70.6% (n = 12) of their workers believe that construction design is planned to a very low or low degree to reduce waste.

Thus, based on the results obtained, we can conclude that the degree to which RCDs are managed in Ecuador is still in an incipient phase. Although the majority of the workers of the surveyed construction companies are indeed aware of the need to take care of the environment, very few companies put measures to carry out adequate waste management and reduce the environmental impact caused. For this reason, it is necessary to carry out this type of research to promote a legislative framework for the treatment and collection of RCD in Ecuador. The preparation of this type of report can

serve as a reference for other Latin American countries, which must necessarily contribute to achieving the Sustainable Development Goals that are related to the construction sector.

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ANALYSIS OF THE THERMAL COMFORT OF A SOCIAL HOUSE IN THE COLOMBIAN CARIBBEAN, AND IMPLEMENTATION OF PASSIVE STRATEGIES, BASED ON NATURAL VENTILATION AND ON THE CONTROL OF SOLAR GAINS, FOR THEIR OPTIMIZATION

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Keywords: *energy efficiency; passive cooling; ventilation; social housing; design builder*

Abstract

The human population is on the rise and by 2016 there were more than 7 thousand inhabitants on earth [1]. This is reflected in a greater demand for energy, especially in relation to the building industry due to the energy requirements of buildings to provide the conditions of interior habitability and thermal comfort [2].

Against this background, the need to think about a new way of projecting, constructing and managing buildings in terms of energy efficiency, through mechanisms that allow providing the conditions of habitability and comfort, interpreting and taking advantage of climatic phenomena, with low or no energy requirement [3].

In tropical regions these objectives take a more complex dimensioning due to the high temperatures and high solar radiation characteristic of these latitudes. Here, some research has determined that natural ventilation is the passive strategy that, accompanied by the control of solar gains through the building envelope, can better provide the desired interior conditions [4] [5].

In line with the above, this research addresses the energy analysis of a low-income housing located in the city of Barranquilla, in the Colombian Caribbean region and that presents a warm humid tropical climate [6], proposing passive cooling strategies through of natural ventilation through an association of a solar chimney [7] [8] and a Canadian well (ground-air heat exchanger) [9], enhanced with the control of solar gains, as suggested in research consulted; studying the applicability of the different

possibilities that this mechanism provides, in conjunction with the characteristics of the place and the building under study.

For the development of the research, and having determined the climatic characteristics of the place, the specific object of study is selected, which refers to a house whose constructive and architectural characteristics correspond to what is defined by the Colombian state as social housing or housing VIS [10].

This house was modeled and simulated for its energy behavior using the HVAC (heating, ventilation and air conditioning) and CFD (computerized fluid dynamics) tools of the DesignBuilder software.

Based on the original parameters of the house, 3 cases were raised with improvements to the envelope:

Case 1: addition of a 5 cm thick rock wool insulation layer under the roof and incorporation of glazing with solar control features (double glazing in aluminum frame with thermal break).

Case 2: it maintains the improvements of case 1 and a 5 cm thick layer of rock wool insulation is added on the inside of the façade in contact with the outside air.

Case 3: it maintains the improvements of case 1 and a 5 cm thick expanded polystyrene insulation layer is added to the outside of the façade in contact with the outside air.

Once the 3 cases mentioned have been modeled and simulated and the results analyzed in each of them, the passive cooling system is activated and they are simulated again by means of HVAC, under simulated climatic conditions for the month of July as a typical summer month. in the north of Colombia.

The evaluations of the comfort index produced by each of the cases analyzed were carried out under the parameters of the ISO 7730 standard, which is based on the models developed by FANGER for this purpose (estimated average vote or VMP and the percentage of dissatisfied people PPD) [eleven].

With the information obtained from these simulations, it was determined that case 2 of the envelope improvement with the passive cooling system activated, presented the best energy performance, which was subsequently evaluated by means of the CFD.

Table 1 shows the results of the simulations for case 2 and the home in its original condition for comparison, managing to establish the optimization percentages of the strategies implemented on the interior comfort conditions.

***Tabla 1**. Comparison of case 2 with the house in original condition.*

VARIBLE	UNITS	HOUSE IN ORIGINAL CONDITION	CASE 2	PERCENTAGE OF IMPROVEMENT OF THE ANALYZED PARAMETERS
T. ext. BS.	°C	28,4	28,4	
T. aire	°C	31,3	26,1	-17%
T. Radiante	°C	31,8	27,9	-12%
T. Operativa	°C	31,6	27,0	-14%
H. Relativa	%	72,7	85,4	17%
PPD Fanger	%	84,7	38,1	-55%
VMP Fanger	W/m2	2,3	1,2	-48%
Gan. Solares por ventanas	kW/h	8,7	6,9	-21%
Infiltraciones ext.	kW/h	-2,4	1,8	
Ventilación ext.	kW/h	-5,0	-31,3	
Renovaciones aire/hora.	Ren/h	2,7	15,4	

From the information contained in table 1 it can be mentioned that the interior temperatures are reduced by around 5 ° C in the optimized model, which corresponds to a performance between 14% and 17% compared to the records of temperatures measured indoors. the house in original condition. This reduction in temperatures has a significant impact on the improvement of the VMP and PPD comfort indices, going from 2.3 W / m2 and 84.7% respectively in the base house, to 1.2 W / m2 and 38 % in order for the model that incorporates the conditioning strategies, which means an improvement of 48% and 55% in the same order; with which, these indices manage to bring the parameters that the ISO 7730 standard establishes for a thermally comfortable interior space to very close values.

However, in contrast to the above, the model with the best comfort indexes shows a particularly high relative humidity compared to that registered by the reference home, even higher than the annual average of the city of Barranquilla, which has a negative impact on the environmental quality of the interior of the spaces. Decreasing the register of relative humidity indoors requires electronic equipment to dehumidify the air, which is not included within the objectives of the work and has not been taken into account in the analysis.

Solar gains are reduced by 2 kW / h with the use of windows with better performance, but this does not seem to affect the improvement of the overall interior conditions of the house, as demonstrated in the detailed analysis of the cases of envelopes.

Another relevant aspect to point out is the exponential increase in air renewals induced through the SEP which, in the opinion of this analysis, is what has the greatest impact

on improvements in the indoor climate of the home. As observed in the data, the heat losses through outdoor ventilation go from 5 kW / h to 31.4 kW / h and the heat gains through uncontrolled ventilation (infiltrations) go from negative values (heat loss) in the benchmark housing to positive numbers (heat gains) in the optimized model; This is due to the fact that the indoor air in the basic dwelling was at a higher temperature than the incoming air due to infiltrations, and the opposite is the case in the evolved model.

From all the above, it can be concluded that it is possible to control the factors that directly affect the perception of interior comfort in buildings with zero energy consumption in the tropics. That natural ventilation is a valid strategy for hot and humid climates to achieve more benign interior environments, and this positive effect can be optimized with systems that allow the air to be thermally treated, reducing its temperature, prior to entering the interior spaces.

It can also be stated that the Canadian well system is an effective passive system for reducing the energy load in the form of heat that the ambient air can contain and that solar chimneys are able to generate the convective effects necessary to improve air circulation and renewal. in the interior of the rooms, but for this type of climate, they cannot by themselves improve the internal comfort indexes since it has no effect on the temperature of the air that it circulates.

The control of solar gains by means of insulation affects the caloric gains, but this has no major impact if the indoor air in buildings is directly influenced by the outside air temperature. The effectiveness of the insulation is evidenced when the conditions of the air supplied to the interior of the enclosure are in more favorable thermal conditions.

The relevance of developing a type of regulation through which the evaluation of the interior comfort of buildings can be approached in a realistic way under the characteristic features of the climate studied in this work is also identified. Although it is true that the ISO 7730 standard can be taken as a basic reference, it is also true that this standard is designed for a different type of climate where weather phenomena that are decisive for the comfort of the passengers may not affect in the same way. buildings in tropical latitudes.

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BUILDING CONSTRUCTION MANAGEMENT

AN OPEN-SOURCE BUILT HERITAGE MANAGEMENT TOOL FOR INNER AREAS

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Keywords: *management system; opens-source; database; buildings; inner area*

Abstract

A Management System, which takes into consideration the life cycle of the building and aims at improving the energy performance of the existing building stock, is the objective of the research project whose first results are presented in this contribution. The building park of Piaggine [Salerno], a minor historical centre in the National Park of Cilento and Vallo di Diano and Alburni, as part of the enhancement of inner areas characterised by a significant architectural, naturalistic and environmental heritage, was chosen as a sample area for the experimentation of this tool. The characteristics of the built environment were analysed and collected in a GIS system which, through "dialogue" with known databases, made it possible to implement and associate a quantity of information and data on the existing built heritage. After that, a new database was generated that defined a first life cycle of the buildings, indicating their stratification, maintenance and building density, and identifying unauthorised building and unsuitable building management. In this way, it will be possible for the public and private sector to monitor consumption, plan interventions and manage the built heritage.

The added value in the use of this tool is its application by the Public Administration, which will operate with: consultancy activities, through a personalised relationship with the user and convention with public officials and authorised technicians, it will provide suitable hypotheses concerning services for the management and renovation of existing buildings or for future interventions and, through incentive tools, which work dynamically with the system, it will be able to promote access to energy efficiency of goods and services contrasting the phenomenon of energy poverty. In order to follow models for sustainable development through the implementation of projects capable of limiting environmental impacts, satisfying the new housing needs linked to current lifestyles and ensuring the quality of urban environments, it is necessary to adopt policies that are oriented towards promoting, in the first instance, the transformation of the existing building stock, from ancient nucleus to more recent expansions [1] and revitalising the social, cultural and economic sector, present in the territory of the Inner

Area, characterised not only by significant landscape-environmental quality, but also by cultural identity and social value [2]. In this context, the National Strategy for Inland Areas (SNAI), which are distinguished by their valuable architectural, natural and environmental heritage, is a strategy to mitigate the problems of these territories, which are characterised by a fragile economic system, depopulation phenomena [3] and the scarce presence of infrastructural connections, which generates the need to adapt the existing to the community's demands, through the improvement of the performance and services of the urban texture and the built heritage. Inland areas are identified as those areas that are significantly distant from the centres offering essential services and are rich in important environmental and cultural resources. Their conformation is the result of a decisive and respectful anthropic action that has shaped the territory, generating an evocative cultural landscape that exalts the peculiar orographic characteristics and the intense relations between human and natural actions woven over the centuries [4].

A significant part of the inland areas has undergone a process of marginalisation since the Second World War, which has manifested itself through intense de-anthropisation phenomena, such as the reduction of the population below the critical threshold, demographic ageing and the reduction of employment and the degree of utilisation of territorial capital. Secondly, this process has manifested itself in the progressive quantitative and qualitative reduction in the local supply of public, private and collective services, which in contemporary European society represent the quality of citizenship. The area of interest is the Cilento Interno, located in the Campania Region (IT), and is composed of 29 municipalities, of which 14 area in peripheral and ultraperipheral areas. The population lives for 59% in inland areas, with villages that do not reach 600 inhabitants and with depopulation indexes constant over the years, at - 5.9% from 2001-2011 there is a continuity in 2011-17 with - 4%. Therefore, official data show that in recent years the demographic trend has been stagnant with a progressively older population, associated with youth emigration which, despite being connected to its territory, does not transfer its residence; this trend has resulted in a consequent overabundance of empty and obsolete buildings which necessitate the definition of strategies for the reuse of the built environment and the regeneration of contexts at different scales [5].

In this way, it is possible to accelerate the implementation of innovative technologies through specific interventions in each existing building. Through the observation and dialogue of existing databases, it is possible to gain information about the life cycle of the building, to organise and manage interventions to increase energetic efficiency and the production of renewable energy, to reduce the decarbonisation of the existing building stock and to evaluate possible interventions for retrofit energy [6]. Moreover, through incentive tools, which work dynamically with the system, it is possible to promote access to energy efficiency of goods and services, combating the phenomenon of energy poverty. This affects a significant number of families, leading the European Commission to highlight the need to manage the energy transition in an equal and inclusive way, giving particular attention to the segment of the population most

vulnerable to the effects of climate change and environmental degradation [7]. From a methodological point of view, the analysis of the built heritage is the precondition for any kind of technical and management consideration. In fact, after the study of the historical and cultural matrix of the municipal territory, a preliminary cognitive study of the existing built fabric was carried out. The first phase permitted to frame the period of construction of the buildings, which are part of the municipal territory, finding a Medieval origin developed in the valley near the Calore river.

During the Borbonic period, the settlement expanded on the northern side of the territory until it assumed its present appearance, where it is possible to see the different stratifications formed over the years. The second step involved the assessment of the percentage incidence of useful surface area for integration compared to the total useful surface area for residential use. The third phase involved the analysis of the maintenance interventions carried out by the Municipality of Piaggine on the built heritage, taken from the study of the Recovery Plan [8]. The necessity to collect all the information obtained from the graphical drawings required the inclusion of the last ones in a platform where it could be possible to extend and obtain further data on the existing building. The use of an Information Management System (Gis), allowed the "dialogue" between the different existing databases, open-source, obtaining an implementation of information concerning every single building.

The results of the work show how the construction of a knowledge tool of the stratified historical building can be implemented over time through the inclusion of a series of data aimed at practices of valorisation, efficiency and integrated management. The "dialogue" between the known databases will close the information gap that currently makes it difficult to implement strategies on the built heritage, generating a system that takes into account the life cycle of the building, aimed at reducing the decarbonisation of the existing building stock and evaluating energy retrofit measures. This tool enables the Public Administration, where the last one will have an advisory function, through a personalised relationship with the user and an agreement with public officials and authorised technicians, to provide suitable hypotheses concerning services for the management and renovation of existing buildings or for future interventions. The success of the initiatives to be taken in order to continue along this line will be determined by the ability to create synergies to cover technical, socio-economic, environmental and data processing aspects. This requires a capacity for dialogue between stakeholders from different sectors: Public Administration, research institutions and above all citizens. Technological and urban design will have a fundamental role in the creation of built urban environments, moving towards the reduction of human-caused activities that affect the surrounding environment.

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THE EVOLUTION OF PRODUCTION MANAGEMENT METHODS PRECURSORY TO CONCURRENT ENGINEERING: FROM THE INDUSTRIAL REVOLUTION TO ITS IMPLEMENTATION IN THE SPACE SECTOR

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Keywords: *concurrent engineering; product design; just in time; space engineering*

Abstract

One of the most widely accepted definitions of Concurrent Engineering (CE) is that of the Institute for Defense Analysis, which states that CE is a systematic approach to the integrated development of products with their associated products. This approach must consider all elements of the product life cycle, from conceptual definition to its retirement and disposal. This requires that it includes activities such as cost planning, quality control, and user requirements management [1]. This requires that the products, processes, facilities, maintenance and promotion are included in the project from the beginning.

The advent of mass production in the early 20th century reinforced the dominant role of design and helped isolate it from the production chain. The artisan weavers who worked in the workshop were gradually replaced by more and more automated machines and personnel without any technical preparation. The main design concern was to minimize manufacturing time, taking into account that operators had no qualifications and could not make decisions. More than 100 years ago, Adam Smith anticipated this situation in *An Inquiry into the Nature and Causes of the Wealth of Nations*, published in 1776, by pointing out a fundamental dilemma: efficiency in creating wealth is increased by the division of labor, but specialization entails routine and repetitive tasks that deprive the worker of intellectual opportunities and responsibility in decision-making.

In the early 1940s, design was an independent task performed by engineers who developed ideas and were assisted by draftsmen in executing the final plans, which were then passed on to the production system.

At the same time, AT&T Western Electric had been working on developing the first quality control methods since the late 1800s. Statistical Process Control (SPC) was introduced to AT&T Bell Laboratories in 1924 when Walter A. Shewhart, in his 1931 work *Economic Quality Control of Manufactured Products*, first applied a statistical diagram of a manufactured product with the clear goal of cost-benefit improvement [2]. Dr. Shewhart used the control charts to identify problems that occurred during the process. The identification of these problems led to a reduction in variability and an improvement in the process.

With the outbreak of World War II, the world's first quality assurance system was created in the United States. It was triggered by problems in opening the parachutes of North American soldiers. In October 1942 it became known that at least 3.45% of the parachutes did not open. From that moment on, the famous Z1 standards of the North American military industry were created. Dr. Edwards Deming developed the first empirical tests of productivity and quality, and trained military engineers in the techniques of statistical control for quality improvement.

After the war, Deming was invited to Japan, where he taught Japanese engineers from 1950 and became the "father" of Japanese quality. From January to July 1951, Deming's ideas were applied in 45 factories in Japan and quality was greatly improved in all factories. From that moment on, Japan became the benchmark for everything related to the concept of quality, and the stage was set for a new milestone in product development and manufacturing. The need to control product variations and optimize the use of resources created the necessary climate for the development of the concepts of *Just in Time* (JIT) and EC.

It is estimated that around 1980 CE emerged as a method that combines all the techniques for obtaining robust products at all stages of their life cycle. The development of CE in the United States dates back to 1982. At that time, a study began to improve consistency in the design process. This work culminated in 1986 with the first definition of the term CE in a US Institute for Defense Systems Analysis report, "Concurrent engineering is an approach to the simultaneous, integrated development of products and their associated processes, including manufacturing and support. This approach provides for those developing the product to consider all elements of the product life cycle from conception to disappearance, including quality, cost, time, and user needs" [1]. The report points out that the technique is not new and has been used for years.

In the 1990s, various associations and consulting firms joined forces to combine all the methods and techniques that make up CE into a new methodology known as *Design for*

Six Sigma (DFSS). The goal of this methodology is to ensure the high value of a product in all phases of its life cycle.

CE has distinct advantages over traditional (sequential) methodologies. Much of these advantages relate to the overall operation of the company and involve issues such as the rationalization of time, cost, and other resources. Streamlining these resources leads directly to shorter product development time, better control of design and manufacturing costs, and less wasted time due to communication problems.

Regarding the way the work is developed, CE assumes that the work groups dealing with design and manufacturing can work in parallel thanks to the integration between the different departments. In this way, errors can be eliminated and problems anticipated, flexibility in adapting to changes is increased, and the continuous provision of and access to information is ensured [3].

Another large group of benefits has to do with outcomes related to the company's "philosophy." One of these is the company's quality policy. CE assumes that quality requirements must be considered at the design stage in order to achieve that the final product meets all the needs and requirements of the user.

CE is currently a well-known and fully established methodology. The methodology is part of the curricula of diploma and master's degree courses in engineering schools around the world, and there are numerous scientific articles on the subject in prestigious journals. In this sense, in many companies, especially in Japan, it is mandatory for engineers who have just joined the company to go through all areas (design, production, sales, after-sales service...) in order to achieve a simultaneous vision.

However, the globalization of both markets and product manufacturing leads to uncertainties in CE. In many cases, production is not only distributed in several centers that are very far from each other, but these centers also belong to several companies. In this new scenario, competition demands new means of communication, currently based on the Internet.

To ensure the use of CE in this new scenario, the concept of Concurrent Enterprising has emerged, which includes practices and methods as well as directions of study and research.

In the space sector, the development of space missions is very complex, even in the initial conceptual phases, due to the high interdependence of mission subsystems and the constraints imposed by mission requirements [4].

CE methods have been used since the 1990s and introduced by NASA and ESA to speed up the process of defining new missions with increasing complexity, and are currently a widely used method.

Currently, the use of CE in the space sector generates a huge amount of data due to the multitude of actors and disciplines involved, which, together with the multitude of data exchanges required, implies the processing of a huge amount of information. In order to facilitate the handling of this information for all stakeholders, ESA has produced a technical reference manual [39]. The aim of this manual is to develop a standard for data exchange that is available in the early stages of space system development. This method is known as Integrated Concurrent Engineering [5] and essentially aims to remove the physical and organizational constraints on communication so that designs can be completed in the shortest possible time.

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THE EFFECT OF BUILDING INFORMATION MODELING ON PROJECT PLANNIING, CONTROL AND MANAGEMENT

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Keywords: *project planning; control and management; BIM; IFC; BEP*

Abstract

Today, in the industries of architecture, engineering, and construction (AEC), it is essential to implement management techniques and tools, especially with increasing project scale. While the search for better techniques and tools continues, BIM building information modeling is one of the most promising developments in the industry, reflecting a digital picture of the physical and functional characteristics of a structure in order to create a reliable basis for decision making, During the life cycle of the structure and presents the project in multidimensional. Geometric data is modeled and, most importantly, project-related data such as element performance, material specifications, execution details, program, cost, etc. are also stored with the model. The BIM also incorporates many of the functions needed to model a building's life cycle, paving the way for new designs and capabilities, and changing roles and relationships between project teams. The goal is to provide a single model for all stakeholders at all stages of the project. In this paper, the main challenges in the current method of project management and control are analysed and how BIM-based project management overcomes these challenges. It explored how to use BIM to manage and gather information to build a BIM model. The benefits of planning, cost estimation, sustainability, and facilities management of BIM-based multiple-dimensional in the areas of planning, control, project management and construction were explored. At the end, a brief explanation was given about the BIM software platforms and how to work with them.

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SITE PRODUCTION MANAGEMENT: CASE STUDY OF THE DIGITALIZATION OF CONSTRUCTION COMPANIES IN PORTUGAL

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Keywords: *building construction; digitalization; management; integration; mobile*

Abstract

The Construction Industry (CI) is characterized by its low-skilled labour, low levels of digitalization, and information integration. It suffers from low productivity and low efficiency when compared to similar industries [1, 2]. This paper explores alternatives for obtaining data from the construction site, to improve production management on-site through the control of labour, considering the technical capacity of field-based workers.

The main objective of this research is to suggest solutions for the digitalization of on-site processes. Applying technologies, namely mobile applications, speeds up the transmission of productivity information to allow managers to make educated decisions, removing friction from the control process.

The methodology applied in this study aims to answer questions regarding the use of mobile applications in the Construction Sector. Through the use of a systematic review process and additional eligibility criteria, we seek to gather relevant information in this area of study.

This research was executed using the Web of Science, Scopus databases, and Google Scholar in a secondary role. The established protocol defines the keywords and phrases in other to reach a broader range of results, namely the field of web-based software and other mobile solutions.

The following questions were specified, in other to better understand the scope of this review:

a) What are the research trends in the field of site production management?
b) How is the construction workforce affected by implementing these technologies?

c) What are the main tools described in the literature?
d) What are the main limitations?

18 papers were read in full, followed by a categorization concerning parameters such as topic, citation metrics, authors, journal, and year of publication. According to the protocol, only articles from the last 4 years would be relevant for this research, so a low number of citations is expected, yet this sample had an average of 10,32 citations per article.

Most authors conducted case studies to assess their proposed models. Four case studies were interview-based, seven mentioned experimenting with pilot projects. Many of these experiences were based on a BIM model to obtain data. BIM information is then combined with field data to analyse productivity.

Five of the papers study AR for productivity improvements, proving the existence of this niche around mobile technology in civil engineering.

Construction quality and productivity are expected to benefit from increased speed, volume and standardization of shared data. However, difficulties in assimilating these technologies by workers are likely, not only regarding handling and understanding but also due to the overload of information and the speed with which information can be changed. This can result in poor life-work balance.[3-6]

The following answers are offered to the question posed:

a) Most articles describe case studies with custom-developed applications. The main research topics are Construction Management and AR. Most of the models concentrate on the management and transmission of data. Improving communication and collaborations between the project participants seems to be the most efficient way a mobile app can positively impact the construction site's productivity.
b) Increased quality and productivity of those involved in the project are expected due to the speed, amount, and standardization of information exchanges. Despite this, workers may find it difficult to assimilate these technologies, regarding handling and understanding but also due to the overload of information and the speed with which information can be changed.
c) The most mentioned software is BIM 360 from Autodesk.
d) The case studies are specific to the country where they were implemented, and there are limitations due to the socio-economic characteristics of these countries. Worker feedback and assimilation is expected to differ due to cultural differences. The impact on productivity may change on account of the company's digital infrastructure and readiness. Further studies about the transition between digitalization levels are essential to determine the real impacts on a company’s productivity.

Following this review, a case study was conducted to assess the usefulness of mobile ICT in the Portuguese context. In this project, the tool's compatibility with current working methods is studied, as well as the usability of the product, and its comparison with current working practices to determine productivity gains.

Of the different apps studied, Raken [7] was selected for implementation, because it can respond to the company's needs, offers a version in Portuguese, is easy to use, (essential for use by a general supervisor), cross-platform readiness (smartphone, pc, tablet), different permissioning and cloud storage. The case study aimed to verify if there was the ability to monitor employees' work by quickly checking whether deadlines are being met through production ratios, and doing so enable managers to respond to delays through thoughtful decision-making and document errors to correct in the future.

The authors have implemented and adapted Raken to the company workflow and tested its ability to respond to the outlined objectives. It was possible to advance the digitalization of on-site processes, namely, obtaining information and sharing data with the administrative hierarchy promoting direct control and active, thoughtful, and sustained management.

The method practised in the application of the software can be summarized in 3 phases: (i) Software Preparation; (ii) Data collection in the field; (iii) Data interpretation and processing.

By configuring the application in its computer version, it was possible to customize the mobile version for its use by a foreman on site. He had the function of gathering data about the job through photo and video collection and filling out daily surveys. Most importantly, associating quantities with tasks and their cost codes (previously entered through Excel sheets and MS Project plans, with the option of manual input), allowed a comparison with the original planning, making forecasts and estimates of work performance possible. These actions result in a series of standardized pdf documents

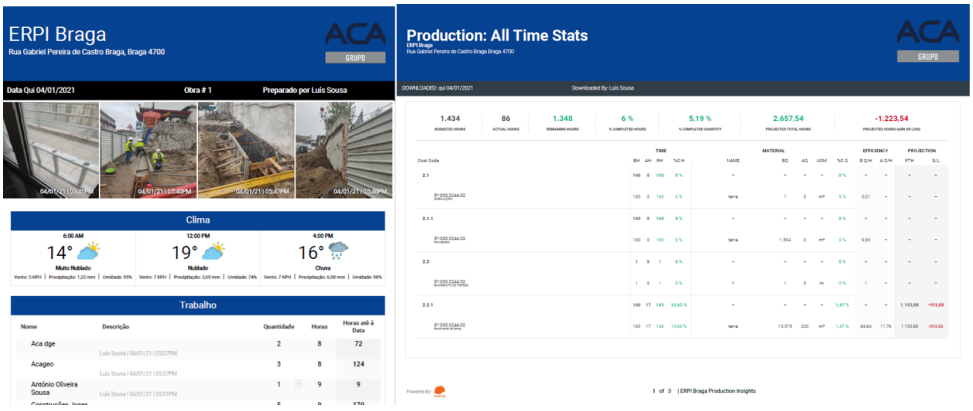


Figure 1: *Example of the reports produced by the application during the case study. On the left a daily report, and on the right the production report.*

that can routinely be sent to management, the most relevant of which are the routine reports and the production reports, Figure 1.

The case study suggests that this software improves current reporting, which involves written or orally communicated notes that support the weekly measurement reports. Using a mobile application could bridge the gap between the site and the office. Moreover, there was general satisfaction and recognized value amongst the different levels of users, from the foreman to the production manager.

The introduction of tasks with respective cost codes, questions that make up the daily survey, and the customization of the daily report format demonstrate the app's configuration capacity and the possibility to adapt to the specific situation of different companies. Also, sending an automatic e-mail with the daily report to the relevant people is a powerful tool for automatically transmitting the information.

Naturally, the program has some flaws, namely errors in the translation to Portuguese. Interoperability is limited, as it only reads CSV files in a specific format. As a result, considerable effort is required to transform the planning files from the typical Excel sheets into the format which Raken can read.

The case study shows how mobile applications can improve the way reporting is traditionally done. It also concludes that employees must be trained on how to use these applications.

A system that allows the integration of software is needed to obtain lasting results for the transmission of information through the project management hierarchy.

Considering the expected difficulties in adapting to new technology, an approach that relies on simplicity might be preferred when adopting digital technologies on-site. Following a phased plan, beginning with familiar file formats and software tools, the adaptation by the company's staff can become more straightforward.

The need for further studies to determine the real and long-term impacts that the application of a cross-platform cloud-based integration software would have on a company's productivity is essential.

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RC STRUCTURES LONG-TERM DETERIORATION PREDICTION FOR THE IMPLEMENTATION OF BUILDING MANAGEMENT SYSTEMS

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Keywords: *durability; aging prediction; reinforced concrete deterioration; deterioration curve; building management system*

Abstract

Nowadays, an increasing number of reinforced concrete (RC) structures require refurbishment and repair works due to their advanced deterioration. However, the level of damage that RC structures may experience due to the action of different aggressive agents is not always evident to the naked eye, representing risks for buildings' owners, concessionaires, and users.

The number of Management Systems that are being implemented to control different sets of buildings and infrastructures has been growing steadily in recent years. Both public and private Administrations and companies responsible for the preservation of structures in a good condition arrange periodic visual inspections to check the condition of these structures at certain moments. With the information gathered during inspections, those structures which are in a bad condition, and therefore may entail risks for users and owners, are identified to be repaired [1, 2].

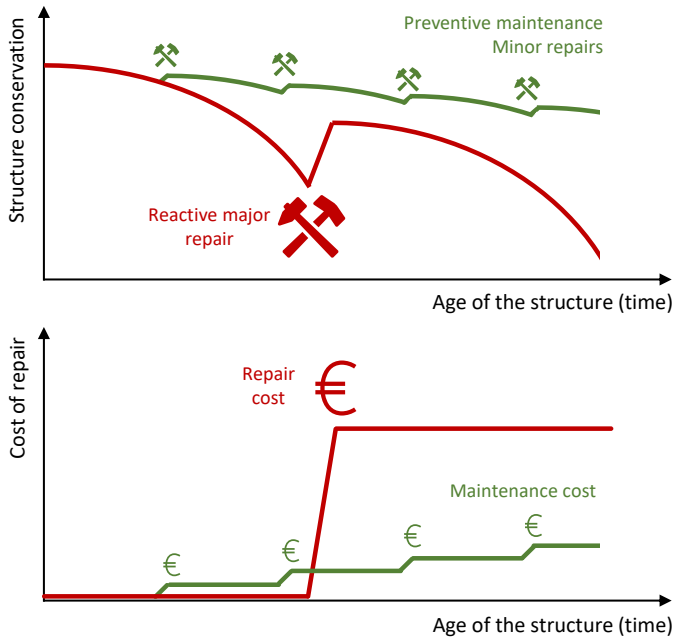


Figure 1: *Preventive and reactive approaches for maintenance and repairs (Source: own elaboration)*

As it may be derived, this maintenance strategy could be defined as 'reactive', as measures (repair or refurbishment works) are taken when the level of damage of a certain structure is high enough to be observed during an inspection. However, a 'predictive' or 'preventive' approach is also possible if certain analyses are carried out with the Management System inspections' databases [3]. Differences between 'reactive' and 'preventive' approaches can be quantified not only in terms of the level of conservation but also in terms of monetary cost.

In the paper, a methodology is proposed to predict with high precision the future deterioration of RC structures managed under a Management System, based on the analysis of the inspections' database of the system, which includes the valuation of all damages identified during all the inspections carried out in the past.

The proposed methodology and criteria to be followed are presented through its application to a real Management System. However, while inspections-based Building Management Systems are still at a less developed stage, Bridge Management Systems are nowadays further developed. For the purpose of the paper, since extensive inspections' databases are needed to perform the analyses described, real data from the 'AURA' Bridge Management System, which includes a database of hundreds of Spanish bridges' inspections, have been used as a reference for the implementation of an inspection-based Building Management System.

Based on any inspections-based Management System, a numerical quantification of field inspections can be obtained, and a damage index (*DI*) can be calculated as the weighted sum of all damages detected in a field inspection [4]. Therefore, each

structure counts on a *DI* value per inspection, which allows its deterioration evolution modeling as the *DI* value decays in time.

If all damages are considered to calculate the *DI* of a certain inspection, this index is then defined as the global damage index of the inspection, as it is an indicator of the global condition of the structure at that time. However, different sub-indexes could be also calculated by taking into account only different subsets of damages instead of the total collection of potential damages considered in the whole Management System [2].

Firstly, a durability damage index is proposed to consider only damages with consequences on the degradation of the durability conditions of the analyzed RC structures, subject to certain aggressive conditions. Thus, leakage of water, rust spots, typical cracking pattern induced by rust or corrosion evidence, as well as concrete degradation due to sulfate attack, scaling due to de-icing agents, etc. are examples of symptoms associated with durability.

Secondly, a structural damage index is proposed to estimate the level of structural damage of any RC structure at the time the inspection is performed. All visible symptoms of structural degradation, such as deformations or cracking, must be considered to calculate this index.

Finally, a functionality damage index is considered to assess the deterioration of any RC structure in terms of its potential risk to users.

Once the above-described damage indexes are calculated for each inspection of a certain RC structure, the estimation of its future deterioration is then possible.

A large amount of different deterioration models has been proposed during the last decades to assess the deterioration of RC structures in terms of durability [5]. For the specific goal of this research, analytical models can be considered as the most appropriate for the analyses of Management Systems' databases [6, 7, 8, 9].

The most widely used analytical deterioration model for the prediction of the aging process of structures is the model proposed by A. Miyamoto [10, 11, 12]. This model is empiric and has a clear physical sense, as it is based on field data. Moreover, it results easy to apply to different structural elements and typologies [8]. In the paper, the evolution of each *DI* in time is fitted by the expression proposed by Miyamoto.

The proposed methodology is applied in the paper to predict the deterioration of one RC beam bridge included within the 'AURA' Bridge Management System database. Figure 2 shows the results of that RC beam bridge deterioration curves, estimated according to the methodology proposed in the paper. Discrete points corresponding to the inspections' real data are included to demonstrate that each estimated deterioration curve is coherent with the real observations.

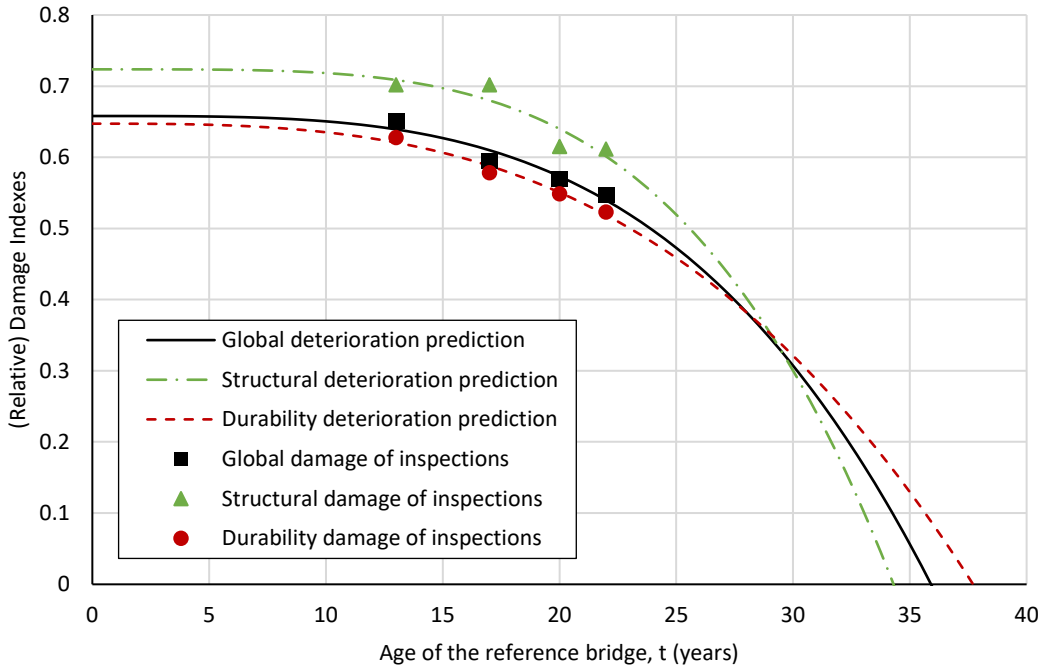


Figure 2: *Deterioration curves of an RC beam bridge of the 'AURA' database (Source: own elaboration)*

One of the main advantages of Miyamoto's model, when used to analyze an inspections database, is that it is possible to carry out linear statistical and correlation analysis, as the change of variable required to convert it into a linear equivalent expression is simple [6]. Moreover, the correlation between the real data from inspections and the estimated deterioration curve can be quantified.

The paper analyzes not only the correlation of the deterioration curves with the inspections' discrete valuations, but also the correlation between the different calculated deterioration curves. The analyses performed show that the evolution of the durability damage index is highly correlated to the evolution of the global damage index (99% in the case of the bridge shown in Figure 2). Therefore, the evolution of the global deterioration of any RC structure can be modeled through the sole observation of those damages with consequences on the durability.

However, if more precision is desired in the estimation of the global damage, or if the structural or functional deterioration of a structure is to be calculated individually, specific damage lists to be observed during inspections must be created, and they must be particularized depending on the type of the structure to be evaluated. Unlike durability damage, these damage lists will be different in the case of buildings from those that can be considered in the case of bridges. A building is not designed to resist the same loads as a bridge, and therefore its structural strength will be different and the indicators of structural damage to be searched for during inspections will be different. The same applies to functionality; the components of a bridge are different from those of a building and have different uses. Nevertheless, whenever a structure is built with structural concrete, deterioration processes will be the same whether the

concrete or reinforcing steel are placed in a building or a bridge. It may change its deterioration reaction rates (carbonation, corrosion, etc.), but not the reactions themselves.

The paper includes a durability damages catalog to be considered both in inspections and in the numerical estimation of deterioration curves of any RC structure. As explained, this catalog is independent of the type of RC structure to be assessed. However, if the structural and functional deterioration of RC buildings is to be estimated, specific damage catalogs, such as the ones proposed in the paper, do have to be defined. The methodological approach presented in the paper has been tested by applying it to the prediction of deterioration of RC bridges, and the criteria for its application to RC buildings is explained for the implementation of an inspection-based Building Management System.

In the case of RC buildings, durability deterioration processes tend to act at a slower rate, since the structural elements are more protected than in the case of structures such as bridges or ports. This advantage comes with the disadvantage that structural elements of buildings are more difficult to inspect as they are often covered or hidden by non-structural elements, both internally and externally. Therefore, it is more difficult to set inspection targets, and the use of the deterioration curves defined in this article can become extremely useful in managing the maintenance of RC buildings.

However, investments are needed in this regard. While many Bridge Management Systems were launched decades ago and Administrations' databases are now extensive enough to perform the numerical and statistical calculations presented in the paper, more investment is needed from Administrations and private companies to implement Building Management Systems at the same level of detail.

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KEY COLLABORATIVE TECHNOLOGY IN THE CIRCULAR ECONOMY

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Keywords: *Collaborative Intelligence; circular economy; collaborative technology; artificial intelligence.*

Abstract

In 2019, the consulting firm McKinsey & Company commissioned the Ellen Macarthur Foundation, together with Google, to produce a report entitled "Artificial Intelligence and The Circular Economy. AI as a Tool to Accelerate the Transition", to determine how Artificial Intelligence - AI - can improve and accelerate the development of new products, components and materials suitable for a Circular Economy - CE - through iterative design processes.

The report concludes that "collaboration between relevant actors and a sufficient degree of oversight will be key to supporting these systemic applications of AI, to ensure that data can be shared openly and securely, and that AI is developed and deployed in ways that are inclusive and fair to all" [1].

On the other hand, the European Commission in the new Circular Economy Action Plan, calls, "for the principles of the circular economy to be fully integrated into the next wave of renewal" [2]. In other words, the "evolution towards a more circular economy"; understood as the evolution to "maintain the added value of products for as long as possible and exclude waste" [2]. Linking this to the business area, the European Commission's communication also refers to key resources analysed from a life cycle and value chain perspective, with housing and mobility being the sectors responsible for most of the environmental impact. Specifically, in the value chain, the key products are construction and buildings. Therefore, it is considered that the circular economy should focus, at the moment, on the rehabilitation, reuse, change of use and/or refurbishment of existing buildings, which are currently being developed in different European cities, treating buildings as a resource.

A study by [3] titled "Strategies, challenges and opportunities in the rehabilitation of housing estates built in Spain between 1940 and 1980" describes a series of common problems in large Spanish cities during the decades from the 1940s to the 1970s. These represent a very significant part of the set of problem neighbourhoods, as is happening

in the rest of the industrialised countries, which gives an idea that certain approaches to public action should be reconsidered [4].

Until now, the interventions that have been carried out in Spain in these areas have been developed in different ways, the so-called: Integrated Rehabilitation Areas (ARI), Urban Renewal Areas (ARU) and those aimed at isolated rehabilitation.

ARI are areas in which actions are carried out in delimited residential fabrics in urban and rural areas, functionally recovering historical complexes, urban centres, degraded neighbourhoods and rural municipalities that require the rehabilitation of their buildings, housing and public spaces, seeking to improve the conditions of habitability, safety, accessibility, energy efficiency and promoting the use of renewable energies.

ARU are areas in which actions are carried out in certain neighbourhoods or groups of buildings and dwellings, which require the demolition and replacement of their buildings, the redevelopment of their open spaces or the revision of their equipment and facilities, including, where appropriate, the temporary relocation of residents, seeking to improve the conditions of habitability, safety, accessibility, energy efficiency and promoting the use of renewable energies.

Specifically, in the city of Madrid, in 2016, a report was drawn up entitled "Report justifying the proposal for the identification of preferential areas to promote urban regeneration (APIRU) within the framework of the territorial cohesion policy of the city of Madrid", which affected an area of 3,546 hectares and 1,198,326 inhabitants, representing 38% of the municipal population [5].

Of the three interventions mentioned, practically no ARU intervention has been carried out, which is the one that contemplates demolition and new construction in specific areas. Most of the interventions that have been carried out are related to housing accessibility.

In 2016, the European Environment Agency (EEA) warned that the transition to a Circular Economy requires fundamental changes in many different areas of the existing socio-economic system [6].

The Circular Economy action consists of a cyclical flow that involves extracting, transforming, distributing, using and recovering materials and energy from products and services. [7] [8], according to [9] the performance of the CE can be obtained from three levels: micro, meso and macro:

Table 1: *Levels of Circular Economy.*

Micro	They focus on improving their own processes and practices, use of clean energy, efficient consumption of raw materials, eco-design of their products, implementation of eco-labels, traceability to reduce their environmental footprint, among other initiatives [8]
Meso	Organisations are beginning to interact in networks to share resources and revalue or reuse waste, such as in eco-ecological industrial parks (Industrial Symbiosis) [10]. It also highlights the collective action of business associations whose common characteristics allow them to generate inter-organisational symbiosis that benefits all members [11]
Macro	Initiatives developed at regional or national levels such as eco-cities, eco-municipalities or ecological provinces [9]

Own elaboration. Information gathered in [12]

In the proposal made in this article, the level that concerns us is the macro level, since the scope is at the level of municipality, city, province and involves a multitude of actors of different kinds.

Therefore, the objective to be achieved is to relate Collaborative Intelligence with the Circular Economy, based on one of the pillars that define CI, which is Collaborative Technology. To this end, both concepts will be defined and related.

To achieve Collaborative Intelligence, the collaboration of individuals working together in a coordinated way to achieve a common goal is required. To collaborate is to work with others to achieve shared and explicit goals. The collaborative process should provide the different actors in the process to generate knowledge transfer:

Table 2: *Levels of Circular Economy*

Knowledge generation process	
Transparency among project partners:	• Establishing relationships based on trust • Agreements based on cooperation and transparency
Spontaneous or natural participation of participants:	• Inherent cooperative ethic, with the service acting primarily as an intelligent intermediary. • Knowledge transfer enables the creation or refinement of cooperative structures.
Trust in the team formed:	• Trust becomes a fundamental factor in motivating the participation of individuals, groups, at both intra- or inter-organisational levels. • It is the groups who, in consensus, define the validity of the concept and then continue with the knowledge combination phase.
Availability of information and knowledge:	• Access to different sources of information and knowledge storage.
Cooperation:	• Structures through which knowledge transfer proceeds. Members must be willing to cooperate and share what they know.
Interactivity:	• People interact and participate. It allows the creation and improvement of services or products.

Own elaboration. Information gathered from [13]

In this context, collaboration is presented in the technological platforms that will support the knowledge transfer process, these platforms are made up of a large number of electronic tools and technologies. To improve the way of communicating in a business or organisational environment, collaborative technology must be leveraged to bring together all available information in the form of requirements, design and implementation. It is therefore necessary for the actors involved to collaborate in order to achieve the desired goal.

The methodology is carried out by means of a literature review, with a subsequent discussion. It is expected that the results obtained will provide a direct relationship in which it is shown that Collaborative Intelligence through Collaborative Technology is a revulsive for the Circular Economy as far as Artificial Intelligence is concerned.

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DIGITAL ASSET MANAGEMENT FROM A LEAN PERSPECTIVE: A CONCEPTUAL FRAMEWORK

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Keywords: *production theory; standardisation; information management; information waste*

Abstract

While design management is advancing in construction management research and practice, various technical documentation is developed to manage exchanges for the intense amount of information among multidisciplinary parties, who have trade-offs between their interest and responsibility. The relationships between them mainly rely on procurement type, technology, and management style, which influence team individuals to request/share information through informal communication channels. This phenomenon is also related to tight schedules and time pressure issues in design, leading individuals to evaluate trade-offs of design value and functionality in hand through ad-hoc decisions. Those decisions are taken based on acquired information using formal (emails, documentations, meetings) or informal (word of mouth, or chats on digital ecosystems), which negatively affect information transparency and create an improper collaborative production model [1]. That can be described as a lack of self-awareness, trust and commitment, and a negative mood among the involved parties [2]. Technical measures can partially incentivise participants to request, develop, and exchange information with tactical and operational prescriptions; if social measures were added to the formula, a culture of self-regulated processes and self-aware people minimum waste and value-added could be possible.

This paper selected BIM Execution Plan (BEP) and Level of Development (LOD) specifications according to their popularity in the current practice of construction information management and due to their frequency in ISO 19650:2018 standard. The information level detail for use, milestones and user needs to be included in LOD and LION. BEP is collaborative documentation that sets actionable plans to identify work packages and information shares, then categorise them into responsibilities and needs for each party. Nevertheless, BEP, LION, and LOD are isolated from short and medium planning and occasionally are not updated as the digital product is developing, when the interest of individuals in utilising them decreases across time.

Lean construction has brought significant solutions for execution stages by connecting the process and operation information to product design and integrated decision-making processes from the project, site management, and team assignment management [3][4]. Various lean construction methods and principles can be applied to the total supply chain of the construction [5]. Lean design management (LDM) adapted theories and principles into the design stage, which employed socio-technical measures to improve process-product and standardise workflows by reducing variabilities and providing value for internal and external customers. Creating a coordination and responsibility culture through in-process inspection is communicated using visual or textual instructions and constructive methodologies to define, identify waste, and visualise the flow and value-added [6]. LDM provides instruments to regulate information production based on flow management to facilitate two-way communication between directive and operational teams. Last Planner System (LPS) as the application of the socio-technical lean system, breakdowns project into multilevel of detail (milestones, processes, operations, and assignment), using collaborative planning methods to structure work packages, sequence events, and remove constraints for each task [7].

This paper investigates enhancements for the BIM Execution plan, LOD and the level of information needed (LION) through lean design management principles and methods. Firstly, it reviews the theories of lean design management and lean practice in information production management. The paper qualitatively analysed Last Planner System, Design Structure Matrix, and Value Stream Mapping and explored the relationship between the current standards and LBDM concepts and methods. The study found that LPDM concepts are implicitly applied in the current information management standards, but the social measures were rarely captured, and the existing task management software is external to BIM standards and functionalities. Finally, the study provides a general understanding of ordinary information and production waste and explains the shortcomings of the current information management practices using traditional methods.

A literature review is applied to analyse and synthesise two mainstream areas (lean construction) and (information management standards) as shown in

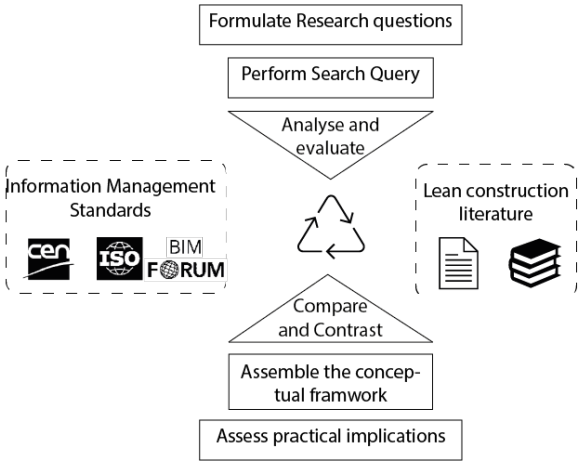


Figure 1: *Literature review methodology according to [8]*

The review showed that using Action Language during LPS sessions impacts team consistency and reduces conflicts between parties, stabilising the workflow and information flow. The assembled conceptual framework in (Figure 2) illustrates the combination of information management standards and their derivatives with lean methods; the model shows that team consistency indicators (mood, trust, commitment, and self-awareness) can be improved by using LSP, VSM, DSM, and action language theory.

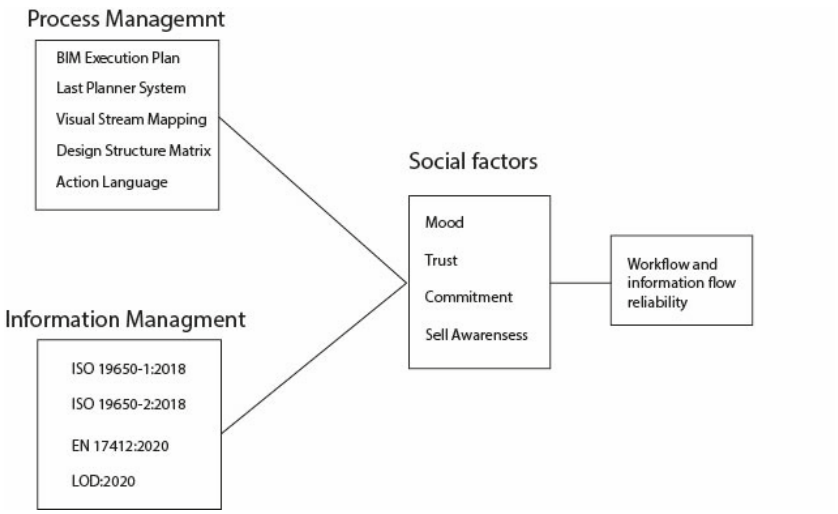


Figure 2: *Assembly of social-technical factors to improve workflow and information reliability*

The proposed framework is limited for verification and application in real life. Also, the study ignored value from the research, which missed the chance of investigating TVD (Target Value Design), SBD (Set-Based Design), CBA (Choose By Advantage), and Concurrent Engineering in information production management.

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CONSTRUCTION PROJECTS COMMUNICATION THROUGH A DISTRIBUTED LEDGER

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Keywords: *construction; RFI; BIM; Hyperledger; fabric; composer*

Abstract

Blockchain is a disruptive technology and a foundation layer for web 3.0 applications. The internet in its current form helps individuals and organisations exchange information faster; however, the quality and the integrity of the information is not vouched for. This forced organisations to add multiple layers of security to increase the reliability of data exchanged through the internet. Blockchain was first used in Bitcoin by Satoshi Nakamoto [1]. Bitcoin uses a decentralised, distributed Ledger to verify and register every transaction [1]. The Use of Blockchain as an underlying technology in Bitcoin encouraged organisations from several industries to investigate the possibility of implementing it within their traditional digitalised businesses. Projects such as Hyperledger [2], R3 Corda [3] and Multichain [4] are examples of Blockchain implementation within the traditional information and communication enterprise systems. This article investigates the recent development of Blockchain to support businesses data exchange processes. The article presents a review of the recent development in Blockchain construction industry related studies and Blockchain enterprise-grade solutions with an example of a construction project through a distributed Ledger. The results show an uptrend in the number of studies during the five years between 2017-2021. Fifty-seven studies were published in 2021 compared to one study in 2017. The search was limited to Scoups to give a general overview and avoid duplicated records. For a detailed literature review, refer to Darabseh and Poças Martins, 2020 [5]. Blockchains, according to their records exposure, can be categorised into two categories: (1) public; and (2) private. While the number of public Blockchains can be counted, the number of private Blockchains is unknown. Private Blockchains are used within the organisation level or at the inter-organisational level to track assets or record the activities of these organisations. The Hyperledger is a consortium created by the Linux Foundation and developed by multiple organisations to accelerate Blockchain adoption at the organisation level [2]. Fabric is one of the six frameworks developed under the Hyperledger project and developed by IBM [6]. Fabric modular structure allows the deployer to choose the components that fit the purpose intended for the Blockchain network. Fabric offers several types of plug-and-play components, such as

consensus, which refer to the method used in the Blockchain network between nodes to determine the validity of the data before adding the transaction to the ledger. Hyperledger Composer is a tool designed to facilitate the interaction with Hyperledger Fabric [7]. Fabric is a standalone framework which means it does not require Composer to work. However, Composer simplifies interacting with Fabric. Composer provides users with the following benefits: (1) Graphical web user interface for Chaincodes development and testing; (2) simplified Chaincode approach where the Chaincode components are built-in separate pieces then joined together in Business Networks Archive (BNA) file; (3) simplified Chaincode interaction process for users and applications through Rest API. Rest API is a standardised application programming interface for web services [8]. Trust in construction Projects is discussed throughout the construction projects management and performance literature such as the Latham report [9], Egan Report [10], Khalfan et al.[11], and Gad and Shane [12]. Khalfan et al. [11] study showed three important aspects for trust in construction: (1) communication honesty, (2) reliance, and (3) the delivery of the project defined outcomes. This article uses Blockchain technology through the Hyperledger project products Fabric and Composer to show how Blockchain can be used to improve construction project communication. However, the Chaincode will be tested only inside the Composer testing environment. The Request for Information (RFI) is a formal recurring process during a construction project lifecycle, carried out by a stakeholder to clarify, verify or gather information regarding one or more of the projects activities, processes or issues [13]. This article uses Fabric and Composer to store construction projects RFIs as assets on a Blockchain ledger. In order to manage an asset using a Hyperledger Fabric, it is necessary to design the Chaincode. The Chaincodes are built around the assets meant to control. When using Hyperledger Composer, the model file contains the primary information about the Chaincode such as assets details, participants and transactions. Participants are the users of the ledger who will own the assets registered on the ledger. Transactions are the defined possible modifications for the assets defined, such as transferring the ownership of the asset. In Blockchain ledgers, assets are represented by a set of data strings, integers, and Booleans. Therefore, a basic RFI template was transformed into an asset. Figure 1 shows a visual representation of the RFI process, including the RFI process structure and participants.

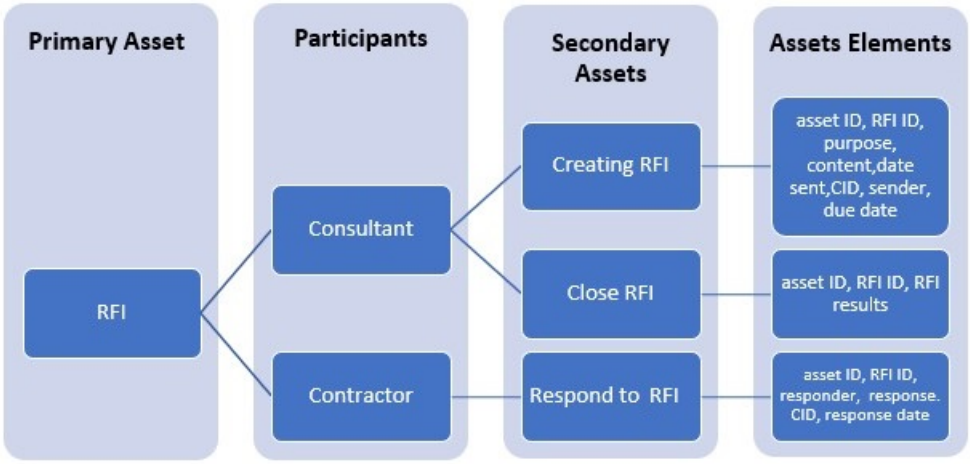


Figure 1: *RFI components visualised*

The information exchange process in the construction process often suffers from several problems, such as slow and inaccurate information without efficient tracking for the information quality and its source. In this article, a Hyperledger Fabric and Composer was presented in order to streamline the RFI process during construction projects lifecycle. The RFI was translated to a model file then used in Composer to act as a smart contract or, in Hyperledger terminology, a Chaincode. RFI recorded in a Blockchain creates a verified trustless source of information for all participants, which could help make the process transparent and accurate. The article contributes to the Blockchain in construction research by presenting a visual representation of the RFI process running on Blockchain. However, further details need to be investigated to create a functional Chaincode that fits the construction industry in a real project environment.

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ACCESSIBILITY

ACCESSIBILITY AND INCLUSION IN REAL ESTATE. MEANING AND TRAINING OF THE SUPPORT CONSULTANT

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Keywords: *real estate; accessibility; cognitive disabilities; architectural construction; support consultant*

Abstract

Real estate, built or newly built, must be *accessible* and *inclusive*. In the current building framework, the regulations related to accessibility contemplate mainly the physical aspects, diminishing the needs of the cognitively disabled people. The expert thus moves in a well-defined field and, using the regulations, can validate design solutions, evaluate dimensions, define categories or qualities in materials, identify and assess risks, standards, occupations, etc. All of this is tangible and measurable. The world of the cognitively disabled transcends these aspects, leaving architects devoid of quantitative tools. This article raises the need to train persons that can fill these gaps.

The Universidad San Pablo CEU provides training for disabled people as a *Consultant in Universal Accessibility*. Their profile can be outlined as *borderline intelligence*, *cognitive problems*, and, in some cases, *associated physical disabilities*. These students provide a *unique perspective* and information to the designer to provide them with tools and resources in the project and the construction stage. This type of consultant becomes necessary, and the labor market is starting to demand these profiles.

By his contact with a problem that affects the project, the consultant in universal accessibility must acquire *technical knowledge* [3] and *teamwork skills.*

- *Technical knowledge* is necessary because the training implies the need to read architectural plans (floors, elevations, sections), recognize the context on which we work, and recognize the functional elements of the building (envelopes, structural, facilities). The programmatic approach (program, spatial relations, relationship with the context, etc.) and developing a capacity for analysis of the project solution interacting with the architect are vital milestones.

Once the conclusions introduced in the technical documentation have been implemented, the consultant must recognize them, submit them to discuss, and help their validation.

- *Teamwork skills* are necessary because the consultant must work alongside the architect or expert in professional architecture and project offices [5], identifying potential problems and translating their sensory experience into the architectural proposal.

Incorporating the disabled into this task, which is complex and demanding from the point of view of the required expertise, requires an effort that must follow their abilities. The experience accumulated in these years shows that not all disability profiles, necessarily diverse, can adapt to this activity. To select the students suitable for the training, a team makes a previous analysis of their profiles of specialized university psychologists.

The program offered by the Universidad San Pablo CEU works on three teaching axes: (1) *accessibility in the built heritage*, (2) *accessibility in digital environments*, and (3) *accessibility in communication*.

(1) *Accessibility in the built he*ritage focuses on the building, the nearby urban environment, and the city. It is closely related to the Degree in Architecture. It takes advantage of some of the degree's contents, adapted to this new type of student, and the dynamics of the teaching workshops and laboratories.

(2) *Accessibility in digital environments* focuses on adapting, improving accessibility, web pages, and applications of computer environments. It is related to the Degrees in Engineering of Information and Communication Technologies and Degrees of Communication Sciences.

(3) *Accessibility in communication* focuses on accessibility to information through easy-to-read techniques. It is related to Degrees in Communication Sciences and Humanities.

In this article, we are going to deal with the first area [1].

The *teacher's challenge* is to adapt technical content at the university level for a profile of students with *limited intelligence, cognitive disability,* and, in some instances, limitations or physical *disabilities.*

The university teacher faces a very different *panorama* than the one is used to [3]. These students tend to express themselves freely, uninhibited, without the prudence that is customary to find in the university student, without filters. They interrupt the rhythm of the class constantly with questions that may be alien to the prepared speech because these questions are of immediate interest to them. These events break the cadence and order of the class, anticipating topics that will be introduced later or ending the class by asking about aspects that were concluded.

In *classes with theoretical contents, constant reinforcement* and *repetition* from different disciplines are essential. *They are exclusive classes.* They are based on learning basic concepts, making a great effort in the practical and visual, relying on aesthetic resources related to social networks or digital platforms.

The *workshop classes* are *active classes* where they work with classmates from the last years of the engineering and architecture degrees. *These are inclusive classes.* The disabled student focuses much more, becomes more aware that they are in college, and assume a more significant commitment in class since they must work with two or three university students.

The class group of disabled students *is very heterogeneous.* This forces the teacher to discover the *potentialities of each student* and develop additional pedagogical effort. Teaching tends to adapt individually to each of them [1].

In classes, (1) *theoretical aspects* are taught in a classroom, and (2) these aspects are *fixed through practice and play*.

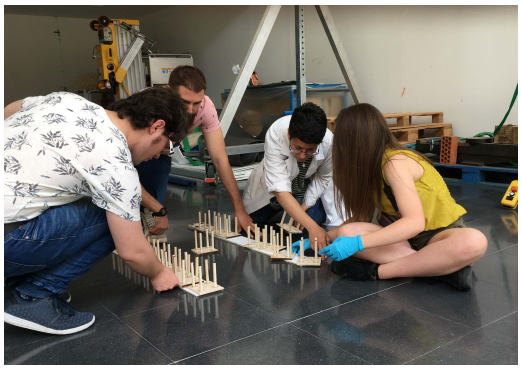
(1) The *theoretical aspects* are structured in short sessions that help the student focus on the crucial technical contents. The theoretical and practical elements contemplated by the training program cover and apply the contents of the CTE (Technical Building Code): SE (Structural Safety), SI (Fire Safety), SUA (Safety of Use and Accessibility), and others. The classes seek to develop dynamics of *debate and discussion*, sharing the opinions of students and the disabled teacher support.

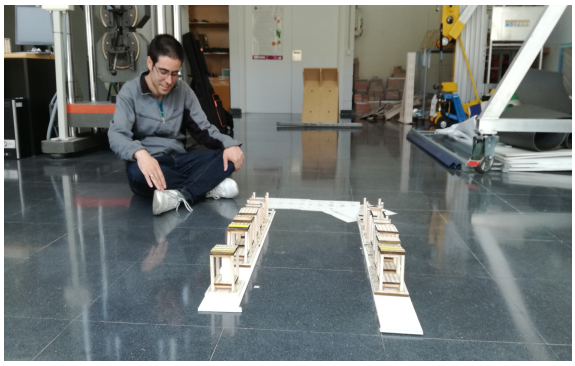
(2) *Fixing the theoretical aspects through practical experience and play* has turned out to be a reliable pedagogical method. It is pursued in *practical sessions* (learning by doing) and *laboratory sessions*.

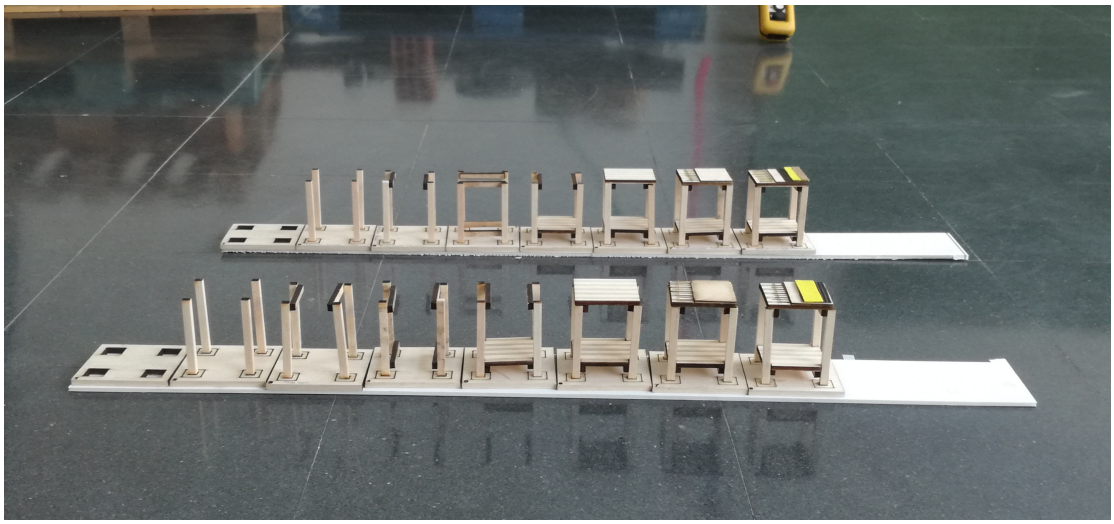
In the *practical sessions,* the students share the model workshops with the students of the degree, and they explore what they have learned theoretically in 3D modeling. In the *laboratory sessions,* the student has a realistic approach to the behaviors and responses of the materials on site.











Workshop classes seek to develop teamwork skills and are inclusive [3].

In the *workshops*, disabled students interact around a project *developed by students of last years of Architecture.* The disabled student approaches what will be his work in an office with the designer, and the architecture student receives information or criticism about their project that makes them understand aspects that, due to their education or preconceived vision, they are not able to detect [8].

The *student of architecture* has internalized accessibility, understanding it as *physical accessibility.* It affects considering the limitations of a disabled person and excludes cognitive disability. The disabled person provides his or her unique view of the problem detected [7]. An additional and significant benefit is that the university student knows and *accepts the disability* and *learns to relate to it naturally* [6].





The result of experience has been as follows:

(1) The programs promoted by the EU through the *European Social Fund* and the *ONCE Foundation* try to incorporate the disabled into university classrooms. This field has not been considered until now.

(2) The *university teacher* has entered a totally *unknown environment*. Since disabled students have another way of understanding the formative process of relating in class, their learning pace is different. In some cases, they have physical and perception disabilities, and the heterogeneity of behavior within the group is manifest. The teacher must exercise their *patience*, their *pedagogical skills*, their *communication skills*. They spend a lot of time preparing their classes, and the results may be more uncertain, having to make an interpretation of these, preparing to modify his strategies constantly [1].

(3) The *disabled student* enters an enriching environment in which he improves his *self-esteem*, that allows him an *intense and inclusive life experience*. It should be noted that some of the pupils with disabilities have not been able to enjoy inclusion in education usually, and such an experience improves them as people

[4]. They have the opportunity to access the university. This is a benefit for their *personal curriculum* and *improves their employability* [2] and possibilities of *social insertion* [5].

(4) The environment favors *finding potentialities* that have been numb or nullified.

(5) Regarding the *university students* of the degree in architecture, the inclusion of disabled people in their work opens a whole world of possibilities within their work in the project of architecture or urbanism. The *sensitivity towards inclusion* and *accessibility* stands out in all his projects.

(6) The experience in the training of the consultant shows us that professional practice can gain an *important figure that helps to improve accessibility* in the architectural and urban heritage. Suppose *all people can go through a mild or severe disability situation*, transient or permanent, at some point in their lives. In that case, their contributions to the technician will help those who have physical, cognitive disabilities and, ultimately, everyone. The experience of the first graduates, and their work in some studies sensitive to accessible problems, have shown this [5].

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UNIVERSAL ACCESSIBILITY AND INTERACTION ACADEMY SPAIN AND COLOMBIA

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Keywords: *academic interaction; build and human disability; Colombia; state of art; Spain; universal accessibility*

Abstract

Accessibility is a universal concept as mentioned in the definition given in the document called The Meaning of Universal Accessibility and its Justification in the Spanish Regulatory Framework, which states that accessibility is "the condition that environments, processes, goods, products and services, as well as objects or instruments, tools and devices, must meet in order to be understandable, usable and practicable by all people in conditions of safety and comfort and in the most autonomous and natural way possible. It presupposes the strategy of "design for all" [1], in relation to this, accessibility should be an aspect that is deepened from two fields such as the academic field that trains technicians, technologists, professionals and specialists in the construction sector and this is transferred to the second field which is the professional, since it is necessary that from the conception of the design for the accessibility of people with disabilities is materialized in the constructive development.

Having said the above, the main purpose of this paper was to present a state of the art on the following aspects, developments, advances and applications of accessibility in Spain and Colombia, being clear that a country like Spain has an important advantage over what has been developed in Colombia, however in Colombia some advances have been developed that are worth presenting.

In view of this, the research question that arises is: What are the academic challenges in Colombia and Spain regarding the issue of universal accessibility?

The method used for the development of the results of the objectives set for this document was the realization of two states of the art, understanding this concept as the collection of information [2] that is reflected in high impact scientific journals, information from government entities that address the issue of accessibility, guides, documents and others that would allow to have an overview of what is happening

worldwide with respect to the issue of universal accessibility and then land the look in countries like Colombia and Spain in the field of construction.

The second state of the art focused on reviewing how the issue of accessibility is addressed in academic environments worldwide and then proceeded to review the academic environment in Colombia and Spain.

Once the aforementioned reviews were carried out, the results of the experiences obtained in the development of academic interaction activities between Spain and Colombia in which the topic of universal accessibility was addressed were presented.

When performing an analysis of the areas of knowledge in which the application of universal accessibility has been carried out, the following information is found when the following search equation is generated TITLE-ABS-KEY (buildings AND accessibility) AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "ENVI")) AND (LIMIT-TO (EXACTKEYWORD , "Human") OR LIMIT-TO (EXACTKEYWORD , "Health Services Accessibility") OR LIMIT-TO (EXACTKEYWORD , "Health Care Delivery")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish")) in the Scopus database, the number of products found are 132 [3], and when doing the analysis of results that can be seen in Figure 1.

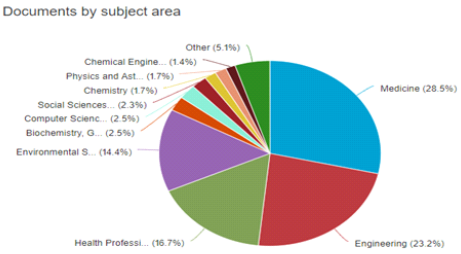


Figure 1: Áreas que abordad el tema de accesibilidad (Scopus)

It is found that the area that most addresses the issue of accessibility is medicine [4] with 28.5%, which numerically represents 101 documents, most of which have been written in the United States.

Once the general review on accessibility has been carried out, the next step is the review of accessibility in the country of Colombia were using the following search equation "TITLE-ABS-KEY (buildings AND accessibility AND in AND Colombia)" [5], 14 results were found which, when analyzed with the results analysis tool of the Scopus database, show what can be seen in Figure 2.

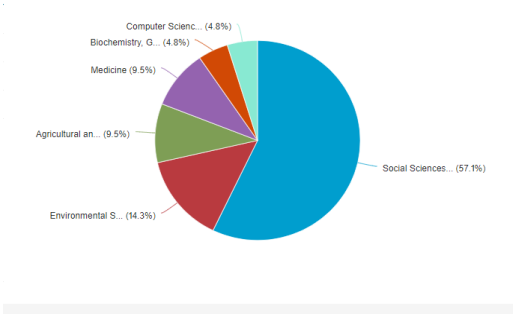


Figure 2: Áreas que abordan el tema de accesibilidad en Colombia (Scopus)

The area that Colombia addresses with greater emphasis about the issue of accessibility is the social sciences with a number of 12 documents that address different social issues such as legal strategies that promote responsibility inaccessibility issues, [6] also on the lack of interactive accessibility tools for active mobility, [7] the evaluation of equity in the accessibility of transportation to work and study [8].

After the review for Colombia, the analysis for Spain is presented below, where according to the following search equation "TITLE-ABS-KEY (buildings AND accessibility AND in AND Spain), 69 articles were found in the Scopus database, which present the distribution of the areas that address accessibility as shown in Figure 3.

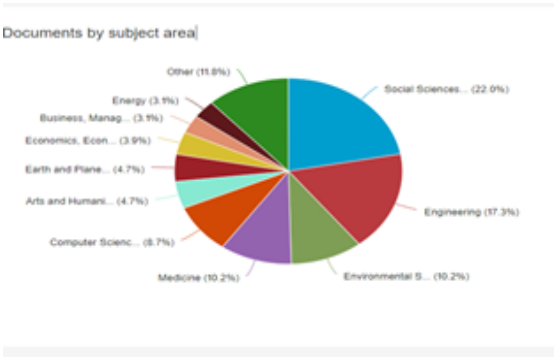


Figure 3: Áreas que abordan el tema de accesibilidad en España (Scopus)

Figure 3. It can be seen that for the country of Spain the diversity of areas that address the issue of accessibility is much greater than for Colombia and as a determining result with respect to the area of construction there are specifically 22 documents that represent 17. 3% of the total number of documents found, of these 22 documents it is important to highlight the following and that is that in Spain according to the different titles found in the documents in the country accessibility is addressed as a heritage of the Spanish society [9] and currently also the renovation of buildings integrating accessibility with very recent methodologies such as environmental ones addressing concepts such as energy efficiency. [10], another relevant aspect is the construction of

accesses for emergency situations that allow the evacuation of people with disabilities in swimming pools [11].

Once the general and particularized reviews for Colombia and Spain in terms of construction have been carried out, the general and particularized review for Colombia and Spain is carried out, but this time from the academic field and the results are the following.

In Figure 4, it can be observed that the behavior of the academic areas that address accessibility in general terms is very similar to the areas that address it from the subject of construction, in the analysis of the results obtained by placing the following search equation "TITLE-ABS-KEY (universal AND accessibility AND in AND academic AND studies AND of AND construction) in the Scopus database, which resulted in 5 documents within which the area of medicine stands out with a percentage of 33.3% which are 3 documents and as a second area the area of engineering with a percentage that gives as amount 2 documents within which it is worth mentioning the following, "Design solutions creating barriers to achieving universal design compliance of academic buildings in academic buildings in universities in Nigeria" [12] and "Universal access in heritage site: A case study on Jantar Mantar, Jaipur, India" [13].

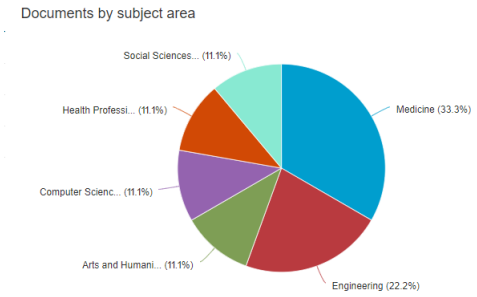


Figure 4: Áreas que abordan el tema de accesibilidad en lo académico (Scopus)

With regard to universal accessibility in Colombia, it was found that it is approached from three areas of knowledge: social sciences, computer science, and mathematics, and for Spain, the result was that the areas of knowledge where universal accessibility is most strongly addressed are psychology and science.

Finally, the study presented the experiences of academic activities such as the Inclusion + Construction Day and mirror classes and from these activities, it was concluded that:

The issue of accessibility is a topic addressed from the construction sector, however, there are still several fields in this sector that need to be explored, articulated with new advances in technology, methodologies, and the changing needs of human beings.

Accessibility from the academic field for professionals in the construction industry still has much to explore and share from the classroom, where awareness is created and accessibility is given value as an important and relevant aspect since the construction professional should not only think about the construction, but also for whom and why he/she builds, and for this purpose, academic articulations should continue to be built to address universal accessibility.

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THE ACCESSIBILITY OF THE ENVIRONMENT AS A GUARANTEE OF INCLUSION, PARTICIPATORY MODEL OF PEOPLE WITH INTELLECTUAL DISABILITIES

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Keywords: *accessibility; inclusion; sustainable development goal; accessibility consulting*

Abstract

The present work presents a teaching methodology in construction, based on compression, which allows learning by people with other abilities.

The idea arises from having to teach the subject of construction, specifically the "Construction of Concrete Structures", in the Own Title of the Polytechnic University of Madrid, aimed at people with intellectual disabilities, which is taught at the ETS. Edification. This novel and innovative situation forces us to incorporate a new teaching methodology, based on pictograms and the application of the "Easy Reading" method, which guarantees easier learning and capturing basic concepts in building.

The "Easy Reading" is aimed at all people, especially those who have transitory reading difficulties (immigration, late entry to reading, poor schooling ...) or permanent (learning disorders, functional diversity, ...)

Taking into account the possibilities offered by this methodology, together with the advantage offered by construction, whose teaching system is fundamentally graphic, the possibility of combined learning through architectural details, images and pictograms was considered, complemented by easy-to-read texts.

The study is in an initial stage, it was being applied in other contents of the Own Title, the novelty is its application to teach the "Construction of Concrete Structures", so that in the future new experiences will continue to be analyzed, which allows progress in order to implement inclusive learning in which students with different abilities participate.

Point out that it requires having the support of experts familiar with the “easy-to-read” method, who in turn have construction knowledge.

It concludes by noting that the experience developed represents a great advance in the learning of people with intellectual disabilities, by allowing them to acquire technical knowledge, as well as its application in constructive practice.

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INCLUSION AND MANAGEMENT OF ACCESSIBILITY IN BUILDING

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Keywords: *construction; easy reading; inclusive learning; intellectual disability*

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CASE STUDIES ON THE APPLICATION OF ACCESSIBILITY IN PUBLIC BUILDINGS

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Keywords: *rehabilitation; accessibility; reasonable accommodation; built heritage; architectural heritage*

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BUILT HERITAGE AND ACCESSIBILITY, APPLICATION CRITERIA

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BUILDING WITH AND FOR EVERYONE

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Keywords: *universal design; intellectual disability; accessibility consultant; inclusive learning*

Abstract

The concept "universal design" was brought to light by the Architect Ronald Mace (1941-1998). It describes the design of buildings, products and environments attractive and accessible to all people, without any specific adaptation.

The definition involves not only physical accessibility (that is already included in the regulations and applied in most of our public buildings). It also comprises cognitive accessibility, web sites design or any other everyday task that can be simplified. Understanding the Universal Design Principles and applying them in the creative and building processes, is advantageous for everyone.

People with physical or intellectual disabilities feel somehow limited in many daily activities. Nevertheless, it is demonstrated that their disability not only depends on their own but also on their relationship with their environment. In appropriate environments, designed and built properly, they can manage pretty well.

Besides, every human capacities vary along our lives: from baby carts, to injures due to accidents, senses lost, old age, or even nowadays the pandemic challenges… If the professionals of our buildings design and construction realized the benefits of applying the principles of the Universal Design, the everyday life of all the people would become easier. Would the future architects and engineers realize the importance of designing and building for everyone if they shared classes with students with disabilities?

"*Good design enables, bad design disables… the build environment, everyday objects, services, culture and information… everything that is designed and made by people to be used by people must be accessible, convenient for everyone in society to use and*

responsive to evolving human diversity"1. We should raise or students awareness among of the benefits of designing and building to make people's life easier.

For most of the people brought up among our society filters, it is very complicated to detect many of the accessibility problems that surround us, even if they had been trained to find them out.

It is proved that people with intellectual disabilities are able to detect details around them that no one else perceive, due to their way of facing life, with no abstractions. That is the reason why they could be the most appropriate profile to identify in a quick and precise way accessibility issues, if they are trained properly. Would a report done by a person with intellectual disability add value to the project of an Architect or Engineer?

Furthermore, would we be able to train them in the University? Would it be possible to include them in some team activities in our Technical Degrees?

The *contact hypothesis* developed by Gordon Allport in 1954 states that contact between groups, under certain circumstances, can promote tolerance and acceptance among the group members. Thanks to the Fundación ONCE and Fondo Social Europeo funds, in some Spanish Universities, as CEU San Pablo and Universidad Politécnica de Madrid, students with intellectual disability are being trained in technical subjects related to construction. Many of the learning activities are organized to be developed in mixed groups: degree students together with intellectually disabled students. The results obtained are awesome. The *contact hypothesis* works.

Moreover, it is being proved that people with intellectual disability well trained, can add value as accessibility advisor to every step of the building process:

- Phase 0: stablishing the designing conditions;
- Phase 1: building detail decisions;
- Phase 2: information for clients and users;
- Phase 3: refurbishment processes.

Teaching people with mild intellectual disability in the University can seem a crazy idea. However, our experience shows that they widen our University Community. In the same way, our building environment would be easier to use, if they worked as advisors for Architects and Building Engineers. Building with and for everyone is the key for getting closer to the Universal Design Principles.

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BIM

APPLICATION OF BLOCKCHAIN IN BIM: A SYSTEMATIC REVIEW

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Keywords: *blockchain; projects; BIM; construction; technology*

Abstract

A Blockchain Technology (BCT) is an emergent digital technology that in recent years has gained widespread traction in various industrial, public, and business sectors; primarily in financial and banking realms owing to the rapid increase of cryptocurrency valuation in recent years. A blockchain Technology (BCT) is, in essence, a decentralized ledger that records every transaction made in the network, known as a 'block', the body of which comprises of encrypted data of the entire transaction history. It was introduced as the working mechanism that formed the operational basis of Bitcoin, the first digital cryptocurrency to gain extensive mainstream appeal. The introduction of decentralized technology in any industry would require strengthened security, enforce accountability, and could potentially accelerate a shift in workflow dynamics from the current centralized architectures to a decentralized, cooperative chain of command and affect a cultural and societal change by encouraging trust and transparency. It was evident that the underlying principles characteristic of BCT functional attributes and secure digital infrastructure could find application in nearly any conceivable industry. BCT aims at creating a system that would be a robust self-regulating, self-monitoring and cyberresilient system that assures the facilitation and protection of truly efficient data exchange system.

This research depicts a survey of blockchain technology and its applications in the Architecture, Engineering, and Construction (AEC) industry and examines the potential incorporation within the Building Information Modeling (BIM) process. Furthermore, the paper investigates how employing distributed ledger technology (DLT) could be advantageous in the BIM workflow by emphasizing network security, on the other hand in the Looking around, we see a change in all aspects of the digital industry, education, or the economy. The digital sector has witnessed a larger volume of transformation. Significant work and changes and improvements have been made in the field of design and manufacturing industry. The digital sector, as well as the construction sector, are

witnessing digital transfers. Technology is evolving in solving various problems arising from all industries. The Blockchain is also moving towards the construction industry. Combining blockchain with BIM (building information modeling) is a great combination. Blockchain is really useful in the manufacturing industry. The blockchain is a chain of linked blocks in which each block relates to the block before it. The main characteristic of blockchain is to ensure information security. All the information is held in the blockchain in a codified and hashed form that has been encrypted. The blockchain is used for the accuracy of information transacted between two actors. The overall structure of blocks in the blockchain consists of two main parts. The first one includes the main information of the block in hashed form and the second part includes the address of the prior block in hashed form. In different construction projects, these data can include the smart contracts concluded between the employer, contractor, and consultant and also the correspondences done with different organizations, evaluation of workers' work hours. The structural information is the most significant data in the sensitive projects the accuracy of which should be assessed, since filtering such information leads to heavy casualties. The research method is descriptive with the Goal of getting acquainted with blockchain and combining it with the construction industry and building information modeling.

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NEW REQUIREMENTS IN THE PROCESS OF IMPLEMENTING BIM METHODOLOGY IN THE AEC SCOPE

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Keywords: *building information modelling; AEC adoption BIM; BIM technology; BIM maturity in Spain*

Abstract

Building information modeling (BIM) as a digital information management system is one of the most significant and promising changes in the construction industry [1]. In fact, practitioners, educational institutions and organizations have started to adopt BIM software tools and adapt their own project delivery systems to meet market requirements [2]. The goal is to design, build and maintain a project throughout its life cycle. The effort involved could include new and existing projects such as residential construction, commercial construction, industrial construction, heavy construction, infrastructure construction and heritage maintenance [3].

During the last decade the BIM methodology has been progressively implemented in different countries, being for some of them a priority objective of their Public Administrations. These have imposed or valued its use in public works, following the recommendation of the European Public Procurement Directive 2014/24/EU. In Spain, Law 9/2017, of 8 November, on Public Sector Contracts, transposing into Spanish law the Directives of the European Parliament and of the Council 2014/23/EU and 2014/24/EU, of 26 February 2014, incorporates, in section 6 of its Fifteenth Additional Provision, entitled "Rules relating to the means of communication to be used in the procedures regulated in this Law", a precise reference to the methodology by stating that "contracting authorities may require the use of electronic tools, such as digital building information modelling (BIM) tools or similar tools " [4].

The above, indicates that in order to study and define the real BIM implementation in the AEC sector, we must refer it to the public sector. In it we can determine and study both at a normative and statistical level, the real impact of the implementation. At the same time, it will help us to identify the needs that are suggested in this regard.

Complementing the above, was created in Spain by the Ministry of Public Works in 2015, the National Commission es.BIM, which began analysing how to implement BIM in the sector and how to introduce it in public tenders. Subsequently, in May 2017, the BIM Public Tenders Observatory (https://cbim.mitma.es/observatorio-cbim) was created with the aim of knowing the progress of the implementation of BIM methodology in Spain. Finally, by Royal Decree 1515/2018, of 28 December, the Interministerial Commission for the incorporation of the BIM methodology in public procurement is formalized, being constituted in April 2019.

The intention of this research is to assess the level of BIM adoption in the environment and also to locate and detect the needs that this implies in their incorporation processes. At a general level we can consult the data included in the study [5] carried out in 2019 by buildingSMART, and in collaboration with BIMe Initiative, on the level of BIM Adoption in Spain in 2019 from a survey conducted to a group of experts as a representative sample of the different agents of the AEC sector.

But the real results will be obtained through the study and identification of the general quantitative data relating to the number and investment of public tenders in the Official State Gazette and other official gazettes. Specifically, those that present the incorporation of BIM requirements are studied. The geographical distribution is studied by Autonomous Communities (Administrations), by the type of bidder within the different administrations, by the phase of the life cycle (design-construction-operation), as well as the type of work. The results of its annual evolution are offered.

The period studied corresponds to the values published in the CBIM observatory and covers the period 2017-2020. The relationship between the total number of public works tenders (defined as LGEN) and the total number of public works tenders incorporating BIM requirements (defined as LBIM) in the last year is also studied. The data presented in the BIM Observatory/BIM Tenders of building Smart Spain have been considered. Finally, and as a complement, different types of technical specifications of different LBIM between 2018 and 2021 have been studied to illustrate a partial study on the different typologies of the same.

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MAINTENANCE MANAGEMENT OF EXISTING BUILDINGS SUPPORTED ON BIM

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Keywords: *building information modelling; maintenance management; preventive maintenance; maintenance plans; facility management*

Abstract

The buildings' maintenance management has been suffering significant changes since Building Information Modelling (BIM) implementation in the Architecture, Engineering, Construction and Operation sector. However, the development and management of the preventive maintenance plans resourcing to software is still hard and time-consuming work.

Thus, the objective of this work is to demonstrate the benefits of using the BIM methodology to building state preservation during its life cycle. A preventive maintenance plan was made and it includes the maintenance actions to be implemented, the respective cost and the periodicity of intervention. These data will be available in Revit software and Excel database, allowing the accessibility of all BIM users and no-users.

For this purpose, the methodology developed aims to implement BIM methodology in Maintenance Management by exploring the interoperability between the Revit software and the Excel database, allowing the synchronization of preventive maintenance plans between these two platforms. The methodology developed and applied to a case study consists of documentation analysis, case study modelling on Revit and the introduction of correspondent parametric information. After, Table 13 of Omniclass standard, which classifies the spaces according to their using were applied. Then, a building inspection makes it possible to evaluate the building state conservation and based on that a maintenance plan was developed for some elements of the case study. Finally, the

bidirectional interaction between Revit and Excel was set up by a Dynamo routine for Revit and by a commercial add-in.

This work shows a methodology to avoid information fragmentation along the building life cycle, enabling its efficient management, culminating in a cost reduction in future interventions. It also facilitates the insertion of new elements by the period of use with the respective parametric information in a fast way. This work gathers all the building information in a unified model and intends to develop a methodology easy to apply even to other building typologies.

HOW TO GENERATE AN ANALYTICAL MODEL FOR SIMULATION FROM A BIM MODEL IN IFC FORMAT

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Keywords: *BIM; IFC; energy; acoustics; simulation*

Abstract

Building Information Modelling is a methodology that aims to cover all phases and processes of construction with the objective of digitizing this sector to the maximum, thus saving time and costs for the different agents involved.

This maxim therefore makes it essential that processes that in the past were carried out digitally but independently are now necessarily connected through BIM. This is the case of building design (traditionally carried out with CAD tools) and its energy simulation (supported by calculation engines such as EnergyPlus or DOE-2) and acoustics (supported by calculation engines such as Acoubat).

With the emergence of BIM, the communication between design and simulation becomes a clear demand of the construction sector. As is well known, any communication problem is in fact a problem of interoperability between different software solutions which, whereas in the past they could work independently, are now necessarily forced to understand each other.

The conversion of an architectural model (BIM), composed of elements such as walls, floor slabs, roofs, windows, doors, etc. to a simulation-ready model (SIM), composed of plans, edges, volumes, boundaries, etc. has generated a clear bottleneck because the architectural modelers (Revit, Archicad, Allplan, CYPE Architecture) do not define the information in a way that is understandable to the calculation engines.

That is why CYPE, through the European BIMSpeed project, has the objective of generating a tool capable of converting the architectural model to the analytical model in a simple way, solving the interoperability problems previously mentioned.

Open BIM Analytical Model is a free program capable of automatically transforming any architectural model stored in the IFC standard into an analytical model. The algorithm in charge of this task relies on the definition of enclosures and the architectural elements of the IFC for the creation of surfaces and edges, as well as the determination of boundaries and joints. The resulting analytical model is exported in the standard JSON format widely used in the software development industry.

In addition, the program allows the user to process all this information manually, giving the user full control over the final result. The user can enter the elements that make up the analytical model (enclosures, surfaces, edges, joints, etc.) as well as define their relationships (membership of enclosures, adjoining surfaces, edges forming a joint, etc.). In order to take into account the different thermal and acoustic requirements, the application allows defining different groupings of spaces. Thus, it is possible, for example, to establish a grouping by units of use and a grouping according to thermal zoning criteria on the same analytical model.

The program has been tested in BIMSpeed with real buildings that will undergo a renovation process in Poland and Spain. The objective of this project is to demonstrate that BIM can be a driving methodology for building retrofitting by allowing to estimate energy savings and CO2 emissions.

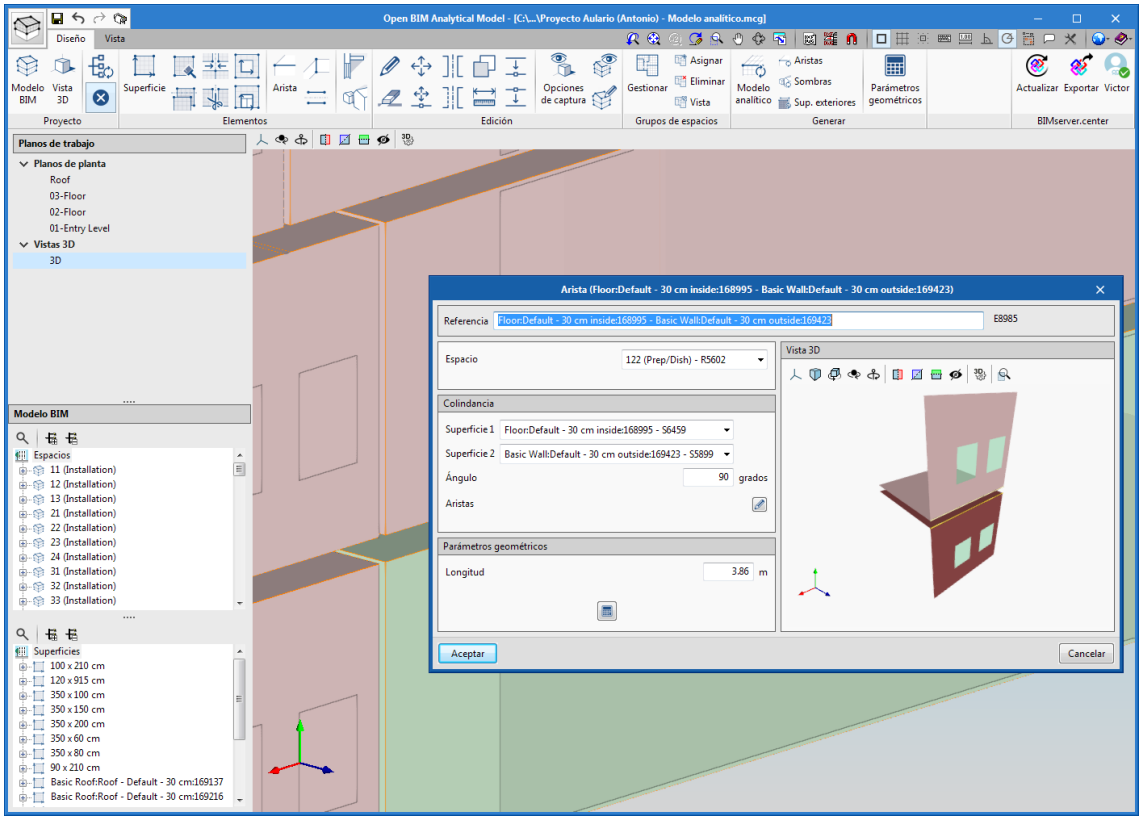


Figure 1: *Open BIM Analytical Model interface and edge definition.*

HISTORIC BUILDING INFORMATION MODELING (HBIM) AND COMMON DATA ENVIRONMENT. THE CASE STUDY OF PALAZZO VITELLI IN SAN GIACOMO IN CITTÀ DI CASTELLO

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Keywords: *HBIM, CDE, Digitalization, Data Management*

Abstract

The paper constitutes an experimentation regarding the HBIM representation to support the management of historic buildings, with particular attention to the methods of organization and sharing of information placing itself in the point of view of public administrations. Following a research agreement between the Department of Civil and Environmental Engineering of the University of Perugia and the municipality of Città di Castello (PG), it was decided to analyze the case study of Palazzo Vitelli in San Giacomo, a building sixteenth century located in the historic center. The goal is to provide and support the municipal administration with a BIM model of the building in digitalization processes, which is complete from an information point of view and inserted within a valid data sharing and management system. The BIM modelling of historical architecture is an opportunity for reflection on the potential of this logic, entering into the many issues inherent in the complexity of the historical-architectural heritage. Furthermore, the comparison with a context with modest possibilities poses the challenge of adapting information sharing structures created for different purposes to a BIM use, highlighting how, in many cases, the transition to new forms of data management must take place in the sign of continuity and intelligent use of resources.

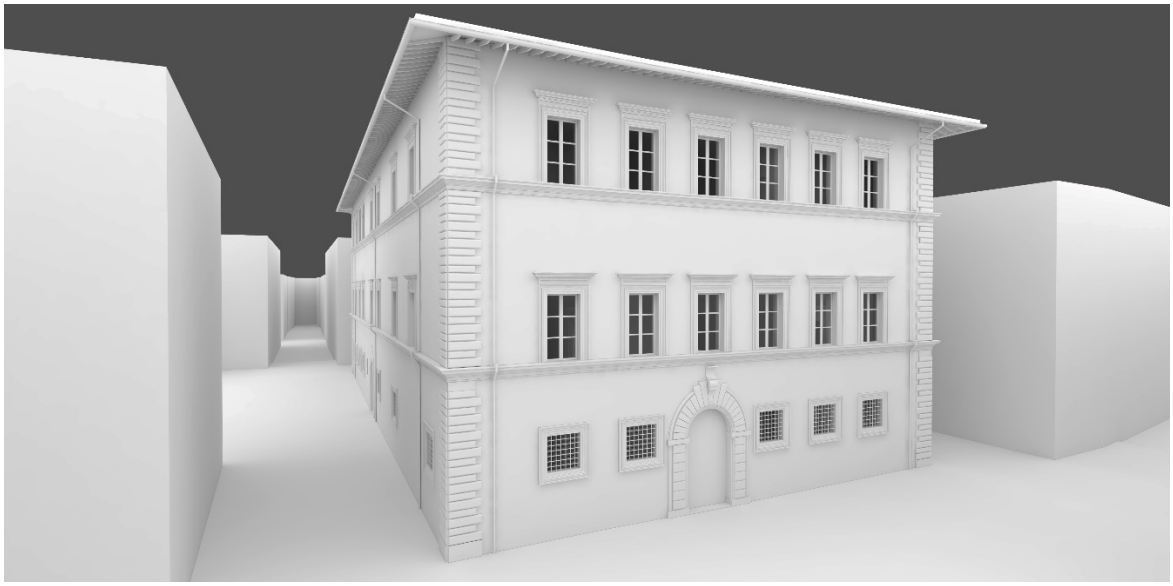


Figure 1: *General view of the Palazzo Vitelli in San Giacomo in Città Di Castello BIM model*



Figure 2: *Detail of the internal courtyard of the BIM model*

GENERAL ISSUES

ANALYSIS OF ORIGIN AND DIFFUSION OF THE BAROQUE AND ITS IMPACT IN CHINA

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Keywords: *baroque; architecture; neo-baroque; Europe; China*

Abstract

The baroque style is trending in China because of some resemblance to Chinese design concepts. This work is dedicated to the study of the "Song Pou" building, in the city of Harbin, the study is developing a graphic survey and trying to identify their architectural elements of Baroque influence.

The main objective of this work is to show the investigations carried out on the infiltration of traditional Baroque architecture in China and later Neo-Baroque architecture in the city of Harbin (China).

In recent years, previous study has been conducted on Neo-baroque in China. After the Neo-baroque architecture expanded all over Europe where it reached Russia with great force. Then this architecture style from Russia spreaded to China, specifically to the north of the country. In Harbin, for instance, there are numerous neo-baroque buildings built at the beginning of the 20th century [1].

Different Exploration of heritage and architectural surveys will be conducted in this study.

Song Pu Company Building is located at 120, Zhongyang Street, Dao Li district, Harbin, China. Its construction work started in 1906 and finished in 1909, the architect who designed the building was the Russian AA. Myakoko [2].



Fig. 1(a): The building “Song Pu” in 1909 [3].

Fig. 1(b): The building “Song Pu” in 2019.

Based on the graphic survey carried out, plans of the building's facades have been drawn using the AutoCad tool, obtaining front views of them (see Fig. 2(a)).

Starting from the floor plans of the building and the elevations, the building has been 3D modeled with the Sketchup software. Subsequently it has been exported to the 3D Max software for rendering.

In the 3DS Max Software, different views of the building have been obtained, allowing points of view of the same that cannot be seen by natural human vision. It is allowing a better visualization and interpretation of the building (see Fig. 2(b)). From this textured three-dimensional model, VR and AR techniques can be applied that would allow the building to be viewed on a real scale or to add additional information about it in order to make a virtual visit to the building for different cultural or educational purposes.



Fig. 2(a): Facade plan of the "Song Pu" building.



Fig. 2(b): Facade render of the "Song Pu" building.

In the building numerous elements of baroque inspiration were found from the architectural, formal and stylistic viewpoint.

Some of the most unique elements are found in the chamfer of the building. We find a Caryatid and an Atlantean that emerge from two volutes that frame the main entrance of the building. We can also find semi-circular arches surmounted by mixtilinear friezes and a large curved balcony with a balustrade. On the third floor, the central arch has a large frieze with volutes, with rich decorative plant motifs and a large mixtilinear balcony formed by curves and contracurves. On the fourth floor is the circular drum on which the hemispheric dome rests. There are eight small oval windows with mouldings and eight ribs were built on the upper surface that form various mouldings. Baroque architecture is very focused on utilizing the effects of light, so these oculi play a decisive role in illuminating this architectural space. On the rooftop, the dome is surmounted by an upper element consisting of a series of curves and contracurves in the shape of a crown (see Fig. 1)[4].

The research explored the process of evolution from baroque to neo-baroque, and his transition from Europe to China.

In 1910 the share of Baroque architecture gradually rose in China; examples are found

in Shanghai, Harbin, Wuhan, and other Chinese cities.

The research explored the process of evolution from baroque to neo-baroque, and his transition from Europe to China.

The 3D model of the building allows it to be viewed from different points of view; as well as allowing to catalogue and study both the whole and the different architectural elements that compose it. It is also a very useful tool to perform conservation and maintenance tasks on the building. On the other hand, it would allow its digital diffusion through various platforms or Web pages, allowing its visualization through VR and RA techniques.

The building has many characteristics of Baroque architecture. In addition, we find on it other characteristic elements of the neoclassical and modernist style, so the building could be framed within the Eclectic Style, although with a clear predominance of the Baroque influence.

Traditional Chinese architecture uses elements similar to Baroque architecture, such as motifs of lions, plants, flowers and fruits. The neo-baroque architecture was very special and modern in its time in the Chinese cultural environment, assuming great influence over the style of Chinese architecture.

In China, people have little knowledge of Baroque architecture, they even think of it as Russian-style buildings. The publication of this article, may help to spread the knowledge of this area of study and allow this information to reach more people.

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THE ARCHITECTURAL AND ENGINEERING DRAWING AS A METHOD OF BUILDINGS' ANALYSIS

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Keywords: *architectural drawing; engineering drawing; building; educational innovation at university; new technologies in project presentations*

Abstract

At the Escuela Técnica Superior de Edificación of the Universidad Politécnica de Madrid (UPM), we are studying THE PRESENTATION OF THE ARCHITECTURAL PROJECT. How to elaborate the representation of a building, a personal way of approaching architecture. It's important how we "read" the building. We will see the methodologies used in the representation of the architectural and/or engineering object and how it changes depending on the graphic form used.

The media and its evolution are important, the professional takes a working method, an understanding of the architectural language and its application as an instrument of representation of the Architecture, both built and not built. As a tool of Graphic Expression in the elaboration of the plans of a building or a built architectural fact is not conceived, without a previous sketch. It is a scaled drawing, for presentation in different media, professionals, administration... This scaled drawing can be manually and/or by computer. The arrival of the computer in the seventies did mean a technological breakthrough in the domain of architectural design. The world of the architect, has been changing according to innovative changes and has been closely linked to the so-called culture of the image, being useful the communication facilities that suppose the use of this new tool.

There are new ways to draw, based on the BIM (Building Information Modelling - information form for the building). For BIM applications, with programs like Revit, architecture and engineering is much more than a three-dimensional model with different representations. If we try to compare AutoCAD - AutoCAD Architecture - Revit, we will fall into the simplicity of doing it as tools to represent reality, forgetting the most important thing about Revit, which is to simulate reality.

We are at the beginning of a great revolution in the field of learning. Since the invention of mechanical printing (J. Gutenberg), there has not been a technological innovation of such importance to the educational system as Internet distance learning. It is clear that the current situation of distance learning is not definitive. The current media are relatively poor compared to those that will exist in a few years. A 3D printer really produces a design created with the computer in a 3D model. With this we can get electronic documents and physical documents. In general, the materials used to manufacture the objects can be of 100 different types.

A building information model contains not only the design of a building, but also details of its components, construction and maintenance. 3D printing is one of the major trends of recent years in the technological area. In fact, we see as little by little, different models of printer come out to market can be bought both on the Internet and in department stores.

Our students manufacture models with a 3D PRINTER. We will see some examples of their work. We must think that regardless of the technique used, the most important thing is to know the objective we want to obtain, since this is the only way to achieve it. 3D printers have been one of the great inventions that has reached its fullness in this 21st century, specially thanks to the fact that a large number of companies are innovating in their production and in the uses that can be given to them, marketing a large number of 3D printers with different purposes, sizes and prices, opening up millions of possibilities for a simple production that even allows trial and error without excessive costs. In the photos we can see some examples of models made in the ETSEM 3D Printing laboratory. In the Figure you can see the models.



Figure 4: *El laboratorio 3D Impresoras 3D printer Marketbot Replicator TM 2 DESKTOP 3D PRINTER (Source: The authors)*

Therefore, it is advisable a constructive understanding of the architectural work, or Engineering before making any representation of it, and from it, we will choose the most appropriate technique of representation. Drawing is learning Architecture, provided that the Drawing is approached not as a mechanical convention but as a process of thinking-acting. Through spatial symbols that imitate, invent and confront

each other, reflecting, perceiving and realizing them. To do this we must be aware of the specific methodology to be employed, in each medium, since it is difficult to achieve mastery in something without being aware of the sequence of acts that have to be performed.

However, the medium is only an instrument for the achievement of the end, but it is by no means the objective of our work. More emphasis should be placed on teaching than on technology. We have much to learn about the learning process, using new technologies. An in-depth analysis of the educational system is therefore necessary to realize whether our current strategies and techniques, even the most advanced ones, are the most suitable for the society of the future. We must be prepared for the changes that society demands from us. This will create a professional adapted to the demands of the social future.

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SEISMIC MICROZONATION OF GROUND MOTION AND SITE EFFECTS: STATE OF DEVELOPMENT AND APPLICATIONS FOR ITALY

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Keywords: *seismic microzonation; ground motion; site effects*

Abstract

Seismic microzonation is a more rational and general design approach, particularly for seismic regions, in which the design criteria are expressed in terms of achieving stated performance objectives. In this approach it is relevant the performance required to structures and to geotechnical works subjected to stated levels of seismic hazard, as well as the geotechnical constitutive model used to predict the performance. The parameters of the constitutive models are related in turn to soil properties. Earthquake hazard zonation in urban areas is the first and most important step towards a seismic risk analysis in densely populated Regions. The Seismic Microzonation is nowadays a world-wide accepted tool for the mitigation of seismic risk. It is a complex process involving different disciplines ranging from Geology and Applied Seismology to Geotechnical and Structural Engineering. The aim achieved in seismic hazard microzonation studies throughout the last 20 years performed at the presented typical case histories in Italy was to quantify the spatial variability of the site response on some typical historical scenario earthquakes that would be expected in the area. In order to quantify the expected ground motion, the manner in which the seismic signal is propagating through the subsurface was defined. Propagation was particularly affected by the local geology and by the geotechnical dynamic ground conditions. Large amplification of the seismic signals generally occurs in areas where layers of low seismic shear wave velocity overlie material with high seismic wave velocity, i.e. where soft sediments cover bedrock or more stiff soils. Therefore, essential key issue here is to obtain a good understanding of the local subsurface conditions.

Local site effects can be defined as the modification of predicted rock outcrop “reference” motions to give actual motions at the local site in question. The accuracy of zoning based on local site investigation data can be further enhanced using computer modelling of ground response [1-3]. The seismic hazard analysis can be

performed by means of a deterministic or probabilistic evaluation. The actual Italian seismic code NTC 2018 [4] links the seismic design actions on structures directly to the probabilistic seismic hazard analysis (PSHA) [5-6]. However, the deterministic seismic hazard analysis (DSHA) confirms that peak ground acceleration values are larger than those given by the PSHA in area where large earthquake are observed [7-8].

This study builds on the recent experience of seismic microzonation studies in Sicily (Italy), after the effects of the 2018 seismic sequence. It describes the results of numerical modelling studies in six municipalities (Alì Terme, Termini Imerese, Campofelice di Roccella, Finale di Pollina, Trabia and Cefalù) of Messina (ME) and Palermo (PA) provinces in Sicily (Italy) (Figure 1). In particular, three different test sites have been selected for Alì Terme municipality (ME): the Nursery School on M. Teresa Federico Street, the “Nino Prestia” Elementary School and the "Stefano D'Arrigo" Middle School.

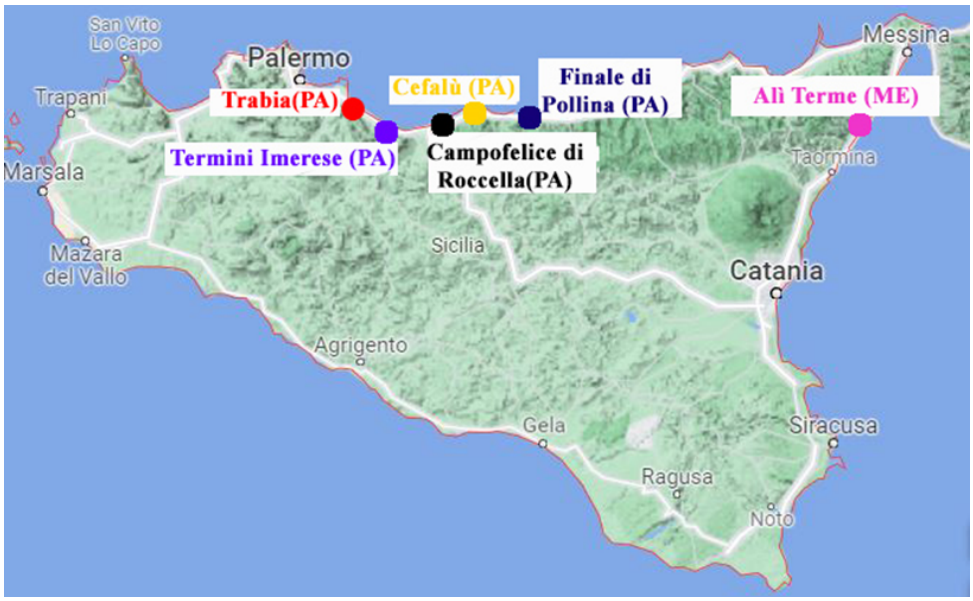


Figure 1: *The location of the study areas in Sicily (Italy)*

In order to evaluate geotechnical characteristics of the soil, an intensive geotechnical site characterization has been carried out in each of the 8 test sites. Geotechnical investigations performed in the three test sites of Alì Terme (ME) include: n. 3 active MASW tests, n. 1 seismic refraction test, n. 2 dynamic penetrometric tests, n. 1 HVSR test, n. 2 electrical tomographies. The types of tests performed are the same for the five municipalities of the Palermo province (Termini Imerese, Campofelice di Roccella, Finale di Pollina, Trabia and Cefalù). In fact, for each site, a borehole has been carried out, with undisturbed soil sampling. All boreholes have been also equipped in order to perform a Down Hole (D-H) test.

The analyses of the ground motion have been conducted in three main phases: the definition of the geometric and geotechnical model, the definition of the seismic inputs and the analysis of the results.

Local site response analyses have been performed using 1-D linear equivalent code STRATA [9]. The V_S profiles used for soil response analyses are obtained from geophysical tests. To take into account the soil non linearity, laws of shear modulus and damping ratio against strain have been also inserted in the code.

Numerical analyses have been carried out for Alì Terme (ME) sites using six input seismograms obtained by a source modeling of 1908 Messina and Reggio Calabria earthquake [10-12], scaled to the value of 0.332 g [13], provided by the Italian seismic code [4]. For the five municipalities of the Palermo province, five sets of seven accelerograms have been derived from REXEL v. 3.5 (http://www.reluis.it) [5-6]. The software allows to search for suites of waveforms, from the European Strong-motion Database, compatible to the reference spectrum in a defined range of periods according to the new Italian seismic code [4]. The disaggregation data for the five municipalities have been obtained considering a probability of excess of 10% in 50 years (return period of 475 years).

The soil dynamic response has been investigated in terms of accelerations, response spectra and amplification functions for the 8 site tests using the 1908 seismograms and the five sets of seven accelerograms obtained from REXEL v. 3.5. Results of the site response analyses show high values in soil amplification effects. Moreover, soil amplification factors obtained from site response analyses are greater than amplification values provided by Italian technical code[4]. Finally, mean response spectra at the ground surface have been also compared with the reference elastic response spectra, provided by NTC 2018 for each of the 8 test sites.

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PUBLIC-PRIVATE COLLABORATION: INSTITUTIONAL GOVERNANCE AND CORPORTATE SOCIAL RESPONSIBILITY

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Keywords: *Public contracting; Outsourcing; Corporate Social Responsibility; Governance; Public waste.*

Abstract

The study focuses on the outsourcing processes of the health services suffered from the nineties to the present day in the Valencian Community, specifically in the administrative concessions and in other examples of public-private collaborations at the national level, such as the constructions of infrastructures by the general administration of the state and the regional and local entities of the rest of the autonomous communities.

Many theories, such as those postulated by Professor Ramió [1] tell us that not infrequently public-private collaborations have turned out to be of great harm to public coffers without demonstrating their usefulness and / or viability, because in Most of the cases have occurred as a reactive model, that is, to cover deficits (mainly fiscal restrictions and cost reduction) or on other occasions as a simple electoral claim of the political party in power and that the Administration has made passive use of its management prerogatives and has not carried out a good control and evaluation on private companies.

Throughout the study we will try to see that there are a multitude of mechanisms and legislation that this type of public-private collaboration must comply with, in order to reach a successful conclusion and not incur over costs and waste of public budgets and different organizations that must ensure that the proper functioning of public-private collaborations and contracts, as well as the monitoring by public administrations and companies that provide services of corporate social responsibility so that these types of agreements are not carried out over exorbitant costs.

Our study will be based on an analysis of the New Public Management approach of the late 1990s, where we will delve into the analysis of bibliographic documents and include key concepts such as outsourcing and therefore administrative concessions and contracting. public.

The methodology that we propose in the research will maintain a correspondence between qualitative research through the analysis of documents and data collection

(analysis of documentation of the Sindic de Comptes, Conselleria and the health departments, of relevant bibliographic review) and a quantitative research (interpretation of the results found in the different reports of national and international organizations) and qualitative analysis of the case studies [2].

In the next section we will see some examples of public-private collaborations and contracting that have caused unnecessary expenses for public entities and we will show what mechanisms we currently must improve these processes.

They began to be forged in 1997 after Law 15/1997, on the enabling of new forms of management of the National Health System, being the Ribera health department, managed by Ribera Salud [3], the first, assigning it a population of about 260,000 inhabitants.

The financial model that was chosen was the capitation payment, the Department paid an amount established for each person, whether it was attended or not. The first concession was for 10 years, but in 2002, the UTE admitted losses of about 5 million euros and to try to save the model, the contract was rescinded, and later awarded to the same company, but yes, with certain changes, the capita was raised, it was allowed to serve citizens from outside its health area, and they would be billed by the process system, the management of primary care in the area (a dozen health centers) was privatized with the In order for the manager to obtain true control of demand at all levels of care.

Upon termination of the contract, the Conselleria, contractually bound, rescued the hospital, and paid the UTE the amount of the investment made, around 44 million euros. And as the icing on the cake, the Department paid Ribera Salud 25 million euros as "lost profits" for the six years that remained in the concession and a new contract was signed for a period of 15 years [4]. The real cost of the La Ribera hospital doubled the initial economic forecasts. The final cost rose to 63.4 million euros according to an official act of February 27, 2002, that has never been officially released when the estimated investment in the preliminary exploitation project was estimated at 32.4 million euros [5]. After more than two decades of indirect management, the Ribera (Alzira) health department was reversed, by the Conselleria de Sanidad Universal y Salud Pública of the Valencian Community on March 30, 2018.

We are going to focus on waste, as an inefficient action, which almost always entails costs with respect to efficient operation and we will fundamentally base ourselves on a report from the Association of Spanish Geographers [6] which includes projects and events with an initial budget. greater than 10 million euros, at the three levels of state, regional and local government. According to his estimates, a table is shown with the expenditure in millions of euros of the amounts wasted, which in his opinion are a lower figure than what they really would be, because not all the areas have been selected and the budgets are not lower than 10 million euros.

Table 1. *Inadequate estimate of public spending on infrastructure in Spain (1995-2016). Millions of euros.*

Central administration	45929,5
Catalonia	9160,5
Community of Madrid	7721,1
Valencian Community	5936,0
Asturias	2380,1
Andalusia	2657,2
Aragon	2978,0
Castilla la Mancha	1530,0
Galicia	844,0
Castilla-León	368,9
Community of Murcia	251,1
Balearicis	250,0
Basque Conuntry	175,0
Cantabria	127,8
Canary Islands	89,5
La Rioja	108,0
Navarre	106,0
Extremadura	13,4
TOTAL	*80526,6*

Source: Bulletin of the Association of Spanish Geographers (2018)

Some studies tell us that, if institutional quality were at the level that would correspond to it, GDP could be increased by around 20% more [7].

There is a broad regulatory framework so that the different public-private contracts are carried out in the most efficient way possible. I will name the two main laws, on the one hand, there is Law 9/2017, of November 8, on Public Sector Contracts, by which the Directives of the European Parliament and of the Council 2014/23 / EU are transposed into the Spanish legal system. and 2014/24 / EU, of February 26, 2014 (hereinafter LCSP) and on the other hand, Law 19/2013, of December 9, on transparency, access to public information and good governance.

As a result of the LCSP, the main control body is the Independent Office for the Regulation and Supervision of Procurement (OIReScon), which is created ad hoc by this law as a procurement supervision body, it must coordinate supervision in matters of public procurement and to ensure the correct application of the legislation in this matter and of the functions attributed to it by the LCSP [8].

We can also mention the National Markets and Competition Commission (CNMC) and the Court of Accounts, as the main bodies, but there are many more at the state, regional and local level.

Summarizing, CSR "is the consequence of a commitment adopted by an organization with its stakeholders, beyond the legal requirements established, in economic, social and environmental matters, to take responsibility for the consequences and impacts that derive from development. of its activity and maximize the creation of shared value for the entire group of stakeholders"[9].

It is clear that efficiency in public procurement, authorities and society is something that worries and occupies them. A great example of this is the LCSP and the OIReScon and the large number of organizations that exist between local, regional and national entities to supervise public-private collaborations and that the commitments acquired are fulfilled in the best possible way.

But there is still a long way to go, as the European Commission report [10] shows us, Spain has only exceeded one of the twelve indicators in the study, being only in the European average in two indicators and being unsatisfactory in the rest, it is the worst country in the entire euro zone, with only one satisfactory indicator.

In conclusion, we will refer to different reports that refer to certain aspects that we have to improve so that public-private relations are carried out in an efficient manner [11], [12], [13], [14].

For this we must make the processes much more transparent, where the information is channeled by a backbone body and advance in electronic contracting.

Work should be done on the professionalization of public contracting, to carry out good contractual planning.

We cannot forget to exercise continuous evaluation and periodic accountability to private companies.

Finally, apply the principles of Corporate Social Responsibility, improving competition for small companies and considering social and environmental criteria in public-private contracts.

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LEARNING OF CONSTRUCTION FROM COMPRESSION, TEACHING METHODOLOGY FOR EVERYONE

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Keywords: *construction; easy reading; inclusive learning; intellectual disability*

Abstract

The present work presents a teaching methodology in construction, based on compression, which allows learning by people with other abilities.

The idea arises from having to teach the subject of construction, specifically the "Construction of Concrete Structures", in the Own Title of the Polytechnic University of Madrid, aimed at people with intellectual disabilities, which is taught at the ETS. Edification. This novel and innovative situation forces us to incorporate a new teaching methodology, based on pictograms and the application of the "Easy Reading" method, which guarantees easier learning and capturing basic concepts in building.

The "Easy Reading" is aimed at all people, especially those who have transitory reading difficulties (immigration, late entry to reading, poor schooling ...) or permanent (learning disorders, functional diversity, ...)

Taking into account the possibilities offered by this methodology, together with the advantage offered by construction, whose teaching system is fundamentally graphic, the possibility of combined learning through architectural details, images and pictograms was considered, complemented by easy-to-read texts.

The study is in an initial stage, it was being applied in other contents of the Own Title, the novelty is its application to teach the "Construction of Concrete Structures", so that in the future new experiences will continue to be analyzed, which allows progress in order to implement inclusive learning in which students with different abilities participate.

Point out that it requires having the support of experts familiar with the “easy-to-read” method, who in turn have construction knowledge.

It concludes by noting that the experience developed represents a great advance in the learning of people with intellectual disabilities, by allowing them to acquire technical knowledge, as well as its application in constructive practice.

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LEARNING FROM THE BAE JUAN CARLOS I: LESSONS FOR AN ANTARCTIC ARCHITECTURE OF 21ST CENTURY

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Keywords: *Antarctic architecture; research bases; building management*

Abstract

Since the end of the last century, Antarctica has been revealing its great global importance for the scientific study of such relevant phenomena as climate change. In fact, there are currently more than 50 research bases, and there is a marked trend focusing on architectural design and the use of new technologies, all in a particular context marked by an extreme climate and the zero environmental impact required by the Antarctic Treaty. Among them is the Spanish Antarctic Base (BAE), managed by the Unidad de Tecnología Marina - CSIC. This study aims to contribute to its knowledge since, despite its tight initial budget and having reached half of its expected life, its interesting design (reminiscent of certain utopian proposals) and the use of specific technological and constructive solutions have turned it into a space not only useful for research but for the very definition of an Antarctic Architecture (see Fig. 1).

The objectives and hypothesis are to analyse the BAE in order to conclude that it is possible to define a preliminary methodology for the design and construction of future bases and for the Antartic Architecture of XXIth Century.

It consisted of an analysis of the key parameters of its design and construction, supported by a 3D drawing of module A of the BAE (see Fig. 6). The following key parameters have been chosen for the analysis:

1. SITE: It is located on a firm sloping towards the sea, not affecting the lichens of the surrounding areas.

2. PROGRAM and FORM: It is a temporary use base, inhabited only during the austral summer. It is made up of 10 scattered modules, each one of them owns a different function. The main building houses the bedroom modules (B1 and B2) and the habitability module (A) where the offices, kitchen, dining room and pantries are located. Each module has two floors, with the main uses located on the upper floor and the services and facilities on the ground floor. These three modules are arranged forming a "Y" joined by a core (N) with a hexagonal plant. The science module (C) is located away from the others to avoid risks in case of fire propagation. It is made up of two floors where the laboratories and services are arranged. The rest of the modules have a single floor and a specific function (see Fig. 2).

3. RELATIONS BETWEEN SPACES: Table from Figure 2 shows the areas and percentages of occupation per use. It should be remarked the importance of working areas corresponds to the largest surface areas. It is also relevant that the index of occupants per square meter of space dedicated to the rest and leisure areas is 16.9 m2 per person. The spaces related to these functions are collected in a single set of three modules (A, B1 and B2). However, the work areas and facilities are located independently, separated from each other. All spaces are communicated through a path that facilitates the movement of people and machinery between the modules (see Fig. 2 and 3).

4. CONSTRUCTION: It was carried out in the stages indicated below, and always during the Austral summer seasons:

1. Transport of material to the beach in small boats.
2. Land grading and foundation construction.
3. Construction of spatial structure, columns and beams.
4. Cladding.
5. Facilities installation.
6. Decoration and furniture.

5. CONSTRUCTIVE ELEMENTS: The following part of the building have been considered as key elements:

- FOUNDATION: Isolated footings made up of precast concrete slabs, stacked in situ using prestressed bars and filling material.

- STRUCTURE: Spatial bar structure made of galvanized steel against corrosion, raised above the ground by means of metal supports anchored to the foundations. Above it there is a simple structure of galvanized steel beams and pillars.

- CLADDING: Made of sandwich panels with double metal skin with core made of thermal insulation (polyurethane foam inside). The outer sheet also has a thin layer of protective coating based on polyester reinforced with fiberglass and a red gel coat finishing layer. It is remarked that due to the strong UV radiation, low temperatures and thermal contractions, the sealant between panels has turned out to be a very important

component of adequate durability. Finally, double-glazed windows with an air gap filled with argon, and solar coating were placed (see Fig. 5).

- FACILITIES: The most relevant are summarized below:

• Fire protection: Extinguishing system by an antifreeze solution of water solution, fire-resistant doors, and a detection system.

• Energy production / air conditioning: Cogeneration system. The heat from the three Diesel generators that produce the energy is used to heat the water and heat the indoor spaces. It also has 24 solar panels and 3 wind turbines that produce energy and are stored in 24 batteries, allowing the continued work of the research teams.

• Variable production of drinking water and water treatment: During part of the Austral summer, the nearby stream brings melt water. There is a stream water treatment plant and a reverse osmosis treatment plant to purify sea water.

• DHW production: It is provided thanks to the cogeneration system; starting from the tank, from there it is pumped to the different modules through thermally insulated external pipes.

• Waste disposal: The base has an incinerator and a compactor for the treatment of waste and a selection and segregation system. The waste is stored until it is removed from the mainland.

The critical aspects to consider for the design of a base are:

1. OCCUPATION: Temporary or permanent. The logistic cost and maintenance of a permanent base is much higher than in a temporary one, that is why there is a general tendency to design temporary bases. Permanent bases are more restrictive because they must accommodate staff and meet their needs during the severe Antartic Winter weather. Given these restrictions, it is more advisable to design focusing on permanence, even if it turns out to function as a temporary base.

2. LOCATION AND SITE LAYOUT: Defined by the scientific research program together with resources and ease of transport, terrain, climate and accessibility, which will define its location. Compact or dispersed settlement of the base and its complementary or temporary facilities.

3. ZONING: Classification of interior spaces into four categories of zones or uses: rest, leisure (especially important because of isolation and harsh working conditions), work and facilities. The sleeping areas include the sleeping rooms and their services. The leisure areas are the social spaces such as the dining room or recreational areas, among others. As for the working areas, these refer to the laboratories and offices where research is carried out. Finally, the areas for installations will provide shelter for the equipment necessary for the base operation.

4. CONSTRUCTION PLANNING: It is necessary to organize previously its transport and assembly, which requires the construction of full-scale prototypes, in order to avoid logistical and constructive problems later on, as well as the need to provide accommodation for the personnel required for the construction.

5. CONSTRUCTION SYSTEMS AND INSTALLATIONS: Prescription of prefabricated materials and construction systems, not necessarily innovative, but favorably assessed in terms of their fitness for the intended use, e.g. (DIT, DITplus, DITEX) of their demonstrable durability in an extreme climate (low temperatures and strong radiation).

Care in the design and construction of foundations, structure, envelope and installations, as an example an elevated pillar layout, which will be necessary to limit the accumulation of snow due to wind. In order to avoid burying the base or blocking access.

Complex thermal, DHW, fire protection installations, capable of responding durably, reliably and effectively in case of emergencies.

6. FUTURE LINES OF RESEARCH: Antarctica is not an earthquake-free zone. Consequently, this new seismic factor will have to be studied and analysed in order to understand the risks and, therefore, the strategies to be followed in terms of the location and design of future base structures.

The scientific research bases in Antarctica were designed for a certain estimated useful life and based on technical solutions available in the market. In the case of the BAE, this would be 20 years, of which almost a decade has elapsed. That is why there are opportunities for the development of new lines of research in the field of construction in the building itself, for example by incorporating super-insulating materials, ultra-resistant sealants, interior coatings with antibacterial properties among others.

List of Illustrations

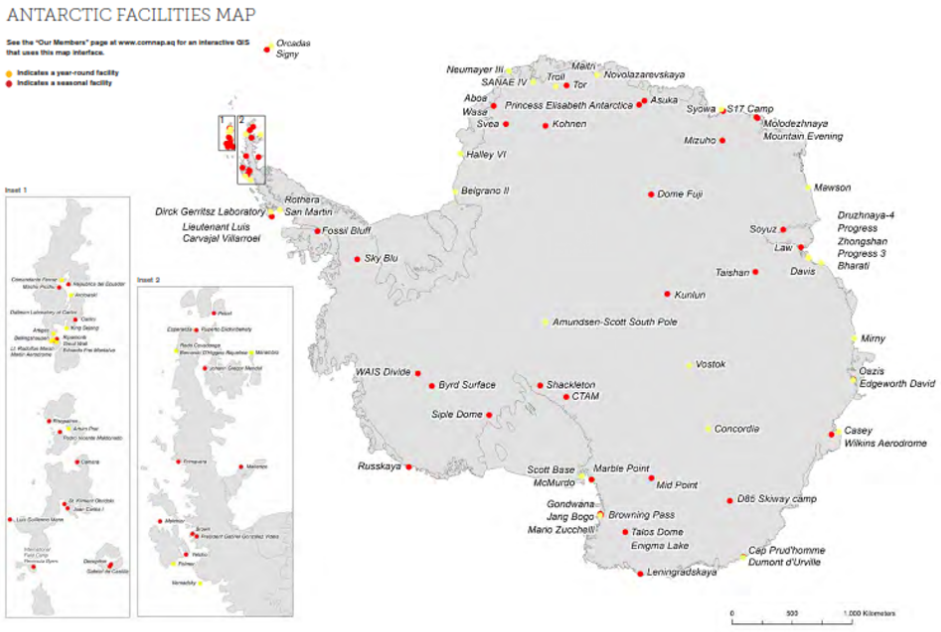
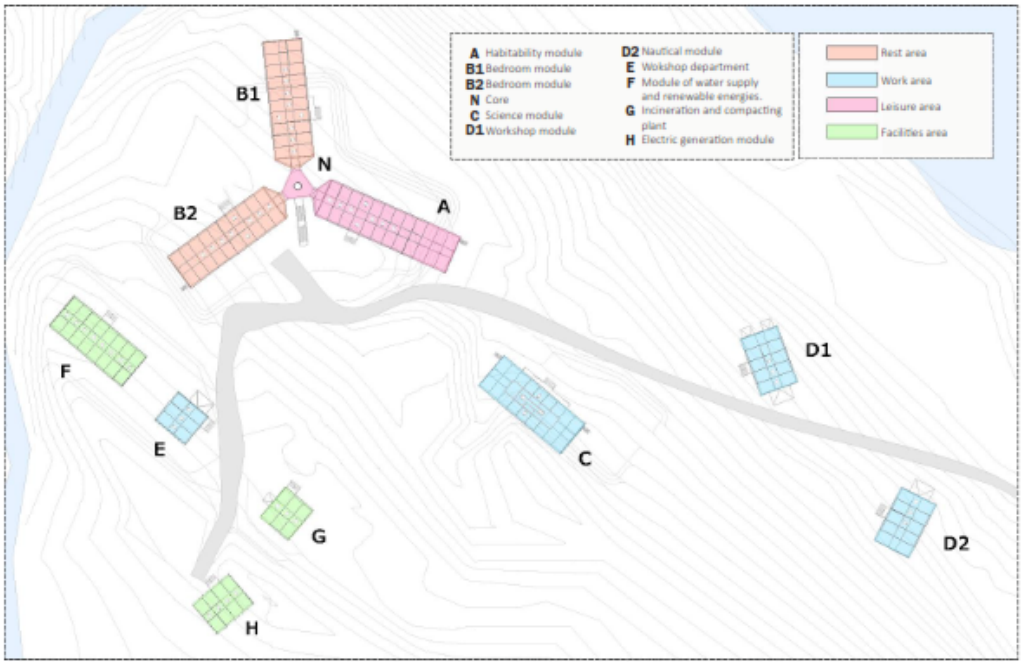


Figure 1: *Antarctic map. (Source: COMNAP Catalogue)*



AREAS	Surface area (m^2)	Percentage (%)
Rest area	423	24
Work area	550	32
Leisure area	421	24
Facilities area	356	20
Total	1750	100

Figure 2 and Table 1: *Base program. (Source: own elaboration)*

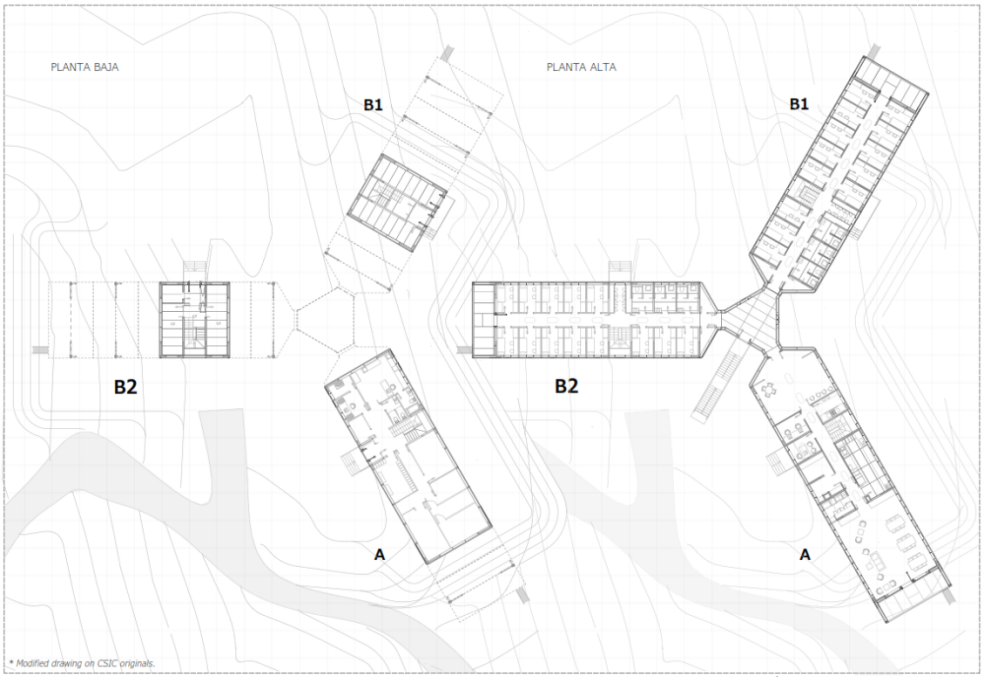


Figure 3: *Habitability area plan. (Source: own elaboration)*

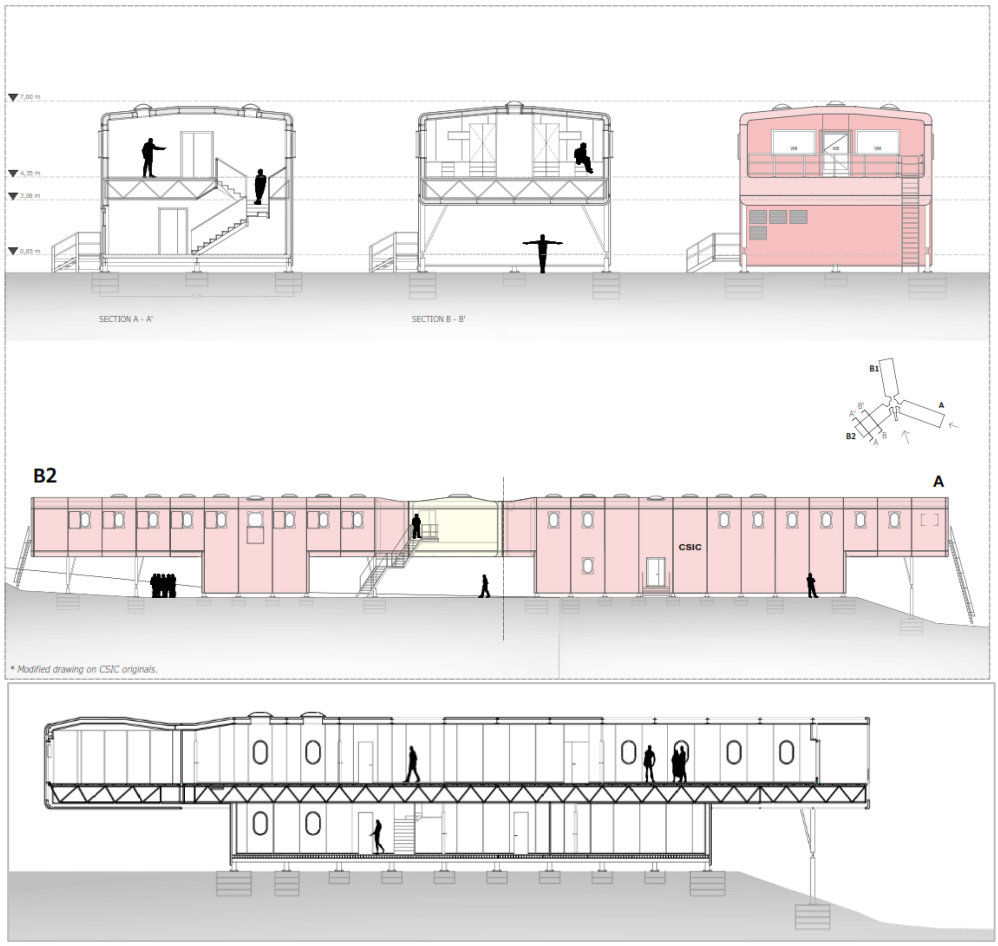
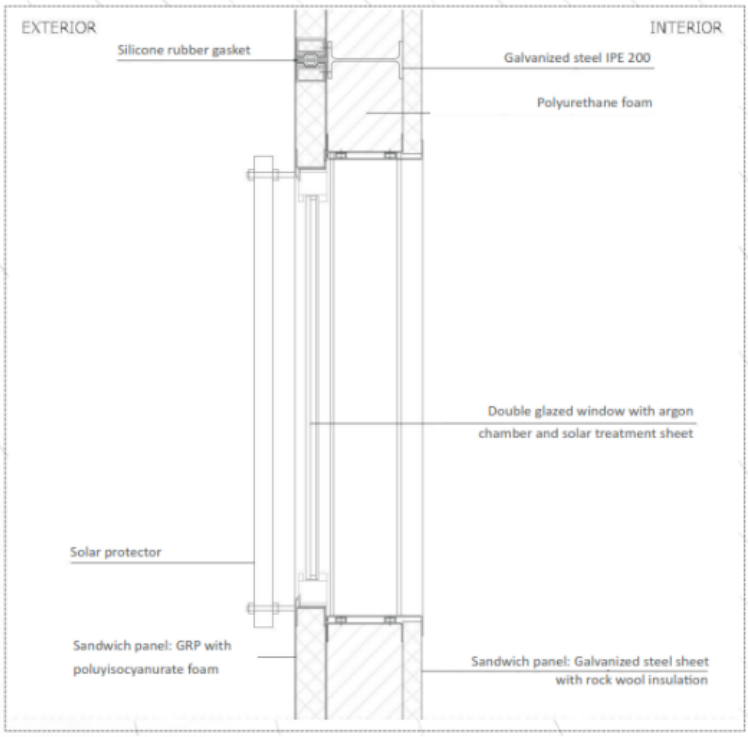


Figure 4: *Habitability area. Elevation and sections. (Source: own elaboration)*



LAYER	THICKNESS E (mm)	CONDUCTIVITY Λ (w/ M·k)	THERMAL RESISTANCE (m2 ·K/W)	MATERIAL
J	3	0,4	0,0	Glass Reinforced Polyester
K	80	0,025	3,2	Polyisocyanurate foam
J	2	0,4	0,0	Glass Reinforced Polyester
L	205	0,028	7,3	Polyurethane foam
O	2	0,4	0,0	Polyester lacquer
M	50	0,037	1,4	Rock wool insulation
O	2	0,4	0,0	Polyester lacquer
TOTAL			11,9	
TRANSMITTANCE (W/ m2 K)			**0,08**	

Figure 5 and Table 2: *Cladding components. (Source: own elaboration)*

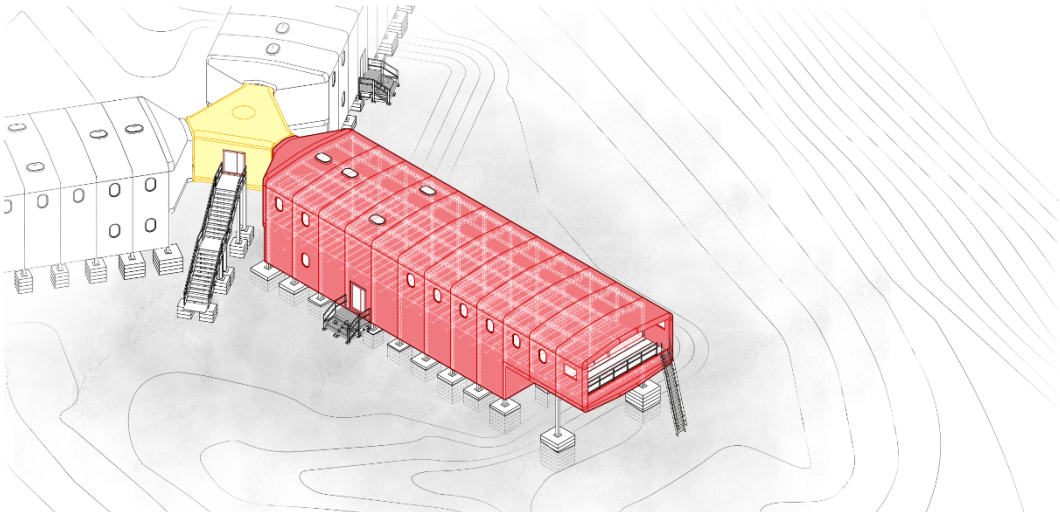


Figure 6: *Isometric perspective Juan Carlos I base. (Source: own elaboration)*

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INTRODUCTION TO THE PROJECT MANAGEMENT IN THE DEGREE OF BUILDING

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Keywords: *project management; scheduling; degree of building*

Abstract

Several methodologies for project management have been introduced over the years in the construction industry. However, in this industry, it is not uncommon for projects to fall behind and exceed the allocated budget mainly due to high dependency on labour. Furthermore, the construction industry is fragmented due to the many stakeholders and phases involved in a construction project [1].

On the other hand, currently students ask university professors to connect their teaching with professional reality, in a similar way to how the Bologna Plan understands the design of university degrees [2]. Scholars universally agree that practically applicable knowledge of construction management tools and methods is difficult to learn [3]. Therefore, our educational contribution in construction and management is based on the learning of Project Management as part of this demanded reality (Fig.1).

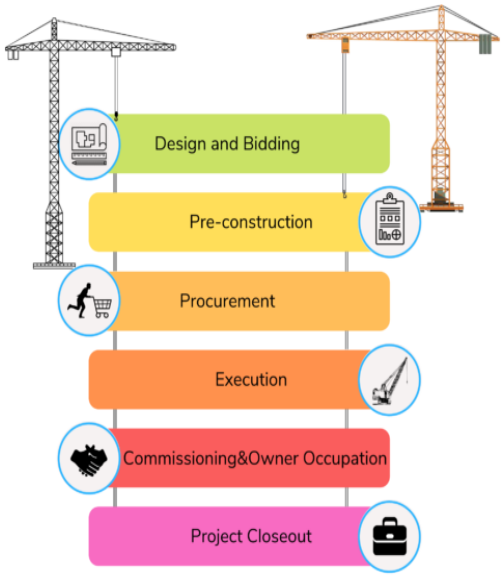


Figure 1: *Project Management phases.*

The main objective is to incorporate basic knowledge of Project Management as part of the subject of Planning and Scheduling of Works II, in the degree of Building at the Polytechnic University of Madrid. This knowledge includes everything from the management of project information in the different phases of Project management, to the collaboration of the interested parties (Fig.2).



Figure 2: *Project Management lessons content.*

It takes a program-wide approach to implementing Project Management as the central spine for linking subject based case study content and related problem-solving activities. This begins with the theoretical basis as a tool for teaching and learning, and the intention of drawing together built environment students under a more common and collaborative theme of study.

The curriculum design allows individual subjects to access and make relevant use of Project Management as non-prescriptive teaching infrastructure. All of this helped students learn to apply different formal project management methods to real-world project management problems.

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INFLUENCE OF ARCHITECTURE ON THE COMMISSION OF A CRIME

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Keywords: *security by design; architectural design; protection from crime; CPTED; iter criminis; path of crime*

Abstract

The environment where the human being lives and interacts influences their interactions.

Undoubtedly, the objective of any self-respecting society is to have safe spaces that allow the community to evolve in a sustainable, egalitarian and risk-free way. The Constitution itself reflects this, "everyone has the right to liberty and security" [1].

The European Estates work to achieve an urban and architectural design that improves the safety of all citizens. Its basis of commitment was created in the European Urban Charter of 1992 [2], where it was included as a basic right of citizens who can count on “a safe and protected city, free, as far as possible, from crime, delinquency and aggressions”.

Shortly after, the Final Declaration of the International Conference of the European Council of February 1997 [3], determined as fundamental the collaboration between the professionals of Architecture and Urbanism and the Security Forces and Bodies. The objective is the achievement of safer spaces, with two clearly differentiated lines of work, one path of commitment is the improvement in the design of the spaces and another path of work is the training of Security Agents on Architecture with influence on the possibility of the materialization of a crime.

Security is the foundation for the development of a balanced society. Preserving freedom, stability and ensuring the proper functioning of its institutions should be the priority objective of any State [4].

For all these reasons, the European Union works to create architectural designs that increase security. With this approach, the UNE-EN 14383 standard for crime prevention, urban planning and building design arises [5].

Looking for the means of increasing the security of the spaces that we all share, I carried out a scientific investigation in which I analyzed the architectural parameters influencing real physical security and perceived security. In 2019 I published the results in the article "National security, basis of architectural design work" [6]

The architectural design parameters that were studied were analyzed with two complementary views. On the one hand, there was a general perspective where different architectural aspects were related and on the other, a more specific vision of each parameter was deepened and sought. All these architectural points were studied during all the phases of a security incident, being crime prevention, its development and the response by third parties.

Among the architectural aspects that I specifically analyzed, it was lighting, visibility, noise, maintenance, perimeter, gaps in the facade, the composition of exterior and interior walls, interior distribution, and interior gaps. With a general vision, I valued the influence of urban planning, the parameters of the architectural design and its attractiveness, the environmental agents, the surroundings and the facilities (not specific to security).

Based on these results, it is possible to study which crimes may have a greater or lesser probability of success depending on the architectural parameters identified above, affecting a property and during all phases of the commission of a crime.

If we speak of crimes, without a doubt we must resort to our legal system, as indicated by the Royal Spanish Academy of Language (hereinafter the RAE), since it defines crime as "voluntary or reckless action or omission punishable by law" [7]. The law with criminal scope in our country is the Penal Code (hereinafter CP) and it is the one that limits the acts punishable by crime [8].

The environment where a crime is committed can be logical or cybernetic and physical. The scope of the crimes committed within a logical environment is not the object of study in this work, but all those crimes included within our legal system that may take place in a physical environment are.

The punishable acts that are the object of this analysis are those carried out within an architecturally defined environment, space or property, as they are where they occur. Therefore, these spaces will have a greater or lesser probability of the materialization of a crime depending on their architectural design and maintenance.

Historically, the analysis of the security or Security Plan that is developed in the countries, in the cities and their infrastructures is after its construction. With this reactive approach, scenes or spaces appear where it is impossible or very expensive to eliminate criminal risk, thus increasing the probability of suffering a security incident.

It is essential to consider safety from the conception of spaces and buildings, from the beginning of a construction or urban development, but also to keep safety in mind throughout the life cycle of the real estate asset.

The scope of the influence of architecture in the commission of a crime is developed throughout the doctrinal exposition.

Therefore, the influence of architecture in the commission of a crime is justified, exposing existing regulations, the CPTED method and a specific study of architectural parameters and their influence in all phases of the criminal process. It is concluded that all the parameters analyzed affect all phases of the security incident, the most influential parameters being lighting, maintenance and upkeep, visibility, gaps in the façade and facilities.

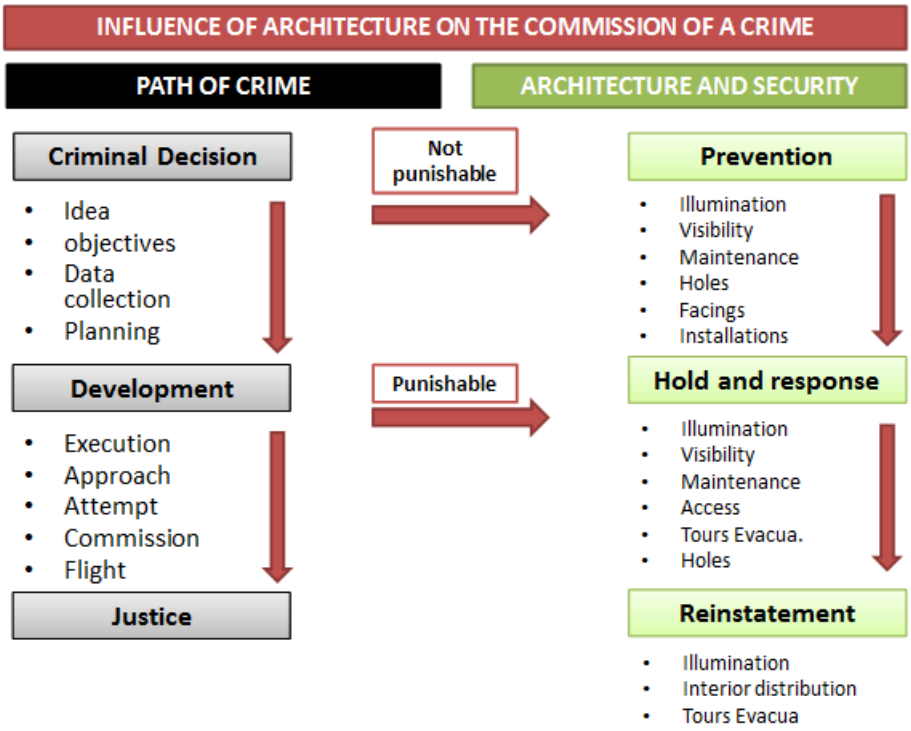


Figure 1: *Relationship between the path of crime and architecture*

The concept of crime and its trajectory are defined. The different crimes that our legal system contemplates and that are influenced by the environment where they occur are identified. It is shown that more than 90% of the crimes committed in our country are influenced by architecture.

And finally, the direct and indirect costs of a security incident are examined. The material, immaterial and human cost of the incident itself. As an indirect cost, the psychological consequences and all the costs of the judicial process are valued.

As a conclusion, it is proposed as a mandatory nature, the contemplation of safety by design or safe architectural design, in all stages of the life cycle of an asset. From the project phase, the building book, the maintenance book.

The final and innovative objective is to reduce crime and its associated costs, both material and human, through architectural design and maintenance.

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COVID-19 IMPACT ON END-USER'S MAINTENANCE REQUESTS. A TEXT MINING APPROACH

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Keywords: *building management, work order, text mining, sentiment analysis*

Abstract

COVID-19 pandemic changed our way of working, limiting the usual physical attendance of working spaces. Despite the drastic reduction in the number of daily users due to the pandemic restrictions, working buildings were often kept open to provide services to internal and external users. Pandemic obliged to change operation and maintenance (O&M) plans, due to the increase of ventilation requirements and the reduction of other types of services, with a strong impact on cost and management. Now the pandemic is reducing its effects and is time to question the future asset of buildings' O&M plans, based on the pandemic lesson. Data collected by Computerized Maintenance Management Systems (CMMS) during COVID-19 then become an important source of understanding the future management of working places. End-users' maintenance requests are usually expressed by natural language, then a text mining approach can be a useful tool to discover hidden knowledge from unstructured data stored in CMMS.

Text mining is a fundamental tool to discover hidden knowledge from massive and complex data stored in databases or other information repositories [1]. Recently, sentiment analysis methodologies have been applied to analyze some aspects of the building management process [2]. Text mining techniques [3] were applied to identify the major treated topics related to the energy use and management of buildings. Loureiro and Alló [4] employed Natural Language Processing (NLP) tools, based on the National Research Center Canada lexicon (EmoLex). Sun et al. analyzed microblog posts to derive information about energy policies [6]. Liu and Hu performed sentiment analysis of the public attention status toward green buildings, based on Ekman's six basic universal emotions [7]. NLP models were applied to the facility management of buildings, collecting sentiments and opinions from end-users, to improve the building operability and the cost of the management process [8], [9]. Bortolini and Forcada developed a methodology to determine the typical problems that end-users complain

about the building systems and their perceived severity [10]. Gunay et al. analyzed operators' work order descriptions in Computerized Maintenance Management Systems (CMMS), extracting information about failure patterns in building systems and components [11]. Bouabdallaoui et al. proposed a machine-learning algorithm based on NLP to manage day-to-day maintenance activities [12]. Sexton et al. Compared different NLP methodologies to extract keywords from maintenance Work orders [13]. Bardhan et al. employed two emotion lexicon databases to collect information from users' groups regarding housing management in India [14]. Sun et al. calculated sentiment value on energy price policies, using polarity and intensity of sentiment words, based on the China HowNet Thesaurus.

In the field of building maintenance, sentiment analysis methodologies could be also useful to reduce the risk associated with delays in intervention. Indeed, they could extract useful information at the beginning of the process (at the end-users' request moment) in order to categorize and prioritize the requests. However, users' perception can affect this outcome, since requests' features also depend on the psychophysical state of each person, due to contextual internal and external factors. In this sense, COVID-19 dramatically changed people perception in several aspects, comprising the interaction with buildings. Hence, it is necessary to understand how COVID-19 altered users' perception about Facility Management (FM) processes.

This study applies text mining methods, including sentiment analysis, to the field of building maintenance, with the scope to evaluate how COVID-19 changed some aspects of the facility management process, including users' perception.

The impact of the COVID-19 pandemic on maintenance activities of a set of 23 university buildings has been evaluated through a text mining approach, applying TF and sentiment analysis methods. The end-users maintenance requests generated during the different pandemic phases have been analyzed and information was collected about the shifts recorded in the end-users' maintenance requests in terms of amount, type and end-users' perceptions.

Basing on the textual classification performed by FM technicians involved in the process, the number of monthly WOs/m2 has been derived for each COVID period. A total of about 12000 end-users' maintenance requests has been processed through R statistical software (rel 4.0.3). For each intervention category, the number of WOs/m2 has been also derived to evaluate possible shifts in their proportion and trends due to the pandemic. Then a Term Frequancy (TF) analysis has been performed on the end-user's sentences in the WOs corpus, through KH Coder software to check the most frequent words describing the issue and the action required. After that, a hierarchical cluster analysis has been performed using the ward method and the Jaccard distance to obtain a visual association between the most frequent words into specific clusters (TF > 400), useful to evaluate the recognizability of the required intervention categories. Then, sentiment analysis methods based on polarized lexicons have been applied [10]. The unstructured textual part of WO's dataset (e-mail or message text) has been analyzed through R statistics software, and the following packages: "Sentimentr" [36], "Syuzhet",

"SentimentAnalysis", "Lexicon", and "Vader" [37]. Polarity based and Valence-based lexicons have been considered [38], [39]. Finally, to compare the coherence between the lexicons in the attribution of the polarity score, correlation analysis has been performed, based on the Spearman non-parametric method, due to the verified non-normality of the samples. Statistical analysis was performed through the R statistical software and the "stats" package.

The results show that the pandemic caused a shift in the amount and type of requested interventions. Apart from the general reduction during the lock-down phase (Table 1), we observed changes in HVAC category, due to the interventions required for security reasons. However, COVID seemed to have a short term impact. The distribution of the interventions in the last two phases of the pandemic remains almost the same as the pre-covid situation. However, TF analysis showed shifts in the user perception. Similar results are derived from sentiment analysis, but it is evident that the application of current lexicons and methodology need improvements when applied to technical languages such as the ones of FM (Figure 1,2). In fact, Sentiment analysis is based on lexicons that contain in some cases only a limited number of related technical polarized terms, beiung developed starting from general purposes datasets. Then, future researches should improve them so as to ensure a possible application of these methodologies, and then to automatize some aspect of the facility management process (i.e. categorization of the end-users maintenance requests, priority assignation).

Table 1 *Monthly mean number/m2 of end-users' maintenance requests*

Phase	Building components	Electrical	HVAC
1	0.0048	0.0069	0.0041
2	0.0016	0.0028	0.0015
3	0.0025	0.0036	0.0038
4	0.0045	0.0064	0.0033

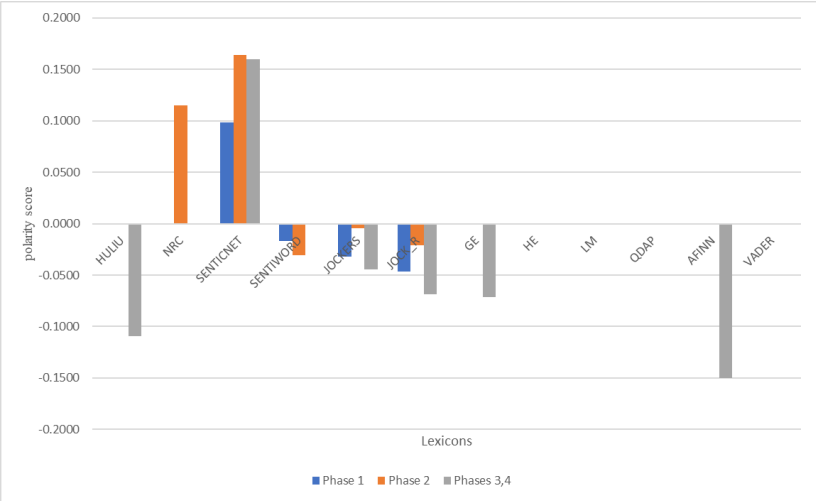


Figure 1: *Sentiment analysis performed through lexicons. (a) Pre-covid data – phase 1; (b) Lockdown data – phase 2 a; (c) Post-lockdown data – phases 3 and 4; (d) Total dataset.*

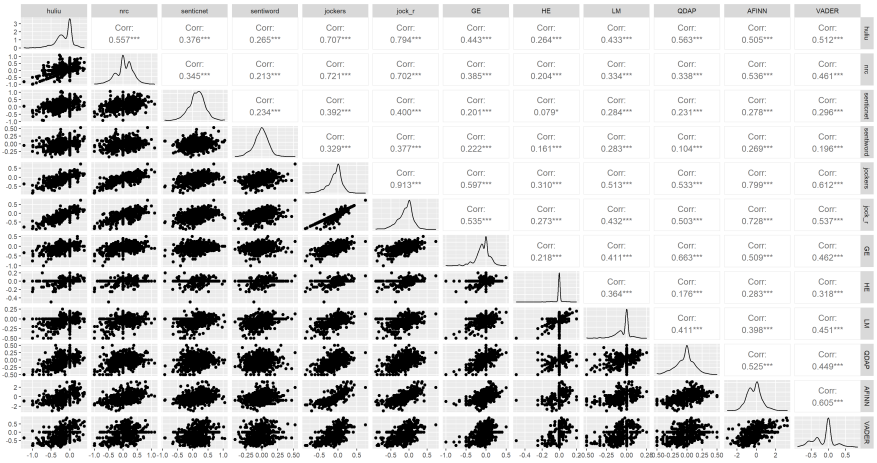


Figure 2 *Correlogram of the scores attributed through the Sentiment Analysis.*

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AUTOMATION SYSTEM FOR ADAPTIVE COMFORT OPERATIONAL PATTERNS: A CASE STUDY

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Keywords: *adaptive comfort; energy efficiency; climate change*

Abstract

Using adaptive setpoint temperatures, which are setpoint temperatures based on adaptive thermal comfort models, has been studied and proved to be an energy conservation measure (ECM) with an important energy saving potential in the last years [1,2]. In order to use adaptive setpoint temperatures, these were applied to the EnergyPlus building energy models by means of Schedule:Compact objects, which resulted to be the most efficient among other methods. However, since adaptive setpoints varied for each location, it was necessary to run the simulations manually one by one after changing the EPW file and the Schedule:Compact for each location, thus the process was still quite inefficient, tedious and error-prone, considering the simulation runs were numbered over dozens or hundreds. These weaknesses were strengthened when the recently published Adaptive-Comfort-Control-Implementation Script (ACCIS) was developed, which allows to extend the air-conditioning usage to adaptive thermal comfort [3]. ACCIS transforms Predicted-Mean-Vote-based into adaptive setpoint building energy models according to both an Input Data File (IDF) and the setup specified by the user. Originally, ACCIS was an Energy Management System (EMS) script, but available functions have been extended, and ACCIS has been nested in an easy-to-use Python package called 'accim' [4]. What makes 'accim' interesting is that it allows customised adaptive setpoint simulations to be run with no limit number, and this is achieved by means of two main features. The first feature is that accim allows a high customization of the output IDFs because multiple values can be used for multiple arguments, which are the adaptive standard to be used, the category or acceptability thresholds, the Heating, Ventilation and Air-Conditioning (HVAC) mode, among others, which are 9 no (Figure 1). The second feature is that adaptive setpoints can be calculated 'on the go' by both the EMS programs and EnergyPlus, and therefore any IDF can be simulated with any EPW file. Therefore, while performing simulations with adaptive setpoints was previously limited to dozens or hundreds, the use of ACCIS and 'accim' allows to increase the number to thousands or millions, or even without any limit, since it only depends on the computational cost that can be assumed (Figure 2). This provides

new possibilities to perform energy simulations, and subsequently energy poverty, adaptive comfort or climate change mitigation studies not only at a country or continent scale, but a global one. The aim of the study here presented is to carry out a computational approach test study, based on different input parameters, considering different locations and present and future climate scenarios, and analyse the energy saving potential of using adaptive setpoint temperatures.

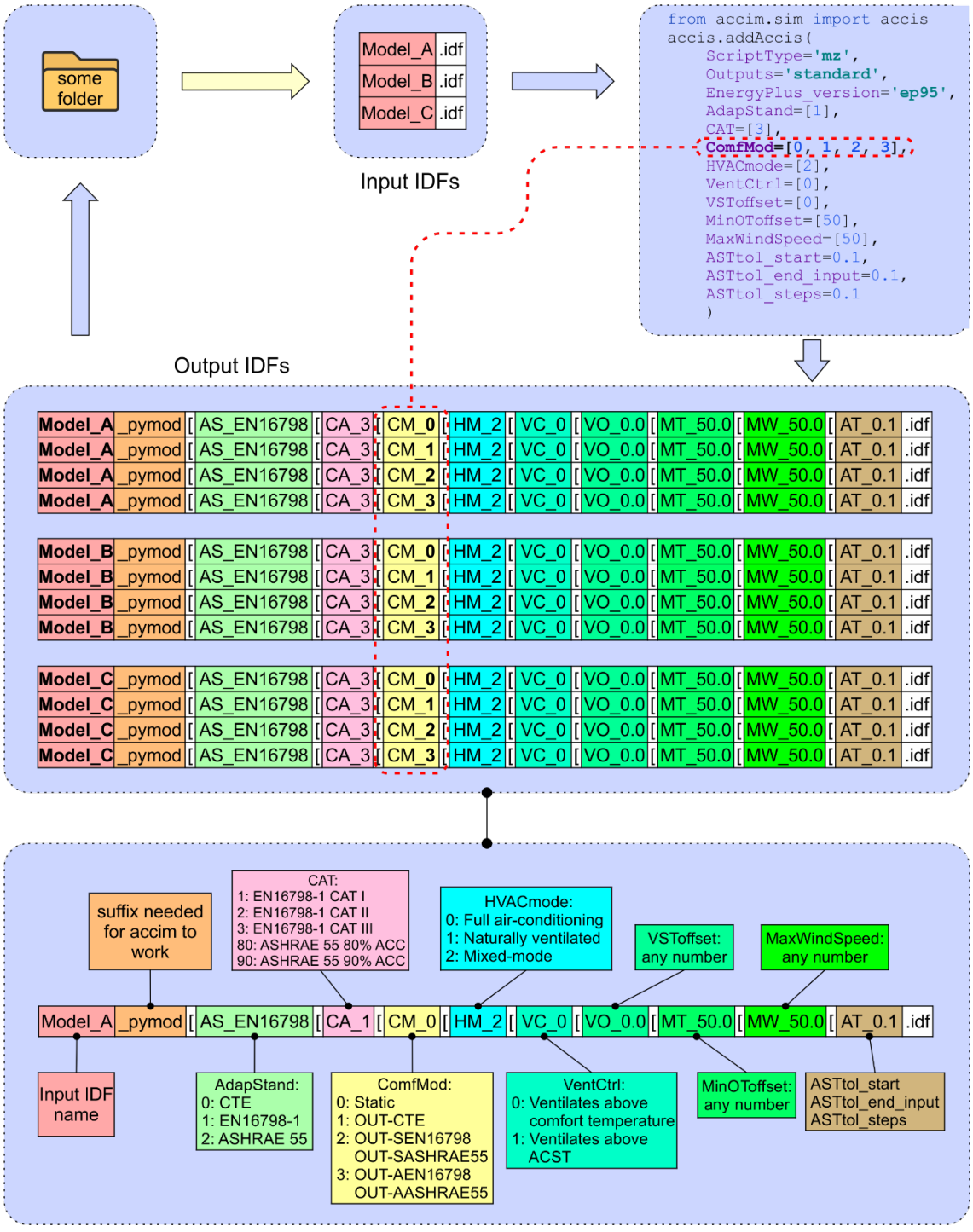


Figure 1: *Output IDF generation process*

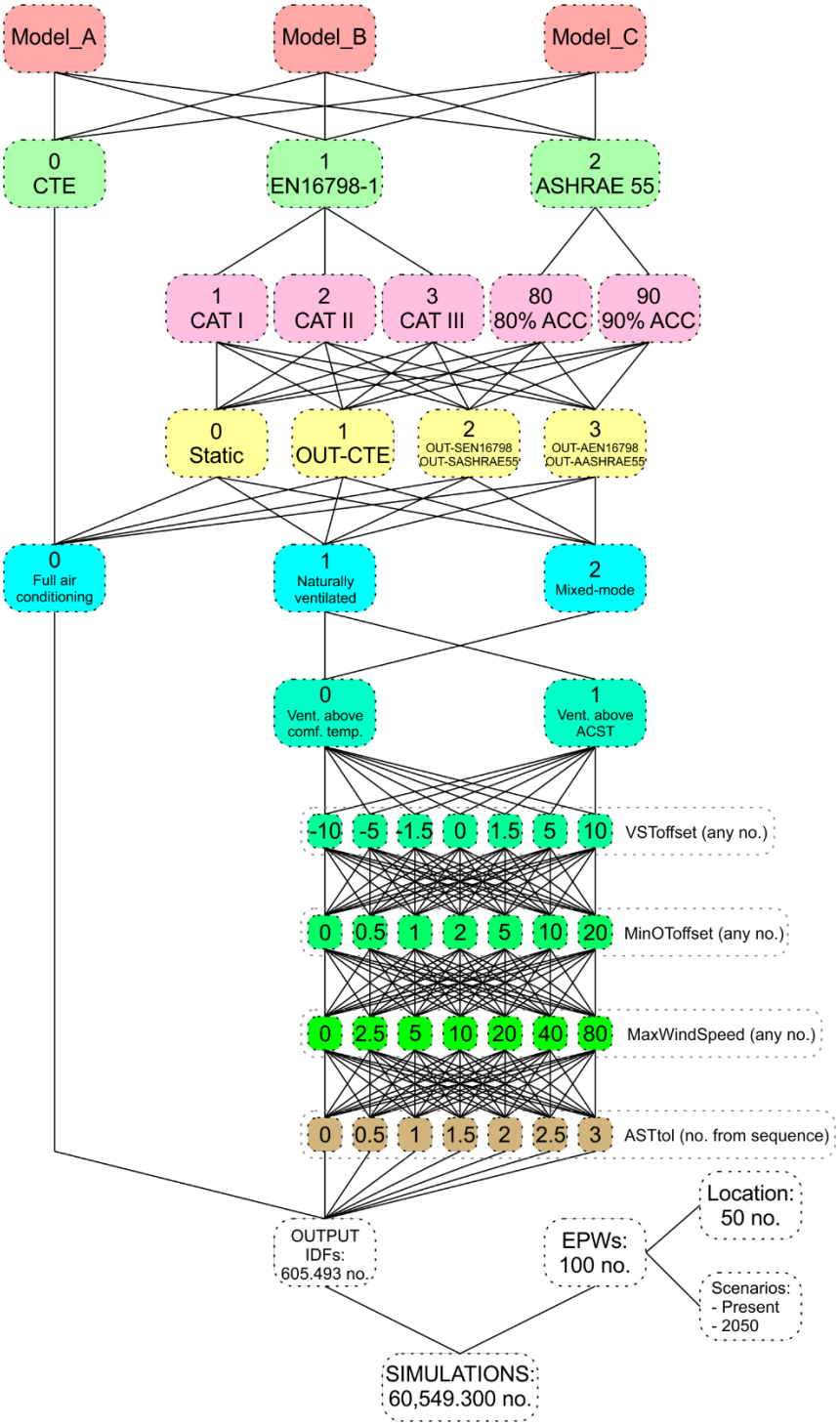


Figure 2: *Extensive Output IDF generation*

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