CITE 2020

DEPARTAMENTO DE TECNOLOGÍA DE LA EDIFICACIÓN

25th,26th and 27th of March 2020

ESCUELA TÉCNICA SUPERIOR DE EDIFICACIÓN
UNIVERSIDAD POLITÉCNICA DE MADRID
Avda. Juan de Herrera, 6-28040-MADRID

LIBRO DE ACTAS

ABSTRACTS BOOK

International Conference on Technological Innovation in Building

Congreso Internacional de Innovación Tecnológica en Edificación

V CONGRESO INTERNACIONAL DE INNOVACIÓN TECNOLÓGICA EN EDIFICACIÓN

CITE 2020

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Depósito Legal : **M-4789-2020**

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PRESENTACIÓN

V CONGRESO INTERNACIONAL DE INNOVACIÓN TECNOLÓGICA EN EDIFICACIÓN

(CITE 2020)

25, 26 y 27 de marzo de 2020

CITE nació en 2016 con el objetivo de favorecer la transferencia de conocimiento sobre aprendizaje, innovación y competitividad entre ámbitos productivos y formativos, así como dar a conocer mejores prácticas sobre innovación en formación y aprendizaje en el sector de la edificación. Así mismo, el congreso ha actuado como punto de encuentro entre distintos agentes sociales relacionados con la formación, a fin de fomentar la cooperación entre sus participantes y extenderla a otros ámbitos relacionados con el aprendizaje, la innovación y la competitividad en dicho sector.

Esta nueva edición del CITE, la quinta, es diferente a todas las anteriores. Como sabéis, todos nuestros planes, rutinas, eventos,… han cambiado radicalmente a causa de la pandemia COVID-19, y no nos ha quedado más remedio que reinventarnos y seguir con un congreso virtual. El destino nos ha brindado este reto que hace que sigamos aprendiendo, superándonos, innovando y avanzando juntos. Muchas gracias a todos los ponentes que han sabido adaptarse a los repentinos cambios y están respondiendo muy satisfactoriamente a los nuevos formatos.

Pretendemos que esta nueva versión del Congreso Internacional de Innovación Tecnológica en Edificación, CITE20, sea un éxito de comunicaciones, en formato virtual, y del que podamos obtener resultados enriquecedores en el campo de las innovaciones tecnológicas, que nos ayuden a mejorar futuras ediciones.

La organización del **programa CITE 2020** contiene este año y de manera excepcional, todas sus actividades (comunicaciones orales y posters) en formato virtual y disponibles a través de la página web. Las diferentes áreas temáticas son materiales y sistemas constructivos, prevención y seguridad eficiencia energética, domótica, rehabilitación, mantenimiento y patología en edificación, experiencias en innovación tecnológica en edificación.

También agradecer la inestimable colaboración de las empresas Placo-Sain Gobain y Ursa Ibérica Aislantes, y la Cátedra-Empresa Proiescón.

El Comité organizador

Building Environment

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Materials and Construction Systems

Rehabilitation Pathology and Building Maintenance

General Issues

BUILDING ENVIRONMENT

MODULUS OF ELASTICITY OF REINFORCED MORTARS WITH MINERAL WOOL FIBERS RESIDUES FROM CONSTRUCTION AND DEMOLITION WASTE

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Keywords: *Cement mortars, mineral wool, recycling, young's modulus, construction and demolition waste*

Mineral wool is currently the most used insulation in the European Union, and quantities of this waste have increased alarmingly in the last decade [1], making it essential to recycle or reuse the material, which is not current practice.

This study is part of a research that analyses the viability of the mineral wool from the construction and demolition waste (CDW) as reinforcement of cement matrices [2]. The experimental investigation started with a preliminary study on the applicability of the waste material for its incorporation into a cement matrix based on its physical and chemical characterization [3].

The objective is to analyse the elasticity behaviour of a material composed of a cement mortar matrix to which the aforementioned waste is incorporated.

For this purpose, an experimental plan is made in which cement mortar specimens are made with 30% of different types of mineral wool waste, on which Module of Young test is carried out to evaluate their viability as a reinforcement material (Figure 1).

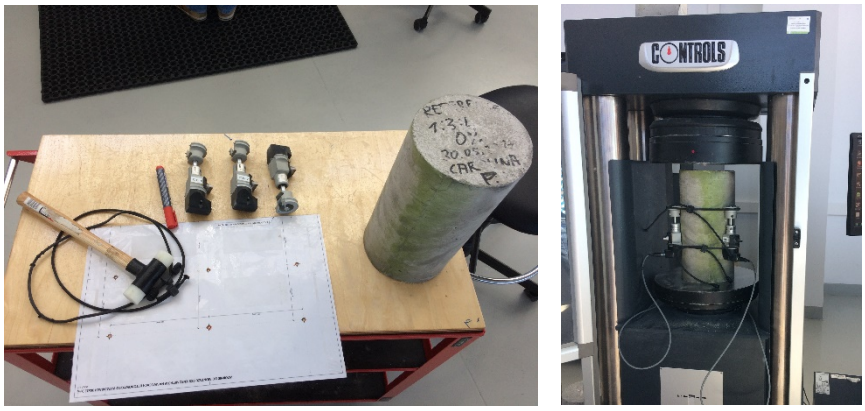

Fig. 1. Module of Young test

It is verified that the incorporation of fibre waste reduces the modulus of elasticity of the compounds analysed, for the addition of 30% of the three types of mineral wool waste used (Table 1).

Fibre content (% vol.)	Cycle (MPa)	Young's Mod.	Standard deviation
Reference	22.87	22.92	0.12
	22.83		
	23.06		
30% RW	19.30	19.23	0.11
	19.29		
	19.11		
30% FG	18.20	18.22	0.02
	18.24		
	18.22		
30% MIX	18.89	18.89	0.01
	18.88		
	18.90		

Table. 1. Values of the Young's Modulus (MPa)

In the values obtained it was observed that the mortars that incorporate rock wool waste, fiberglass waste and mixed waste of mineral wools, present 16%, 20.5%, 17.6% less rigidity that the reference mortar. It is also reflected that the most elastic compound is the mortar to which fiberglass is incorporated.
It was found that the incorporation of waste of mineral wool to a cement mortar matrix is a viable alternative for its recycling.

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CONSTRUCTION AND DEMOLITION WASTE AS DRAINAGE IN LANDSCAPED ROOFS

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Keywords: *Waste management; recycling; ceramic waste; concrete waste; green roofs*

Since 1990, the world has seen an increased gathering of its population in urban areas. This trend is not new, but relentless, and has been marked by a remarkable increase in the absolute numbers of urban inhabitants. In 1990, 43 per cent of the world's population (2.3 billion) lived in urban areas, by 2015, this had grown to 54 per cent (4 billion) [1].

As the urban population increases, the land area occupied by cities has increased at an even higher rate. It is expected that by 2030, the urban population of developing countries will double, while the area covered by cites would triple [2].

Thus, cities must play a greater role, because urban areas have the potential to reduce ecological footprints and to connect rural and natural environments, and this is the reason why cities are included in the 2030 agenda for sustainable development, in the goal 11: to make cities and human settlements inclusive, safe, resilient and sustainable [3].

In this sense, green or landscaped roofs can be an important asset for the recovery of abandoned spaces in the city, and an opportunity for the development of more sustainable cities. In addition, the incorporation of vegetation into the urban system generates benefits in all three aspects of sustainability: social, economic and environmental [4, 5].

On the other hand, and according to the UK Green Building Council [6], the construction sector uses more than 400 million tons of material each year, much of which has a negative environmental impact**.** Therefore, in recent years there have been numerous researches that have aimed to find alternatives for construction and demolition waste trying to replace the costly raw material for the environment and incorporate Circular Economy criteria in the sector [7-14]. However, after a detailed bibliographic and documentary search, no studies have been found that attempt to analyze the possible replacement of the drainage layer of the landscaped roofs with construction and demolition waste, which is the objective of this study.

Therefore, an experimental plan in two phases was designed. In the first phase, the ceramic and concrete wastes were selected, and their physical properties (density and water behavior), as well as their leachate were analyzed. In a second phase, the capacity of these materials as a substrate is checked.

The results of the experimental plan were that ceramic waste has greater capacity for water absorption, which means a better use of rainwater and a decrease of the water necessary for cultivation, which is an interesting issue for roofs located in dry climates.

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VIABILITY OF THE USE OF TITANIUM COATINGS IN BRICK FACADES

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Keywords: *Titanium dioxide, photocatalysis, VOC, coatings, brick facades.*

Recent studies and research projects have shown that the use of TiO_2 (anatase) on the surface of some building materials would contribute to the reduction of volatile organic compounds (VOCs) [1]. Since then, many material manufacturing companies have considered this issue and are working on developing materials that include TiO_2 in one way or another. For this, the TiO_2 is combined or added to paints, tiles, glass, plastics, aluminum panels, paper, blinds and, in civil construction, such as acoustic panels, tunnels, traffic signs, street lamps, etc.

Generally, materials with TiO_2 reduce the consumption of resources, are resistant to water, fire, are not toxic and make the building improve in terms of safety and comfort, taking care of human health [2].

The applications and effect of titanium dioxide as a coating have been studied with cement, concrete and other materials [3]. However, few studies about the application of TiO_2 as a coating on brick factories have been found [4].

In this sense, this work analyzes the viability of these coatings on brick facades to improve their self-cleaning and their photocatalytic capacity to absorb VOCs.

To achieve the objective, the methodology used by I. González Morán [5] to determine the photocatalytic viability of TiO2 coatings on pine wood is followed.

The specimens, on which the tests were carried out, have ceramic surfaces (perforated bricks). But also have cement mortar (CEM 32.5) surfaces, and plaster surfaces, because we took into account the joints of the masonries.

For the experimental Plan, three types of Titanium preparations were used: The first one is: Ti 4+ in a hydrochloric base, the second one is an Ethoxide base and the third one is an Ixoproxide base.

After the application of the preparations, it is confirmed that in the first case hydrochloric gas was emitted, so we decided not to use it and in the other two cases, alcohols gasses were emitted. This should be taken into account at the time of application, although it would not be problematic because these coatings, in general, would be applied in open spaces, and the alcohol would quickly absorb by the atmosphere.

Conclusions of the experimental plan were that, after the treatment, the samples changed their colour, but the surface becomes smoother and softer.

However, we decided to reject the use of these coatings on the brick of heritage buildings, because their colour could change.

And considering that the photocatalytic effect is more important on the cement and plaster surfaces, it is proposed to study, the applicability of these coatings in the joints of the masonries, in a deeply way.

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PASSIVE STRATEGIES TO IMPROVE INDOOR AIR QUALITY AND WELLNESS IN BUILDINGS. STUDY CASES.

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Keywords: *Passive strategies; indoor air quality; healthy materials; regenerative construction*

In recent years, society is becoming aware of the serious environmental impact that buildings have. Therefore, in the last decade there have been many research projects that look for solutions to improve their sustainability. While it is true, these solutions have been, basically, to improve energy efficiency and introduce Circular Economy criteria [1-7].

In contrast, fewer studies are looking for solutions to build buildings considering positive impacts, on both, the environment and the health and well-being of users and the community. This new way of thinking is what it defines as regenerative construction [8, 9].

In this sense, issues such as the improvement of indoor air quality are the key to improve the comfort and wellbeing of users. Nowadays, we can find, on the market, different equipments for buildings, that allow this improvement, but it is more difficult to find buildings that integrate passive solutions, such as the use of materials that reduce formaldehydes or emit smaller amounts of toxic substances.

On the other hand, it is proven that people spend, on average, 90 percent of their time inside the buildings, and that in addition, we are not aware that indoor air is five times more polluted than outside air, even in large cities.

Numerous documents that address this issue in hospitals, such as the Green Guide for the health care sector [10] and also studies about the influence of indoor air quality in schools have been found, however, studies that consider this issue in residential building have not been found.

Therefore, the construction company Arpada, together with the UPM School of Building, is developing a study about how to improve the indoor air quality, by replacing the materials currently used for interior spaces (cladding, carpentry , glasses, etc.,) by alternative materials, more sustainable and, above all, healthy for people.

In a first phase of the study, the review of the state of the art and the analysis of some case studies was carried out, resulting in a list of possible alternative materials to coatings and finishes.

The second phase will consist in the selection of some of these alternative materials and their application in a company project, quantifying quantitatively and qualitatively, the benefits provided and comparing these results with other similar projects.

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STUDY OF THE PERFORMANCE OF PASSIVE COOLING SYSTEM IN BUILDINGS IN ARID CLIMATE

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Keywords: *Passive cooling, local materials, thermal comfort, PMV, PPD, TRNSYS*

The building sector is the largest consumer of energy; indeed, studies show that the building sector consumes around 40% of the world's energy, and accounts for around 1/3 of greenhouse gas emissions [1]. It is now a high stakes industry as regards the potential for energy savings and reduction of greenhouse gas effect. Therefore, a real determination to reduce energy costs and to improve environmental conditions is required [2]. In Algeria, the building sector is one of the most dynamic sectors in the country, a result of a high population growth rate and urbanisation. This inevitably has led to a housing shortage and the public authorities favoured the following construction criteria: speed and low costs without undertaking any thought-through thermal design. An analysis of Algeria's energy balance sheet shows that internal final consumption is constantly increasing, reflecting annual growth of around + 7% [3]. In addition, according to the APRUE final energy consumption report, 2014 edition [4], the building materials sector represents an increasing share of the industrial balance sheet, going from 22.7% in 2001 to 42.3% in 2013, which makes it the most energy-intensive branch of this sector. Actually, brick and concrete constructions have become widespread in all climates (especially in semi-arid and arid climates) leading to the realization of thermal sieves. The objective of this work is to explore passive solutions to reduce discomfort hours inside buildings and reduce overuse of air conditioning systems. We first made a bioclimatic analysis and air conditioning potential of the passive systems of an arid climate region of Algeria represented by the city of Bechar. The approach used is that based on Szockolay's psychometric diagram [5]. Research has shown that hourly values of global radiation can be generated using stochastic models [6]. This makes it possible to predict and also to define design strategies that are better suited to certain regions by analyzing their climatic / environmental elements. In a second time dynamic modelling with TRNSYS software [7] is used to investigate typical buildings, built with conventional materials and others with local materials. The efficiency of some passive cooling systems in a semi-arid climate was evaluated. We have modelled some constructions that correspond to those commonly encountered in Algerian constructions: old traditional buildings and modern buildings. The terms "traditional" and "modern" refer to the building materials used: stone and adobe for traditional and brick and concrete for modern ones [8-10]. The performance

evaluation of the various building was made on the basis of the following criteria:

-evolution of the indoor temperature,

-evaluation of comfort indices: Predicted Mean Vote (PMV) and Predicted percentage of dissatisfied (PPD), [11]

-evaluation of the cooling need.

The interest is to analyze the effect of replacement of local materials with modern materials in arid climate. The climate data used are those of Bechar region (southwestern of Algeria).

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BASIC CRITERIA FOR THE MEASUREMENT OF SUSTAINABILITY IN THE CONSTRUCTION SECTOR. A CHAIN SUPPLY OUTLOOK.

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Keywords: *Building, standards, methodology, parameters, sustainability*

Corporate transparency is a natural right conferred from sustainability to society, furthermore it comprehends a key technique applied to achieve a sustainable development [1], exemplified perfectly on the investigations delivered by Aragón-Correa (1998) [2], Marcus & Geffen (1998) [3], González & González (2005) [4]. Nevertheless, the study of the connection between this part of corporate proactivity and the building segment isn't thoroughly developed yet [5]. At the same time, the diversification of the construction scope during the last years has increased its market range of activity [6], adding complexity to the study of both subjects.

As direct a response to fulfill this void of corporate accountability in the building sector, this research includes some of the most used methodologies by enterprises to measure their sustainability approach at all levels. These strategies were procured from a study accomplished out from the public records of a sample of Spanish companies during 2018, whose involvement goes from a specific section or through several areas of the construction supply chain. Due to general acceptance among organizations, belonging to various economy sectors around the globe [7], the GRI Standards have been implemented in this analysis as a universal base line to establish the most used indicators by this type of companies.

These common parameters are intended to serve from an administrative perspective, as a guideline of 'basic measures' for the strategic stakeholders involved directly in the decision making, by providing them the minimal necessary aspects to evaluate a project involvement and its impact on sustainability matter; still considering that there are many green standards in the market, which instead of considering a universal foundation, have to be applied from a local point of view [8].

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VALORIZATION OF HARBOR DREDGED SEDIMENTS IN SELF-COMPACTING CONCRETE

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Keywords: *Harbor dredged sediment; valorization; self-compacting concrete; environment*

The accumulation of sediments in dams and harbors, and their possible pollution is a very complex natural phenomenon which has now become a real threat to these structures. Therefore it is urgent to carry out regular dredging. This operation leads to the extraction of huge quantities of sediment and poses the problem of their storage. One of the solutions to this last problem is the recovery of these sediments as building materials and can participate in the ecological and economic development of some regions. Some treated sediments acquire pozzolanic properties and can be used as additions or substitutes for cement. This can make concrete technology a privileged way to recovery. A recent study reveals that harbor dredged sediment (HDS) can be used in the field of building materials to produce eco-friendly bricks. The use of 15-20 wt% of HDS gived rise to bricks with physical, mechanical and thermal properties superior to the control bricks [1]. The present study aims to make a contribution to the recovery of the treated mud from the dredging sediments of the port of Bejaia (Algeria), as a mineral addition in the composition of self-compacting concrete (SCC). The use of mineral additions is very important, it plays two roles, physical: directly affects the workability and chemical: combines the different materials of the mixture (reactions of silica and amorphous alumina with calcium hydroxide $Ca(OH)_2$ released during hydration of the cement) [2]. Limestone fillers are characterized by interesting properties as a function of their particle size which improve the physical properties of cements such as the workability or the water retention capacity, they can be inert or have weak hydraulic properties, good filling granular and low cost [3 - 9]. In this study, the aim is to compare the influence of the incorporation of calcined mud with that of limestone fillers and that of the quarry fines from aggregate quarries in the SCC on their physical-mechanical characteristics. The formulation of the SCC was obtained using Dreux Gorisse method [10]. The study is conducted on six

mixtures of SCC. The first two mixes contain 100% limestone fillers and 100% aggregate quarry fines respectively. The other four mixes contain 25, 50, 75 and 100% calcined mud from the dredged sediments of Bejaia harbor, respectively. In addition to the economic interest which presents the SCC based on calcined mud, our study showed that the latter present performances very comparable to those obtained from SCC based on limestone fillers and fines from the quarry. The objective is to show the possibility of valorization of the mud (sediment), resulting from dredging operation of the port of Bejaia, this possibility opens a very interesting way for their use as raw material in the field of civil engineering, and more particularly as new binders which can be exploited industrially with the advantage of improving the physico-chemical and mechanical characteristics of concrete. So, the use of this sediment could produce important economic and environmental benefits.

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ADOPTION OF PASSIVE STRATEGIES TO REDUCE THE ENERGY DEMAND OF THE BUILT ENVIRONMENT: CASE STUDY OF A RESIDENTIAL BUILDING IN FORT KNOX (USA)

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Keywords: *Retrofit, NZEB, passive strategies, building energy modelling*

In the European Union, the Energy Performance of Buildings Directive (EPBD) requires all new buildings from 2021 (public buildings from 2019) to be nearly zero-energy buildings (NZEB). Australia has gone even further with the Carbon Positive House (CPH) that moves beyond carbon zero by making additional "positive" contributions, producing more energy on-site than the building requires [1].

However, most of the buildings designed during the previous centuries didn't pay enough attention to the energy consumption related to their use. Since the building stock is composed mainly by old constructions, there is an urgency to retrofit them in order to reach the carbon neutrality of the entire built environment by 2050 [2].

The energy use of a building depends on the construction technology, the efficiency of the services and the occupants' behaviour. Passive strategies are those that upgrade the components and materials adopted in the building. Active strategies are related to the improvement of the building services, minimizing the use of fossil fuels. Lastly, the occupants' behaviour refers to the sustainable attitude they should have. For instance, the correct clothing level or the adaptation principle can cut the energy use while preserving good indoor environmental quality conditions [3].

Therefore, the adoption of passive strategies is the first step to improve the energy behaviour of a building. The aim of this paper is to analyse and suggest how to reduce the energy consumption of a residential building from the 70's located in Fort Knox, a site in the U.S.A. characterized by cold winters and hot and humid summers. The upgrades are measured by looking at two parameters: the heating and the cooling energy demands. The mechanical systems are not taken into consideration.

Each strategy applied to the base case building is simulated through a yearly dynamic analysis from an energy modelling software, IES VE. The software uses the engine ApacheSim, able to calculate the performance of a building during the 8760 hours of the year [4].

The upgrades can be divided in three main areas: opaque envelope, transparent envelope and use. The opaque fabric considers the installation of an ETICS (External Thermal Insulation Composite System) on the external walls and on the roof, the enhancement of the thermal inertia (both in the external and in the internal partitions) and the interaction with the sun (solar emissivity and solar absorption). The glazed parts consider the reduction of U-value and g-value, the improvement of the frame and the installation of a shading device. Finally, natural ventilation is studied to exploit the free cooling [5] [6].

The results show that all the strategies help to reduce the energy demand of the building. However, their contribution is different and only some of them are related to a short payback period or return on investments. For this reason, a detailed economic and financial analysis may be useful to provide a holistic feasibility overview.

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CONCEPTUALIZATION OF A BIFUNCTIONAL THERMAL-PHOTOVOLTAIC PARABOLIC TROUGH SOLAR COLLECTOR IN ONE AXIS SOLAR TRACKER

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Keywords: *Concentrating solar power, bifunctional parabolic trough, distribution networks, self-consumption, sensor*

It could be said that of all the great varieties of solar energy (thermal, photovoltaic and concentrating solar power), the latter is the least known not only at a popular level but even at a professional level within the building sector [1, 2]. What do we mean by concentrating solar power? Concentrating Solar Power (CSP): a technology that seeks to increase the amount of irradiation received on small surfaces, either to bind heat on very small surfaces (and subsequently generate steam to produce electricity through a thermodynamic cycle) or to do so on photovoltaic panels that also increase their electricity production [3]. Could this technology be applied to new buildings: the answer is undoubtedly yes. Not surely making a literal adaptation (for reasons of cost, very high temperatures, very high dimensions in scale by the precise facilities ...) but with sufficient modifications to adapt the physical principles to the needs of homes and buildings. What is the approach of this work then: as the title of the article itself suggests, conceptualize a small-scale parabolic trough solar collector with solar tracking to an axis, which presents the possibility of capturing solar energy for two purposes. The first of these would be the production of DHW [4], support for heating, heating of swimming pools and absorption cooling. What is the possibility of success of this analysis: there is no doubt that the scope of the reflections made in this paper cannot be known, but the legislative evolution in our country in the short term seems to help in this sense. The new CTE that will come into force in Spain in June 2020, increases the percentages of solar fraction for DHW production throughout the country, which in itself is a technical challenge for Building Engineering. And that is without counting on future regulations that urge the achievement of a certain level of solar contribution also for heating support. And on the other hand, RD 244/2019 on photovoltaic self-consumption with the possibility of a net balance

of electricity, promotes the self-generation of energy either for the building itself or for injection into the network of distributed intelligent networks. In short, this will make it possible to meet the electricity needs for use in lighting, household appliances, air conditioning, electric car recharging... The anticipated bivalence of this device will be implemented by alternating the component located at the focus of the parabolic trough, which may be a conduit through which the heat-carrying fluid is transferred, or a row of photovoltaic panels that generate electricity [5]. And the criteria for alternating one or the other need will be marked by the above-mentioned regulations and implemented by means of the pertinent control automaton, which will capture data from the sensor included (captured in temperature and irradiance probes) and the actuators and servomotors incorporated.

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THE IMPACT OF CALCAREOUS POWDERS IN GYPSUM STRUCTURES

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Keywords: *Egg shells, mussel shells, gypsum, sustainable, reinforcement*

Currently, the construction industry is increasingly focused on finding high value outlets for the ever-increasing amounts of accumulated waste. In the last decade, poultry and aquaculture presented an increase in their activities, which in turn has created a great concern in scientist and environmentalist who seek to dispose of the millions of shells generated each year by these industries. [1-2]

These types of wastes are usually dumped in landfills or tossed along coastal regions. This situation, apart from creating ecological problems, also generates a serious health problem, since they serve as a breeding ground for harmful organisms. Therefore, it is essential to study how to convert these types of wastes into high value products. [3]

Shells are mainly composed of calcium carbonate ($CaCO_3$), one of the most abundant materials in the earth's crust. Many authors have sought to use these calcareous powders in various industrial applications to take advantage of their possible benefits while introducing a sustainable outlet. However, to our knowledge no study or publication has validated the optimal concentration of these powders in a gypsum matrix as well as the effects that they may cause when applied to the building envelope. [1-4]

Therefore, the following work is proposed in order to mitigate this research gap using shell powders as a valuable biological filler in gypsum structures. The proposed technique proves to be a promising technique to avoid depletion of natural resources and to reduce the adverse impact of these types of wastes on the environment.

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ENVIRONMENTAL QUALITY MANAGEMENT IN THE BUILDING SECTOR: A PRACTICAL APPROACH

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Keywords: *Quality, environment, circular economy, construction and demolition waste (CDW)*

The progressive deterioration of our planet that arises as a result of human action (exponential depletion of fossil fuels, desertification, deforestation, CFC and CO_2 emissions into the atmosphere...) is a real, severe, and urgent fact, which requires a rapid action as indicated by the United Nations Environment Program [1].

Together with the population explosion of the last century, current production and consumption systems are primarily responsible for this growing deterioration. More specifically, the construction sector in Spain, which continues to use traditional techniques and materials, contributes greatly to the consumption of natural resources [2]. It can be said that today, buildings are the cause of about 75% of energy consumption [3], considering this as an alarming fact that should encourage entrepreneurs and engineers towards a new situation in which they have reduced the damage caused in nature.

As indicated by Miranda, Chamorro, and Rubio [4], eco-efficiency can be defined as: “the ability to meet the client's needs by minimizing its impact on the environment throughout its entire life cycle”. In this sense, the implementation of environmental quality management systems in the works joins efforts to meet the housing needs of individuals minimizing the impact of buildings on the environment. It is, therefore, to reduce the harmful effect that constructions may have throughout their entire life cycle in their surroundings.

In this work, some of the main actions that can be carried out in construction companies to improve environmental quality are presented, in each of the stages of the building's life cycle and taking into account the recommendations of the ISO Standard 14001. Therefore, as a strategic objective, the involvement

of all the agents involved in the design phase and in the execution phase is addressed. Seeking environmental excellence through continuous improvement, understanding total quality management as one of the values that professionals in the building sector must assume.

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LIGHTNESS AND TRANSPARENCY IN THE TEACHING ARCHITECTURE. THE LOW THERMAL INERTIA AS A MEASURE OF ENERGY EFFICIENCY

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Keywords: *Energy efficiency, comfort, thermal inertia, teaching architecture, sustainability*

Lightness and transparency are two qualities that modern architecture has pursued since the facade lost its bearing condition and could dematerialize [1]. The use of transparent enclosures in buildings without taking into account the climate in which they are located sometimes presents difficulties. These enclosures allow the entry of solar radiation into the building, which affects thermal loads and habitability [2]. The transparency, thermal transmittance, solar factor and orientation of the transparent enclosures have a decisive influence on the energy efficiency of the buildings [3]. Although this incidence differs depending on the use made of the building. A university classroom is used for 30 weeks a year. If it is used intensively for 12 hours a day, the classroom is used for 1,800 hours of the 8,760 hours per year, which is 20% of the time. Given this situation, it is worth considering whether the low thermal inertia of light enclosures can be an advantage in terms of the energy efficiency of the building because it is not necessary to use energy to heat the enclosure of a space with so little use. To carry out this analysis, a university classroom built with a polycarbonate panel is chosen. The energy consumption of its air conditioning installation is studied as well as its habitability conditions. Thanks to its low thermal inertia, the energy consumption of the classroom is lower than a conventional building despite having a greater thermal transmittance in its enclosures.

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TOWARDS AN INNOVATIVE AND COLLABORATIVE REFURBISHMENT ECOSYSTEM FOR EUROPE

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Keywords: *Renovation, energy reduction, NZEB, Horizon 2020, gypsum*

The REZBUILD project [1] grows with the main aim of defining a collaborative refurbishment ecosystem focused on the existing residential building stock. Nowadays, the Near Zero Energy Building (NZEB) renovation methodologies are required as one of the key enablers supported by Horizon 2020 Framework Programme [2] in order to promote business research and innovation through energy-efficient buildings.

REZBUILD is addressing these challenges by widening the construction sector with the integration of innovation technologies in order to pave the way towards an annual renovation rate of 2,5% instead of the current rates lower than 1%.

The technologies will be merged in a common decision making platform related to an innovative concept of refurbishment plan. The methodology interconnects on one hand, advanced refurbishment technologies and existing ones based on a decision tree strategy. On the other hand, it communicates all stakeholders involved in the housing renovation process from designers, refurbishment to private consumer and public / private owners.

The main objective of the REZBUILD project is to develop one refurbishment ecosystem based on the integration of cost-effective technologies, business models and life cycle interaction to deep NZEB renovation to diverse residential renovation typologies and interconnecting both, building renovation stages and stakeholders [3].

This ecosystem will ensure the fulfilment of three KPIs:

- Energy Reduction
- Time saving
- Rapid payback

Saint-Gobain Placo Iberica is one of the partners in the project, developing new systems based in gypsum with this KPIs to innovate in the renovation buildings and achieve the better improvements in Energy Efficiency and Comfort, with installation time saving and rapid payback [4].

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VULNERABILITY AND FUEL POVERTY.
NEIGHBORHOOD OF PAN BENDITO

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Keywords: *Fuel poverty, vulnerable areas, different scales, micro-works, research-action.*

Fuel poverty is a problem that has gotten attention for a relatively short time in Spain. However, around 4,6 million of people couldn´t keep on a comfortable temperature their houses in 2016, and around 3,6 million couldn´t pay the energy bill on time, [1]. It is not an isolated issue without consequences. The population who is in this situation of vulnerability, in particular children and old people, has a higher risk of mental and physical diseases, (asthma, arthritis, rheumatism, depression, anxiety, etc.), caused by bad thermal conditions. [2]

On April 5th, 2019, the Spanish Government approved a "*National Strategy against fuel poverty*", to be developed between 2019 and 2024. This document has set the first fuel poverty´s definition in Spain: "*A home is in a fuel poverty situation if its basic energy needs cannot be satisfied, as a result of low income which can be aggravates by an energy inefficiency building*" [3]

This paper raises the potential situation of vulnerability and fuel poverty in Pan Bendito. This neighborhood is located on the south-west of Madrid, in Carabanchel´s district. It is known for having one of the higher poverty coefficients of Madrid, [4]. The objective was to determine the existence or not of this situation in the analyzed area, to study the limitations and success of the current approaches, to act in particular cases, and to get conclusions in order to allow to address the problem from different actors, (public administration, owner´s community, occupant), and scales, (neighborhood, building, apartment). It also aims to influence positively for educating people in this knowledge and performing micro-works for improving the energy efficiency of the apartments. Finally, it helps to involved them in an active way from an easy approach and being realistic with the limits of these type of interventions, (time and budget)

This approach resulted in a mixed methodology, by combining the academic development of the problem and the field, discussing with the neighbors.

Every aspect has helped to fulfill the objectives, verifying the hypothesis and allowing a direct contact with the reality of the problem.

Finally, we want to acknowledge the collaboration of the "*Universidad Politécnica de Madrid*" and "*Asociación Paso a Paso*", which develops its social works in Pan Bendito.

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REGENERATIVE TECHNOLOGIES FOR THE INDOOR ENVIRONMENT: TWO BUILDING CASE STUDIES IN SPAIN

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Keywords: *Construction, sustainability, passive house, environment*

Currently, many natural disasters are constantly occurring worldwide due to the global warming caused by the human activities and in particular from the construction sector, as it is one of the major responsible industries, which directly affects climate change [1, 2]. For this reason, the construction sector must change from implementing degenerative or "less bad" strategies to other strategies aiming at a positive net environmental impact, by means of regenerative sustainability criteria. Regenerative sustainability promotes buildings that not only achieve zero environmental impact, but their impact is positive, meaning that buildings are able to "regenerate" their users and the environment [3, 4]. In this sense, the COST Action "RESTORE" (REthinking Sustainability TOwards to Regenerative Economy) was developed, aiming to transform the sector and promote this new way of understanding sustainability.

This work presents some of the results obtained in Working Group 4 of Restore Action which deals with technologies for a restorative sector. For this, several case studies, which incorporate technologies aiming at improving the indoor environment of the building, were collected and analysed. The information provided for each case study includes not only general information about the building and the technologies, but also more detailed numerical information

about the indoor environment performance. Two Spanish case studies are presented and described: a nearly zero energy building (NZEB) medical centre located in Lodosa and an apartment block located in Pamplona, both of them hold a Passive House certification. Finally, passive house strategies can help to improve the indoor environment and health of the people and therefore it are strategies which can boost regenerative sustainability buildings.

Acknowledgements

This work is based on research activities of COST Action CA16114 “REthinking Sustainability TOwards a Regenerative Economy” (RESTORE) project, funded by COST (European Cooperation in Science and Technology).

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ENERGY COSTS ANALYSIS OF BUILDINGS FROM VALUES OF THE ENERGY PERFORMACE CERTIFICATE

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Keywords: *Buildings efficiency, energy costs calculator, energy efficience, public awareness*

In 2002, more specifically in the European Directive 2002/91/EC in its article 7 section 2, it was mentioned the following: *The energy performance certificate for buildings shall include reference values such as current legal standards and benchmarks in order to make it possible for consumers to compare and assess the energy performance of the building* [1].

This sentence meant an intention guideline proposed by the high ranking organisms of the European Union for the Energy Performance Certificate (EPC). That complement its aim of measurement the efficiency in buildings, focusing in the public awareness.

Continuing this guideline, it was established, more in-depth, the exposing requirements of the EPC for buildings occupied by public authorities and buildings frequently visited by the public, in the European Directive 2010/31/EU [2].

But the truth is that, in Spain, this added aim of the EPC as a differentiating element in the purchase decision of buying a house cant be achieved, and many other parameters are above the energy efficiency such as location or price.

Consequently, in this work a new simple, user-friendly and free tool is provided for non-technical people to calculate their home energy costs, their energy mortgage, having as the starting point the EPC.

Moreover, using this tool, it has been calculated the annual costs of the energetic basic consumptions of a building (heating, cooling and domestic hot water) in the national climatic zones and for all the levels of energy performance.

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ENERGY AND COMFORT SIMULATION AND IMPROVEMENT MEASURES PROPOSAL USING DESIGNBUILDER TOOL: CASE STUDY OF A SINGLE-FAMILY HOME IN SPAIN

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Keywords: *Sustainable development, BREEAM, DesignBuilder, NZEB, energy efficiency*

Some studies [1,2] recognize that the building sector consumes a third of global resources and it is one of those responsible for the highest energy consumption, around 40-50% of energy use and global greenhouse gases emission (due to anthropogenic causes). Because of that, it is demonstrated that, implementing sustainability in architecture and consequently in building, climate change can be actively fought.

Currently, there are a lot of sustainable assessment tools (BREEAM, LEED, Verde ...) that help to evaluate the sustainability of different types of buildings, implementing improvements to reduce their environmental footprint. One of the most used certificates by the building sector professionals is the BREEAM tool (developed by BRE in the UK) [1]. This case study evaluates the efficacy of BREEAM methodology, in *Energy* and *Health and Well-being* categories, to get a healthy space and a *Nearly Zero-Energy Building* (nZEB).

To achieve the goal, an energy simulation model of a single-family home in Madrid has been developed, using DesignBuilder tool. It allows us to get parameters such as the demand for heating and cooling, the thermal comfort of the occupants or the CO_2 emissions of the home can be known throughout one year. Once the initial simulation has been done, we have applied some energy efficiency measures (for example, an increase in thermal insulation or an incorporation of renewable energies) to evaluate new energy consumptions, CO_2 emissions and building comfort. Besides, we analyse the impact on BREEAM certification.

The results expose the effectiveness of the measures implemented from the different points analysed. It should be noted that it is necessary to develop more studies such as this one in buildings or homes (new or rehabilitated) of different characteristics in order to establish specific guidelines or recommendations that help professionals in the construction sector in their decision making.

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APPLICATION AND ENVIRONMENTAL STUDY OF PLANT FIBER BLOCKS IN BUILDING CONSTRUCTION

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Keywords: *Plant fiber block, life cycle, sustainability, environmental impact*

Construction is a sector which generates a significant environmental impact. . Life Cycle Assessment (LCA) is a tool that is widely used to quantify environmental impacts in the construction sector [1]. Construction is an activity that produces high greenhouse gas emissions, which cause global warming. It is becoming increasingly important to use sustainable materials which reduce the environmental impacts of construction [2].

The present research analyzes the environmental impact associated with the production of Plant Fiber Blocks (PFB) as a building material, using the Life Cycle Assessment methodology (ACV) [3]. In addition to looking at the sustainability of this material [4], it also compares it with other conventional building materials.

Furthermore, a financial analysis has been carried out of the costs and benefits of this material compared with the most common solutions. We conclude that the impacts caused by manufacturing a PFB make it a material that displays more sustainable behavior than other insulating materials.

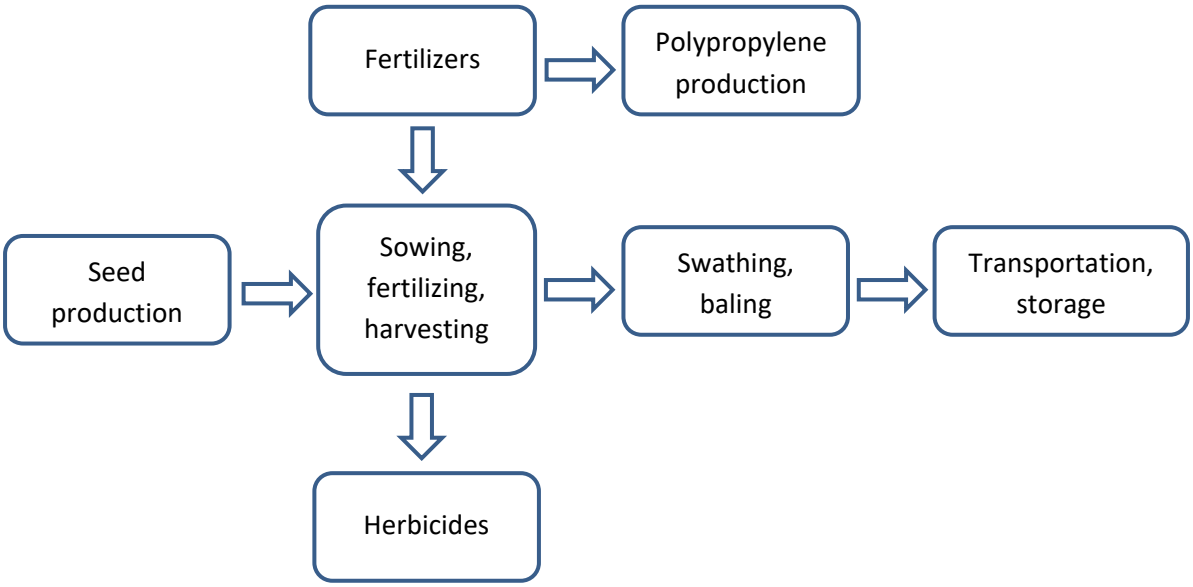

Figure 1: Stages in the life cycle of the production of a plant fiber block

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THERMAL PRODUCTION ALTERNATIVES FOR THERMALLY ACTIVATED CONSTRUCTION SYSTEMS (TABS) IN OFFICE BUILDINGS IN CHILE, ACCORDING TO CLIMATE ZONES

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Keywords: *TABS, thermal production,office buildings, power generation system*

The work compares the behavior of different thermal production systems and equipment for specific use in office buildings with TABS (Thermally Activated Building Systems). TABS are water conditioning systems that use the thermal mass of concrete slabs and walls to regulate the temperature of the environments. To this end, these construction elements are thermally "activated" by means of a water coil inside, operating with small differences in water temperature with respect to the environment [1]. Based on the operational requirements set forth by the authors in a previous work [2], the behavior of three different power generation systems has been evaluated: A conventional system, consisting of a boiler and water chiller. A semi-conventional system, consisting of solar collectors, accumulation system, auxiliary boiler, cooling tower and a water chiller. And one last, efficient, consisting of solar collectors, accumulation system and an air-water heat pump. These systems are evaluated under the environmental conditions of six climatic zones in Chile. For this, the systems have been numerically modeled using TRNSYS, obtaining that the conventional system has the highest energy consumption in all the cities studied, followed by the semi-conventional system and, finally, an efficient system. Comparing these systems according to the amount of CO_2 emitted to the environment, it is shown that the use of solar collectors and cooling towers significantly reduces (between 30-50%) carbon dioxide emissions. However, the use of a heat pump, despite consuming less energy in all the cities studied, both in Calama and Valparaiso generates a higher CO_2 emission.

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STUDY OF THE BEHAVIOUR OF GYPSUM MORTARS WITH THE ADDITION OF WIPES FIBRES

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Keywords: *Gypsum, wipes, compression, bending, thermal conductivity*

The history of construction does not run in a continuous evolution, but is marked by two revolutionary periods, which originate stages of very different characteristics, even contradictory [1]. The history of plaster evolves into three main stages, the artisanal one that is characterized by a scarce and discontinuous production, the industrial stage in which the product was standardized and produced in series thanks to industrialization, and finally the last stage where “third generation” plaster is born, with the use of additives and additions [2]. Gypsum is one of the oldest materials used in building due to its low cost of production and its easy workability. On the other hand, wipes represent a major environmental problem, due to their presence in the sewers, in places like Spain [3]. In the city of Cadiz for example the 65% of the solid waste in the sewers is constitute by wipes [4]. The objective of this research is to get to know the mechanical, thermal and acoustic behavior of gypsum with the addition of wipes fibres in different percentages, in order to study its feasibility as a construction material in building, while promoting the conservation of the environment.

To achieve this objective, test pieces of different shapes and sizes have been made according to the tests carried out. The following percentages of addition of wipes by weight of gypsum have been studied: 0,10 %, 0,20 %, 0,30%, 0,40%, 0,50%, 0,60%, 0,70%, 1,00 %, 1,50% e 2,00 %, since this additional percentage greatly reduced the workability.

The addition of wipes reduced the density of the material, as well as the surface hardness, as the percentage of wipes increased. The maximum flexion and compression voltages are also reduced by the presence of fibres, but this reduces the detachment effect in case of breakage. In addition, even in the most unfavourable case, with a higher percentage of wipes, the gypsum meets the minimum requirements established by the regulations at the level of strength.

Other parameters studied show that the highest capillary absorption occurs for a an additional one percent of 1,00% wipes and that the greatest resistance to the diffusion of water vapor occurs for an addition of 2,00% wipes. The adhesion of the gypsum paste and the thermal conductivity decrease with the addition of wipes, while the acoustic absorption is not affected by the addition, except slightly in low frequents. All the parameters investigated in the various gypsums are found in the parameters established by the corresponding standards. Bending studies at the gypsum plate level show an improvement in its behaviour with regard to gypsum paste without wipes, particularly in the content of 1,00% of fibres.

After analyzing all the variables and as a final conclusion, it can be indicated that the addition of wipes in a percentage of 2,00% in weight of gypsum, is a good alternative to traditional gypsums, because by meeting the requirements for this type of construction material, it contributes to the possible solution of an environmental problem.

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BUILDING TECHNOLOGY

THE IMPACT OF CARBON-BASED NANOMATERIALS IN STRUCTURES

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Keywords: *Graphene, graphene oxide, rGO, surface sealer, reinforcement.*

The construction industry is regarded as one of the most important economic sectors across the globe. However, despite its economic importance, the construction industry is filled with inconveniences. To face this challenge, carbon-based materials have shown great promise to revolutionize in this manner. Several reports include materials, such as graphene or graphene oxide (GO) as novel solutions for building materials. The present work describes and compares the results between articles, to achieve this, five (5) articles related with the introduction of carbon-based materials in structures.[1-3]

The selected articles had similar approaches and possess information regarding compressive & flexural strength, density, electric and thermal conductivity. However, a limitation of this work is the fact that the obtained values cannot be compared in an absolute way since the selected authors apply various formulations and configurations in their research, suggesting a statistical comparison in order to determine the effectiveness of the applied methods. [4]

Carbon-based materials are related to each other, but each one of them possess unique properties depending on their chemical structure. The studied materials suggest they can be used as surface sealants, additives or can even be applied to manufacture sensors for structure monitoring. [5]

The work can conclude that low addition ratios are capable of providing an improvement in mechanical properties in a cement matrix. In addition, there is no information available regarding the influence of these materials in a gypsum matrix.

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MATLAB MODELING OF THE EXPECTED ARROW OF CANTILEVER BEAMS

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Keywords: *deflection, cantilever beam, piezoelectric actuator, monitoring, MATLAB®,*

The measurement of the arrow in construction beams is of predominant importance for the control of the execution tasks on site. In this work, a system has been developed for the MATLAB® simulation of deflection behavior for cantilever beams. From the placement of two piezoelectric actuators on both sides of the beam (below and above) of the beam, it is possible to perform real-time monitoring of the construction element and measure its deformation.

An analytical study has been carried out by using partial differential equations in a finite element model of three dependent variables; geometry, mesh, and boundary conditions. This model has been studied extensively by various authors for its application using piezoelectric sensors in the analysis of structures [1, 2].

In this investigation, the study was carried out with bimorph piezoelectric materials, the material used being Polyvinylidene Fluoride (PVDF), which is a chemically inert and weatherproof thermoplastic fluoropolymer, ideal for application in building structures.

In other previous works, the ANSYS calculation engine has been used to determine the relationship between the dimension and natural frequency of the cantilever piezoelectric [3]. On the other hand, there are studies where the parameter to be controlled was the thickness of the piezoelectric material, with the aim of achieving maximum energy extraction from the vibration of the environment [4].

Figure 1 shows how the electrodes have been placed in the cantilever for later simulation in MATLAB®. In the said figure, a simple circuit is shown where a cantilever beam and the location of the sensors are schematically shown. In such a way that, by means of a potential difference, it is possible to excite the electrodes placed on both sides of the cantilever, the variation in the response of these piezoelectric receivers being the one related to the arrow at the end of

the cantilever.

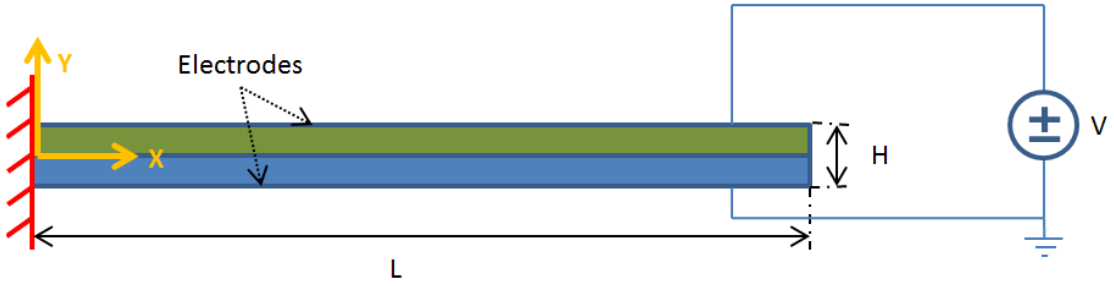

Figure 1. Circuit schematic applied to the cantilever beam.
Source: Partial Differential Equation Toolbox Examples, MATLAB® Help.

The analysis and simulation have been carried out through the adaptation of the MATLAB® PDE Toolbox of the aforementioned parameters (geometry, mesh, and boundary conditions). The code used in MATLAB® for the calculation of the deformation in the cantilever is made from Equation 1, which is indicated below:

$$Deflexión = \frac{-3 * d_{31} * V * L^2}{8 * h^2}; (1)$$

where: d_{31} [C/N], piezoelectric strain coefficients; V [volt], voltage applied in the circuit; L [m], beam length; and h [m], height of each layer.

The results show how it is possible to model the behavior of flown construction beams, determining their arrow at the end based on the response collected with the help of the piezoelectric devices used.

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ACOUSTIC CONDITIONING STUDY FOR THE ETSEM AUDITORIUM OF THE UNIVERSIDAD POLITÉCNICA DE MADRID: A CASE OF STUDY

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Keywords: *Acoustic conditioing, reverberation time, acoustic insulation*

The architectural projects that are design every day and that we inhabit frequently, present great technical flaws in many aspects that we can ignore. The acoustic development of the spaces within different buildings, in most cases does not behave optimally for the corresponding use. Classrooms where students fail to perceive the teacher's voice, sports centers where athletes do not hear the sound of the whistle or restaurants and libraries with high noise levels are common examples that are present in the buildings we currently frequent. Different investigations on the acoustic behavior of architectural spaces have been developed worldwide, analyzing the reverberation times and improvement methods implemented. The studies of the sacral room in the dome form of the Pentecostal Congregation in Katowice in Silesia, Poland, where it had a high reverberation time, and an insulating material deposited by spraying was applied for optimum acoustic conditioning. The reverberation study of a Catholic church in Curitiba, Brazil, where the measured and calculated values were consistent with those proposed by the problems for speech auditors (RT500Hz = 1.18 s, D50> 50% and ITS> 0.45). This type of analysis how you can develop an acoustic evaluation of spaces and generate proposals for improvement for these. [1-3]

A case study is developed to analyze the acoustic behavior of the auditorium of the Technical School of Building ETSEM, of the Polytechnic University of Madrid. To which an in situ test was carried out with the procedure established in the UNE-EN ISO 16283-1: 2019 standard [4]. With 2 sound source emission points and 6 measurement points from a spectrum analyzer. The reverberation time obtained was 1.54s, this time is not the one desired for the uses currently in this space. Achieving an architectural proposal for the auditorium conditioning

to the uses of the Conference Hall (Spoken Word) obtaining a reverberation time of 0.9 and a percentage of AlCons intelligibility coefficient of 8.6%, Chamber music with 1.1 RT, Cinema with 1.2 of RT and Symphony with 1.4 of RT. Applying flexible systems of mobile panels that transform the space according to the need of the use that is being given at the moment. Thus achieving a conditioning of the space that adapts to what is required by the regulations, for the uses that are used today.

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GROUND PENETRATION RADAR (GPR) AS NON-DESTRUCTIVE TEST FOR MUSLIM PLASTERWORK CHARACTERIZATION

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Keywords: *GPR, radargrams, plasterworks, architectural heritage*

Ground Penetration Radar (GPR) is a cutting-edge technology in different fields like archaeology, topography and construction. It has been widely used to obtain information about underground labels and reinforced structures [1-3]. In fact, it is possible to gather information not only about geometry and location but also about the type of embedded elements such as pipes, rebars and voids. Several authors have just studied the possibilities offered by GPR in construction and have demonstrated that its applications are widespread in architectural and civil engineering [4].

Notwithstanding, being a non-destructive testing (NDT) is the main advantage of this technology. Based on the electromagnetic wave and the processing technology of radargrams, GPR is capable of differentiate materials, layers, discontinuities and also detect embedded objects in structures without any destruction.

GPR supposes an opportunity to study the architectural heritage without damage the structure and allows us to know if there are moistures, hidden structures, cracks, voids, water leakages, etc. [5-6]. This NDT is essential to assess the conservation status of a building and establish the necessary preservation measures. In this regard, we have chosen the Real Alcazar of Seville as a case of study, being the evaluation of the plasterworks our main objective [7-10]. In order to correctly interpret the radargrams obtained in the scans several constructive models have been prepared and analysed in the laboratory. These units have been carried out respecting the construction of the Alcazar walls and several embedded elements have been placed in order to recognised them by GPR. Thus, we elaborate a specific database in which the main pathologies that plasterworks can present and their corresponding radargrams are collected.

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EVALUATION OF THE MECHANICAL CONCRETE OF THE CONCRETE WITH ADDITION OF POLYPROPYLENE FIBER IN FUNCTION OF THE TEMPERATURE

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Keywords: *Concrete, polypropylene fibers, temperature, thermocouple*

Reinforced concrete is the most used structural material worldwide, both in construction and civil engineering, hence the importance of its study at all levels, the different behavior of concrete as a function of temperature makes it very interesting to study, since the safety of a structure in case of being subjected to a fire or being in environments with high temperatures, depends on the resistance that is able to reach in those conditions. The addition of fibers in the concrete also conditions its behavior when it is subjected to high temperatures [1-4].

Taking in to account these premises, the objective of the work is to study the mechanical behavior of concrete with additions of polypropylene fiber when they are subjected to a range of temperatures between 20ºC - 250ºC.

For the experimental phase, 2 kneaded ones were carried out, the materials were prepared in the established dosages, they were introduced in the vertical axis planetary kneader. Initially a mixture was made between the coarse and fine aggregate for 2 minutes, then the cement was added in order to homogenize the mixture and finally the water was added. Once all the materials were introduced in the kneader, it was kneaded for 5 minutes.

In the second batch the entire process mentioned above was repeated, the SIKA polypropylene fibers were added, and finally the water was added.

We proceed to select the 2 types of furnaces found in the materials laboratory, in order to subject the specimens to high temperatures after 28 days of curing. The temperatures to which they will be exposed are 20 ºC, 100 ºC, 150 ºC 200 ºC, 250 ºC.

When the concrete begins to heat it does so from the outside of the specimen to the inside, that is to the core, causing a thermal gradient between the surface and the core, which results in the appearance of internal stresses.

The compressive strength test consists in determining the behavior of the cylindrical specimens under axial loads following the UNE-EN 12390-3 standard

Polypropylene fiber concrete is a good alternative to traditional concrete in terms of the strengths achieved, but the form of cooling completely determines the residual strengths that a structure can have, after reaching temperatures of up to 250 ° C.

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BIM-EDU: A BIM-BASED METHODOLOGY FOR INFRASTRUCTURE MANAGEMENT. CASE STUDY OF ETSI CAMINOS, CANALES Y PUERTOS DE LA UNIVERSIDAD POLITÉCNICA DE MADRID

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Keywords: *BIM, BIM management, future BIM possibilities, BIM-EDU, BIM FM*

This paper summarizes the development of the BIM-EDU project performed by the authors at the School of Civil Engineering (ETSICCP) at Universidad Politécnica de Madrid (UPM). Including BIM in the syllabus of students has shown to improve the acquirement of knowledge about automatization processes, affection of the project to the global environment and precisions in terms of quantification [1–3]. It wa estimated by “The Construction Industry Development Board (CIBD)” that around 300 to 600 graduates with BIM knowledge per year from AEC (Architecture, Engineering and Construction) will be needed in the construction industry. Moreover, BIM implementation in early stages match with an open mind in terms of procedures related to the possibilities of BIM along all the project phases [4–9] as well as in existing constructions and infrastructure [6,10,11] or facility management profits [12].

As result of BIM-EDU application, a three-dimensional information model of ETSICCP was obtained. Such significant infrastructure houses two BEng studies: Civil and Territorial Engineering and Materials Engineering. Additionally, the building offers various master’s degrees: MEng of Civil Engineering, MEng of Materials Engineering, MEng of Structures, Foundations and Materials and MEng of Systems in Civil Engineering. The complexity of this educational institution entails a detailed management according to the properties of the infrastructure, which is 51 years at the time of writing.

The availability of this model not only involved an efficient tool for educational management but also provided UPM with the chance to set the BIM implementation related to infrastructure management [6,10,11] and emergency simulations [10] in complex buildings [13].

Thus, the BIM model can work as an information repository [5,14–16] of the varied typology of information that the building houses such us educational

management, space management or personal control. Moreover, the model was elaborated giving raise to future possibilities by means of new technologies related to web service and Internet of Things and Big data [7,17,18]. The outline of the modeling process can be seen in Figure 1.

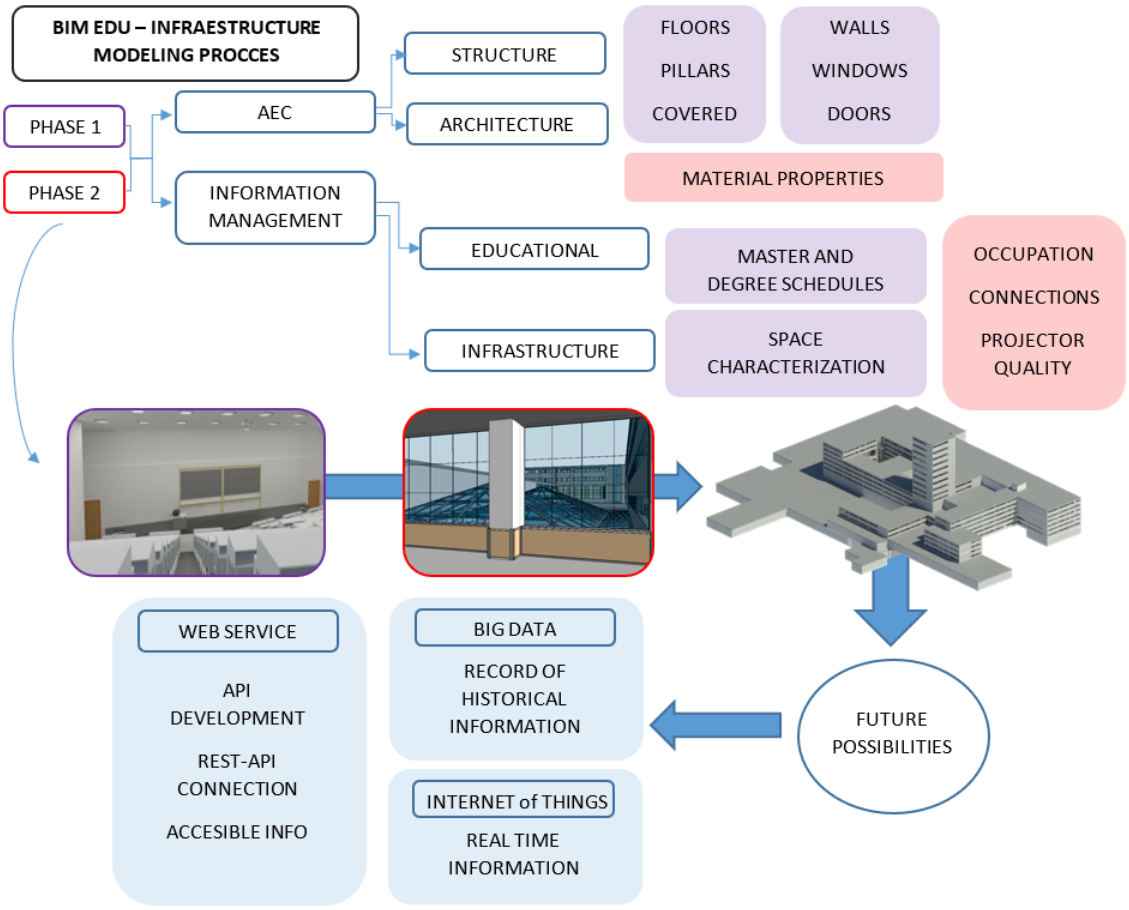

Figure 1. Infrastructure modelling process

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PROPOSAL FOR REUSE OF RAIN WATER AND GRAY WATERS IN A HOUSING

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Keywords: *Efficiency, urban systems sustainable drainage, sustainability and reuse*

The exponential growth of cities in recent decades has led to a continuous increase in surface waterproofing, which is generating a significant alteration of the natural water cycle, increasing problems related to drainage and storm water management [1]. These difficulties are increasing due to the increase in droughts and floods and complications with the amount of water available as a result of the climate change process that humanity is experiencing. In this direction the floods in the Mediterranean coast are taken into account as a result of the passing of the Gloria storm in January 2020.

In addition to these problems and alterations, conventional drainage systems, installed in cities, basically consist of transporting water runoff at lower levels as quickly as possible. All this through waterproof conduits, which solves a problem, but generates other different problems.

For these reasons, a new way of treating rainwater emerges, the Urban Sustainable Drainage Systems (SUDS). These are a great variety of systems that capture, treat and infiltrate / store the water and can use it for various uses such as aquifer recharge, irrigation, recreational ... and even for reuse in buildings and homes. In this way, and through these systems, the uptake of rain is increased, increasing the amount of water available for consumption [2], [3] and [4].

This paper briefly explains and exposes the Urban Sustainable Drainage Systems that replace conventional drains and proposes its application to a conventional single-family dwelling [5]. In addition to the study of the different Urban Sustainable Drainage Systems, different systems that can be used in the dwelling under study for gray water reuse are studied. First, those that reuse rainwater and that are found in conjunction with the former are indicated [6]. Next, the operation process, yields of flow that can be obtained and investment necessary for its implementation are exposed.

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CONTINUOUS, COMPLEX AND POROUS CLUSTERS OF HYPARS: PARAMETERS AND METHODOLOGY FOR THEIR DIGITAL DESIGN AND ADDITIVE MANUFACTURING

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Keywords: *Morphology, complex surfaces, shell structures, doubly ruled surfaces, digital design and fabrication*

The development that has happened throughout this century in the fields of advanced digital design and digital manufacturing techniques, as additive laying manufacturing 3D printing, has allowed engineers and architects to recover shell structures with behavior of monocoque, in which hypars define their spatial and structural form, and the result is the definition and existence of new types of complex continuous clusters from simple pieces relatively easy to design, edit and build using digital tools. These new types of complex clusters will produce the possibility of developing new architectural typologies and spatial configurations with great adaptive possibilities [1], in which the form is related to a simple structural work.

In the twentieth century, for a few decades at least, shell structures formed by hyperbolic paraboloids were very popular. Architects and engineers, as Torroja, Isler, Candela, Otto, Le Corbusier and Fisac, among others, used this type of doubly ruled surfaces in many different works, taking advantage for their efficiency, structural behavior and constructive simplicity. The structures built with hyperbolic paraboloids were of different types, they can be found configured by grouped elements forming doubly periodic sets of hypars, umbrellas, in their multiples variants of shape, configuration and arrangement, and groin vaults are examples of this. They can be found as isolated elements too [2].

The hypars structures aren't currently used so much in architecture and engineering because they are expensive, their complex shapes need complex and labour intensive formwork, and they are useful for small structures [3].

In this context, for obtaining new architectural solutions based on complex, continuous and porous clusters of hypars organized in all directions of the space in different ways than we are used to project and build until now in small, medium or large scales, the constructability principles that are present in the morphogenesis and epigenesis of minimal surfaces with crystalline structure [4]

can be applied to architectural production. These surfaces, triply periodic minimal surfaces, are characterized for their continuity, complexity, efficiency and connectivity capabilities [5][6][7]. They emerge from a simple patch to which the operations of the associated crystallographic group of the surface, related to Bravais lattices, are applied [8].

The aim of the research is to present and understand the way through which a great variety of clusters of complex, continuous and efficient surfaces, built by connecting multiple hyperbolic paraboloid patches with straight borders, related to triply periodic minimal surfaces, can be designed by digital tools and can be built by digital advanced manufacturing methods by applying the inherent principles that are present in the generation and the deformation of these particular type of surfaces.

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DETERMINING THE EFFECT OF AMBIENT TEMPERATURE IN A MONITORED BUILDING WITH EMBEDDED FIBER OPTIC SENSORS

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Keywords: *Fiber bragg grating, fiber optic sensors embedded in concrete, temperature, cracking*

There are many studies of structures monitored with fiber optic sensors embedded in concrete. This article shows the integral monitoring of a prefabricated concrete panels building with embedded fiber optic sensors using the Fiber Bragg Grating (FBG) methodology.

During the data collection process, the influence of the ambient temperature on the structural deformation has been observed. Other studies about the temperature effect have used FBG sensors to measure deformations and temperature in a reinforced concrete beam [1]. In this case, after the curing process, the beam has been heated to 200ºC with a load of 5 kN. Some electric gauges have been placed on the surface too. Evidences shows that FBG sensors can identify deformations in concrete structures that cannot be identified by visual inspections.

On the other hand, fiber optic sensors have been used by researches in order to monitor temperatures in structures during a fire. Some authors propose a new fiber optic sensor based on FBG specially designed to be embedded in concrete and capable of measuring temperatures during a fire [2]. Test is performed on 5.8 m in length beam which is monitored with nine optical sensors. The results are similar to those obtained by the Finite Element Model designed.

Regarding the maintenance of a building, monitoring a structure is a cost-effective method since it gives us precise information on how it is behaving and what damages it can suffer, benefiting the repair of them [3].

The cost of monitoring a structure is manageable compared to the benefits obtained by its application. The correct choice of the sensor is decisive to that end [4, 5].

Fiber optic sensors based on FBG are capable to identify internal deformations undetectable by visual inspections. As we can see in the work presented here,

the sensitivity of the fiber optic sensors is greater than the visual inspection of the structure.

The novelty of this contribution lies on verifying how the ambient temperature influences the deformation of a concrete structure by means of the inclusion of temperature sensors. These are necessary to compensate the effect of temperature on deformation sensors.

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PRELIMINARY TECHNICAL ASSESSMENT OF AN INNOVATIVE GYPSUM PLASTERBOARD BASED INTERNAL PARTITION KIT

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Keywords: *Technical assessment, innovative partition kit, gypsum plasterboard, safety of use*

Drywall partition kits based on gypsum plasterboards [1] and cold formed galvanized steel profiles are actually the most frequent solution for this particular use in house buildings, thanks to its quick and standardized installation, good experience and composition based on standardized elements. However there is room for innovation. A recently appeared innovative kit based on thicker gypsumboards, up to 25 mm instead of 12,5 mm, allow a greater modulation up to 900 mm between vertical profiles and even faster installation. Nevertheless, it is not fully covered by the Standard UNE 102043 [2] and a favourable technical assessment is needed to demonstrate its fitness for use.

The objective of this research is to demonstrate in a preliminary way this fitness for use as it is focused only on the mechanical performances related to the fulfillment of the Basic Work Requirement 04: Safety of Use as described at the Construction Products Regulation.

For that purpose, resistance to uniformly distributed horizontal load has been tested as required at the Basic Document DB-SE-AE of the Spanish Building Technical Code. But also, calculation and a set of tests [3] comprising resistance to soft body impact resistance [4], eccentric vertical load resistance [5] and flexural strength on real-scale rigs simulating behaviour on site.

The results obtained confirmed that on one hand, the feasibility and favourable result of the mechanical tests but also, the need to updated the Spanish Building Technical Code in relation to this performance, not only based as it is now on the uniformly distributed horizontal loads but also on the soft body impact resistance, eccentrical vertical load in order to let architects, technicians, promotors and users be more aware of the requirements of Safety of use and how innovative partition kits can reach them.

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MECHANICAL BEHAVIOR OF REINFORCED CONCRETE WITH CARBON FIBER AFTER THE STRUCTURAL FAILURE

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Keywords: *Concrete, fiber, polypropylene, CFRP*

The reinforcement of the concrete structures emerges as a solution to solve the possible pathologies of the buildings, defects of execution, erroneous designs, structural damages due to accidental events (earthquakes), or even changes of use in the buildings. The important investments that generate in some cases, the investment in repair and reinforcement is greater than in the construction of new structures [1].

There are different construction systems that make it possible to reinforce reinforced concrete structures, such as covering or confinement of columns using concrete or steel and reinforcement with composite materials [2,3].

Taking these premises into account, the objective of the work is to analyze the compressive behavior of concrete structures reinforced with carbon fibers, after having reached the structural failure. This behavior will be compared between traditional concrete and concrete with polypropylene fibers.

Four types of carbon fibers have been used to make the reinforcements: MapeWrap C UNI AX 300, MapeWrap C UNI AX 600, MapeWrap C BI AX 230, MapeWrap C BI AX 360, which will allow the study of the influence of the type of reinforcement on the resistance that concrete can reach.

The results obtained allow us to conclude that both the reference concrete and the one that has polypropylene fibers, when are reinforced with carbon fiber, reach tensions much higher than those of unreinforced concrete, where the smallest increase in reference specimens is of 125% in the BI-230 reinforcement. The increase in resistance is greater in concretes that start from lower resistances and higher tensions are achieved, with unidirectional reinforcements than with bidirectional ones.

Acknowledgments: To the Technical Department of Mapei, for their collaboration.

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ASSESSMENT OF THE COOLING ENERGY PERFORMANCE OF THERMALLY ACTIVATED BUILDING SYSTEMS (TABS)

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Keywords: *Thermally Activated Building Systems (TABS), building energy retrofitting, Building Management Systems (BMS), energy audit, energy signature*

Thermally Activated Building Systems (TABS) ensure uniform temperatures and energy savings, thanks to their storage capacity. In the frame of a comprehensive building energy retrofitting, the thermal mass activation of existing structures is aimed at exploiting the energy storage capability of construction elements for the climatization of buildings, in combination with low-grade energy production systems.

The inclusion of thermoactive elements or the enhancement of the thermal mass of existing structures is not always feasible and effective, due to several limitations. In a building energy retrofitting process, there is a need for a case-by-case design, due to the many variables involved in defining the thermal and energy performance of thermoactive elements in the climatization of buildings.

The efficiency and limitations of the thermal mass activation of existing buildings has been investigated. The energy performance of TABS has been compared with the energy performance of rapid-response systems, within their practical application in a refurbished office building located in calle Apolonio Morales 29, Madrid (Spain), provided as an emblematic case study.

The provision of a Building Management System (BMS) allows the monitoring of operative parameters and the management of setpoint values via its control interface. Monitoring and analyzing parameter trends and charts are useful to identify specific faults or anomalies that are causes of energy waste and draw up new action strategies. In this respect, a proper energy diagnosis is necessary to reduce weaknesses and optimize the thermal and energy behavior of TABS. Previous work [1–2] demonstrate how a detailed energy audit requires

frequent data and appropriate analysis tools to provide pointers to possible problems areas and faults.

The analysis of the energy response of TABS in cooling (summer 2018 vs. 2019) was carried out. The results show that significant energy and economic savings have been achieved in 2019 by applying properly conducted optimizing operations for TABS (Fig.1): they are essential to minimize weaknesses, while reducing thermal discomfort and energy waste, and adapting the control parameters to the effective situation in buildings [3–4].

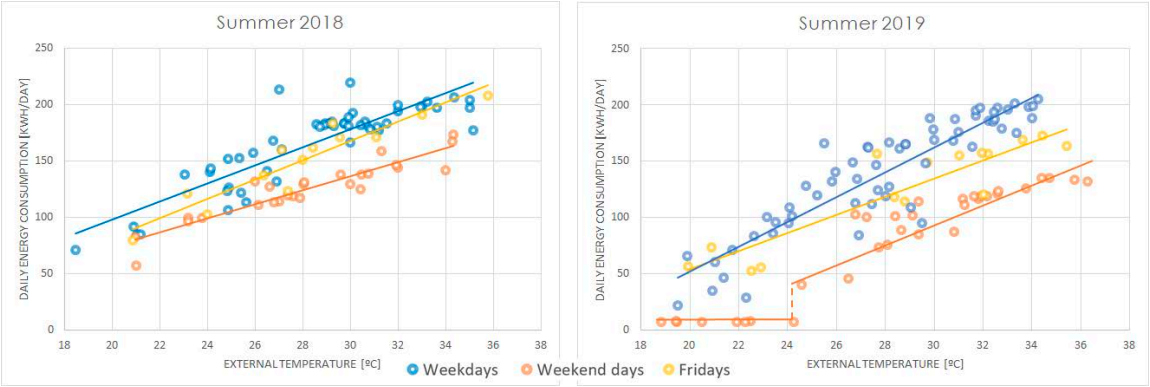

Fig. 1. Energy signatures. Cooling periods: Summer 2018 vs. Summer 2019, Weekdays, Fridays, Weenend days. © 2019, Apolonio Morales 29, Madrid. Control System. Self elaboration

The optimization of the overnight strategy for TABS, evidently contributed to reducing the operating hours of the Air Handling Unit (AHU), which was one of the main factors of energy consumption in summer, while providing the acceptable thermal comfort conditions for the occupants. This evidently contributes to the minimization of the consumption for air conditioning in summer, while reducing the size and the operation of rapid-response systems.

The complexity of the building-plant system, along with the experimental character of the intervention, requires the development of an effective auditing methodology. This research also suggests how the parameters of energy signatures can be used diagnostically to qualitatively corroborate the energy savings achieved, while neutralizing the weather influence on the energy consumption for climatization [5].

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DOMOTIC AND SMART CITIES

SELF-SUSTAINING GREEN ROOF PROTOTYPE

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En las últimas décadas se ha producido una creciente interiorización social, económica y política de las consecuencias que el modelo energético actualmente utilizado en los países desarrollados tiene sobre el planeta. El agotamiento de los combustibles fósiles, las crecientes emisiones de CO_2 a la atmósfera y el aumento del efecto invernadero, son algunas de las consecuencias de la acción humana como consecuencia del progreso.

De esta manera, la Agencia Internacional de la Energía ha alertado sobre las consecuencias del consumo energético actual y de la insostenibilidad del mismo, animando a todas las naciones (y en especial a Europa, China y EE. UU.) a que tomen medidas correctivas. España, se ve afectada en este sentido por las Directivas europeas, viéndose obligada para el año 2020 a reducir en un 20% las emisiones de CO_2 respecto a las que se contabilizaron en 1990, y aumentar en un 20% el peso de las energías renovables.

La electricidad se presenta como la forma más útil y empelada de energía, y se encuentra presente en todos los ámbitos de la sociedad gracias a sus múltiples aplicaciones. En este sentido, cabe destacar el empleo de la energía solar fotovoltaica por su facilidad de instalación y su ratio elevada de generación/precio.

En este sentido, una aplicación inmediata y poco explotada del riego fotovoltaico es para el mantenimiento de las denominadas cubiertas verdes o ajardinadas. Esta tipología de cubiertas planas surge en las ciudades más desarrolladas como alternativa a las cubiertas planas tradicionales, con el objetivo de introducir espacios de vegetación en zonas urbanas con fines estéticos, lúdicos y sobre todo medioambientales.

A nivel funcional presentan unos requisitos de mantenimiento similares a cualquier plantación ajardinada en el suelo, incorporando como salvedad en su ejecución una lámina de protección impermeable y una capa aislante. Estas cubiertas están contempladas por el Código Técnico de la Edificación donde se indica que deben tener una pendiente de entre 1-5 %.

Esta tipología de cubiertas ajardinadas es especialmente útil en climas mediterráneos para reducir las temperaturas ambientales en épocas veraniegas. Este fenómeno es debido al sombreado que realizan las plantas y la mayor transpiración del cerramiento. Además, se produce un aumento de la inercia térmica respecto a cubiertas tradicionales que disminuye las pérdidas de calor en invierno. De tal forma, que se pueden alcanzar ahorros cercanos al 25%/anual en edificios de viviendas y alrededor del 7%/anual en edificios industriales.

Así pues, para épocas de verano se resalta la idoneidad de disponer de plantas con buen follaje extensivo en horizontal que favorezca el sombreado, limitando la incidencia de la radiación solar sobre la superficie de la cubierta. Además, es conveniente utilizar sustratos ligeros que reduzcan el peso del cerramiento, así como favorecer el proceso de evapotranspiración que permita dispar mayor cantidad de calor. La disipación de calor a través de la cubierta se ve favorecida cuando el sustrato está húmedo, lo cual a su vez es contraproducente para climas mediterráneos como el que nos atañe cuando se trata de estaciones de invierno, donde el ahorro energético se puede ver. Por otro lado, en verano la radiación que alcanza la capa de sustrato es retenida por el mismo, y durante la noche con el descenso de las temperaturas, esta inercia térmica invierte el proceso cediendo el calor acumulado al interior de la vivienda.

Son varios los autores que se han dedicado a monitorizar diferentes tipologías de cubiertas vegetales en base al clima. En general, se caracterizan por la colocación de termopares en las diferentes capas de la cubierta que permitan medir la transmisión de calor a su través, así como, la medición de otros parámetros alternativos como humedad, velocidad de viento, radiación, etc. Estos datos recopilados son empleados posteriormente para realizar simulaciones mediante motores de calculo como EnergyPlus que permitan comprender mejor el funcionamiento de estas cubiertas.

El objetivo de este trabajo es desarrollar un sistema automático de riego que permita favorecer el mantenimiento de este tipo de cubiertas, y que permita su monitorización mediante Arduino siendo alimentado con energía 100% renovable.

MAGNETIC SENSORS USED IN MODERN TECHNOLOGY

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Keywords: *Magnetic sensor, magnetic materials, permeability, modern technology*

For a robot to perform tasks such as location and dimensioning of objects in a work place, the action of a sensor is needed. The data collected by the sensor also feed back to the environment, enabling the robot to examine them and take decisions.

The use of external sensor mechanisms allows a robot to interact with its environment in a flexible way, in contrast to preprogrammed actions in which a robot is taught to carry out repetitive tasks out of a set of scheduled functions. Although current industrial robots operate most frequently according to the latter mechanism, the use of sensor technologies to equip machines with a higher intelligence level when dealing with their environment is actually a topic of active research and development in the field of robotics [1–3].

Among the current sensors that can be handled, magnetic sensors are a good alternative for the detection and measurement of various phenomena because of their “simple” technology and because they can be easily acquired. A wide range of magnetic materials is available to build these types of devices, among which amorphous ferromagnetic materials should be highlighted [4–6]. Since these materials are available on the market, the production of different kinds of sensors can be realized without the expensive investments needed for the manufacture of their magnetic cores. These sensors are not fragile and do not require special care, which enables the construction of very solid and reliable devices. Another important feature in their behalf is that these sensors can be developed without electric contact between the measuring device and the sensor, making them especially fit for use in harsh environments. Magnetic sensors work basically by detecting [7,8]:

(a) Variations of magnetic core permeability produced by the parameter to be measured.

(b) Changes in some physical parameters produced by changes of the magnetization direction.

(c) Mutual induction changes between two circuits produced by geometric modifications of the magnetic core positioning.

The permeability of magnetic materials depends greatly on their magnetic anisotropy, on the difference between the direction of the applied field and the

anisotropy direction of the material, as well as on their homogeneity, magnetization state, frequency of the applied field, surface roughness and form. In the development of a sensor for measuring a physical parameter, it is necessary that changes of magnetic permeability or of the magnetization direction caused by a change in the parameter to be measured are as large as possible. Amorphous and nanocrystalline materials meet these requirements particularly well.

This work presents the state of the art of magnetic sensors based on amorphous ferromagnetic materials used in modern technology: security devices, weapon detection, magnetic maps, car industry, credit cards, etc.

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NEW SYSTEM FOR HEAT TREATMENT OF MAGNETIC MATERIALS

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Keywords: *Amorphous materials, current annealing, magnetic labels*

The excellent magnetic properties of amorphous materials arouse great interest from a technological point of view, due to their use in sensors and security systems [1]. Since the appearance of the first amorphous metal in 1960 [2], the study and development of amorphous materials has represented a field of great interest due to their basic characteristics, such as the lack of translational periodicity and the non-directional nature of their bonds. This constituted a major departure from other materials known at the time.

One of the fundamental characteristics of amorphous materials is their soft nature. The large amount of compositions that exist and the option to vary their properties through various treatments, make it possible to design the most suitable material for a given application. Starting with annealed amorphous ferromagnetic samples, their properties can be changed locally to obtain the most suitable type of material for use in the field of sensors and magnetic labels [3–6].

Some of the magnetic labels that exist on the market can be deactivated (on taking a product out of a shop, for example) or activated (on returning a book to the library, for example). These kinds of labels are composed of a base made of soft magnetic material, with several pieces of hard magnetic material put on top of it. That way, the stray field of the hard magnetic material inhibits the magnetisation of the soft part, such that if the hard material is demagnetised, the label remains activated. This method implies the use of two different materials and requires a complicated and expensive manufacturing process. These disadvantages could be addressed if it were possible to obtain materials which featured alternate soft and hard areas. In addition to the aforementioned advantage of using a single material, the manufacturing speed could be high enough to warrant its use in industrial processes.

Due to the metastable state of amorphous materials, heat treatment would result in significant variations in their characteristics. Since heat treatments must be applied in annealing processes in order to reach different temperatures and be able to study heat transfer processes, various research projects have

focused upon the design of the furnaces so that their energy consumption is as low as possible [7,8].

This work presents an alternative method which on the one hand circumvents the issues associated with using large and expensive facilities, and on the other hand resolves the problem of possible rusting during the annealing process. Our device permits pulsed current annealing of the material within a dissipative material such as oil, which enables magnetic labels to be obtained.

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DEVICE FOR MEASURING WATER QUALITY

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Keywords: *Low cost, inplace analisys, flexibility, Arduino, clean water*

First of all an analysis of the importance of water to humans and the development of their life and activities on planet Earth [1] has been carried out, highlighting the amount of organizations worldwide interested in providing collectives with guarantees in the quality of water, both consumption and irrigation among others [2].

The essential problem lies in the costs that analyzing water involves, either by the location of sources over long distances, as in the journeys of the vital liquid to reach consumption.

Having diagnosed the problem has investigated what are the main parameters to quickly and in real time determine the quality of water in order to develop a low-cost device that promises to provide an effective solution to the problema [3-4].

Among the main parameters are PH [5], turbidity [6], and temperatura [7], so a C02[8] sensor has also been incorporated into the device, to diagnose the air quality inplace, as increasing the levels of carbon dioxide in the atmosphere acidifies water, this can affect aquatic ecosystems [9].

Through the platform and Arduino Uno Board [10], a physical system of four sensors has been designed and implemented. It has been programmed and calibrated in such a way that the several sensors work sending real time information to the screen. Moreover the device is easy to move thanks to its quite small size, related to large equipment in the industry that perform the same functions.

The results obtained have been quite promising, this prototype could become a pilot project of incorporation for easy analysis of water quality, to ensure health even in fairly distant populations.

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ENERGY EFFICIENCY

COST-EFFICIENT SKIN DESIGN TOOL FOR HOUSING

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Keywords: *Sustainability, customized buildings, energy savings, envelope optimization, heat balance*

Buildings account for 40% of energy consumption in the European Union according to the 2010/31/EU directive of the European Parliament and the Council on the energy performance of buildings. Since the objective of the directive in 2010 was to reduce by 20% the energy consumption in the sector by 2020, currently, the reduction of energy consumption in the life-cycle of buildings as well as the consolidation and increase of renewable energy sources in the use of buildings are still goals for all the European Union governments in order to follow the same direction to enhance sustainability and reduce carbon emissions.

The energetic behaviour of house-buildings is defined by both the building skin properties and the HVAC systems operation. On the basis that users are conscious of the efficient way to use HVAC systems, optimizations in the design of all the passive elements and components of the envelope will reduce heating and cooling loads to the point of reaching passive-house behaviour in many cases. However, on the one hand, highly efficient building performances may entail important initial investments, consequently diverting the attention of customers. On the other hand, customers are also interested in customization [1], that may result on building designs far away of passive-house ones, with poor energetic performances and high maintenance costs.

The main aim of this research is to define a methodology that includes customers in the design process of their houses and helps them to obtain an optimal building envelope configuration from the point of view of cost and energy savings. The developed tool will show them via Pareto charts the energy

consumption and the initial costs of as many building skin configurations as they want, facilitating the task of choosing the appropriate building design according to their main priorities. Inefficient usage practices may also be included in the resulting charts in order to make customers aware of their impact not only in the environment, but also in the yearly costs of building maintenance.

The main goal of this proposed tool is that customers will have the key to balance design, construction costs and energy efficiency of their house-buildings with a visual tool that will make them feel like architects, and, unconsciously, will aid the industry to make a step towards sustainability.

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INNOVATION IN BUILDING AND CIVIL WORKS

TUNNEL LINING WITH FIBRE REINFORCED CONCRETE

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Keywords: *Lining, NAMT, SFRC, temperature gradient*

Steel fibers as concrete reinforcement is a technique with more and more uses in construction, due to fibers ability to increase the ductility of concrete and to improve its behaviour against impact loads, as well as the possibility of replace the conventional reinforcement in the case of elements mainly in compression. Thus the use of fiber reinforced concrete (SFRC) nowadays are widely extended for the design of pavements and for the execution of tunnel segments [1].

On the other hand, the New Austrian Tunnel Method (NAMT) is one of the most common methodologies for the execution of tunnels both in rock and in soils. With this typology, soil pressures are withstanded by means of a primary support based on anchors bolts and shotcrete [2]. Besides the main primary support system it is necessary to design a second structural element to guarantee that both soil and groundwater loads, such as thermal loads and those due to the service of the tunnel are withstanded during the service life of the tunnel. Normally these structural linings are executed by means of a moving-formwork that allows the pouring of the required lining thickness, usually between 25 and 40 cm [3-4].

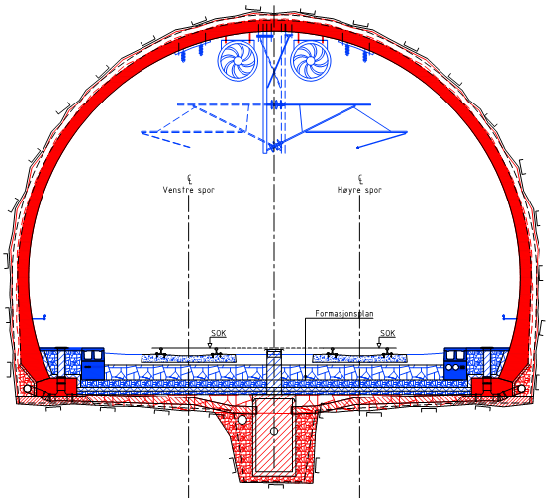

Figure 1. Tunnel section

Usually tunnel sections are antifunicular parabolic arched-shape of the applied soil loads, so this type of action in general will only cause on these structural elements pairs of compression and bending forces with small eccentricities. At

the same time, thermal loads due to the uniform temperature variation will not cause any effect beyond the modification of the permanent axial forces (the section will be compressed against the soil when a increase temperature and with low temperature the lining will be shortening leading to a decrease of axial forces). To deal with this action, it will only be necessary to design transverse expansion joints at mininum distance.

Instead thermal gradient between outer and inner face of the lining will be the most unfavorable action for the design, since it will cause bending moments throughout the perimeter, which will be added to forces due to selfweight, soil pressures and uniform temperature loads. In other words, thermal gradient will lead to axial forces with maximum excentricies.

Inspite of previosly commented, small eccentricities of the overall N-M forces will be obtained in most cases and then this let design structural linings with plain or lightly reinforced concrete. As an alternative, recently it has begun to be considered the use of SFRC concrete or mixed solutions with reinforcements. These options, given the low or null amount of reinforcement, allow its execution in an easier and faster way, thus being a cost and time saving alternative against conventional designs.

As an example, a design of a tunnel lining is described, focusing it on the hypothesis and assumptions that have allowed the use of steel fibers as the only reinforcement of concrete. Also, special emphasis will be placed on the required properties of the fibers.

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BIM-BASED METHODOLOGY FOR THE LOAD TEST OF A CABLE-STAYED FOOTBRIDGE IN THE SEVILLE RING ROAD SE-30

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Keywords: *BIM, Infrastructure project, Revit, Footbridge Design*

Building Information Modelling (BIM) is a collaborative and multidisciplinary work methodology for the management and maintenance of engineering projects along its life cycle by using 3D digital models. Therefore, the purpose behind BIM is not only to satisfy the clients but also to enhance the businesses' benefits as a consequence of better-quality projects.

Its original approach was architecture and building. That is why it is widespread in those fields. For the case of infrastructure projects, due to the late arrival of the methodology to this discipline, it still has not reached all its potential [2, 3]. Hence, during the last few years, BIM methodology has been increasingly used until the point administrations of several countries have made it compulsory. This is the situation of Spain, being compulsory for all infrastructure projects with public funding since 2019 [1].

Nowadays, there are various software available in the market with different purposes. For the development of this study, the software used included Revit, Autodesk Civil 3D, InfraWorks, QGIS and Google Drive.

This project modelled a cable-stayed footbridge construction project in Seville. The main idea was to combine a 3D model of the original footbridge with an application to record the deflection measured in different points of the structure during the load test. The application would compare the measurement with the expected value obtained with a finite elements model.

One of the problems encountered was the complexity of the structure and its 3D curved steering axle. The limitation in Revit of horizontal levels made it difficult to model this geometry. Therefore, in order to overcome this restriction, it was combined with Autodesk Civil 3D to achieve the final product.

Figure 1.Footbridge integrated in final location.

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BIM METHODOLOGY FOR THE EXTENSION OF AN EXISTING BRIDGE

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Keywords: *BIM, bridge, 3D model, BIM 4D, interoperability*

This study shows a case study of the possibilities to solve the duplication of a road bridge through use of BIM (Building Information Modelling). It summarizes the works performed by the authors in the frame of the module Smart Construction: BIM, in the MEng in Civil Engineering at Universidad Politécnica de Madrid (UPM) [1-4]. The project involved an existing bridge in Madrid Region to be replaced by a new structure under construction. Thus, it entailed the construction of a temporary traffic diversion bridge, the demolition of the existing bridge and, subsequently, the construction of the new bridge.

Given that both the existing and the new bridge were located in the same place, it was possible to make best use of BIM possibilities. Hence, the use of BIM was of great interest in order to ensure the absence of any clashes between the existing, the temporary and the final construction at any of the construction phases. The new bridge was designed to be executed in two phases in order not to interrupt traffic at any time. The project also included the final demolition of the old structure.

Considering the relevance of interoperability among programs when using BIM, this study was developed by using varied software and plugins. These computer programs were Civil 3D (earthworks), Revit (modelling structures), BIM ONE (Revit plugin that allows bidirectional data transfer with Excel), Excel (quotation), Inventor (modelling of families for Revit), Navisworks (construction

management and clash detection), Rhinoceros (simple modelling from the Revit model for final 3D printing of the model) and InfraWorks (final presentation).

The conclusions of the study showed that BIM methodology is a very useful tool for this type of solutions. The use of BIM enabled the clash detection at both design and execution stages as well as during the coexistence of the old structure and part of the new one. Moreover, the three-dimensional modelling of the construction process may allow the reduction of errors, uncertainties as well as lacks of definitions of the project.

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HOW MUCH IS LEFT FOR FULL IMPLEMENTATION OF BIM IN CIVIL ENGINEERING?

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Keywords: *BIM, Civil Engineering, adaptability, BIG DATA*

There are several cases where BIM's knowledge of infrastructure has been applied successfully, such as hydraulic works [1-3] or linear works [4-5]. However, the use of BIM methodology in the area of Civil Engineering is mainly focused on the use of tools in the design phase. Thus, in terms of work methodology, the way to integrate the information obtained, interrelate it and transfer it to third parties still remains complex, being the information regarding this issue very limited.

The incorporation of the BIM methodology into the curriculum of the Master's Degree in Civil Engineering [6] has allowed the students to develop projects in the area of Civil Engineering through use of various software [7]. In most cases, however, this sector has been forced to use software developed for building. That is to say, software has implemented most of the families needed for the design of buildings as it is the case of Revit. This implies that the time-cost for modeling civil projects is much higher because it is necessary to adjust or to create most of the items (Figure 1).

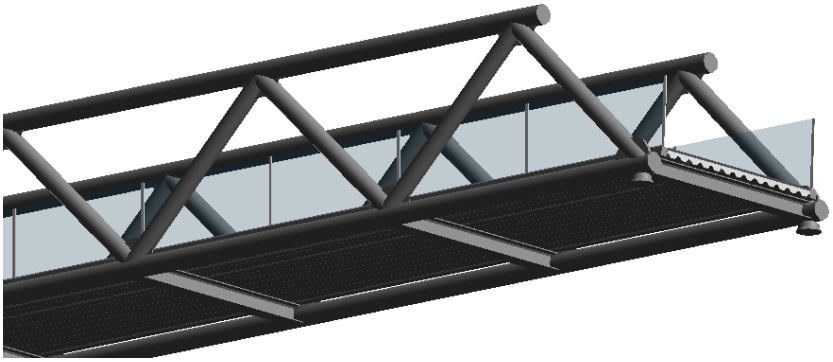

Figure 1. Model of mixed traffic bridge by students in the 2019-2020 academic year

Furthermore, the scale of the model has increased exponentially as can be seen in Figure 2. The models encompass a huge scope of interaction with infrastructure and environment and that leads to the need of managing high volumes of information, with a resulting problem in the data management. This involves a BIG DATA analysis.

In addition, the models in many cases require different disciplines for their realization and, therefore, different software is needed. There is evidence that in many cases it can be translated into a loss of information between programs from the same company. This makes that its implementation could be even more difficult.

Figure 2. Model of Access road by students in the 2019-2020 academic year.

The aim of this research is to show the number of problems detected which slow down the implement of BIM methodology in Civil Engineering. At present, the greatest efforts have been devoted to building and the attempts in Civil Engineering are limited and poorly documented, not forgetting that the potential of this methodology is limited [8].

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IMPLEMENTATION OF BIM METHODOLOGY INTO THE CONSERVATION AND MAINTENANCE OF BRIDGES

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Keywords: *BIM, Dynamo, bridge, conservation*

Building Information Modeling has shown to be suitable not only for the project and for design of building and civil engineering constructions but also for facility management, construction management as well as the conservation and maintenance of existing infrastructure [1-3].

The main purpose of this project was to apply BIM methodology to the conservation of existing bridges, connecting the three-dimensional model of the bridge with associated worksheets. The tool that enabled the authors to do so was Dynamo.

Dynamo is a tool that can only be developed from Revit and it uses an easy programming language with predefined functions that allow the introduction of the elements to be added and obtained from the Revit model.

Every damage found on any of the elements conforming the structure was assigned to a previously created parameter of the structure.

Once all the information from the model was added, it permitted to be exported the same way back to another worksheet. In the case of this study, every damage added was exported, so that it was possible to perform a budget analyzing the costs of the potential reparations based on prices log.

In order to do so, three worksheet files were needed. The first file allowed importing data from visual inspection, the second file contained costs and budget information and the third one enabled the gathering of all the structures with common features.

This type of linking can also lead to many other applications such as collecting the information for dealing with bridges under concessions.

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INSTALATIONS

ENERGY SAVING ACHIEVED WITH ADAPTIVE SETPOINT TEMPERATURES IN THE CITIES OF THE ALGARVE (PORTUGAL)

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Keywords: *Energy consumption, adaptive setpoint temperatures, Algarve, building, HVAC system*

The deceleration of climate change and the decrease of environmental degradation are two of the main international problems of the society. High emissions of Greenhouse Gases are generating more and more extreme living conditions. Regarding existing buildings, their high energy consumption is mainly responsible for the contributions of Greenhouse Gases emissions to the atmosphere. Ambitious goals for reducing Greenhouse Gases emissions have therefore been established by 2050 [1]. For example, the European Union has set the objective of reducing emissions of these gases by 90% in the building sector [1]. This study analyses the potential of the energy saving achieved using adaptive setpoint temperatures. These setpoint temperatures based on different adaptive thermal comfort models as energy conservation measures have been analysed in previous research works. These studies have shown that the energy savings achieved with these energy conservation measures are higher in cooling than in heating. Therefore, these measures have a greater potential for application in warm climates. Nevertheless, these studies have been carried out in the same cities (e.g., Seville or Madrid) [2,3]. Thus, the conduct of new studies that apply these measures in other warm climatic zones could allow to have a greater knowledge about their potential of application. For this reason, this research applied this energy conservation measures in a case study located in the cities of Algarve (the southernmost region of continental Portugal). According to decree-law 80/2006 [4], Algarve has the most severe summer climatic classification (V1), as well as different winter classifications (I1, I2, and I3). This aspect could vary the potential for applying the measures in the cities of Algarve. The standard EN16798-1:2019 [5], is therefore used in this research. The case study was analysed using EnergyPlus. The energy

consumption obtained with adaptive setpoint temperatures was compared to that obtained using a static setpoint temperatures. The results reflected the potential for the energy saving obtained by using adaptive setpoint temperatures in Algarve. Moreover, the results were compared with demographic and employability indicators [6] in order to have more knowledge about the impact of this energy conservation measure in the region.

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CFD APPLIED TO THE DESIGN AND OPTIMIZATION OF HOSPITAL CRITICAL ROOM AIR CONDITIONING

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Keywords: *Indoor air quality, operating theatre, CFD, HVAC, healthcare engineering*

Indoor environmental quality requirements in critical hospital areas require the keeping of a number of environmental parameters within narrow margins [1]. Quantitative variables, such as temperature, relative humidity, overpressure, presence of biocontaminants, etc.; and qualitative variables, such as the pattern of movement and direction of air flow must be ensured [2, 3]. The influence of design criteria on the qualitative performance of the room is not systematically collected in the technical literature. As a result, the energy demand of the air-conditioning facilities in these areas is four times higher than in other rooms in the building [4]. The aim of this work is to demonstrate the potential of Computational Fluid Dynamics as a tool in the design phase of hospital critical rooms. As results, graphs and contours can be generated, which can be specified on points, lines, surfaces or volumes of interest. The power of this tool allows us to evaluate the performance of air conditioning at each point in the room, obtaining a wider range of possible results than by experimentation. Consequently, it allows the prediction of the qualitative behaviour of the air conditioning during the design phase, with the importance that this implies. In this way, the energy efficiency of these installations can be maximised.

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PREVENTION OF LEGIONELLA IN THE WATER SYSTEM OF PRIVATE HOSPITALS

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Keywords: *Legionella; hospital; water; facility management*

One of the primary sources of Legionellosis has been identified as potable water systems [1]. Outbreaks are associated with buildings that have complicated water storage and distribution systems including hotels, long-term care facilities, and hospitals [2]. Although hospitals aim is to guarantee the absence of Legionella from their water distribution systems, there is no ideal method for ensuring total disinfection [3]. Preventive measures shall be based on eliminating or reducing dirty areas by maintaining the facilities and avoiding conditions that favour the survival and multiplication of Legionella by controlling the temperature of the water and desinfecting it continuously [4]. The vulnerability of patients in hospitals increases the risk of severe disease [5].

The objective of this study is to analyze the anti-legionella treatments carried out between 2015 and 2019 in the potable water system in 7 private hospitals located in the province of Madrid (Spain). They have a number of beds between 20 and 198, and a surface area between 2,314 and 23,300 m^2.

For this purpose, the installations of cold water for human consumption, hot sanitary water and water for the fire protection installation were studied.

Currently, there are 2 internal departments involved: maintenance, which assumes the preventive interventions that are carried out on the water production and distribution systems, and preventive medicine, which is

responsible for taking samples at the points of consumption for subsequent analysis in an external laboratory.

The results show resources used to reduce the chance of an outbreak and to comply with existing legislation [6] [4] although merely complying with existing legislation and guidance does not necessarily mean that a system is safe or operates reliably [7].

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MATERIALS AND CONSTRUCTION SYSTEMS

RECYCLED RUBBER LIGHT CEMENT MORTAR (CCR). AN ECO-ALTERNATIVE TO THE FILLING MORTARS FOR URBAN INFRASTRUCTURES

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Keywords: *Tire waste; waste management; rubber granulate; lightened cement mortars.*

Working towards a greater sustainability in waste management implies being able to assess the efficiency reached in terms of saving raw materials as well as avoiding waste.

From all the construction and demolition waste (CDW) generated in Spain, approximately 60% comes from masonry waste and 20% from concrete waste [1]. These types of waste are mainly used to produce recycled aggregates, which are added to produce concrete, mortars and asphalts by substituting natural aggregates. These aggregates are basically applied to bases and sub-bases of road surfaces. In addition to this types of waste, other industrial wastes can also be used for these applications. In this article, a research project about using rubber coming from used tires as an aggregate for the cement mortars used in urban infrastructures, is presented.

The European Catalogue of Waste [2] includes used tires as non-hazardous waste, and the 99/31/CE Directive [3] of the European Union Council, on waste dumping, establishes the prohibition of whole tire waste and the prohibition of broken tires dumping. In addition, it establishes that in public works, in which the use of used tires is technically and economically viable, priority will be given to the production of materials from recycling. The aim is to encourage State members of the EU to recuperate and recover 100% of used tires.

Presently, in Spain, 50% of the used tire waste is dumped in landfills, 17% is energetically valorised and only 14% is recycled [4].

The research presented here shows a new application of the tire waste. That is, the results of adding rubber granulates, originated from rubber waste from used tires, within a cement matrix. This addition implies the substitution of expanded clay aggregates used commonly to lighten mortars.

Numerous references have been found on research projects using rubber granules as addition to concrete [5-8]. However, no studies were found about the use of rubber in high quantities in cement mortars as an alternative of the expanded clay applied in infrastructure.

The experimental plan designed consists on the elaboration of several series of prismatic 40x40x160 mm specimens of cement mortar where sand has been substituted by rubber granules or by a mixture of different percentages of clay and rubber.

As a conclusion it can be said that the substitution in lightened mortars of part of the expanded clay by rubber, increases 50% of the density values of mortars lightened only with expanded clay and this increase implies a great improvement of the mechanical strength. At the same time, this density is similar to the lightened mortars, which are currently present in the market [9].

This rubber substitution provides also an improvement in the sustainability of these mortars, as they use a great volume of waste and thus, natural materials (sand, aggregates, etc) and the expanded clay, used presently for the production of commercialized mortar, can be substituted.

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VISUAL DIAGRAMS WITH RECOMMENDATIONS FOR THE EXECUTION OF EXTERNAL BRICK WALLS OF FACADES

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Keywords: *Quality control, construction processes, work methods*

Facades are one of the most important and significant parts of buildings. In addition to their technical-construction function, facades are the main elements conferring buildings with their character and personality, differentiating them from other buildings as well as adopting to a great extent the architectural style of the time in which they were raised.

Facades are also among the construction elements with the greatest accumulation and percentage of problems, from among 58 elements analysed over 10 years [1]. Indeed, they accumulate more problems than roofs, that are especially known for their anomalies due to infiltrations, particularly in flat roofs. The percentage of problems in facades stands at 19.90% of problems in the Spanish building stock, mostly relating to humidities, fissures caused during construction and detachment of pieces [2].

Part of these problems are caused by designs that do not properly specify how to address critical points nor include sufficient construction details in the graphical documentation [3]. In addition, however, the construction process (in general) is increasingly flawed and leads to an increase in errors – whether by amplifying design errors or by inserting new errors during the execution stage of facades [4].

This communication, which will be formatted as a poster, will review, in a visual and eminently graphical manner, the process of the execution of external brick walls of facades, as this is the component in which the most problematic points, with the most significant anomalies, are concentrated.

The graphical presentation offered in this technical-scientific contribution summarises the knowledge from several works of research carried out by the author on the design, execution and deficiencies of facades, and constitutes a easy and very visual way of understanding them (whether with photographs or with drawings produced ad hoc for this presentation).

The sequence of drawings and bullet points may well serve as an overview for students in the final year of their technical architecture courses, as well as for those professionals that have recently graduated. They also contain some regulatory aspects (such as the slope that external windowsills should have according to the Technical Building Code) [5], and other recommended principles for good construction.

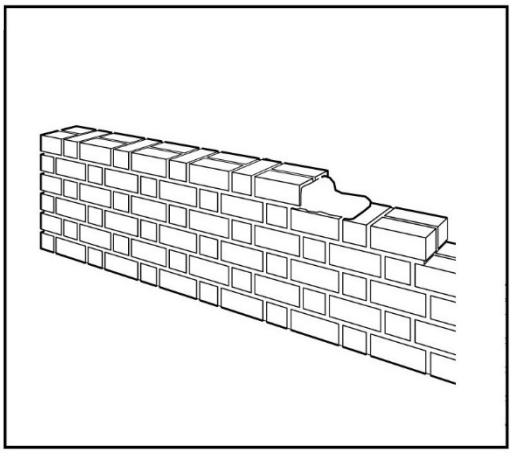

Fig. 1: Process with alternating rows, flemish bond (walls of 1 foot)

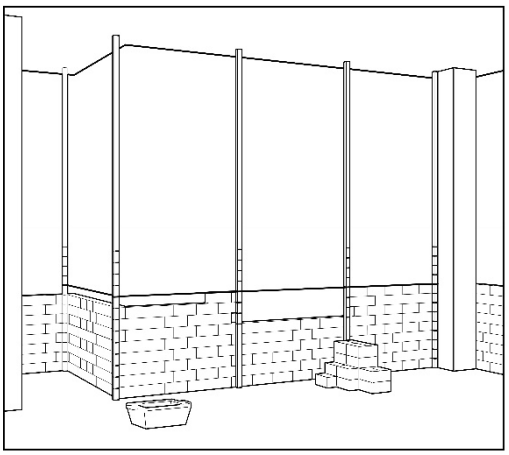

Fig. 2: Laying the external wall of the facade with slots at the height of the external windowsills

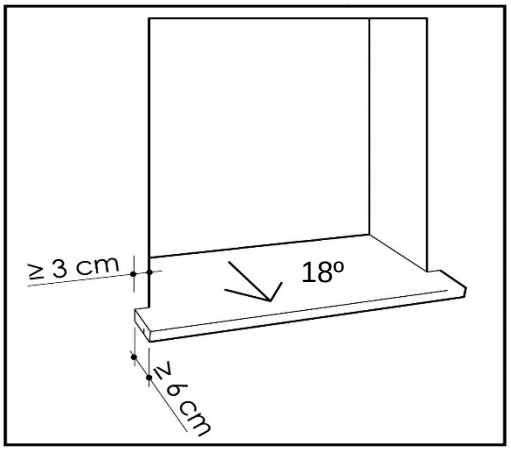

Fig. 3: Slope, embedment length and overhang of external windowsills

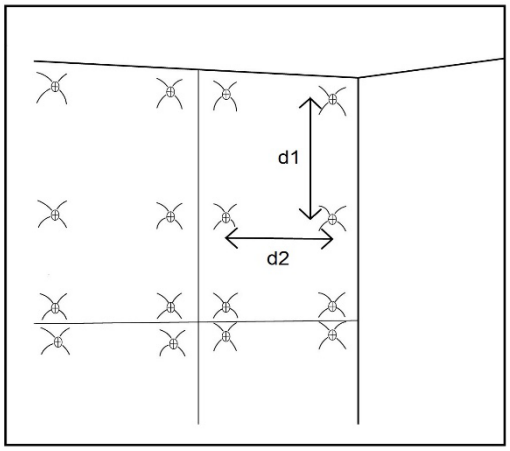

Fig. 4: Placing the chamber insulation, vapour barrier and distance between fastening points

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PRECAST CONCRETE PIPELINES. RESPONSE AGAINST MECHANICAL, PHYSICAL AND CHEMICAL ATTACK

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Keywords: *Precast pipes, sanitation pipes, drainage, concrete, durability.*

Precast concrete pipelines are currently essential to the health and running of the modern cities. These concrete pipes are submitted to a number of mechanical, physical, chemical and microbiological actions during their service-life. It is well-known that when a pipeline is out of service, may originate great problems with expensive results [1-2]. As consequence, precast concrete pipelines have to be designed in order to keep their mechanical and durable properties, dimensional stability and tightness. Therefore, they have to be manufactured following the specifications established in the high quality standards [3-4]. In addition, installation of reinforced concrete pipelines is a complex phase to ensure that the pipeline system performs properly. Such installation is identified as a necessary second step which should secure both the tightness and the dimensional stability resulting from the interaction between the pipe and the ground [5-6].

Along with mechanical-structural and hydraulic capacity aspects of reinforced concrete pipe, its durability is another significant aspect to consider during the design phase. Stakeholders are responsible for ensuring that reinforced concrete pipeline durability is adequately considered in any hydraulic project. In addition, concrete pipe service-life cannot be predicted with the same degree of precision as the structural and the hydraulic performance, because there are several external factors that could affect the long-term performance and cannot be controlled by the designer. The main aspects in the production of durable concrete include:

- Appropriate type of cement selection.
- Sound aggregate and steel reinforcement properly selected.
- Adequate mix design.

- Efficient compaction and effective curing.
- Specified concrete cover, consistent with the environment.
- Accredited quality control systems (manufacture and installation).

Precast concrete pipelines in Spain (ANDECE) are characterised by quality controlled manufacturers (AENOR), who are able to manufacture pipes with excellent durability.

This work assesses the mechanical, physical and chemical actions which can negatively affect to concrete pipelines utilised in sanitation and drainage systems.

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PORTLAND CEMENT MORTAR CARBONATION ASSESSMENT BY USING THYMOL BLUE INDICATOR

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Keywords: *Carbonation; ground granulated blast-furnace slag; Portland cement; Thymol blue indicator*

It is well documented in literature the carbonation reaction of calcium hydroxide contained in the Portland cement mortars [1-5]. This reaction proceeds in two steps. During the first step, carbon dioxide is absorbed onto the alkaline pore water on the sample surface. The result is the precipitation of calcite crystals where the controlling factor is the dissolution of carbon dioxide and calcium hydroxide in the pore solution. The second step of carbonation is controlled by the carbon dioxide diffusion through the mortar pore network. Given that, the rate of carbonation is defined by the rate of carbon dioxide uptake by calcium hydroxide among other Portland cement constituents [6-7].

One commercial common Portland cement CEM III/B 32.5 N-LH/SR according to the European standard EN 197-1:2011 [8] was used in this study. This cement contains 62.2% ground granulated blast-furnace slag. Chemical analyses of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3 and free lime were performed according to the European standard EN 196-2:2014. The testing mortars were prepared according to the European standard EN 196-1:2016. They were cured under water for zero, one, three, seven, 14 or 28 days. Thereafter, mortars were tested for natural carbonation using a thymol blue indicator solution. Natural carbonation testing was performed exposing the mortars to the natural exterior environment under shelter from rain conditions (CO_2 concentration of 0.035±0.005%, a temperature of 20±2ºC and a relative humidity of 65±5%). Measurement was taken at 12 months of natural exposure after the curing period.

Normally, testing for natural carbonation is made by using a phenolftalein indicator solution; however, in this study a thymol blue indicator was chosen. Carbonation rate after one year of natural exposure increases with decreasing curing time under water. Also, it increases when ground granulated blast-furnace slag content in mortars increase.

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COMPRESSIVE STRENGTH DEVELOPMENT OF TERNARY PORTLAND CEMENTS

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Keywords: *Ternary cements; coal fly ash; granulated blast-furnace slag; compressive strength; synergy.*

Ternary cements is the name used to classify cements made with Portland cement clinker and two other constituents. This type of cement has been introduced to improve some properties of this binder and to reduce the carbon dioxide emission impact of clinker production. This fact is agreement with the low carbon economy roadmap [1]. The worldwide cement production was 4.65 billion tons (2016) and, probably, it will reach about 7 billion tons in 2050. Given that, cement clinker production will spend a huge amount of energy and natural resources. In addition, the production of 1 t of clinker releases around 0.87 t of carbon dioxide [2]. In line with this, ternary cements use is a partial solution to minimize the environmental impact of the cement industry. Consequently, the new prEN 197-1:2018 [3] includes some ternary cements.

Blast-furnace slag is a waste of the steel industry with pozzolanic and hydraulic properties. This slag improves the durability and 90-days compressive strength. Coal fly ash has a positive effect on the 28-days compressive strength due to its pozzolanic reactivity. Some studies on ternary cements have been published recently [4-9] and mix optimization is one of the key points [5-9].

The scope of this paper is to study the 28-days compressive strength development of ternary cement mortars made with CEM I 42.5 R, ground

granulated blast-furnace slag and coal fly ash. A factorial design of experiments has been used to optimize these cements. Consequently, the main effects of these ternary cements on two, seven- and 28-days compressive strength are discussed.

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CIGARETTE BUTTS WASTE WITHIN GYPSUM MATRIX: MECHANICAL BEHAVIOUR

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Keywords: *Cigarette butts; recycling; waste; gypsum; mechanical testing*

Most of cigarettes used in the world have filters. Filters are made of non-biodegradable materials and remain in the environment for a long time [1]. Billions of cigarette butts (CBs) are being daily thrown away in the world. For that reason, it is one of the most common types of garbage in the world [2], [3], [4], [5]. A typical cigarette was shown to have a water footprint of 3.7 L, a climate change contribution of 14 g CO2 equiv, and a fossil fuel depletion contribution of 3.5 g oil equiv. [6]. On the other hand, the construction sector is one of the industries responsible of the highest ecological footprint, as it consumes great amounts of natural resources and generates vast quantities waste [1]. Therefore, an urgent swift within the construction sector is currently needed to improve the situation. The ecological footprint of the construction sector can be reduced by promoting waste recovery; using environmentally friendly materials and renewable energy resources; and by optimizing bio-productive land use through the construction of multi-storeyed buildings [3].

Considering the issues mentioned above, the main aim of the research is the mechanical characterization of gypsum composites containing cigarette butts waste. That means to test it a material with better, or at least similar properties than regular gypsum one. For this, several gypsum specimens were prepared incorporating different percentages of waste based on the weight of the gypsum (0.3%, 0.5%, 0.7%, 1.0%, 2.0% and 2.5%). Samples without waste additions were also prepared in order to compare the results obtained. All samples were tested in the same laboratory with same methodology. The following mechanical characteristics were determined: surface hardness, flexural and compressive strength. A comparative analysis showed that it is possible to produce materials with a gypsum matrix adding cigarette butts, improving the behavior of the traditional gypsum and applying them in various construction

applications. In order to find suitable applications for the new building material developed, other properties as thermal behaviour, capillary absorption and acoustic performance should be research in future works.

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STUDY OF MECHANICAL BEHAVIOR OF MICRO CONCRETE WITH ADDITIONS

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***Keywords**: Micro concrete, additions, mechanical properties, recycled*

Structural concrete is the most widely used material in structures worldwide. There is currently a growing tendency to use smaller maximum addition sizes, as well as a low water/cement ratio, leading to particularly high resistance micro-concrete.

When analyzing this material, the nuances that it presents in its definitions are evidenced. Some authors consider it as a mortar with better properties and others, as a high-performance concrete. In general, it is presented as a high-performance cement-based material with micro additions whose maximum sizes vary from 100 μm to 8 mm and where its main use is for non-structural elements. For this reason, by sharing characteristics with concretes and mortars, the comparison of different micro additions can provide valuable information to determine the physical and mechanical properties [1,2].

Many of its compounds are usual additions such as limestone dust or limestone filler, silica fume, fly ash or blast furnace slag. All these improve the compressive strength and compactness of the mixture, resulting in a reduction in pore volume, better resistance to chemical attacks and greater durability [3-5].

At the same time, and following the global trend of reuse of materials, studies have been conducted where natural aggregates are replaced by recycled or also incorporate various types of fibers and particles of recycled materials. Some of these additions are glass fibers, polypropylene or polyvinyl alcohol. The last two presented a matrix more resistant to flexural strength and hardness [6]. On the other hand, the incorporation of polystyrene and polyethylene particles did not produce mechanical improvements in relation to their reference, only lightened concrete was obtained [7].

The objective of this work is to analyze the different aspects that the subject presents. Therefore, 9 articles were selected to compare micro-concrete, considering a maximum aggregate of 9,5 mm.

The results obtained are based on a better compressive strength with the use of granulometry additions from 0 to 4 mm. These same compounds also have a higher density in their mass. Flexural strength was only improved with the addition of polyvinyl alcohol fibers. Recycled aggregates, such as polystyrene, polyethylene and fiberglass, do not improve the mechanical strength of the material.

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HISTORICAL AND METRIC REFERENCE OF THE MURCIAN COTAGGE: ESTIMATION OF ITS CONSTRUCTION COSTS THROUGH THE PRACTICAL APPLICATION OF THE PREDIMENSIONED MODEL Pcr.5n

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Keywords: *Murcian cotagge, cost pre-dimensioning, minimum housing, sustainability*

In 1878 the architect D. José Marín Baldo, described the Murcian Barraca as "... a nest like that of the swallows, which is made of mud and dried reeds and herbs, for those who have to live there ..." [1] also in 1879 the Barraca "resistant" against floods and avenues, ... whose budget was 635 pesetas and four cents of the time [2].

The traditional murcian cotagge was a rectangular construction with a gable roof, with dimensions of 6.60 meters in length and 4.60 in width, divided into two approximately equal units. The main dependency of relationship and family life, which was accessed through the south-facing facade to take advantage of the sun, and whose functional use was that of kitchen and dining room, had an area of approximately 16 square meters. Through this main dependence, a wooden frame was accessed through the bedroom area of approximately 14 square meters, the separation of which was made by a simple curtain or sheet. The “andana” or mezzanine was located on the sleeping area, where the crops were stored, the grain and temporarily, the silkworm was raised, and which was accessed by a transom staircase located in the northeast corner of the bedrooms.

Due to its small size, the murcian cotagge can be classified as “minimum housing”, and because it is built with reeds and mud materials from its “immediate environment”, in addition to “minimum” it can also be considered as a sustainable construction. Integrating both attributes, the murcian cotagge meets the characteristics of a low-cost housing.

To corroborate this last statement, the material execution costs of the murcian cotagge are estimated in its "traditional" and "contemporary" versions. Given the difficulty of obtaining a budget by the analytical method, due to its configuration and the type of materials used, the technique of cost pre-dimensioning is used, applying the Pcr.5n Model: “Predicted reference costs, with 5 levels of calculation”, the result of the practical application of the PhD thesis entitled“ Development of a model of pre-dimensioning of construction costs in the architectural project” [3].

The estimated cost of the murcian cotagge in its "traditional" version, that is to say, built with "reeds and mud" from its surrounding environment, amounts to 17,962 euros, according to the following estimate (394.42 euros / square meter built).

For the "contemporary" version of the murcian cotagge, built with materials and construction systems of average quality and performance, it amounts to 27,573 euros (605.47 euros / square meter built).

Given that the average reference cost of material execution of a "single-family house" of medium quality, according to the Precio Centro of the Official Association of Technical Architects of Guadalajara [4], is 862.38 euros / square meter built (2018), the murcian cotagge can be considered as a low-cost construction, since in its "traditional" version, it represents 45.74% of the average reference cost, and in its "contemporary" version, its cost is also a 70.21% of the average material cost of reference execution.

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HOW TO CREATE HEALTHIER SPACES IMPROVING INDOOR AIR QUALITY

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Keywords: *ceilings, health, air quality, VOCs, Activ'Air®*

We spend 90% of our time indoors, where exists the necesity to create more comfortable and healthy environments every day.

The pollutants found in our work and living spaces, called VOCs (volatile organic compounds), can cause health problems and a reduction in our overall well-being. People, pets, cleaning products, as well as furniture, carpets and paints, emit them naturally in the different rooms, reaching higher values than in the outside air. One of the most common VOCs found in our living and working spaces is formaldehyde.

With Activ'Air® technology, it presents in walls and ceilings through our product ranges of plasterboard with this technology, we can contribute to the decomposition of formaldehydes present in the indoor air into non-harmful inert compounds [1].

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https://www.placo.es/systems/techos/techos-tecnologia-activairr

ANALYSIS OF THE GEOPOLYMER-BASED CONSTRUCTION MATERIALS STUDIES WITH DEMOLITION WASTES AS A RAW MATERIAL

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Keywords: *Demolitions, materials technologies, geopolymers*

The environmental emergency and climate change are on the agenda and can no longer be turned a blind eye to them. The indiscriminate use of raw materials, energy consumption and unsustainable design have led to a redefinition of the criteria and policies needed to ensure environmental protection.

The construction industry is part of this scenario, representing one third of the total energy consumption in the European Union, with a strong environmental impact due to the exploitation of raw materials that are gradually becoming poorer and poorer. Demolition activity is an important part of the construction industry, in fact the production of tons of waste materials and the consequent costs of transport to controlled landfill and disposal have a significant impact on the environment and the general economic situation.

In this regard, the European Commission, with the aim of reducing the environmental impact and safeguarding resources, has identified construction and demolition waste (CDW) as a priority stream, due to the huge quantities generated (about 850 Mt/year) and the high potential; for this reason, Article 11 of Directive 2008/98/EC states that 'by 2020, the preparation for re-use, recycling and other types of material recovery, including backfilling operations using waste as a substitute for other materials, non-hazardous construction and demolition waste, excluding material in its natural state as defined in item 17 05 04 of the list of waste, shall be increased to at least 70 % by weight' [1].

How to transform these waste materials into primary materials and what are the advantages?

With the aim of protecting raw materials and the environment, reducing emissions and waste, it is necessary to rethink design in a sustainable way, introducing recycled materials with innovative solutions.

Therefore, starting from environmental, economic and social analysis of the impossibility of building recovery, we want to investigate the possibilities of recovering building materials in a sustainable way, looking for a possible answer in geopolymers, which represent an important alternative to current binder production systems for their potential to reduce emissions and energy consumption while respecting the properties of the mixtures [2].

This work presents the results of the analysis of the current state of the art about the experimentation done on geopolymeric materials obtained from building demolition wastes and the results about the research works focused on the most produced CDW in Italy and in Spain with the aim of select the CDW more adequate to produce new eco-sustainable materials to be introduced in the construction market.

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ENERGY AND ECONOMIC ANALYSIS OF REFLECTIVE THERMAL INSULATIING COATING IN SPANISH BUILDINGS

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Keywords: *Thermal insulation paint, energy efficiency, energy simulation, energy savings*

Nowadays one of the main problems worldwide is the environmental pollution due to the low energy efficiency of the energy usage in the industrial, transportation and construction sectors. Due to the above, the European Union (EU) promoted the 20 20 20 agreement to encourage European members to reduce greenhouse gas (GHG) emissions, increase the use of renewable energy and reduce energy consumption [1]. For that reason, different methodologies for the efficient usage of energy have been created for different consumption sectors. In this work, the study will focus on energy efficiency for residential buildings located in Spain, in which the use of reflective thermal insulating coatings is proposed with the aim of reducing the energy consumption of both natural gas in winter and of electric power in summer.

This work analyses the energy and economic behavior of a type of reflective thermal coating which have been applied to the same house located in different locations within Spain. A building energy simulation model of the house meeting the requirements of the Spanish building code was developed [2]. In a first step, the house was simulated with and without the reflective thermal coating in both Madrid (cold zone) and Sevilla (warm zone). In order to set up the model of the house was necessary to include both insulating and reflective parameters of the material as well as to create a new layer as a coating. The coating was applied in different parts of the building envelope.

The preliminary results show that the coating offers better energy efficiency results in cold weather while in the warm seasons the coating does not make considerable contributions according to the investment made. In order to know the energy efficiency potential of the coating used, a new simulation was carried out in a very cold European city (Kasprowy located in Poland). The new results show that the coating give more advantageous about energy-economic saving compared to the previous cases.

Therefore, the reflective-thermal coating is recommended for buildings located in climates with low temperatures such as the Nordic countries where the use of this new technology is justified energetically and economically, adding to this the reduction of CO2 emissions into the atmosphere, without leaving aside that the thermal coating will always support the parts of a building where it cannot be insulated with common materials because of the small space.

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IMPROVEMENT OF BEHAVIOR AGAINST FIRE OF PLASTIC WASTE ADDED IN PLASTER PANELS

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Keywords: *Physical barrier; incombustibility; plaster compounds; plastics and fire, combustion gases*

In the field of construction materials, the requirement of Fire Resistance tries to reduce the chances of an uncontrolled fire starting or spreading. This not only affects the danger involved in the destruction of the element of which the construction material is part, but also the risk that arises from the production of flue gases during the fire.

When fighting a fire, two basic strategies can be used: the disappearance of the fire once it started and the prevention through the protection of materials [1]. While for the first one there are the specialized professionals, firefighters, the innovation in materials can contribute to the second strategy.

Consequently, alternatives trying to change the behaviour of the materials during a fire are sought, either by modifying their composition, properties or

characteristics, either by providing a physical barrier that prevents the first element exposed to the source of ignition from being inflamed.

Plastics are composed of a series of organic monomers giving off CO_2, water and other combustion products during a fire.

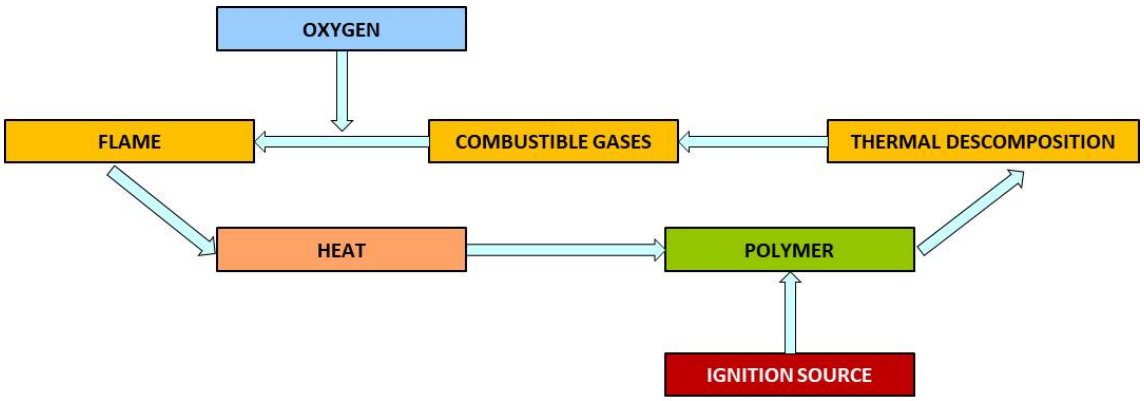

Fig. 1: Scheme of the combustion cycle of a polymer [1]

To verify the real effect of fire on drywall with plastic waste added, a real test was carried out with direct fire in the Fire Station of the Community of Madrid located in Collado Villalba. For this, a fire load during 30 minutes was used, according to ISO 834 [2].

Then, following the indications of the investigation by Serrano [3], specimens were made as panels that were transferred to the test site. Temperature was measured at 3 points of each specimen for 30 minutes every 5 minutes using a Testo 845 model laser temperature reader.

Fig. 2: Gypsum panels added with plastic waste during direct fire test (left) and after test (right)

The calculation of CO_2 and CO emitted during the combustion of plastic waste was obtained by the thermogravimetric analysis in air atmosphere and by elemental analysis [4].

This study proves that the incombustibility of the plaster contributes to the improvement of the behavior of the plastic waste in a fire, providing it, for a time, a physical mechanism of protection.

During a fire, the concentration of CO_2 generated by gypsum panels with plastic waste added, assuming complete combustion, would not exceed the amount considered as a risk to people's health. The calculated CO values were very

high but other factors such as the total amount of synthetic materials inside the rooms must be taken into account [5]. These synthetic materials would emit CO before the panels with plastic waste, whose emissions would be delayed by the physical barrier of the plaster.

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RECOVERY OF RECYCLED COARSE AGGREGATES COMBINED WITH EXPANDED POLYSTYRENE IN THE PREPARATION OF CONCRETE FOR PREFABRICATED PANELS

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Keywords: *Recycled coarse aggregates, Expanded polystyrene, Prefabricated*

The large volume of contaminating waste generated by the Industrial and Construction Sector has a negative impact on the environment, which has led to recycling and use them in the production of concrete for the production of prefabricated elements. The effective use of construction materials to achieve sustainable construction is of utmost importance due to the rapid depletion of natural resources by construction industries to obtain raw materials and aggregates [1]. Among the multiple alternatives in the use of conventional materials for the creation of new systems and construction products, is the reuse of construction and demolition waste that is mixed with common components giving rise to new materials with low impact on the environment [2].

The replacement in such concretes of natural coarse aggregates with coarse aggregates recycled in percentages that do not affect their properties is the great challenge for many researchers. [3], state that it is feasible to replace up to 40% of recycled coarse aggregates of C&D in specific applications of low intermediate strength concrete with the specified mix design. Several investigations have assumed responsibility for the characterization of RCA and its properties. [4], They argue that it is density and absorption, the most sensitive properties for the quality of the recycled aggregate. The combination of recycled coarse aggregates for the improvement of the overall durability of concrete has been studied. [5] They say that to improve the durability of concrete, pozzolanic materials should be incorporated, either in the RA coating or to intermingle it within it.

The experimental characterization of the physical and mechanical properties of EPS has also been analyzed and therefore it has been incorporated as one of the recycled concrete materials, stating that the use of SPS based on expanded polystyrene (EPS) for the manufacture of Lightened concrete in terms of mechanical and density criteria is almost satisfied with fire, similar to the reference samples when adding recycled EPS to concrete [6].

The study consisted of valuing new concrete mixtures where the replacement of the natural coarse aggregate with the recycled coarse aggregate from demolitions of brick masonry, concrete blocks and structural elements, were in the order of 25, 50, 75 and 100% , combining them with expanded polystyrene,

without additive and checking the resistance to compression, density, absorption, tensile compression diametral, durability, wetting-drying, with respect to conventional concrete and other previously tested mixtures.

This investigation verified other mixtures of intermediate strength concrete with recycled coarse aggregates based on rubble of: bricks, concrete blocks and bricks with structural elements, combined with expanded polystyrene without additive; for the elaboration of thermo acoustic and eco friendly prefabricated panels, as a solution to the problem of environmental pollution.

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OPTIMIZATION OF WET-MIX SHOTCRETE WITH VARIOUS RHEOLOGY MODIFIYING ADMIXTURES

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Keywords: *Elastic limit, plastic viscosity, wet-mix shotcrete (WMS)*

The quality of the concrete has a strong relation with its rheological properties in the fresh state and during its placement on site [1]. Rheology is an important tool in providing this practical information [2], being a key parameter in the characterization and optimization of concrete flow behaviour. It has been established that fresh concrete can be considered as a Bingham fluid [3, 4]. That is to say, it is a plastic material that when certain elastic limit is exceeded (τ_o) its flow exhibits a linear relationship between the shear stress and the shear rate.

The use of rheometers allow measuring the consistency of concrete in terms of fundamental physical units [5] such as elastic limit and plastic viscosity. Obtaining rheographs of a fluid representing the changes between the elastic limit τ_o (y axis) and the plastic viscosity μ (x axis) depending on the properties of the material, time, additives, etc. This graph is a diagram that reveals the effects of various changes in the rheological behaviour of cement-based suspensions [2]. Moreover, the hysteresis cycles obtained by the rheometer are important evaluating pseudoplasticity and thixotropy of the material before and after the structural break down of the fluid by shearing.

All these variables permit performing more adequate analysis regarding the pumpability and shootability of wet-mix shotcrete (WMS) mixtures as well as determining the quality of this concrete on site [6]. In this study, greater emphasis will be placed on the analysis and optimization of different viscosity modifying admixtures by comparing their elastic limit properties, plastic viscosity correlated with rebound values, construction thickness and pumping pressure, establishing workability areas or boxes according to fundamental physical units to define a more optimal WMS design, reducing material loss and wear of equipment on site.

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ALKALI-SILICA NUMERICAL MODELS IN CONCRETE

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Keywords: *Concrete, durability, alkali-silica reaction, modelling*

Alkali-silica reaction (ASR) is one of the most challenging process of deterioration of concrete structures. ASR damage is usually detected after decades of use of concrete structures, making difficult its prediction. In addition, this reaction degrades gradually the internal structure of concrete, increasing the duration and costs of the repair works of the affected structures.

Although the reaction was defined by Stanton in 1940's [1], there is still a lack of information about the factors that influence the mechanisms of ASR as well as the products resulted. When concrete contains high alkali content in the cement, availability of reactive silica in the aggregates, and sufficient level of water content, ASR occurs and an amorphous gel is created within the internal pores. During the reaction, this gel is hydrated, increasing its volume. If the production and hydration of the gel continues after filling the pores, its expansion will induce additional stresses to the skeleton of the concrete, causing internal cracks that negatively affect its resistance and stiffness [2]. Therefore, concrete deterioration depends on the formation and capability of hydration of the gel formed, which is determined by its chemical composition and reaction kinetics.

Alkali-silica gel general composition is (SiO_2) $(Na_2O)_n{\cdot}(K_2O)_k{\cdot}(CaO)_c$ $(H_2O)_x$ [3] where Na, K, Ca and H_2O concentrations depends on several factors such as cement composition, relative humidity, temperature and pH of pore solutions. Thereby, several experimental and theoretical investigations have been conducted to reproduce and predict the alkali-silica gel formation and the swelling and cracking process considering different factors affecting ASR. These methods vary from the micro-scale range where the chemical reaction kinetics and gel swelling are modelling with representative volume elements (RVE) to macro-scale range where the ARS induced damage in concrete structures is realistically simulated, commonly applying the finite element method (FEM) [4].

Therefore, this paper aims to make a comprehensive review of the numerical models of ASR developed in last decades. For a better understanding of these

models and the methodology applied, a first approach to ASR and their mechanisms is drawn.

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INFLUENCE OF SAWDUST IN THE CHARACTERISTICS OF SOIL-CEMENT BRICKS

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Keywords: *Soil-cement, sawdust, diametral compression test, bricks*

In the construction, the materials reach the 60% of the cost of a building [1]; due to the manufacturing processes that generate a high degree of pollution such as greenhouse gas emissions and the generation of waste, such is the case of the production of fired bricks.

Therefore, need arises to manufacture an alternative material similar to brick, that is environmentally friendly, stable, resistant and high performance [2].

The soil-cement bricks turn out to be an excellent option, as they are the result of the stabilization and pressing of the soil and whose mechanical properties depend on the characteristics of the soil and mix design [3].

With this antecedents it is proposed to design soil-cement bricks with the incorporation of sawdust in order to evaluate their behavior and properties of this material.

For the development of the investigation has been used Ecuador's raw material, with availability; in combination of soil (zone Centza) with river sand (zone Quiringue), has been made the characterization of the raw material with analysis: physical and chemical, likewise, the mix design was established of soil-cement sawdust (SC-As) and soil-cement-sand-sawdust (SC-Ar-As) in different percentages of inclusion of sawdust (0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15%), according Fadele [4] for obtain a satisfactory performance in lateritic bricks the percentage of cement recommended is between 4 and 10%, however, Raheem [5] suggested 10% cement for blocks; with this percentage were manufactured discs (7 cm diameter and 2 cm high), cured in a

unsaturated way, and tested for diametral compression [6] to get the optimization factor (Fo) at ages of 3, 7, 14 and 28 days.

The optimal soil-cement brick performace was obtained with a mixture combination of 2.5% sawdust, 2.5 sand, 10% cement and 85% soil, which exceeded in 200% the resistance to diametral compression of the S-C-As mixture.

During the manufacture soil-cement brick was determined that due to the scale factor for larger sections in reference to the discs it is necessary to increase the degreasing material in order to avoid adhesion to the mold walls, therefore the dosage of a brick consists of 70% of soil, 10% sawdust, 10% sand and 10% cement, obtaining a simple compressive strength of 3.27 MPa exceeding spanish and peruvian standars whose minimum values are 1.3 MPa [7] and 1.2 MPa respectively [8].

Properties such as weight, density, absorption and porosity were also evaluated in the SC-Ar-As bricks with 10% of sawdust obtained an 8% reduction in weight with respect to SC-Ar-As bricks with 2.5% of sawdust, knowing that the porosity influences the mechanical strength of the brick, since that a better conformation of the matrix has a small amount of voids but increases its weight [9], in this way the inclusion of sawdust allows to occupy the empty spaces of the matrix and reduce the weight of the brick, on the other hand the density obtained was 1.16 g/cm^3, the absorption percentage was 15.51, which does not exceed 22% absorption according to the Peru standard [10].

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USE OF RECYCLED TIRES FOR REDUCTION OF VIBRATIONS ON RAILWAYS LINES

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Keywords: *End-of-life tires, elastomer, precast block, vibration, stiffness*

This research involves the development and validation of a new elastomeric material manufactured from the recycling of end-of-life tyres mixed with a polyurethane resin [1]. European Commission Directive 2008/98/EC prohibits the deposit of this waste in landfills and requires its reuse or recovery [2]. This material is used as a vibration damper in broad gauge track systems with prefabricated blocks embedded in elastomer, commonly used in railway lines. After determining the static stiffness of the system and characterising the elastic components of the assembly, four full-scale prototypes were manufactured to validate their mechanical and acoustic behaviour [3-4]. The test results show that this material undergoes a process of flexibilisation instead of the usual stiffening with synthetic rubbers, due to the effects of fatigue. Numerical results confirm the viability of this new eco-material for use as a vibration damper on railway lines since a resonant frequency of 15 Hz is obtained, a maximum damping value of 31.5 dB at 34 Hz and 15 dB above 45 Hz.

Figure 1. Prefabricated concrete block system embedded in elastomer

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MECHANICAL BEHAVIOR OF MICRO CONCRETE WITH ADDITION OF RECYCLED PLASTIC FIBERS (TETRABRIK)

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Keywords: *Micro concrete, waste, tetrabrick, compression, flexure*

The growing concern and the need to reduce the amount of plastic waste disposed of incorrectly in landfills, added to the need for housing due to the considerable increase in population, opens up an opportunity to merge these two problems and create new forms of construction with recycled materials [1].

In the 21st century the use of recycled materials as a component of concrete is gaining popularity, in many cases thanks to the use of environmental legislation [2]. Among them the system of environmental legislation that is currently in force in Spain UNE-EN ISO 14001 [3].

Based on these premises, this research is focused on the development of concrete with the addition of recycled plastic fibers from tetrabrik. For this purpose, experimental tests have been carried out to determine the characteristics of the material and its density; with the results obtained, a comparison has been made between them, their capacity of resistance and deformation that each one of them has reached. Within these results we conclude that the addition of recycled plastic fibers of tetrabrik to the micro-concrete lowers the compressive strength, but in terms of bending they have a better performance in their ultimate deformation than the ones without addition; also work better in impact resistance and retraction.

The 20mm tetrabrik fiber has been able to benefit in the results of resistance to impact and retraction, in addition to having positive effects on its ultimate deformation of flexion.

Acknowledgments: To the Technical Department Additives of Mapei for their collaboration.

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DEFORMATIONS AND CRACKING OBTAINED THROUGH DIGITAL IMAGE CORRELATION ON FIBRE REINFORCED CONCRETE SUBJECTED TO SHEAR

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Keywords: *Fibre reinforced concrete, crack pattern, deformations, digital image correlation*

The contributions of fibre reinforced concrete can be considered in structural design. In order to do so, the standards have established certain requirements [1, 2] that permit reducing partially or even totally the steel bars [3]. Such requirements are based on residual tensile strengths obtained by three or four point bending tests [4]. This tensile strengths might not be suitable to be applied to any other type of stress to which the material can be subjected [5].

Fibres can bridge the concrete crack, preventing the crack growth and generating a network of cracks with shorter and thinner [6] that improve the material's behaviour when subjected to bending or shear stresses as well as the durability of the element. This reinforcement technique was developed with the use of steel fibres [7, 8]. In recent years, the use of macro-polymer fibres has become an attractive alternative [9, 10] due to the absence of corrosion and other operational advantages.

At the time of writing, it is still important to understand the resistant mechanisms of fibre reinforced concrete elements subjected to shear stresses according to shear-friction theory [11], such as aggregate interlock and the dowel action of the rods or fibres that seal the crack.

Having that said, the main objective of this study was to analyse the different cracking patterns that occurred in fibre reinforced concrete specimens subjected to shear stress and to obtain the displacements on the cracks. In order to achieve these objectives push-off specimens, obtained from residual halves of bending specimens, were tested. The tests were performed by using a digital image correlation system [12] that allowed the cracks on the faces of the specimens to be monitored as shown in Figure 1.

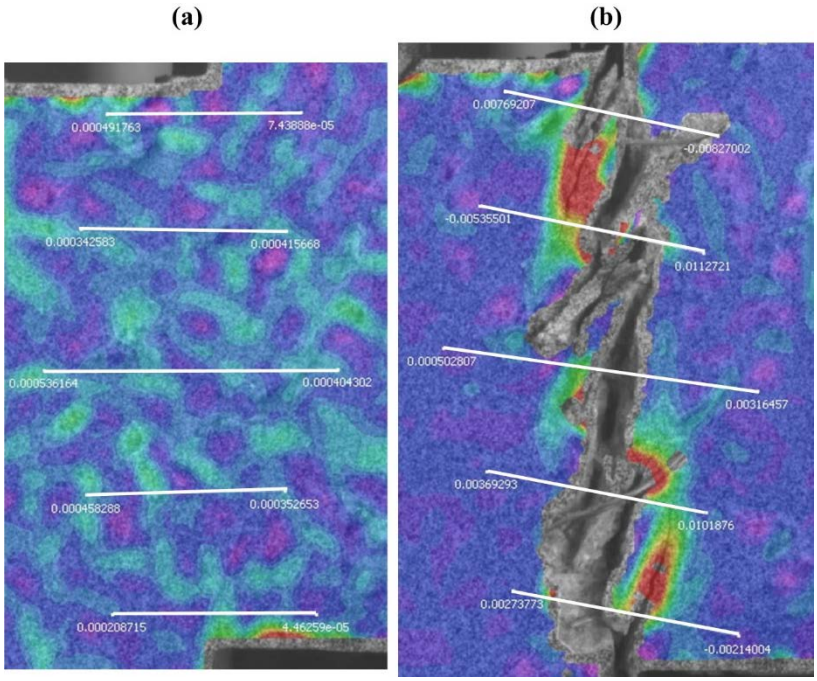

Figure 1: Extensómetros de vídeo-extensometría dispuestos sobre el análisis del software Vic-2D®: (a) al inicio del ensayo y (b) en la fase final del ensayo

Four concrete types were used for the tests: one reinforced with 0.66% volume fraction of polyolefin fibres, the second with 1.10% volume of polyolefin fibres and the others reinforced with 0.64 and 0.90% of steel fibres. According to the results of the tests, the cracking patterns were obtained as well as the displacements on the crack in reference to the shear-friction theory.

Acknowledgements

The authors gratefully acknowledge the financial support provided by Ministry of Economy and Competitiveness of Spain by means of the Research Fund Project BIA 2016 78742-C2-2-R. They also offer their gratitude to SIKA SAU and Calle 30 for supporting the Enterprises University Chairs "Cátedra Sika-UPM" and "Cátedra Universidad Empresa Calle30-UPM" respectively.

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EFFECTIVENESS OF CORROSION INHIBITORS IN REINFORCED CONCRETE

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Keywords: *Corrosion; reinforced concrete; inhibitors; linear polarization resistance (LPR); electrochemical impedance spectroscopy (EIS)*

In construction engineering, corrosion of reinforcing steel in concrete structures is the most important issue in reducing its service life. Corrosion leads to a greater incidence of detachment, delamination and, as a consequence, failures in structural elements and entire structures [1, 2]. Under normal conditions, steel is protected by a passive layer formed by the alkalinity of the aqueous phase of the concrete. Steel is in passive state without corrosion. However, passivation can be reduced by the reaction between the alkaline solution of the pores with carbon dioxide (CO_2) or by the presence of chlorides in the environment of the steel with enough concentration [3, 4]. Most common type of problem is pitting corrosion by which cavities or "holes" are produced in the material. This is due to the localized rupture of the passive film on the surface of the steel caused by chloride ions [5].

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 [6], organic and inorganic inhibitors [7, 8], cathodic protection [9], etc. Currently, inhibitors in reinforced concrete are widely used because their low cost and easy way to apply. 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 [10].

Corrosion inhibitors are generally used for reinforced concrete applications either by adding them to fresh mixture during the concrete preparation (for new structures) or by externally applying them on a hardened concrete Surface (during rehabilitation procedures).

In the present study it's analyzed the effectiveness of three repair methods when reinforced concrete has corrosion. Inhibitors such as hydrophobic surface impregnation (applied from the concrete surface) and inhibitors added in the mixture (mass inhibitors) are investigated. In addition, inhibitors included in the cement for repair mortars are used. Electrochemical measurement techniques are used (assembly Figure 1) such as linear polarization resistance (LPR) and

impedance spectroscopy (EIS). As expected, it has been verified that inhibitors tends to decrease the evolution of current density over time in the specimens. However, it should be noted inhibitors do not exceed the corrosion threshold at which it is considered insignificant.

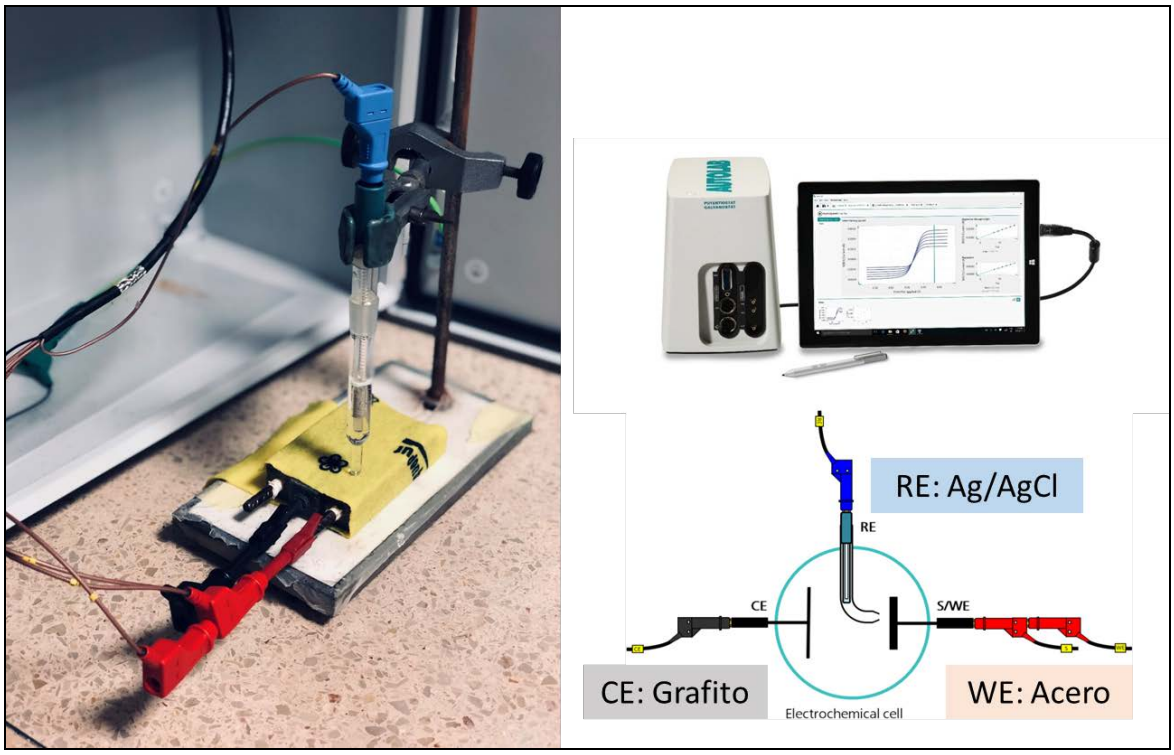

Figura 1. Montaje Experimental de medidas electroquímicas en probetas de mortero reforzado

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CONSTRUCTIVE MATERIALITY: ANALYSIS OF THE ARCHITECTURE AND ENVIRONMENTAL HEALTH RELATIONSHIP

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Keywords: *Health, indoor air quality, pollution, materials, architecture*

Indoor air quality (IAC) reports one of the major environmental health problems in Europe and the planet [1,2,3,4]. In this regard, environmental health sciences researchers collected data about activity patterns as part of exposure and health research in the 1980s [5]. It shows that 86,9% of life is spent in indoor environments such as homes, offices and schools, among others. This prolonged stay has led to health problems that affect the respiratory system with serious consequences, causing morbidity and mortality [6].

As the third leading cause of death on the World Health Organization (WHO) list [7], it reveals that 4 million people die prematurely from diseases attributable to indoor air pollution [8], and even these values have doubled as reported in 2009. They most often affect vulnerable groups such as children, the elderly, pregnant women and people with pre-existing conditions [9]. In reviewing the history of air quality [10], it is reiterated that, indoor air is an issue that has attracted constant attention, and today there are enough studies realize it that account for this [11,12,13,14,15].

Construction materials contribute 40% [16] of the pollutants attributed to the deterioration of IAC, so architectural planning takes this aspect into account generates fewer health and building pathologies. With this the regulations must ensure not only the stability of the building, aspects of materiality, cost, but also the quality of the indoor air. This can be seen as a revision of programs that have been studied since the 1970s in Canada. Reference is made to health architecture [17], which is based on scientific evidence and analysis in the relationship between architectural design and patients, which have a substantial improvement and with this there are considerable economic savings in general.

At the moment the affections of the interior contaminants increase such it is the case of the nano-plastic, indicating that 29% of fibers found are of plastics. Fibers found in textile fibers, natural fibers, animal fibers, vegetable fibers and mineral fibers as well as organic fibers such as coal, ceramics and glass, creating lung inflammation, respiratory irritation, and symptoms similar to allergic alveolitis [17]. So its effects continue to be studied, as is the case with inhalation of combustion particles that can lead to increased loss of bone mineral through systemic oxidative stress or inflammation [20].

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INFLUENCE OF THE CORRODED AREA ON THE TENSILE BEHAVIOR OF STEEL

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Keywords: *Corrosion, ductility, elongation, tensile test*

Many research works that analyze the effects of corrosion on the tensile strength, deformation and tough behavior of corrugated steel reinforcements [1,6]. In them, the analysis of its influence has been developed on bars of different diameters [7]. This work analyzes the variations in the mechanical properties of steel that occur in small diameter hot-rolled corrugated steel reinforcement, in which corrosion has been accelerated, affecting different lengths of it.

Fig. 1: short rolled bars embedded in concrete slabs.

In carrying out the tests, short length bars have been embedded in cement mortar slabs with a proportion of 4% calcium chloride, which has undergone accelerated corrosion, subjecting them to variable amounts of current during different periods of time. Subsequently, the corroded bars have been extracted and subjected to a standardized tensile test, which has allowed us to know their resistant characteristics depending on the area affected by corrosion, always referring to a set of standard bars. The results obtained allow us to analyze the degree of influence of the location, the surface area, as well as the degree of affection reached in the resistant capacity, the deformation before breaking and the ductility of the steel specimen tested [8].

The conclusions obtained from the tests show how the amount of surface involved in a corrosion deterioration process has a statistically significant influence on the tensile behavior of the damaged bar.

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REHABILITATION PATHOLOGY AND BUILDING MAINTENANCE

GOODNESS-OF-FIT ASSESSMENT OF DIFFERENT CALCULATION MODELS FOR ANCHORED FRP REINFORCEMENTS

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Keywords: *Fibre-reinforced polymer (FRP), concrete retrofitting, FRP anchors*

The use of fibre-reinforced polymers (FRPs) to strengthen existing reinforced concrete structures has notably increased in recent years due to the considerable advantages of these materials. However, one limitation of this technology is its premature debonding failure. Several anchorage techniques have been developed to prevent or delay debonding, among which FRP spike anchors have been observed to enhance joint behaviour considerably. Existing guidelines for designing FRP reinforcements indicate that a great improvement can be achieved with such anchoring systems; however as there exists a lack of knowledge regarding the parameters involved in their behaviour, their use in rehabilitation projects is still subject to tests demonstrating their proper functioning. The large number of variables involved in the behaviour of FRP anchors make it difficult to create simple expressions that fit sufficiently well to the real behaviour of an anchored joint. Previous research has shown that installation process, materials properties and arrangement have influence on the maximum load, the load-displacement relationship and the failure mode of FRP-to-concrete anchored joints. With the aim of estimating both the unit load of FRP connectors and their contribution to the anchored joint strength, Villanueva et al. [1] developed and analytical model based on existing models for adhesive anchors and for internal reinforcements. One of the limitations of this model, though, is the fact that it was developed using the quite limited number of results available from literature and from an experimental campaign carried out by the authors, including both isolated anchors and anchored sheets. The model fitted acceptably well to most results from the database, but some of the design parameters were found to require further research. This paper presents a comparison of the model proposed by Villanueva et al.[1], with two other existing models [2,3] applied to an extended database including the results of additional forty-four single shear tests performed by the authors on CFRP anchored sheets in concrete substrate [4]. It also presents a new expression proposed by the authors to estimate the anchored joint strength when optimized carbon FRP connectors are used to improve the bonding strength of the reinforcement.

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A REVIEW OF THE INFLUENCE OF THE CONVECTIVE COEFFICIENT IN THE ASSESSMENT OF THE U-VALUE OF FAÇADES WITH THE INFRARED THERMOGRAPHY METHOD

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Keywords: *Thermal transmittance (U-value), infrared thermography, convective heat transfer coefficient, walls*

In recent years, increasing concerns about the high building energy consumption have been focused on the energy rehabilitation to reduce this consumption. In this regard, the thermal transmittance (U-value) of walls determines this energy consumption to a great extent, so there is a considerable interest in using methods assessing it accurately [1,2]. Such property could be determined by various procedures, both theoretical and experimental, and all these methods are subject to a series of factors that could result in obtaining atypical values [3].

One of the thermal transmittance evaluation methods most studied in recent years is that of quantitative infrared thermography method [4]. This is because the method allows both a qualitative and quantitative analysis of the building envelope. However, the main limitation of this approach is the great variety of different approaches. In total, there are up to 5 different approaches in the scientific literature [5–9]. The biggest difference between these approaches is due to the convective heat transfer coefficient used and the place from where the measurement is made (indoor or outdoor).

For this reason, this research reviews the results obtained from the optimization of the infrared thermography method in two publications made by the authors [10,11]. This analysis was performed based on the different existing approaches and using a wide variety of equations for the convective heat transfer coefficient.

The results showed that the use of experimental correlations of dimensionless numbers for the internal quantitative infrared thermography method constitutes the most appropriate application for this method. The analysis of the data

obtained for this aspect reflected that the number of valid results obtained with this configuration was higher than that of other experimental correlations from the interior and exterior. Likewise, performing tests from the interior ensures the decrease of the influence of environmental conditions.

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PRESENTATION ON LEGAL ACTIONS RESULTING FROM THE APPEARANCE OF INJURIES IN EXTERNAL DOORS IN HOUSES

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Keywords: *Constructional injuries, root causes, insurance, surveyors, pathology processes*

The knowledge and evaluation of the technical performance of the construction elements that are part of a building are very important to lower the cases of flaws and constructional injuries occurring throughout its service life [1]. Nevertheless, a body of research attempts to do so via a small number of buildings, or through surveys [2], even though these methods do not always accurately lead to all parameters relevant to understand the real dimension of the problems. The research work that is presented considers a distinct data source that provides greater precision to the results, for which reason it is regarded as highly reliable.

Among the scientific literature that was reviewed, very few cases were found to expound the types of constructional injuries that frequently occur in external carpentry [3]. Those that were found focus on building windows [4], none of them carrying out an in-depth and exclusive study of external doors.

As such, for this presentation, a detailed study was carried out of the cases of constructional injuries appearing in external carpentry of doors in houses. The study worked from a starting point of the lawsuits filed by home owners when the injuries in question were not properly resolved during the warranty period. The data collection process was difficult and complex given that 10 full years of legal cases in the whole of Spain were considered, which conveys the scale of the data set. Nonetheless, the number of situations was not high (only 362 cases) given that this element – based on these results – was found to not be very prone to the existence of constructional injuries. The key such injuries were ‘air permeability’ and ‘humidities and infiltrations’ (the latter being particularly significant).

After this first stage, a second stage was carried out in which the root causes of said constructional injuries were identified. Six different types were found, with the most prevalent being ‘absence/deficiency of sealant’, followed by ‘inadequate material and/or construction solution’.

Lastly, each of the interrelations between the constructional injuries – and each of the root causes – were studied, quantified and analysed. A total of 15 different interrelations were found, which evinces the high variability of construction situations that can lead to pathology processes, even if the present study is on a single element that is normally quite simple.

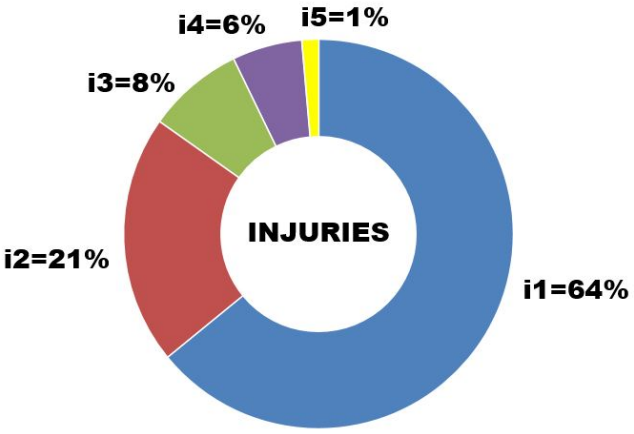

Fig. 1: Values resulting from the five types of constructional injuries found in the study

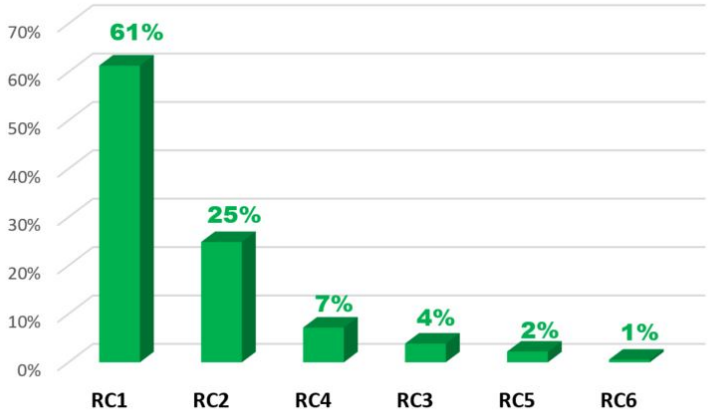

Fig. 2: Percentages found in the six root causes leading to the defects that were studied

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CRITICAL REVIEW ON CONCRETE CARBONATION: FACTORS INVOLVED AND MATHEMATICAL MODELLING

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Keywords: *Concrete carbonation; carbon dioxide; durability; factors; mathematical modelling*

Concrete carbonation is a degradation process produced by the carbon dioxide uptake of the material in the presence of moisture. It leads to a lowering of the pH of concrete, making the material less alkaline, from a pH of 12.6 to the surroundings of 8.3. Even though this phenomenon rarely leads to structural problems, as it does not affect negatively the concrete itself, the durability of the reinforcement steel may be compromised, as its depassivation occurs when surrounding pH falls below 9 [1-2].

It is a complex phenomenon involving a high amount of variables such as: relative humidity, concrete composition, water-to-cement ratio, porosity, alkaline reserve, carbon dioxide concentration, etc. Likewise, a great number of this variables depend on each other and they are also modified as concrete carbonation progresses, making concrete carbonation a non-linear process [3].

It is therefore essential to identify the most determining variables of the carbonation process, so as to define mathematical models that enable the prediction of concrete behaviour against carbonation. Thus, it would permit predicting with higher accuracy the service life of those structures exposed to environments containing high carbon dioxide concentrations such as urban, industrial environments or road tunnels.

Different factors involving the concrete carbonation process were analysed and the mathematical models available were reviewed: empirical models based on carbon dioxide diffusion, concrete compressive strength and concrete permeability as well as numerical and statistical models.

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INDUSTRIAL OLIVE HERITAGE IN EAST ALMERIA. STUDY FOR CONSERVATION AND VIABILITY OF INTERVENTION

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Keywords: *Industrial olive heritage, Bajo Almanzora (Almería), conservation, viability*

Recently, industrial olive heritage has become a set of real estates that promotes conservative interventions in a terriorial context, facilitating local and regional sustainable development. Based on these premises, the present study, located in existing olive mills surrouding Almanzora River Valley in Almeria, aims to give greater visibility to this type of architecture, which does not recognize high local relevance [1]. This means ignoring their possibilities of social and cultural use that may involve their conservation, deriving in disappearance. The research has been performed in two main lines, the first one consists of a comparative study of oil mills located in two Almeria regions, belonging to East Almeria or Bajo Almanzora [2] and Medio Almanzora, analyzing aspects such as state of conservation, typology and surface [3]. The second line is focused on determining its feasibility of intervention, this is why a clasification of the value of properties is stablished, by distinguishing intrinsic or extrinsic ones. Last ones are divided in eight fields: historical, artistic, architectural, landscape, social, authenticity, cultural and economic. Finally, intervention of these building is estimated as positive or negative in a constructive and functional point of view, because these two are the optimal ones. Obtained results allow specify that a single building of the 39 compared is registered in the General del Patrimonio Histórico Andaluz catalog [4]. Despite being cataloged, it is abandoned and progressively deteriorating, as its inner machinery. Regarding the viability of this heritage, 8 valued oil mills of value and only 2 ones positively valued were determined. Their rehabilitation is viable in a technical, economic, urban and environmental point of view. Consequently, the possibility of intervention in each building is proposed following a level scheme based on three phases, ordered from greater to lesser relevance: damage theraphy, provision of a new use and complementary new work. This type of architectural intervention would involve a cultural commitment, coming from the tourism interest due to the large number of foreign residents and the value of the properties. Detailed analysis of this heritage shows that the value of the architecture used in buildings dedicated to oil extraction faces the change of both design and construction techniques as well as extraction systems in the new contemporary oil mills, performed with techniques and industrial materials,

which means the loss of traditional construction techniques and materials, typical of these buildings of great heritage value. It is evident that this architecture needs to be revalued so as not to disappear definitively, especially in areas where olive culture has a long and extensive historical memory, as East Almeria.

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IDENTIFICATION AND ANALYSIS OF DAMAGES OF THE PALACE OF ENRIQUEZ FAMILY

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Keywords: *Deterioration; intervention; characterization; Palace of Enriquez (Baza)*

Recovery and reuse of buildings with great heritage allow extending their useful life and guarantee conservation of social and cultural values of the surrounding environment. In addition to this and considering their interventions to durable construction systems, progress will be made in the area of conservation and value, which will undoubtedly favor the local development of their area of impact.

This article is devoted to the study of the Palace of Enriquez family (listed as an Asset of Cultural Interest) located in the municipality of Baza (Granada) [1]. Its current state is the result of a long process of interventions and extensions starting from its construction in 1506 to the present, being the most recent emergency works of the year 2011. As a palace built outside the city walls and due to its formal configuration and being surrounded by two large gardens, it has become a unique example of a functioning recreation palace of the great Italian Renaissance villas that currently exists in Andalusia [2].

The research aims at presenting the study on the building's state of deterioration and real conditions as well as at introducing the proposal of architectural intervention that would allow its definitive recovery and its use. The methodology that followed includes historical research based on the review of existing literature, study of its transformations, data collection "in situ", systematic analysis of the pathological state, experimental study of characterization of materials and, finally, the proposal for intervention presenting a recovery of residential use.

The analysis of the pathological state shows the degree of serious degradation in different locations of the Palace. All of the damages, including mechanical, crashes, floor and foundation sinking, loss of material and cracks, highlight the overall poor condition and the need for urgent action. Not to mention other damages such as filtrations and their consequences and the biodeterioration

that have caused the loss of singular elements ("Mudejar" wood ceiling, "artesonados" wood ceilings and horizontal wooden ceiling "alfarjes") [3].

It stands out for its interest, the experimental phase developed through the characterization of samples taken from the building (X-Ray Diffraction, microscopy of thin lamina), which will allow to use appropriate materials and conservation techniques that reduce as much as possible the impact of previous restorative interventions and guarantee the conservation of pieces and elements of unique value that are part of the whole.

The results of both analyses have allowed to determine the areas most susceptible to loss due to collapse or complete deterioration, the Tower and the Tower House being the areas that require urgent intervention.

The recovery and value of the architectural cultural heritage of buildings in their different locations and typologies are a challenge for the field of research in the field of materials science as well as in conservation practice. Its compositional origin, its constructive disposition and its state of alteration and deterioration are keys in the necessary analysis prior to the proposal of restorative intervention.

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RECOVERING A FORGOTTEN HERITAGE. THE CASE OF STUDY OF TORRE PESQUERA (ALGARINEJO, GRANADA)

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Keywords: *Military architectural heritage, Torre Pesquera, materials characterization*

Military architectural heritage, in a broad sense, provides society and its territory with numerous resources, some of them inherited from the past and, therefore, recognized in their origin and new ones that are constituted by their value enhancement. Its possibilities depend on the studies, policies and development models that can be carried out and preserve and respect its diversity and its uniqueness, since once lost they are not recoverable.

The present work focuses on the study of the Castle of Torre Pesquera [1], an Arab fortress from the 14th century, belonging to one of the last borders of the Nasrid kingdom and located in Algarinejo (Granada) [2] a few kilometers from the current population center. Unfortunately, the passage of time, the inclement weather and the zero maintenance have led to the fact that today it remains partially standing, although preserving main spaces such as the towers and some cloths of the protection wall [3].

The main objective is oriented to the approach of a material consolidation proposal, congruent with the state that the property currently presents, assuming its location and honoring the history that precedes it with the utmost respect, thereby halting the deterioration and delaying its possible total collapse, adopting the position of minimal intervention.

Based on the background described, the research has consisted of the study of characterization of materials, for which the survey of plans with specification of the different existing materials was carried out, later and being basic for the knowledge of the state of conservation and subsequent intervention proposal, the typological and graphic location of alterations and the punctual study of alteration phenomena were determined. The recognition of the conservation status in this unique location is complemented by the studies carried out in the experimental phase in order to determine the type and state of materials used in its construction, for which, on a series of samples, studies of X-ray diffraction (DRX), ultrasonic pulse measurement and colorimetry.

The results obtained with the different techniques applied allow us to have an exhaustive knowledge of the current state, being able to confirm after the DRX

tests that the majority composition of the masonry of the existing remains is based on air lime, with the majority components being calcite and quartz. For its part, the measurement of ultrasonic pulses provided information on elastic properties, resulting in a transmission speed higher than usual for this type of materials, which guarantees the constructive durability of the material, offering possibilities for intervention. Finally, in order to achieve a proposal that allows applying the basic conservation / restoration principles and possessing a colour standard with the necessary information for this purpose, colorimetric studies were carried out, thus counting on the chromatic range according to the existing materials.

Based on the proposed objectives and the results obtained, the intervention proposal would consist of an archaeological study; followed by a material consolidation and subsequent cleaning [4], to finally make a conditioning of the place that facilitates access and consideration of proposals of a tourist nature and sustainable with the environment and with the development of nearby municipalities.

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THE CAVE HOUSE AS DWELLINGS: EXAMPLE OF TRADITIONAL ARCHITECTURE IN *CUEVAS DEL ALMANZORA (ALMERÍA)*

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Keywords: *Cave house, traditional architecture, cultural heritage, excavated architecture, regulation*

There are numerous examples of traditional architecture In Spain which are part of the cultural heritage. As example of *traditional architecture* [1] of 'Sedimentary Spain', the excavated cave houses are one of the unique examples, where it can appear especially in Andalusia, Murcia, Castile-La Mancha and Valencian Community, although many of them stand out in other communities such as Madrid, Aragon, Navarra, Castile and Leon and the Canary Community.

Most of them, inhabited throughout the year, cannot be considered as housing because they have been culturally considered as *sub-housing* [2], without justifying the requirements related to habitability, primarily those associated to *hygiene, health and environmental protection*, in such a way that *acceptable conditions of health in the indoor environment are reached*, those are required in any kind of housing nowadays.

This type of construction, being excavated on hillside, with adequate wall thicknesses (great thermal inertia) and natural ventilation chimneys, apparently, it is possible to maintain the established health conditions, but today there are no studies that demonstrate that the requirements of air quality and thermal environment indicated by the Technical Building Code (CTE) [3] and the Regulation of Thermal Installations of Buildings (RITE) [4].

On the one hand, the Technical Building Code establishes the basic HS3 requirement for indoor air quality, establishing that a sufficient flow of outside air must be provided to the habitable premises of the housings to achieve the average annual concentration of CO2 in each of them is less than 900 ppm, among others.

The Regulation of Thermal Installations in Buildings [4], establishes in article 11, the requirements of well-being and hygiene that housings must carry out, especially those related to the thermal quality of the environment, so it can maintain the parameters (operational temperature and relative humidity) that define the thermal environment within a range of determined values.

The province of Almeria has numerous examples of residential dwelling inhabited as a cave-house, but without a regulation that guarantees it, so the possible

transmission of the goods makes complicated, and in many cases, they are abandoned.

In the Canary Community, Decree 117/2006 [5] regulates the procedure for obtaining the certificate of habitability for homes and also for cave-houses, if they have been suitable for residential use and haven been used permanent or by season.

The objective of this analysis of a case study in the town of Cuevas del Almanzora (Almería) is to verify, about the data obtained in the hygrothermal and air quality monitoring [6], the requirements established by the CTE and RITE.

On the other hand, verify the requirements similar to those established in Decree 117/2006, in order to technical and urban criteria can be established to consider cave-houses as dwellings.

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MEASUREMENT OF MOISTURE IN THE RESTORATION OF OLD BUILDINGS

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Keywords: *Moisture, restoration, old buildings*

As a building material wood, under certain circumstances, presents decay problems and structural damage, being the decay process also an irreversible one [1]. These problems are caused, among other reasons, by fungi and insects, and it is habitual to find them at the same time in the same construction [2].

Besides other environmental factors one of the causes that favour the growth of xylophagous fungi is moisture [3,4]. Some of these factors, which act together, are temperature, pH value and the amount of O_2 available. This means that they affect each other [5]. Wood has a critical moisture level, and if it is exceeded, there is a risk of fungal development [6]. This moisture level is called the Fibre Saturation Point (FSP). Below this point, water is contained in cell walls, and above this point, water is accumulated in the cellular lumen. This critical moisture value stands at around 30% in wood samples is temperate regions [5]. Some authors place at 18%–20% the minimum percentage of wood moisture needed to suffer the attack of xylophagous fungi, being 25%–55% the optimum interval [7].

Within xylophagous fungi, white rot fungi degrade significantly the cell wall, affecting their physicochemical properties [7]. The types of rot we can find in wood are: white rot, where fungi attack preferably lignin; brown rot, the most harmful, where fungi focus their attack on cellulose; and soft rot, where fungi mostly attack the cellulose of the secondary wall [8].

Regarding xylophagous insects, their growth is influenced by various parameters: wood species, wood moisture, environmental temperature and the presence of rot fungi in the wood. The moisture content of wood for xylophagous insect attack covers the entire range, this means that there are insects which attack dry wood, some others attack wet wood, and there are also insects which attack in intermediate moisture ranges [8].

In addition to what has been said above, changes in moisture content can cause changes in the mechanical properties of wood [9,10].

In this work, temperature differences greater than 2 ^{o}C between different points of the structure indicated differences in their moisture content; and lower moisture contents cause an increase in ultrasonic velocity. This latter technique is very sensitive to changes in environmental conditions, therefore it is very important to know and to control these conditions for a correct interpretation of the results.

Another non-intrusive and interesting technique is time domain reflectometry (TDR), where a signal is propagated and the behaviour of the reflected waves is observed. This technique was originally used for detection of defects in wiring, but today this technique can be applied to measuring the moisture content in porous materials [11]. Dahlen et al. [12] used this technique in their work to measure the moisture content in wood, but these measures were only made in a moisture range above the FSP.

Nevertheless, in spite of the aforementioned works, none of them has reached the required

specification and sensitivity to be able to confront restoration in the building field in a fast, effective and economic way. Therefore, in this work we have developed a non-intrusive transportable and inexpensive capacitive sensor, which is able to measure in situ the moisture of a wooden beam on site, where the wood will act as a dielectric. In this way, we can establish the moisture content of the wood sample and act accordingly to restore the building.

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STUDY OF THE REPASSIVATION OF REINFORCED BARS CORRODED IN ADVANCE INTRODUCED IN MORTAR WITH A VARIABLE AMOUNT OF CHLORIDE

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Keywords: *Steel, concrete, precorroded structure, repassivation*

The study aims to answer classical questions about the corrosion of steel bars in reinforced concrete structures (RCS). What is the maximum allowable corrosion speed of RCS reinforcements? Can a corrosion process be stopped once it has been started? Can an RCS environment with a certain resistivity be considered safe? Corroded structures, is it possible to repassivate? [1-2].

In this work we have studied the possibility of repassivating steel reinforced bars previously submitted to a corrosion process.

They have undergone a process of forced corrosion, circulating a constant anodic current of 10μA / cm2, steel bars to assemble B500SD. The passage of current has been made by manufacturing cement mortar samples kneaded with a percentage of 2% chloride ion by weight of cement in which the steel bars have been embedded. Afterwards, the test pieces were broken and the bars were removed. Half of them have been kept with the corrosion products and the other half have been cleaned, totally eliminating all corrosion products. The bars have been re-imbedded in mortar specimens with varying percentages of chloride ion and kept in a humid chamber for approximately one year. The corrosion potentials of all the bars and the corrosion rates have been measured periodically and constantly using the polarization resistance technique.

Figure 1 shows the results obtained for the corrosion rate for the embedded bars. Each one of the results has been obtained as the average value of two bars.

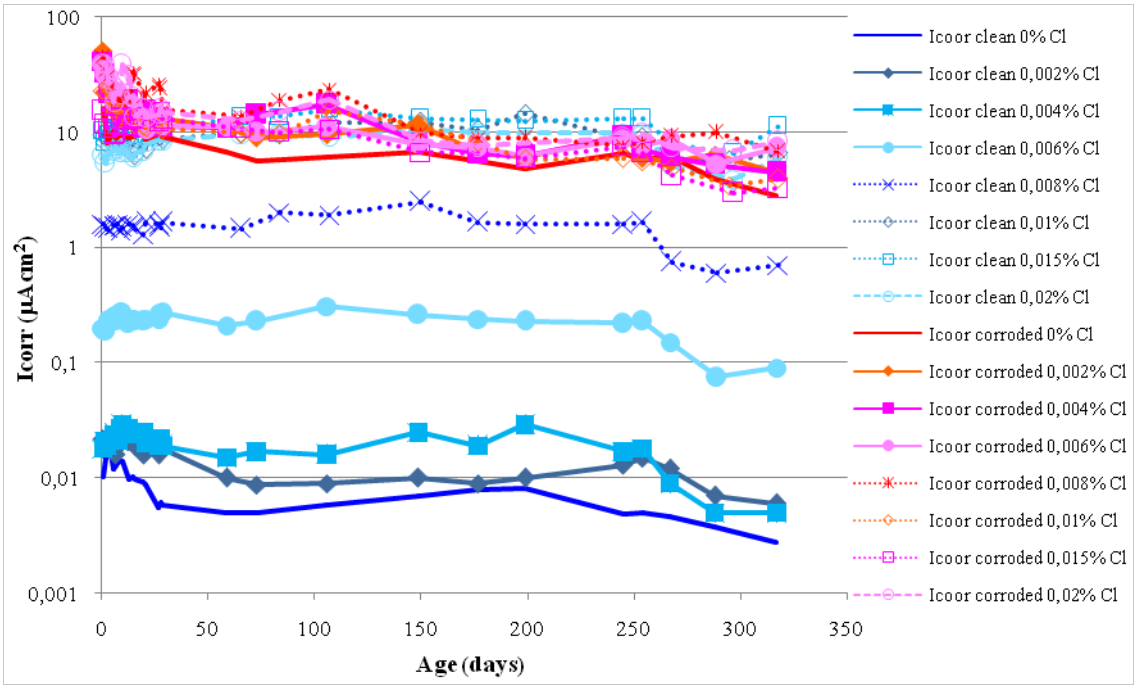

Fig 1. Results of corrosion rate for all bars

The results obtained (Figure 1) show that the bars in which the corrosion products have been kept are not repassed, independently of the chloride content existing in the specimen. In addition, all of them maintain a similar behavior over time, with corrosion rates typical of the active state (icorr≥ 1µA / cm2). Only typical corrosion rates (Cobo et al.) Of the passive state (icorr≤ 1µA / cm2) are obtained in clean bars with chloride ion amounts less than or equal to 0.4% by weight of cement. Clean bars with an amount of chloride ion by weight of cement of 0.6 are maintained in an uncertain position between the thresholds of the passive and active states.

These results also serve to verify that the maximum limit of chlorides allowed by the EHE Instruction, 0.4% by weight of cement, is on the side of safety. In addition, with contents equal to or greater than 0.8% chloride by weight cement, the steel embedded in concrete corrodes. While with an intermediate content (0.6%), the situation is uncertain.

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GENERAL ISSUES

ENERGY BUILDING ANALYSIS WITH ADAPTIVE SETPOINT TEMPERATURES: COMPARATIVE BETWEEN VIP-ENGINE AND ENERGYPLUS

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Keywords: *Energy analysis, adaptive setpoint temperatures, building, VIP-Engine, EnergyPlus*

The decrease in energy consumption of buildings is essential to reduce greenhouse gas emissions and reduce the aggressiveness of climate change [1]. In this sense, the measures aimed at reducing the energy consumption of HVAC systems are the most important since these systems are the main source of energy consumption in buildings (above other energy consumption, such as equipment or lighting [2,3]). One of the possibilities to reduce the energy consumption of HVAC systems is adaptive setpoint temperatures. These consist of adapting user behaviour patterns to adaptive behaviour based on one of the existing thermal comfort models, such as EN16798-1: 2019 [4] or ASHRAE-55-2017 [5]. Many studies have shown how the energy savings achieved with adaptive behaviour can be up to 50% compared to the use of static setpoint temperatures [6–8]. However, most of these studies have been based on the results obtained through simulations carried out in EnergyPlus. EnergyPlus is an open-source whole-building energy modelling engine created by the United States Department of the Energy. It is one of the main engines of energy calculation and one of the most used in the main research of energy modelling of buildings. However, there are more options to energetically evaluate buildings. Some of these options are included in BIM software, which is an adequate workflow for projects developed in BIM. This is because engineers and architects have in the same software the necessary tools to design the building and evaluate it energetically. For this reason, in this study the energy assessment tool included in ArchiCAD was evaluated. This tool uses the Strusoft VIP-Energy calculation engine. To evaluate it, a case study

designed in both ArchiCAD and DesignBuilder (software that uses EnergyPlus) was used. The use of the HVAC system in the case study was adapted to the adaptive thermal comfort model of EN 16798-1. The results reflected the degree of deviation between the energy simulation carried out in BIM and the one carried out with EnergyPlus.

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ENERGY POVERTY

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Keywords: *Energy poverty, health, welfare, indicator*

The research aims to advance the study of the relationship between energy poverty and overall health and people's well-being. It aims to deepen the analysis of a complex phenomenon such as the relationship between energy poverty and health [1-4].

The methodology is divided into two parts:

- Energy poverty

  Revision of the definition of the concept of energy poverty from its inception in 1983 until the approval on April 5, 2019 of the National Strategy against Energy Poverty 2019-2024 (ENCPE). Analysis of the strengths and limitations of the indicators used and proposal of measures to overcome the identified limitations [5-8].

- Health

  Review of the indicators used in different studies on the health impacts experienced by people living in households in situations of energy poverty. Such indicators will cover socio-economic aspects, social determinants of health, lifestyle habits and health status. Drawing up the list of indicators to research and questionnaire to obtain them [9-12].

The conclusion of the research shows a greater concern to obtain more knowledge of energy poverty causes and its effects on health, however, the European Union does not provide a definition to recognize the problem in a general way. In addition, it remains to be recognized that an excess of heat (and not only of cold) also supposes an energy poverty.

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BAIONA AND THE WAY TO SANTIAGO: URBANISM, CULTURE AND HERITAGE.

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Keywords: *Baiona, Historic Site, The Camino de Santiago, Cultural Heritage, Monterreal Fortress.*

Urban transformations, developments sometimes recognize in the heritage an obstacle to the development of their cities, as a result of the complexity involved in its articulation with the new structures, favouring the disappearance of certain historical elements, which implies the loss of the memory and identity of its inhabitants.

Baiona coastal town of the province of Pontevedra (Spain) is located in one of those enclaves where tradition and vanguard converge. Located on the western slope of Galicia sheltered by the Atlantic that penetrates inland through its estuaries, forming a rich and unique landscape. As a whole agglutinates a rich artistic heritage of archaeological type (petroglyphs and forts), architectural (civil and religious) where the former strength of Monterreal stands out today, nowadays National Tourism and Ethnographic Parador .[1], [2], being numerous the medieval bridges through possible Roman roads that today are part of the Way to Santiago by the Atlantic coast and natural.

All of the above makes Baiona a place of reference in the Rías Baixas with a splendid Historical Site typical of medieval civil architecture that forms an interesting monumental and landscape set that justifies addressing, through the present study, an analysis of the current delimitation of the Place Cultural Interest of Baiona, both of tangible and intangible values that it holds, today underlined the importance of the Village for the incorporation to the Way to Santiago.

The Special Plan of the Historic Site of Baiona declared a Place Cultural Interest since 1993, it encompasses its old town and a set of protected external elements but geographically dispersed that entail complex urban management and patrimonial protection. This fact together with the approval of other planning

instruments such as the General Plan, the Coastal Management Plan or the last one under the Law of Cultural Heritage of Galicia that recognizes the Portuguese Way of the Coast as an itinerary of the Way to Santiago and it crosses the Historical Site causing the confluence of different areas of affection in a reduced physical space that hinder the patrimonial protection.

This work is conformed by the need to propose an in-depth analysis of the BIC with the essential objectives of improving both the protection of the Historic Artistic Site and that of its unique and identifying elements, which seek its revitalization, rehabilitation and urban regeneration, encouraging the development of others uses taking advantage of the Way to Santiago as a catalyst for initiatives from a tourist-cultural perspective.

The study on the application regulations, the general and special plans as well as from the contribution of the experience of institutions, professionals, neighbors and economic agents, it concludes with a proposal to modify the delimitation of the current BIC, as a successful instrument in line with all the analyzed aspects that have been developed that denote a necessary improvement and review to achieve a successful and efficient protection from functionality and clarity. All this, as a corollary of the ethical duty of transmitting to the future generations the rich historical-cultural heritage of Baiona preserving their values.

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CHARACTERIZATION OF THE CONSTRUCTION AND PUBLIC SERVICES IN VENEZUELA. DIAGNOSIS AND PROPOSALS

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Keywords: *Construction, public services, competitiveness, Venezuela*

Infrastructure constitutes the fundamental framework that allows the development of each country and supports both the basic needs of individuals and the most complex processes of production, transport or communications [1, 2]. This is the reason why it is essential for the socio-economic performance of each nation and can make a difference in achieving the goals of competitiveness and poverty reduction [1, 2].

The line of research developed by the researchers includes the review of the conditions in Venezuela in relation to competitiveness, energy, infrastructure, construction performance as well as sustainable construction. The authors propose a critical approach to the problem, which highlights the contradictions in the country that - up to two decades ago - was known as a reference and leader in energy and infrastructure development and today confronts the worst situation of energy poverty, deterioration of infrastructure and services and that has lost several positions in the world rankings of competitiveness, energy and infrastructure [1, 2].

These contradictions arise from the particular public policies that exist in Venezuela as well as their implementation. The investigation places a particular emphasis on assessing public infrastructure and services as well as on the conditions that have led to the progressive delay or paralysis of infrastructure construction or maintenance projects, to damage to the quality of life of Venezuelans, as well as the severe loss of competitiveness if we compare the country globally.

As a result of these complex conditions, a large part of the Venezuelan population today lives with levels of incremental poverty, with long daily power cuts, queuing for kilometers to get water and gasoline, with garbage littering all

cities, cooking with firewood instead of domestic gas and with schools and hospitals that seem to have suffered the consequences of a natural catastrophe [2, 3, 4, 5].

In this article the authors deepen the study of the problems that affect the Venezuelan construction sector and its public services, their causes and the impact they have on competitiveness and quality of life. The article includes new data in reference to the conditions of general infrastructure projects and housing, transport and tourism as well as the characteristics of public services, including electricity, water, domestic gas and waste management [2, 3, 5].

With the intention of supporting the restoration of the necessary conditions for the progressive improvement of the quality of life of Venezuelans and leading the country on the path of sustainability, the authors present the compilation of the most valuable proposals presented by experts in the field of troubleshooting infrastructure and public services.

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APPLICABILITY OF STATISTICAL TECHNIQUES BASED ON MARKOV CHAINS IN ENGINEERING

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Keywords: *Markov chain, building maintenance, component deterioration*

Markov chains is a statistical model that allows the determination of the probability of an event happening. This technique is used very frequently to estimate the probabilities that influence the development of engineering activities. The main objective is to develop the methodology of Markov chains and study the different situations that apply the model to determine its effectiveness in engineering. Firstly, a detailed description of the methodology of the Markov chains was conducted in order to obtain the probability that the system is in a specific event described [1]. In this way, the results of the different studies carried out with this methodology were evaluated. The impact of the application of the Markov chains in the different engineering activities was determinated [2] [3] [4]. This study focuses on engineering activities in the healthcare field, due to the importance of healthcare buildings on people's quality of life [5]. Correctly selecting the maintenance of facilities, buildings and equipment makes it possible to improve the health of patients, the safety of workers and the condition and operation of these elements. The result obtained states that the statistical model is suitable for the probabilistic analysis of different situations in the world of engineering, obtaining results of relative importance that allow the improvement and optimization of the different activities. From the point of view of hospital engineering, the application of the Markov chains as a statistical method generates a source of positive results that allow further progress in this type of research and raise the quality of health service.

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THE WAY TOWARDS CONSTRUCTION 4.0. DIGITALIZATION TECHNIQUES AND CHALLENGES

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Keywords: *Construction 4.0, digitizing, sector analysis*

In an increasingly globalized environment and in continuous evolution, the continuous improvement of processes and methodologies is required, and the adaptation of the different sectors that make up the economy to maintain competitiveness in each of them. In this context, the Construction Sector has traditionally been one of the most conservative when it comes to adopting innovations due to its characteristics and the inertia of the sector [1] [2]. This makes it start from an unfavorable position for its digital transformation, in what has been called Construction 4.0. This project addresses the most important challenges in this field, which increasingly incorporates digital technologies in order to assimilate new knowledge and improve its competitiveness. [3]

The importance of this sector is backed by other economic sectors that make up the construction value chain: product and machinery, manufacturing, professional services, infrastructure, real estate management and housing. Likewise, the importance of the sector is also reflected in its ability to fit within the main challenges of the European Union (Fig. 1): employment, digital economy, energy efficiency, circular economy, climate change, demographic changes, health and safety, education, along with the new rules for training and protection of personal data. [4] [5] [6].

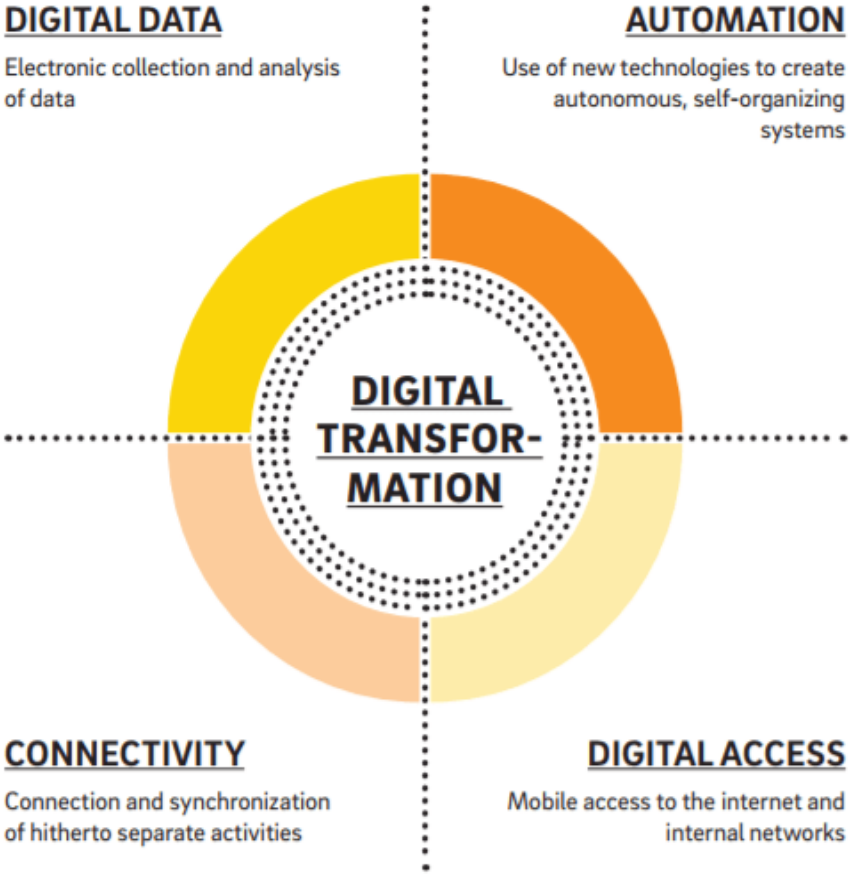

Fig. 1. Digital transformation

This paper presents the results of a statistical study of the geographical level of the autonomous community of the Basque Country (Spain). The challenges and opportunities generated by this disruptive change enable the construction sector to position the local economy at a level of competitive leadership at European and global level are evidenced. Information has been collected from the different agents that make up the sector, collecting information based on the types of company, such as entities and companies of architectural design, construction companies, maintenance companies and administrative management of buildings. Within this characterization, the needs adapted to the size of the company are framed. The needs, barriers and opportunities around digitalization are statistically outlined. The bias presented by means of indicators for each company profile is analyzed and the radiography of the sector with its different actors is presented. Needs are correlated both at the vertical level in company size, and at the horizontal level in the interrelation between areas of application of digital methodologies.

From this study, the state of the art of the companies in terms of the level and plan of digitalization is obtained, in order to extract a list of needs and gateways that can successfully approach the digital implementation.

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THE TRANSPOSITION OF THE COUNCIL DIRECTIVE 92/57/EEC TO RD 1627/97

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Keywords: *Training, prevention, construction, legislation, safety and health plan*

Royal Decree 1627/97 [1] is the norm for the development of the ORP Law [2] in construction works and clearly establishes specific mechanisms for the application of the ORP as well as Royal Decree 39/1997 [3]. This regulation, pertaining to the Spanish legal system, is a direct transposition of Council Directive 92/57/EEC [4], which establishes the implementation of minimum safety and health requirements at temporary or mobile construction sites.

However, there are differentiating aspects derived from our own legislative situation, Royal Decree 555/1986 [4], specifically related to the Safety and Health Plan, where it can be observed that the transposition has not been so direct. Therefore, we wanted to highlight and reflect the differences that concern this study and that affect the Safety and Health Plan, through the main differences listed below:

Royal Decree 1627/97 [1] transposes all the definitions established in Council Directive 92/57/EEC [4] and adds the definition of the following agents involved in the work: designer, contractor and subcontractor.

Royal Decree 1627/97 [1] restricts the responsibility of designating the Safety and Health Coordinator to the promoter, eliminating the possibility of designation by the construction manager.

Council Directive 92/57/EEC [4] does not specify who is the figure in charge of developing the Safety and Health Plan, but rather involves several agents to ensure its development (the construction manager and the property), and the Safety and Health Coordinator in the project phase will be responsible for preparing a preliminary study of the characteristics of the work and the safety and health elements to be taken into account. However, Royal Decree 1627/97 [1] considers that exclusively the contractor may prepare the Safety and Health Plan, in application of the Safety and Health Study, prepared by a competent

technician and designated by the promoter other than the Council Directive 92/57/EEC [4].

Council Directive 92/57/EEC [4] considers that the coordinator at the project stage is the agent in charge of establishing the standards applicable to the work. Royal Decree 1627/97 [1] on the contrary, considers and specifies that the Safety and Health Coordinator in execution phase will be responsible for approving the Safety and Health Plan.

Royal Decree 1627/97 [1] states that only the contractor is in charge of modifying the plan and subsequently must be approved by the Safety and Health Coordinator in the execution phase. Council Directive 92/57/EEC [4] specifies that the Safety and Health Coordinator in execution may make changes to the Safety and Health Plan or entrust it to another agent if it deems appropriate.

At this point, we observe a direct transposition of Article 7th of Council Directive 92/57/EEC [4] to Royal Decree 1627/97 [1], not exempting the promoter from liability even if the Safety and Health Coordinator is appointed.

Article 11th of Royal Decree 1627/97 [1] further develops the preventive obligations of the agents involved in the work.

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GLOBE: STANDARDIZATION OF CONSTRUCTION PROCESSES IN THE PLANNING PHASE TO APPLY LAST PLANNER SYSTEM

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Keywords: *Lean construction, last planner system, collaborative planning, standardization processes, construction processes words maximum*

The methodology "Buiding Information Modeling" (BIM) and the Last Planner System (LPS), which have been developed separately, and are currently presented as two complementary tools to deal with the complexity of the product and the process in the real estate sector. Several unique interactions have been identified between the BIM functionalities and the LPS processes [1]. The LPS is also complemented by the Location Based Management System (LBMS), which is the latest generation of programming by areas [2], and its general emphasis is the planning of productivity [3]. Their implementations require changes in the ways of working, which is more difficult than simply implementing a new technology. Substantial changes require long-term efforts and a stable business and work environment.

The Last Planner System (LPS) theory proposes different levels of planning depending on the phase of the project: master planning, phase planning, and weekly programming. To obtain the baseline of project planning, collaborative planning, pull planning approach and the technique of reverse planning are usually applied in the planning phase. In real estate projects of the same typology, but with different suppliers, a different sequence over the same construction processes can be obtained. To ensure a greater standardization of construction processes in projects of similar typology, the **GLOBE** methodology can be used. **GLOBE**, which is developed in an application over Navisworks software, uses concepts from the LPS and allows to determine, in the intermediate planning phase, a sequence of execution of all activities defined on each object of BIM (Building Information Model) design. This sequence of

execution is obtained with the previous experience of the construction company in projects of the same type in collaboration with the subcontractors for the definition of production rates. The use of **GLOBE** is enabling a standardization of the construction processes of **GRUPO LOBE** projects. The challenge of the methodology / tool is to enable a continuous improvement that allows the success of a project, it which can be measured by the achievement of its economic, temporal and qualitative objectives [4], is also reflected in the relative improvement of these indicators, of productivity and profitability among subsequent projects.

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TECHNICAL AND LEGAL STANDARDISATION IN BUILDING SURFACE MEASUREMENT

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Keywords: *Cadastre, property, measurement, standardisation, buildings*

The incorporation of surface measurements in Spain, included in property, building and land management, has been for years a source of countless problems, both technical and legal.

Technical because there are no standardized application regulations and each institution has used its own methods and regulations to give validity to the measurements, based on different solutions, ranging from direct topographical measurement to the use of photogrammetric techniques; without taking into account data on accuracy, methodology, tolerances, etc [1-2].

Legal because the incorporation of an area data should not be based solely on technical measurement; rather, the analysis of certain laws and circumstances contemplated in law affect this technical measurement performed, which may not be legally correct even if it is technically correct.

The present work is part of the search for a technical and legal solution to satisfy, in a standardised way, the actors involved in real estate management and traffic, mainly the citizen, cadastre, registry and notary public, and public institutions.

The technical solution must be based on a correct and adequate technical measurement, standardized and based on the adaptation of European and international regulations, which have been defined through joint work studies between international commissions and under European directives, with a common objective: to define unique rules for the entire international community, applicable to all buildings, both existing and in Project, which affect and are applied in all phases of construction, from the initial data collection of the existing plot, land or lot where it will be built, until the completion of all construction works [3-6].

The legal solution must analyze all types of realities that converge in the determination of something simple to perform technically, such as a measurement of coordinates or distances, but which may have different aspects of realities different to the physical situation, such as legal, cadastral, urban, legal, procedural, etc…

The final objective is the preparation of a technical legal document to respond to all legal operators and citizens in general.

It must be a quality process, which is cross-border to the Autonomous Regions (and therefore standardized) throughout Spain, related to existing regulations throughout the European Union, with knowledge of the process by the surveyors and technicians in charge of the measurements and / or all those professionals involved, as well as all stakeholders and in all professional areas, from the process of data collection, design, implementation, construction, sale, transfer of properties, rental, sale, tax calculation or any other process that is inherent in the building.

In Europe, the first movements to carry out these standardization tasks have already begun more than 10 years ago, through the IPMS and ILMS regulations, as well as the Measurement Code for the Floor Area of Buildings, developed by European experts from the European Commission.

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A GENDER LOOK ON PSYCHOSOCIAL RISKS OF THE BUILDING SECTOR IN SPAIN

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Keywords: *Psychosocial risks; building; gender; prevention*

If women's access to the Spanish university was late, because until 1910 Spanish women were not allowed to enroll in the university, women's access to technical education was still more , because we must wait until 1931 when three women entered in the School of Architecture, although only two of them finished and remained active [1]. In the case of Technical Architecture, it is still necessary to wait for 1945 when the first female, Elvira de Azúa, joins the professional school in Barcelona, and who remained the only female professional of Technical Architecture for 11 years [2]

With the presence of women in technical studies, a great social change took off. Therefore, at present, in many Architecture and Building Schools female students equal or outnumber their male classmates.

However, in the professional area, although things have also changed, the proportion of women continues to be a minority as they rise in the pyramid hierarchy or seek to achieve greater leadership [3]. Therefore, it can be said that the building sector remains fundamentally masculine, so procedures and the way of working have changed very little. This situation has meant that on many occasions issues arising from professional work have not been analyzed from a gender point of view and have continued to be treated as if they affect, men and women, in the same way.

This is the case of the psychosocial risks, which very few companies in the sector are considering [4] and even less from a gender point of view, although there are many studies that confirm the existence of important differences in the way that men and women react [5-8].

Therefore, the Research Group "Building Technology and Environment-TEMA", of the Higher Technical School of Building (ETSEM-UPM), the ARPADA Chair, the IRSST Chair and the Official Association of Surveyors of Madrid are developing a Project that aims to establish a methodology to determine the influence of gender on the psychosocial risks of the Building sector in Spain.

For this, four work phases are proposed, although this paper only presents the results of the first phase, that is, the bibliographic and documentary study about research and studies carried out on psychosocial risks, highlighting those that are related to the gender.

The first conclusions have been:

There are numerous studies that analyze the evolution of the female architect and engineer in the academic field, but we have found few studies about the professional practice of women.

Although Law 31/1995 on Occupational Risk Prevention requires an evaluation of psychosocial risks, few companies in the sector are analyzing their personnel in this regard.

We have not found studies that analyze psychosocial risks by disaggregating data by gender.

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RESIDENTIAL BLOCK HOUSE ASSESSMENT AND IMPROVEMENT USING THE SOFTWARE DESIGN BUILDER

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Keywords: *Energy efficiency, building simulation, comfort, photovoltaic*

In the European Union, the Energy Performance of Buildings Directive (EPBD) requires all new buildings from 2021 (public buildings from 2019) to be nearly zero-energy buildings (NZEB) [1]. The objective of this research is to optimize the energetic behavior as well as the users´ comfort of the building by energy simulation. To do so, a flat within a residential block built in the 80´s and placed in Barrio del Pilar (Madrid) has been chosen. The climate zone is D3 according to the Spanish Building Code. The model was developed with a Building Energy Simulation (BES) commercial software named “Design Builder®.

The model developed has been into account indoor thermal gain and the operational habits from users. To set up the heating, hot water and refrigeration and thermal properties of materials, the Spanish building code has been used as reference [2]. Since the residential blocks of the neighbourhood are tall, several building blocks were added as a component in order to adjust the solar factor. The house studied is on the 2nd floor of a 12th floor residential block. In order to improve the user´s comfort and to reduce the energy consumption of the flat, the following improvements were applied into the model: new facades, new windows, new lighting, new boiler and addition of photovoltaic panels.

Comparative analysis before and after improvements was done in order to quantify the efficiency of the measures applied. Thanks to the improvements, carbon dioxide emissions and electricity consumption have decreased. However, since the luminaires are LEDs, there is less heat gain in the apartment, which means how gas consumption increases. In addition, indoor comfort has improved reducing indoor temperature several degrees in hot days.

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ENERGY SIMULATION AND THERMAL COMFORT IN A RESIDENTIAL 50´s HOUSING

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Keywords: *Energy consumption, simulation, comfort, residential building*

In the European Union, the Energy Performance of Buildings Directive (EPBD) requires all new buildings from 2021 (public buildings from 2019) to be nearly zero-energy buildings (NZEB) [1]. Residential buildings are particularly important to focus on, since, according to Eurostat (2018), they account for around 25% of total energy consumption as well as around 20% of greenhouse gas emissions [2]. Thermal comfort is one of the most important aspects of user satisfaction and energy consumption in buildings. Approximately 20% of the energy used in Spain is related to buildings. In view of the current energy challenges, such standards must balance reductions in cooling/heating energy requirements of a building with improvements in occupant comfort. The aim of this research is to improve the indoor thermal comfort of a 1-floor housing dating from the 50's by building energy modelling. For that, the main priority is to implement several passive measures. Then, the second step is to achieve comfort through active sustainable measures.

The original building, built in 1950-60, has external walls and flat roof without insulation; single glazing; floor with inefficient insulation and natural gas heating. The improved building according the Spanish Building Code [3] has external walls, floor and flat roof with insulation; triple glazing and windows shading; power generation with solar panels and biomass Boiler system. After simulation, the original building has been compared to the improved building and the main conclusions were obtained. Results show that the improved building have better inertia and the indoor operative temperature now is closer to the recommended values of the Spanish Building Code (22°C in winter; 25°C in summer). In addition, the following improvements are achieved: 61% Reduction in Heating demand (from 68,1 MWh to 26,4 MWh); 9% Reduction in Electricity demand (from 13,6 MWh to 12,4 MWh); 64% reduction in CO_2 emissions (from 20.990 kg to 7.500 kg) and 9% Reduction in Electricity demand (from 13,6 MWh to 12,4 MWh).

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WATER ABSORPTION BY CAPILLARITY IN MORTARS

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Keywords: *Capillarity, mortars, absorption, moisture, recycled aggregates*

Nowadays, the use of recycled aggregates, construction and demolition waste, is being promoted, in order to reduce the use of natural aggregates around the world [1].

It is possible to obtain three types of waste from construction: recycled concrete aggregates, mixed recycled aggregates, ceramic recycled aggregates [2].

It has been evidenced that the use of recycled aggregates is a viable option, and therefore its use is increasing. For this reason, its evaluation is necessary against different pathologies.

Moisture is a constant pathology in building construction and civil works. In order to characterize and prevent the appearance of moisture, there are different measurement methods. These methods can be divided into direct and indirect methods [3]. Direct methods require the removal of water from the material, and can be determined gravimetrically, volumetrically or by chemical analysis. The best known and most used is the gravimetric method, based on the determination of the humidity coefficient by calculating the difference in weight caused by the water absorption [4,5].

However, direct methods require a mortar specimen, so it is not possible to repeat measurements in the same section and it makes moisture monitoring difficult. So, it is necessary to use indirect methods for measurement and moisture monitoring in situ. Indirect methods seek to determine properties that correlate with water content, electrical methods (non-destructive tests) are an example [6].

Electrical resistivity is a method commonly used in cement mortars, that shows that the higher the moisture content, the lower the resistivity. It is necessary to considerer that when applying the resistive method, specific characteristics of the material and temperature are required, since both parameters have a significant effect on the electric conductivity [7].

Another indirect method of moisture measurement is the capacitive method. The capacity measurement is a non-intrusive type of test that determines the overall moisture content in a section of the walls of a material and therefore its accuracy is similar to which can be obtained with electromagnetic transmittance [8].

Within indirect methods, infrared thermography can also be found. Infrared inspection is a fast and non-invasive method that allows to detect moisture spots within a material [9].

In addition, and considering the rapid advancement of technology, it is possible to create custom humidity sensors which allow real-time monitoring of materials and yield readings of the required information. An example is the use of the Arduino platform which, in combination with a humidity sensor is useful and reliable for measurements.

Despite all the existing measurement techniques, those who study pathologies presented in buildings, face the lack of information on new and more reliable moisture measurement methods.

Taking into account the above, in the present work, direct (gravimetric method) and indirect (electrical resistivity, capacitive method, Arduino sensor) measurement methods were evaluated in mortar mixtures prepared with natural aggregates and recycled aggregates (concrete and ceramic), with two cement water ratios 1:3 and 1:4, and two types of cement (CEM II and CEM IV), in order to determine the effect of the addition of recycled aggregates on the mechanical and mortar absorption properties, and design and test new moisture measurement sensors (capacitive sensor and Arduino sensor).

After the tests carried out, it was evidenced that the use of CEM IV cement makes it possible to use recycled aggregates in mortar mixtures, improving mechanical and durability properties (becoming similar to the results obtained for mortars with natural aggregates).

It is also evident that it is possible to measure the water absorption in mortar with a capacitive sensor. This can be used as an indirect method of measurement, in addition to its advantages of low cost and easy operation.

It was not possible to continue with the evaluation of the Arduino sensor, due to problems presented in the data collection.

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MEASUREMENT OF THE HYSTERESIS CYCLE IN FERROMAGNETIC MATERIALS

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Keywords: *Hysteresis loop, Arduino, Hall effect sensor, Ferromagnetic materials*

From a sustainability perspective, the detection of corrosion in reinforced concrete structures is a way to save resources by increasing the life cycle of these structures [1].

In the international market there are several devices that serve to monitor the corrosion of structures, but that use devices or systems have a high price, not being available to a larg part of companies in construction sector [2-3]. Therefore, in this investigation, the development of a simple sensor has been carried out to study its capacity to detect a certain corrosion rate in corrugated Steel bars with thicknesses of 10, 12 and 16 mm. In the tests, we have used both corroded and uncorroded bars, testing for each of them the diameters described above.

For the development of monitoring system for both types of bars (corroded and uncorroded), we have used the following devises: Arduino Uno Rev3, Hall Effect Sensor KY- 0,24, digital multimeter PD-691, digital teslameter Phywe, power source EP-613 y a magnetic coil. The purpose of the investigation was to obtain positive results, which corroborate that the sensor is reliable to detect differences in the graphs of the hysteresis cycle of corroded and uncorroded steel bars and thus, subsequently, get to monitor the reinforced concrete structures to detect corrosion early [4-5]. But, after analyzing the results we cannot say that the method is reliable, since for the 10 and 12 mm diameter reinforcements, if you get differences in the total width of the graph but for the 16 mm diameter reinforcements do no.

As future lines of research, it is proposed to repeat the test with equipment of greater caliber and with greater amount of reinforcements classified by their percentage of corrosion, to check from what level of corrosion, the sensor is able to detect significant differences in the cycle of hysteresis.

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NANOMATERIALS AS A NOVEL SOLUTION FOR BUILDING MONITORING.

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Keywords: *Graphene, graphene oxide, rGO, LrGO, flexible sensors*

The construction industry is regarded as one of the most important economic sectors across the globe [1]. However, despite its economic importance, the construction industry is filled with inconveniences that are difficult to detect early on [2]. To face this challenge, carbon-based materials have shown great promise to revolutionize in this manner. Several reports include materials, such as graphene oxide (GO), as a precursor for mass production of graphene[3-4]. This material has oxygen species present in its structure that makes it electrically insulating [5]. Therefore, in order to develop devices with this material these oxygen species must be removed. In this work we highlight a single step laser-assisted reduction process. The material obtained by this method possesses a high electrical conductivity (180 Ω/sq), chemical and thermal stability and high specific surface area (SSA), suggesting that this laser reduced graphene oxide (LrGO) may be used for manufacturing sensing devices directed towards building monitoring.

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EVOLUTION OF YOUNG'S MODULE DURING THE MORTEROS'S FRENCH PROCESSING

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Keywords: *Arduino, recycled aggregate mortars, Young module, ultrasound, impact acceleration*

Young's module or longitudinal elasticity module is a parameter that characterizes the behavior of an elastic material, depending on the direction in which a force is applied. [1]

There is the impulse excitation technique to measure Young's module of non-destructive molding compounds, this virtually non-destructive technique allows the measurement of changes in mechanical properties in a sample during environmental stress. [2]

This paper shows a simple method for determining Young's Elasticity Module when a disturbance is applied to concrete specimens, since there are no changes in the structure of the concrete during the measurement. [3]
The determination of the Young Module is obtained from the obtaining of the acceleration and speed propagation of waves through standardized specimens (UnE-EN 12680-1) [4] whose dimensions are 4x4x16cm; tested specimens made from natural AN arid, arid AH concrete aggregate and specimens made from recycled ac ceramic arid.
The method applied consists of the application of a disturbance caused by a simple pendulum that regulates the force of the impact that each specimen receives, [5] these signals are captured by a sensor and subsequently transmitted to the Arduino software, so that once transmitted the data is taken we proceed to take the most representative values that indicate the evolution of frequency wave propagation as the specimens reach their process of setting and hardness. [6]
The results of the work allow to relate the evolution of moE with the properties of mechanical resistance, the rate of propagation of waves by ultrasound and the capture of the acceleration captured by a sensor on the X, Y and Z axes of the specimens.

The method applied is reliable to relate the evolution of MoE to other factors, without affecting the test specimens.
The method applied is reliable to relate the evolution of MoE to other factors, without affecting the test specimens.

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STUDY OF THE EVOLUTION OF MORTAR PROPERTIES AS A FUNCTION OF TEMPERATURE

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Keywords: *Temperature, properties, mortars, sand, humidity*

The main objective of this work is to present procedures, results and conclusions on an experimental study to determine the evolution of mortar properties as a function of temperature.

Mortars are construction materials of increasingly widespread and specialized use within the building, whose characteristics and performance are different according to the destination for which they are designed; being necessary, to ensure that their use and properties respond to the purposes intended, ie, to carry out quality control on site.

The influence of the environmental temperature on some physical properties of the fine aggregates was determined and its effect on the workability of mortars was analyzed, giving much importance to temperature variation.

The dosages used in the test tubes were cement type II and IV and a natural sand grain size of 0.04 mm with a dosage of 1:3 and 1:4, as for the water-cement ratio, the necessary one was adjusted for each mold.

The water/cement ratio was adjusted to obtain a soft consistency and a similar fresh working capacity for all the mixtures. A soft consistency was selected because it is suitable for tests on mortar specimens. The sand used was sieved to obtain a grain size of 0.02 mm.

In this investigation, the mechanical strength properties of 24 concrete specimens were evaluated, namely the moulds PH1, PH2, PH3 and PH4. Six concrete specimens were taken from each mould and the sizes of the quadrangular prism samples were 40x40x160 mm. The samples were demoulded after 24 hours and cured for 28 days. As far as the hardness is concerned, the surface area must be taken into account because it varies due to the air bubbles it has, but even so, cement IV is the one that can withstand the most as it has the greatest resistance.

Water and cement are mixed on the one hand, while on the other hand the sand used in the kneader (Ibertest model) is poured. The kneader will mix the water and cement previously mixed with the sand, for which it will be subjected to different times. Once we obtain the mixture by the kneader, we knead it manually for 60-120 seconds and we pour it into the standard mould.

The results obtained indicate that the workability of the mortar depends on the properties of the aggregates, which are influenced by the temperature. As a conclusion, through the analyses we have carried out, cement IV is the one that has more resistance together with the test pieces that we have heated, due to the fact that it has less water contained in the material, which makes its resistance greater with respect to the test pieces in a wet chamber and the frozen test pieces.

On the other hand, exposure to higher temperatures leads to cracking of the specimens according to the analyses obtained.

FIRM FLOOR.
ACCESSIBILITY IN MADRID AND PHOTOCATALYTIC PAVEMENTS

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Keywords: *accessibility, urban planning, pavement, photocatalysis, design.*

Nowadays, there are several sustainable proposals due to the environmental problems that our planet is suffering. Due to the magnitude of the problem it must be tackled from different approaches. The architecture can help with that through a sustainable design of buildings and cities.

Apart from environmental requirements, people's needs have also influence in the design. However, cities have irregularities in their design that must be solved to attend to the of users' needs.

The research aims to unify issues of accessibility and sustainability in the urban environment. The hypothesis is based on the possibility to project and build through urban pavements, cities that attend the needs of the population and to respond to the present situation of the planet.

To achieve this, the city of Madrid has been chosen as a field of study, being able to extrapolate the conclusions to other urban centres.

Firstly, the current regulations [1][2][3][6] have been studied doing comparative tables.

As field work, it has been evaluated through a photographic matrix of the contemporary state of four tours proposed as accessible by the Madrid City Council [10]. This matrix is formed by three columns. The first one shows the location and point of view of the photograph. In the second one, there is a black and white photograph which show the space in perspective and emphasize with a colour the positive or negative features that are identified. Finally, in the third column a detail of the pavement of the analyzed area is shown with its characterization [8].

The field work demonstrates that the main problems of accessibility in the cities are the breach of the regulations and the bad conditions of the pavements. The latter requires a more detailed analysis so it has been considered appropriate to develop in this research. In addition, since 2015, the City Council is working on several sustainable pavement projects [7] through the recycling of bituminous mixtures or decontamination through photocatalysis.

This research focuses on photocatalytic pavements. Related projects [4] [5] deal with management issues, environmental-socioeconomic impact, etc., but not about accessibility. This is why this article is done.

To do so, tests have been carried out (photocatalytic capacity, adhesion, slipperiness, colorimetry, contrast, reflectance, absorbance and ice and thaw cycles) on photocatalytic pavements that respond to the issues raised. That tests have been done following the regulations which appears in the bibliography [9].

To sum up, it has been proposed five accessible and photocatalytic type sections.

The development of the research allows us to verify the hypotheses and conclude that the pavements studied are sustainable and accessible, confirming as an unavoidable line of research and design for architecture.

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ANALYSIS OF THE DYNAMIC IMPEDANCES OF THE FOUNDATION OF A ROTATIVE MACHINE TO LIMIT VIBRATIONS

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Keywords: *Vibration, Dynamic analysis, Foundations, Rotary machines, start-up operation*

Vibrations of the machines are an intrinsic phenomenon of its fabrication. They are produced naturally while working due to the off-centre of the shafts and the masses integrated in the machine, generating dynamic loads on the machine and the foundation. Dynamic loads are variable with time. Part of the energy is wasted in radiation transmitted as radiation finally to the ground [7]. Norms limit displacement, speed and acceleration protecting machines and people of the radiation.

These vibrations can be limited with an appropriate design of the foundation, adjusting dynamic impedances, and fitting the correct start-up operation mode until the permanent speed of the machine.

In this paper is shown how the foundation works as an interface between the machine and the ground. Foundations were designed and analysed its dynamic behaviour of a rotative machine during the transient operation mode and the influence of the design in the permanent operation mode. Besides the foundation, fitting the proper start-up reduces the vibrations.

The designed foundation for a rotative machines includes an inertial block and a foundation block

Dynamic analysis was calculated with the D'Alambert differential equations of the model, based in the Lysmer's analogy [5], in the time domain to study the vertical movement, sliding and rocking [3] of the ensemble foundation – inertial block – machine. Differentials equations were integrated with a time-step scheme [4] using the Newmark's β method [6], getting the amplitude of vibration, speed, acceleration and strength in the transient and in the permanent operation mode.

Impedances and dynamic loads were calculated according to ACI Norm 351.3R-04 [1], API Norm Standard 613 [2] and ISO Norm 1940/1.

A set of 2.000 foundations were calculated randomly with a MATLAB program developed to solve the D'Alambert differential equations using Beta Newmark's method. A set of constraints of vibrations were applied to the transient and the permanent operation mode extracted from the ISO 10816 Norm [8], and the

Rathbone Chart. The amplitude of vibration, speed, acceleration and strength changing the speed of the machine were analysed.

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TRANSPARENCY RELATED TO CORPORATE SOCIAL RESPONSIBILITY OF BUILDING INDUSTRY COMPANIES

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***Keywords**: Corporate Social Responsibility (CSR); sustainable indexes; building industry*

Corporate Social Responsibility (CSR) is one of the subjects which is becoming more interesting in recent years. The growing interest in social and environmental issues has led companies to implement good practices and provide information about them [1]. This paper analyses the relationship among the publication of data related to CSR of companies in the building industry and some financial-economic indicators (such as economic performance, financial profitability, short-term solvency, liquidity or indebtedness). The Spanish companies included in the Bloomberg database are analysed, studying the link between their financial-economic state and the publication of information. This aspect is included in the three sustainability indices linked to the following aspects: environmental, social and corporate governance, as well as a fourth global indicator that includes the previous three [2]. The sample includes information from 51 companies with data from 2018, studying the differences among companies in the building industry and non-building industry companies.

The research is structured in two parts, a conceptual one and another analytical one in which the model is presented as well as the conclusions obtained.

The conceptual part is divided into three parts. The first one is an introduction that sets the objective of the research. The second one refers to the concept of CSR, analysing the different approaches of its historical evolution from the 70s of the last century [3] to the 21st century. This process considers the trends related to CSR that refer to the Theory of the Stakeholders [4] and the Theory of Legitimacy [5]. In addition, the indexes designed to homogenize this type of information are analysed (such as the Global Reporting Initiative, the AccountAbility or the sustainability indexes provided by the Bloomberg Platform). The third part focuses on the building industry in Spain, as well as the different studies that analyse its relationship with CSR.

In the analytical part, it is proposed the methodology of the study, based on a descriptive analysis of the variables used: on the one hand, the CSR indicators provided by the Bloomberg Platform and on the other hand, the ratios of economic performance, financial profitability, liquidity and indebtedness, analysing the relationship of the correlation coefficients among them. The process applies to the sample of Spanish companies collected on the Bloomberg database and to the subsample of companies that are part of the building industry using bivariate correlation coefficients, obtained with the SPSS Computing program.

Regarding the results, it is observed that there are correlations among the financial indicators of liquidity and indebtedness regarding to some CSR indices, and that the companies in the building industry show a significant correlation with the global and Environmental CSR indices unlike what happens with the total sample.

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CANDELA – DIESTE: LIGHT STRUCTURES

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Keywords: *Structures, thickness, behavior, comparison*

Felix Candela and Eladio Dieste took a leading role in the world of architecture in the mid-twentieth century. “When Le Corbuiser said 'here and now 1927, the new Architecture was born, it was not just talking about architecture, it was proclaiming the birth of a new model of thought that had been forging since the late nineteenth century, and that since then it would extend without recognize borders because their reason was not based on an idea or desire for change in itself, their reason was the necessary adaptation to scientific and technical news that would unstoppably transform the world [1-2].

This is what these two authors focused on, which gave the world a new vision of spaces and a new way of building. They created new constructive systems that were revolutionary for the time. Existing materials are rethought and applied in ways never seen before. Being able to project structures of a considerable size with concrete and ceramics, with a minimum thickness, meant a revolution in the way of understanding construction and materials [3-4].

The comparison of the structures has been carried out as follows:

Two representative works of each architect have been selected, namely a religious work and an industrial work. In the case of Candela, the selected ones have been the Los Manantiales restaurant (Mexico City, 1958) and the Church of Our Lady of Guadalupe (Madrid, 1967), while the works chosen by Eladio Dieste have been the church of San Juan de Ávila (Alcalá de Henares, 1998) and the gymnasium and the pavilion of the Don Bosco school (Montevideo, 1983). These works are also related to each other by architectural features such as spatiality, the lights achieved and size.

Once the works have been selected, each one has been analyzed:

- Lights: maximum lights. They are classified in> 10 and <10.
- Supports: if they are pillars, their own structure and operation.
- Execution process: formwork, and time to load the work, as well as systems used, advantages and disadvantages thereof.

Once this analysis is done, a table with the main results and references to each of them will be prepared. Finally, the works of the two architects are compared to each other, to see the suitability of the structure with respect to the type of architecture it hosts.

Once the different points described above have been analyzed, the following results have been reached:

	Arquitecto	Técnica Constructiva	Luces (m)	Soportes	h Sop.	h max	Proceso de ejec.
Colegio Don Bosco	Eladio Dieste	Cerámica armada	24,4	Pilares	14	15	Replanteo + Plomada
Iglesia San Juan de Ávila	Eladio Dieste	Cerámica armada	15	Pilares	11,1	12,5	Replanteo + Plomada
Rte Los Manantiales	Félix Candela	Cáscara de hormigón	35	Propia estructura	-	5,4	Encofrado
Iglesia Nta Sra Guadalupe	Félix Candela	Cáscara de hormigón	30	Propia estructura	-	6	Encofrado

Table 1: data to be compared from the 4 selected works

This table has collected the data to be compared from the 4 selected works. Next, we will break down the results by sections.

At first glance you can see the most basic differences. The lights of Dieste's projects are smaller than those of Candela, in some cases almost half. The construction system, as well as the base material they use in their projects, which we already knew previously, are also completely different.

There is also a difference in the free and maximum heights of the projects of both, in which the difference becomes more than double, reaching Uruguayan projects between 12 and 15 meters, with respect to 5-6m of Candela's designs .

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HOW TO ESTIMATE THE RESILIENCE OF EXISTING FAÇADES THROUGH ICTS DATA: DEVELOPING A PROCEDURE FOR IDENTIFYING PILOT DEMONSTRATION BUILDINGS

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Keywords: *Information and communication technologies (ICTs), building façade, inspection and diagnosis, demonstration buildings, procedure development*

Despite the potential to drive industrial progress through the use of information and communication technologies (ICTs), the construction industry has not yet sufficiently exploited them [1-3]. ICTs can be used in different stages of the lifespan of buildings, being seen here as particularly applicable during the operation phase since maintenance and renovation of existing buildings are the biggest challenges of the sector. Defects in buildings can compromise their structural performance, energy efficiency or indoor air quality, but some of these flaws are hard to identify without the support of technology, particularly when the defects are located in the building façade [4-6]. Innovation applied to the inspection and diagnosis of existing buildings would enable improving their resilience (understood as their adaptive capacity to changes on the economic, physical and social context, recovering their overall required performance and functionality) [7]. Since many defects can occur in a systematic way and can be liked to particular technical features or site-related factors, some of the defects could be foreseen by applying an appropriate method as a step towards the strategical and accurate data collection. We present the developed procedure to select pilot and demonstration buildings to become role models, in which the method and the ICTs can be successfully applied to obtain relevant results that can be extrapolated across different buildings.

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A COMPARATIVE ANALYSIS OF THE BEHAVIOUR OF GYPSUM AND E.L.T. RUBBER COMPOSITES WITH THE INCORPORATION OF FIBRES

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Keywords: *Hydraulic binders with aggregates, gypsum composites, ELT rubber, fibres*

The incorporation of fibres into different binders is a widespread practice to improve the mechanical properties of materials, increasing the resistance to bending tension, hardness, toughness or resistance to impact. Among the most commonly used fibers are polypropylene, basalt, glass, mineral wool fibers and polyolefins [1-6]. In all of them, the influence of the lengths of the fibres and their percentage of addition, as well as the degree of dispersion, is highlighted [7-8].

On the other hand, the stiffness of certain composite has negative aspects that can be seen in some of their properties such as poor thermal and acoustic insulation or lower impact resistance, and therefore less capacity to prevent cracking. The incorporation of rubber from end-of-life tyres (ELT) has been used as a procedure to reduce the stiffness of this type of material, in addition to achieving the waste disposal of a hazardous and toxic material.

The gypsum industry is developing new materials, including plates incorporating glass fibers, to be used where greater flexural strength, fire resistance or improved surface resistance is required.

In the present research, the behaviour of gypsum mixtures with ELT rubber and the incorporation of glass fibres and basalt fibres is analysed, comparing the results with a double objective. Firstly, to obtain products with high resistance and greater elasticity and, therefore, better thermal and acoustic insulation. Secondly, to consider basalt fibres as a possible alternative to glass fibres.

The values of density, bending and compressive strength and the dynamic modulus of elasticity are studied.

Both gypsum-rubber-fibre composites are new materials with the same possibilities as conventional gypsums, with the advantage of being lighter and more elastic, achieving the reuse of ELT rubber from the environmental point of view. It would therefore be applicable for partition panels, false ceiling panels or building rehabilitation works.

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INFLUENCE OF THE MICROSTRUCTURE OF ULTRA HIGH PERFORMANCE CONCRETE ON THE DEVELOPMENT OF COMPRESSIVE STRENGTH AND DURABILITY

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Keywords: *UHPC, durability, compressive strength, resistivity, migration of chlorides*

Ultra-high performance concrete (UHPC) is an interesting alternative to conventional concrete not only for the good mechanical properties but also for its improved durability. The microstructure of the UHPC is directly related to its performance.

The concept of high packing density introduced by De Larrard in the 1990s, and the use of micro and nano additions with smaller particle sizes than commonly used were essential to achieving remarkable improvements in concrete performance. In addition to the low water-cement ratio, the absence of coarse aggregates and the use of superplasticizer additives facilitated obtaining more homogeneous and less porous concrete matrices, capable of achieving high compressive strengths and prolonging the useful life of the structures [1, 2].

This work studies the relation among the behaviour under compressive stresses of UHPC, its microstructure and its durable behaviour. An experimental campaign with prismatic specimens of dimensions 160x40x40 mm^3 and cylindrical specimens with 100 mm of diameter and 50 mm of height was developed. A control mixture without additions and a series of mix designs with substitutions of silica fume, metakaolin and two types of nanosilica with various proportions were produced. In all cases, the specimens were manufactured using 1100 kg of binder per m^3 and 0.20 water-to-binder ratio. Silica sand with 98% of SiO_2 content and a maximum particle size of 0.7 mm was used. The limited water-to-binder ratio entailed the use of superplasticizer based on modified polycarboxylates, which improved the workability of the mixtures.

The prismatic specimens were tested under to compression loading, mercury intrusion porosimetry (MIP) and differential thermogravimetric differential analysis (DTA-TG). The cylindrical specimens, made with the same

formulations used in the prismatic ones, were subjected to tests of electrical resistivity and migration of chlorides. All tests were performed after a 28-day curing.

The results of the MIP and DTA-TG tests showed that the use of additions reduced the total porosity and increased the total CSH gel / total portlandite ratio, explaining the increase of the compression strength. The use of additions, especially nanosilica, significantly increased the electric resistivity of UHPC specimens, consistent with the reduction in the percentage of large capillary pores and the increase in small capillaries.

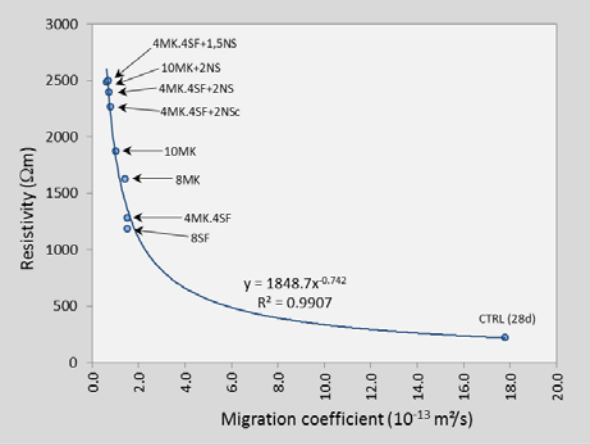

Figure 1. Resistivity-migration coefficient at 28 days

Lastly, such as shown in *Figure 1*, the chloride migration tests showed an inversely proportional relationship between the resistivity and the migration coefficient. The lower migration coefficients are related to a better durable behaviour, such as the samples with higher resistivity values.

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NON-NULLITY OF THE RISK IN IMPLEMENTATION OF THE LEVEL OF PREVENTIVE ACTION METHOD FOR HEALTH AND SAFETY BUILDING WORKS

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Keywords: *Risk Assessment, Building, Construction, Health and Safety, Null Risk*

Abstract

Risk assessment is an indispensable procedure for the company to know its conditions regarding the safety and health of its workers. It is an action on prevention that must be carried out by all companies, regardless of their production or size [1]. Various occupational risk assessment methodologies are used that contemplate the different techniques to fight risk: Work Safety, Industrial Hygiene, Ergonomics and Applied Psychosociology; individually or globally [2].

Current methods for assessing occupational hazards adapted to the particular characteristics of construction works use qualitative and quantitative observation and evaluation parameters [3]. In addition, in these evaluation methodologies such as the methods CONSRAT [4], QRAM [5], WONT [6], MIVES [7], CDEF [8], ORL-OC / PV [9], etc. they use quantification null criteria or negative observation qualitative contexts that imply the risks can be interpreted with zero value or within a null or non-existent context.

The general method published by the National Institute for Occupational Health and Safety (INSST), establishes an assessment of risk tolerances based on the probability that a situation will occur that generates or could generate damage to the health of the worker and based on the consequences that this circumstance implies in a certain severity of injuries. When the risk is Trivial, it is determined that a specific action is not required [10].

When the measurement and observation parameters are null, they involve the agents implicated in the construction (workers, technicians, contractors, promoters, etc.), to interpret that the risk is nil or does not exist. This generates a response effect of no need for prevention and protection in the corresponding work phases [11].

The Occupational Risk Assessment Method called the Level of Preventive Action (L_{pac}) is adapted to construction works [12]. In the very nature of its mathematical expression, there is no possibility of null risk, since the bases for the quantification of the qualitative risk parameters defined by the INSST (trivial, tolerable, moderate, important and intolerable) are taken from the product of Linear

functional expressions for probability (p) and consequences (c), with the expression:

$$f_{p,c}(x) = 2x + 1; taking\ integer\ values\ \{0, 1, 2\}$$

Thus, a functional expression is obtained that quantifies the risk for each of the qualitative variables of the general INSST method and whose matrix is identified in Table 1 and its graph in Figure 1:

$$f_{(p \cdot c)}(x) = 4x^2 + 4x + 1; range\ of\ values\ [0, 2]$$

Table 1. Risk quantification respect to probability and consequences

ESTIMATE OF RISK		SEVERIDAD DE LAS CONSECUENCIAS $f_c(x) = 2x + 1$							
		Slightly harmful		Harmful		Extremely harmful			
		1		3		5			
PROBABILITY $f_p(x) = 2x + 1$	Low	1	trivial	1	tolerable	3	Low moderate	5	
	Medium	3	tolerable	3	high moderate	9	important	15	
	High	5	Low moderate	5	important	15	intolerable	25	

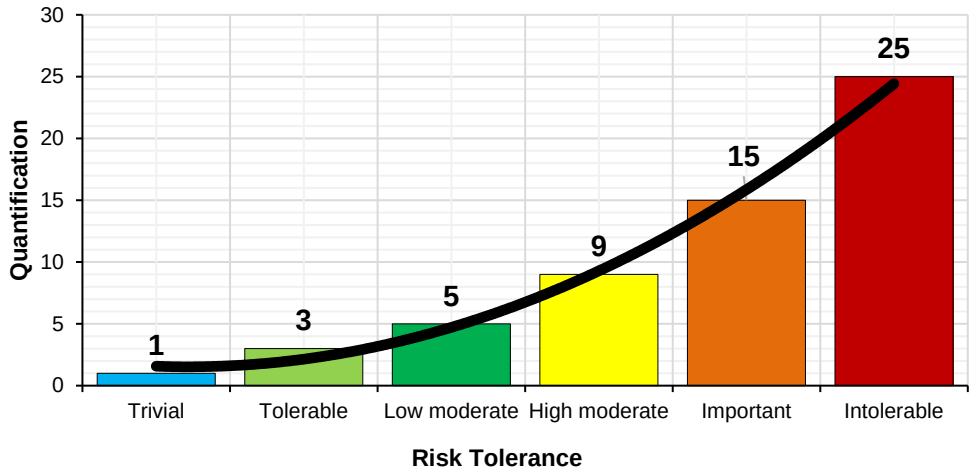

Figure 1 - Quantification of risk tolerance. The abscissa axis does not scale.

All the parameters of the formula of the Level of Preventive Action are quantified according to the ratio of values obtained 1, 3, 5, 9, 15 and 25, and which are renamed characteristic values of relative risk (R_r), border risk (B_r), degree of exposure (E), economic capacity (E_c), participatory interest (P_i) and level of satisfaction (L_s); regarding the product of the absolute or initial risk, with the evaluation of the preventive action on site; The Nacp Method determines the non-nullity of the risk, whose formula is described as follows:

$$L_{pac} = P_{ab} \cdot C_{ab} \cdot \left(R_r \cdot B_r \cdot E \cdot \frac{1}{E_c} \cdot \frac{1}{P_i} \cdot \frac{1}{L_s}\right)$$

$$L_{pac} = R_{ab} \cdot E_{pac}$$

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ANALYSIS OF THE DYNAMIC IMPEDANCES OF THE FOUNDATION OF A ROTATIVE MACHINE TO LIMIT VIBRATIONS

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Keywords: *Vibration, Dynamic analysis, Foundations, Rotary machines, start-up operation*

Vibrations of the machines are an intrinsic phenomenon of its fabrication. They are produced naturally while working due to the off-centre of the shafts and the masses integrated in the machine, generating dynamic loads on the machine and the foundation. Dynamic loads are variable with time. Part of the energy is wasted in radiation transmitted as radiation finally to the ground [7]. Norms limit displacement, speed and acceleration protecting machines and people of the radiation.

These vibrations can be limited with an appropriate design of the foundation, adjusting dynamic impedances, and fitting the correct start-up operation mode until the permanent speed of the machine.

In this paper is shown how the foundation works as an interface between the machine and the ground. Foundations were designed and analysed its dynamic behaviour of a rotative machine during the transient operation mode and the influence of the design in the permanent operation mode. Besides the foundation, fitting the proper start-up reduces the vibrations.

The designed foundation for a rotative machines includes an inertial block and a foundation block

Dynamic analysis was calculated with the D'Alambert differential equations of the model, based in the Lysmer's analogy [5], in the time domain to study the vertical movement, sliding and rocking [3] of the ensemble foundation – inertial block – machine. Differentials equations were integrated with a time-step scheme [4] using the Newmark's β method [6], getting the amplitude of vibration, speed, acceleration and strength in the transient and in the permanent operation mode.

Impedances and dynamic loads were calculated according to ACI Norm 351.3R-04 [1], API Norm Standard 613 [2] and ISO Norm 1940/1.

A set of 2.000 foundations were calculated randomly with a MATLAB program developed to solve the D'Alambert differential equations using Beta Newmark's method. A set of constraints of vibrations were applied to the transient and the permanent operation mode extracted from the ISO 10816 Norm [8], and the

Rathbone Chart. The amplitude of vibration, speed, acceleration and strength changing the speed of the machine were analysed.

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A LOOK AT URBANISM FROM A PHILOSOPHICAL PERSPECTIVE: HENRI LEFEBVRE AND THE PRODUCTION OF SPACE

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Palabras clave: *Lefebvre, philosophy, sociology, space, urban planning.*

Henri Lefebvre (1901-1991) was a French sociologist and philosopher, considered one of the leading Marxist intellectuals of the 20th century, whose production on the theory of space is, today, fundamental in areas such as sociology, philosophy, geography, and urban planning. Throughout his academic career two stages can be distinguished, in the first Lefebvre focuses on the study of daily life and the development of social relations in capitalism, while, from the 1960s, he focuses on the space and time [1].

The objective of this bibliographic review is to bring the ideas of the thinker Henri Lefebvre closer to the world of building and architecture. In order to understand his theories regarding space, it is necessary to carry out an approach to Marxist lexical baggage, since it will be key in his speech, as well as the main idea behind his thesis, which is the maxim that states that space - and therefore, the city - is an active setting, agent in social interaction [2]. Its design and production influence the establishment and development of social relations, that is, space is not a neutral "something". This idea arises from his main thesis, the production of space, which gives name to one of his fundamental works [3], in which he defends that space is a social product, whose construction depends on the mode of production in which it is immersed society to be in one way or another; so each society, with its mode of production, will produce a space with its own particularities. As a product, it can be exchanged and consumed, it will have use value and exchange value and it will circulate in the market.

On the other hand, the transition from one mode of production to another will structure the history of space, a history, according to the author, made from spatial domination. A dominant space becomes a dominated space when the relations of production and reproduction that occur in it in turn change and modify

social practices - among them, the use of space. There is a transition of states: from dominant space to dominated, to return to being a dominant space [4]. The dominant space will house and determine the appropriate places for the relations of reproduction and production, thought from what Lefebvre calls representations of space, as the set of knowledge and notions that shapes and senses impose on space, always from the elites, from the academy: politicians, urban planners, scientists, are in charge of generating what it calls the conceived space. This thought space will collide with the inhabited space, the lived space, because people, in their daily lives, will “fight” with more or less intensity against the imposition of design, giving other alternative uses to the space.

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