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Euro-American Congress
CONSTRUCTION PATHOLOGY, REHABILITATION TECHNOLOGY AND HERITAGE MANAGEMENT

Granada (Spain) - March 24th-27th, 2020

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CONSTRUCTION PATHOLOGY, REHABILITATION TECHNOLOGY AND HERITAGE MANAGEMENT
(8th REHABEND Congress)

Granada (Spain), March 24th-27th, 2020

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DEVELOPMENT OF A TOOL FOR TECHNICAL DAMAGE AND RISK ASSESSMENT IN CONSTRUCTION

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ABSTRACT

The Spanish building construction and rehabilitation sector is regulated by the Law on Building Ordinance (Ley de Ordenación de la Edificación –LOE-) and the Building Technical Code (Código Técnico de la Edificación -CTE-). The former was enacted to protect users interests and it establishes the obligations of the agents that participate in the building process so that their responsibilities and guarantees are specified. The latter, translates the basic requirements of the LOE into technical objectives, defining the requirements to be fulfilled by buildings. With the entry into force of the LOE, the ten-year warranty is the only one that has been materialized through the hiring of a ten-year insurance. Since 2016, various meetings have taken place among the different agents involved in the construction sector, the Ministry of Development (Area of architecture, housing and soil), and representatives of political parties from the parliament, in order to study the opportunity of the compulsory subscription of three-year guarantees. Nevertheless, it still has not had a specific answer from insurers mainly due to the lack of definition of the extension of “damage” and uncertainty in the quantification of the risk.

This paper presents the development of a tool that will allow to assess technical damages along the building process and manage technical risks by the implementation of a sustainable and continuous improvement to ensure adequate response (technically and economically) of the building agents to end users, in line with the guarantees required by law. The methodology identifies existing constructive typologies for every building components and their common pathologies, establishing their origin and the corresponding law compliance breaches. Then, an objective criterion to identify, assess and manage existing risk is presented.

KEYWORDS: Building pathologies; technical damages; sustainable methodology; risk management.
1. INTRODUCTION

The construction sector plays an important role due to its productive and industrial activity and the impact on the well-being of the society. However, it still seeks the enhancement of the quality in the sector and the need of promoting the innovation the sustainable development. [1]

The Spanish building sector is regulated by the Law on Building Ordinance (LBO, Ley de Ordenación de la Edificación –LOE – in Spanish) and the Building Technical Code (BCT, Código Técnico de la Edificación – CTE – in Spanish). The former was enacted to protect user’s interests and it establishes the obligations of the agents that participate in the building process so that their responsibilities and guaranties are specified. The latter translates the basic requirements of the LBO into technical objectives, defining the requirements to be fulfilled by buildings.

The LBO presents a series of basic requirements that must be met by buildings, ensuring the safety of people, the welfare of society and the protection of the environment, basic requirements that refer to functionality, habitability and safety. To this end, a series of obligations and responsibilities are established for the agents so that there are guarantees for material damage caused by construction defects.

In the present paper, the scope of action will be related to the ten-year (structural safety) and three-year (habitability) guarantees. The difficulty of limiting the scope of the basic requirements has repercussions on the difficulty of responding to the ten-year and three-year guarantees required by the LBO. For this reason, this project was born with the objective of developing a tool to assess damages and manage technical risks in residential buildings through the implementation of a sustainable model, to ensure the adequate management of damage risk of different constructive solutions and to ensure that the agents of the construction process respond to the guarantees required by law optimally (economically and technically). Hence, this methodology will lead to protect end-users and improve the life cycle of the building.

To this end, a series of steps have been followed. Initially, the available statistical information (since the entry into force of the LBO 2000-2017) regarding technical damages has been collected and processes. For this purpose, damages covered by the ten-year insurance and those potentially covered by a three-year insurance have been catalogued and evaluated. Afterwards, a tool to manage the risk of damage according to its frequency and consequences as well as the exposure of the building has been developed.

2. METHODOLOGY

The first step consists in the coding of claims: first, the constructive typologies that can appear in the building have been identified and second, the possible damages have been identified, as well as their causes, which can be related to the constructive solution.

In order to identify the constructive typologies, all the residential blocks, detached and terraced buildings, both new and refurbished, have been analysed and each of the systems and subsystems which take part in the complex have been itemised. Thus, the items have been divided into foundation, structure, roof, facade, carpentry, partitions and finishes. In turn, each item has been broken down as much as possible. For a better understanding, the procedure followed for the foundation system is explained. A distinction has been made between shallow, semi-deep and deep foundations, basement walls and others. Within the shallow ones there are elements such as isolated or combined footings, slabs, foundation beams and others. In the semi-deep ones, caissons or strap beams. For deep ones, different types of piles, piled walls, etc. And in other foundations there are some such as pools, reservoirs and tanks (see Figure 1).
After breaking down each of the construction typologies, the causes of the damage were first identified according to the type of construction, and the damages derived from each of the causes were subsequently determined. Continuing with the previous example, for shallow foundations (the rest of the typologies would later be analysed) a series of causes responsible for causing damage to the foundations are identified, whether these are due to a project defect, defect in execution or defects in use and maintenance. These causes are responsible for the appearance of a series of damages which, after all, will be what is manifested in the building and, therefore, the indicator of a possible pathology in the building.

In this way, a database has been generated with all the information gathered, which, conveniently exploited, will be the necessary tool for assessing the risk of the work.

3. RISK MANAGEMENT

The first step is the definition of the term Risk and determined how it will be assessed. According to the standard [2-4] IEC/ISO 31010:2009 Risk management. Risk assessment techniques, aimed at identifying events or situations that may arise and affect the objective of the system, it identifies risk using evidence-based methods, with a systemic approach followed by a group of experts. It also analyses risk by providing an input for risk assessment and for making decisions on the necessity to deal with risks, as well as the most appropriate risk treatment strategies and methods. It is based on determining the consequences and probabilities for identified risk events, taking into account the presence (or not) and effectiveness of all existing controls. The consequences and their probabilities are then combined to determine a level of risk.
Risk is thus defined as the product resulting from the likelihood of damage occurring and the consequences of such damage. In turn, the probability of damage will depend on the constructive characteristics of the building, that is, on the intrinsic characteristics of the solution used that make it vulnerable to damage, as well as on environmental factors that expose the building to damage. Hence, the risk can be expressed as follows:

\[ \text{Risk} = \text{Probability} \times \text{Consequences} = (\text{Frequency} \times \text{Exposure}) \times \text{Consequences} \] (1)

Understanding frequency as the probability of appearance of the damage, exposure as the environmental factors that can generate damage to the system and consequences as the gravity of the consequences derived from the damage.

As a first step before assessing the risk, it is necessary to identify the potential damages that may appear in a building. For this purpose, a database has been created. In this database, existing constructive typologies in the market have been broken down and, for each of them, the most common causes that generate damage have been identified. Furthermore, it has been indicated which regulatory non-compliance is implicit in each damage, which makes it possible to evaluate the consequences of each of the damages.

Two main methods have been used to assess the probability of damage.

On the one hand, there is a document from the Musaat Foundation [5], which provides information on records which legal claim has been filed between 2008 and 2013, with a final judgement handed down before January 2014. The report is based on the classification of pathologies according to zone (location of the damage) and the constructive element in which the pathology originates, providing data about its cause and specific damage. The data will be used in accordance with the coding of claims described above.

On the other hand, it has been considered the consultation of a group of experts, as in [6,7]. In order to collect the most objective evaluations, a series of surveys have been drawn up and sent to a panel of 20 experts with extensive experience in the sector (between 15 and 35 years) and with different profiles (engineers and architects). This survey has been carried out in Excel format, which provides a series of tables, divided into blocks, to be filled in by the respondent. Within each of the blocks, a value of 1 to 9 must be given depending on the probability or consequences of the risk (depending on the factor being analysed -frequency, exposure or consequences), 1 being the minimum value and 9 the maximum. The content of the tables is also based on the above mentioned claims coding.

Finally, through the application of regulations (Technical Building Code) or the use of historical data sources (State Meteorological Agency) certain exposure parameters have been objectively evaluated.

However, these results have to be analysed and properly treated for a correct risk assessment. The followed procedure will be summarized in the next paragraphs.

For the results obtained from the historical data of the Musaat Foundation report, a weighting from 1 to 9 has been carried out, giving the minimum weight (value 1) to the item with the lowest percentage of pathologies, and the maximum weight (value 9) to the highest percentage (see Figure 2).
Furthermore, certain exposure parameters, of which historical data are known, but from different sources to the report of the Musaat Foundation, such as the State Meteorological Agency or the Technical Building Code (TBC), have been evaluated objectively and weighted in the same way described above.

When no statistical data was available, a survey to the Expert Panel was done and, after excluding singular values, a final average value was determined (see Figure 3).

Therefore, the risk assessment would be the result of combining the frequency, exposure and consequences of each work, obtaining the levels of the Figure 4.

Four levels of probability of damage are obtained from the product of exposure frequency: low, medium, high and very high. The risk of technical damage is obtained by the combination of damage probability and consequences. The risk also have four scales: low, medium, high and very high (see Figure 5).

Once the level of each type of construction is known, all the agents involved will be able to focus their activity to reduce the accident rate, and thereby improve the efficiency, productivity and sustainability of the construction process, increasing the quality of the sector and the life cycle of the building, with the consequent positive repercussion on the product that the end users will receive.
4. CONCLUSIONS

This project has developed a methodology to promote sustainable development by reducing the risk of damage in residential buildings and the number of demolition and rehabilitation works by limiting common pathologies. The methodology allows identifying and overcoming technical damages in the building process so that buildings life cycle is extended and it promotes to define adequate guarantees aimed at protecting end-users, according to the law. A continuous update of the accidents rate will enrich the tool and ensure its adequate implementation within the construction sector. This fact would also help to be used by different actors in the whole life cycle of the construction process.

5. ACKNOWLEDGEMENT

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6. BIBLIOGRAPHY


