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Editorial

Assessment, Diagnosis and Service Life Prediction

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Service life prediction is crucial for the adoption of more sustainable solutions, allowing optimizing the costs and environmental impact of buildings during their life cycle. Accurate assessment of the service life of buildings requires a thorough understanding of degradation mechanisms and materials' behaviour. Building pathology assessment methods allow characterizing the deterioration state of the buildings and their components, using as indicators specific measurable properties. Based on this information, different service life prediction methodologies can be defined in order to provide reliable data concerning the most probable failure time of buildings and components according to their characteristics and their age.

This Special Issue intends to provide new perspectives on the existing knowledge related to various aspects of *Assessment, Diagnosis and Service Life Prediction* of buildings and components. The ten original research studies published in this Special Issue come from research centres and university departments of Civil and Construction Engineering, Safety Management, Building and Real Estate, Environmental Engineering, Sustainability and Innovation in Structural Engineering, Geotechnical Engineering, Architecture and Built Environment, with the relevant contribution of international experts from Australia, Brazil, Czech Republic, Hong Kong, Iran, Israel, Norway, Portugal and Taiwan.

All constructions endure a gradual degradation process, from the moment they are built and put into use [1], due to the action of several degradation agents, such as solar radiation, high temperatures, wind-driven rain, freeze–thaw cycles, the presence of chemical substances, among others [2,3]. Therefore, the assessment of the degradation condition of constructions over time is crucial for an adequate diagnosis, service life prediction and management of the maintenance activities over the years. Different approaches can be adopted to model the degradation mechanisms over the constructions' lifetime, namely, (i) fieldwork surveys and (ii) laboratory testing.

Fieldwork surveys, based on periodic inspections, allow obtaining relevant information about the defects that may occur throughout the constructions' service life [4]. In this approach, the degradation condition of constructions when subjected to real exposure conditions is evaluated adopting an ex post facto approach, i.e., making an anamnesis of the construction by studying possible relationships between the anomalies observed and probable causes. Adopting this approach, Coelho et al. [5] proposes a service life prediction method, applied to wood flooring systems, based on the collection of the degradation condition of 96 indoor wood floorings' in-use conditions, located in Portugal. This study evaluates the impact of various characteristics that influence the floors' durability, showing the high importance of the type of protection, the type of wood, and the type of floor on the estimated service life of wood floorings. Mousavi et al. [6] adopt a similar approach, proposing a degradation model based on an extensive fieldwork survey to 162 stone claddings directly adhered to the substrate, located in Tehran. The authors [6] obtained an estimated service life of 65 years, concluding that the exposure to environmental agents, such as wind, rain, and pollutants, is the main cause of degradation of the natural stone claddings in Tehran. Additionally, using visual inspections and archival research, Kroftova [7] identify

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the most common defects and failures of masonry structures in urban residential buildings from the second half of the 19th century and the start of the 20th century. This study [7] highlights that a detailed and accurate analysis of the causes and consequences of defects is a crucial precondition for the reliability and long-term durability of rehabilitation of buildings.

Usually, visual inspections are the most common technique to assess the degradation condition of constructions, and, in most cases, the information collected in this way is appropriate to support the decision to intervene [8]. Nevertheless, new techniques have emerged that allow improving and automatizing the collection of reliable on-site data, reducing the uncertainty of the diagnosis. Dias et al. [8] provide an overview of the emerging technologies for inspection (e.g., 3D laser scanning, infrared thermography, photogrammetry, digital image processing, and drones) and perform a critical analysis of the most adequate technique to detect a specific anomaly in buildings' façades.

Real life conditions and the synergy between different degradation agents are difficult to model in a laboratory [9]. Even so, laboratory tests allow obtaining results more quickly and properly modeling the effects of a specific degradation agent. Asphaug et al. [3] investigate the risk of moisture accumulation in a multi-layered concrete façade system exposed to accelerated ageing in a climate simulator according to NT Build 495 [10]. This study [3] reveals that the amount of moisture accumulation depends strongly on the type of concrete and whether a water-repellent surface treatment is applied, providing relevant knowledge about the degradation condition and thermal performance of the façade systems under analysis.

The reference service life of a construction is often based on historical data, previous experience or the performance of the materials analyzed under similar conditions. Ingebretsen et al. [11] perform a scoping study on the current body of knowledge on the microclimate of air cavities in ventilated roofing and claddings in Nordic climates. This study [11] reveals that the existing knowledge about climatic conditions in air cavities in ventilated building roof and façade systems is limited. The design of future structures only based on experience is not adequate, not allowing anticipating the impacts of future climate changes on the risk of rot and mold growth in air cavities.

Degradation models and service life prediction are also crucial for evaluating the performance of new materials and building systems. John et al. [12] present an experimental study for the creation of a novel modular flooring system that can be flat-packed and built into modular housing components on-site, answering to an increasing demand for lightweight modular construction. The assessment of the new system condition after failure mode tests reveals an adequate structural performance and ease in fabrication as opposed to the conventional formworks and commercial temporary flooring systems.

The assessment, inspection and diagnosis of the construction and building materials are crucial to maintain them in adequate performance conditions over time. The adoption of adequate maintenance is the most cost-effective way to minimize the constructions' deterioration while extending their service life. Nevertheless, even with a rational maintenance plan, there is always a risk that the constructions deteriorate at a faster pace, compared to what was planned, requiring the anticipation of the necessary maintenance actions, so as not to compromise the durability of these elements. To overcome the existing gap, Dias et al. [13] propose property maintenance insurance policies developed based on condition-based maintenance plans, to face the risk of needing anticipated maintenance in buildings' façades. This insurance policy allows changing the nature of the risk and its allocation, transferring the risk to the insurer, and increasing the asset's equity value, reducing the risk associated with the degradation of buildings and components. Santos et al. [4] analyses the risks of not considering distinct structural deterioration processes over time depending on their age, location, structural type, and other aspects, on the definition of bridge management systems. This study [4] affirms that a superior level of safety and serviceability must be reached to ensure the operating status of a bridge network, which is crucial for countries' social and economic development. In this sense, the authors [4] propose degradation models to predict bridge deterioration and improve the inspection periodicity, improving the reliability of the decision process of the bridge management system (BMS) in Brazil. The study by Wang et al. [14] emphasizes the synergy between the maintenance conditions and the safety of educational institutions and public facilities. This study [14] proposes a robust framework for a risk-informed integrated safety–maintenance management framework for educational and public facilities, revealing that maintenance activities significantly affect the safety of electric system components, infrastructures, fire protection systems and structural components. The results of this study [14] suggest that annual safety audits of the systems seem to be insufficient, and higher frequencies of maintenance as well as safety audits with intervals of between 3 and 6 months are suggested.

Now more than ever, the construction industry must adopt more durable solutions and rational decisions at the design and maintenance stages. The different papers published in this Special Issue address the strategic and economic relevance of assessment, diagnosis, and service life prediction of constructions, ranging from facades or components of residential buildings to critical buildings such as schools or bridges. The knowledge about the degradation processes and service life prediction is crucial, considering a detailed analysis of the causes and consequences of defects. An important message from this Special Issue is that the future studies must propose maintenance management frameworks based on the knowledge of the degradation pattern of constructions, adopting proper maintenance actions, in adequate timeframes, considering the specific conditions of the construction under analysis, to ensure the functionality, durability and safety of the construction, while minimizing the financial investment. Moreover, most of the existing studies adopt standard values for the buildings' service life (e.g., 50 years) when performing life cycle cost (LCC) and life cycle assessment (LCA) analyses. In reality, the service life of a building varies according to the materials applied, the construction methods and design, the exposure to environmental conditions, and in-use and maintenance conditions. The adoption of standard assumptions about the service life of buildings and components may lead to incorrect results, leading to rough estimations of their real environmental impact. In this sense, service life prediction and the knowledge about the durability of buildings and their components has a crucial role in accurately assessing their sustainability or environmental impacts over the years.

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