Probabilistic Approach to the Service Life Prediction of Timber Claddings

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1 Introduction

This study evaluates the probability distribution of the degradation condition of timber claddings, using the evaluation of the characteristics of 150 cladding systems inspected in Valdivia, Chile. For that purpose, a logistic regression analysis is used, which allows forecasting the probability of the timber claddings to reach the end of their service life over time and according to their environmental exposure conditions. The results obtained allow quantifying the impact of age and other claddings' characteristics and degradation agents in the overall degradation condition of the timber claddings. This analysis is relevant in developing countries where there are few studies related to the service life prediction of building components (façades). The scarcity of funds to maintain and preserve the built park and infrastructures needs a more rational approach to decision-making.

2 Degradation Phenomena of Timber Claddings

In 2011, Gaspar and de Brito (2011) proposed a numerical index (severity of degradation - S_w) to express the overall degradation condition of facades claddings. The severity of degradation (S_w) index is obtained by the ratio between the weighted degraded area and the total cladding area, assuming the highest possible level of degradation (Silva *et al.,* 2016). This methodology was originally developed for rendered facades, establishing a general framework model, and was adapted to new cladding materials, as natural stone claddings, ceramic cladding systems, painted surfaces, ETICS and, architectural concrete surfaces.

3 Probabilistic Analysis of Timber Claddings Reaching the End of their Service Life Over Time

In this study, a logistic regression analysis is used to model the probability of timber claddings reaching the end of their service life over time and according to their environmental exposure conditions. Logistic regression is one of the most used statistical procedures, which allows describing the relationship between a categorical dependent variable and one or more explanatory variables, in terms of the probability of a given event. In this study, the dependent variable corresponds to the question "Has the timber cladding reached the end of its service life?", and this question presents two mutually exclusive classes: "yes" and "no". For the timber claddings under analysis, it is assumed that a cladding reaches the end of its service

life, when presents a set of anomalies corresponding to a severity of degradation of 20%.

Figure 1 shows an illustrative example of a timber cladding in the end of its service life. The limit to establish the end of service life is conventionally defined and is related to the Chilean context, and with the users' acceptance criteria.

Figure 1. Case study that exemplifies the end of the service life of timber claddings.

4 Results and Conclusions

Bio-materials, as timber, when applied in façade claddings, are exposed to several degradation agents, which generally are biotic agents (fungi, insects, moulds, algae and bacteria) and abiotic agents (water, solar radiation, amplitude and gradient of temperature, pollutants, physical damage, among others) (Prieto and Silva, 2019). These degradation agents strongly compromise the durability of timber claddings. Moreover, the degradation mechanisms usually occur simultaneously, affecting the degradation pattern over time and the extent damages among the different timber claddings analysed. The analysis of timber claddings' degradation over time is a difficult procedure, which must encompass several variables, e.g. the environment where the construction is placed (atmospheric and natural conditions), building's materials, use and maintenance conditions, among other factors. In this sense, stochastic methodologies are more accurate to deal with the uncertainty and variability of degradation phenomena, leading to more reliable results related with the service life of timber claddings. This model allows predicting the end of service life of timber claddings, i.e. the instant after which is necessary to intervene, in order to improve the claddings' condition, ensuring that the cladding is able to fulfil the users' demands and expectations, in a probabilistic way. The results obtained can be useful for a further knowledge of the durability and service life of timber claddings and can be employed to aid the adoption of rational and adequate maintenance policies. In fact, the analysis of the timber claddings' degradation and service life in South Chile, allows establishing new and adapted strategies and maintenance plans, to reduce the repair costs and to optimise the use of scarce funds and resources.

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