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Pathologies of a Glass Building Envelope that Affect Durability and Comfort

Susana Santamaria-Fernandez[1], Arritokieta Eizaguirre-Iribar[2] and Xabier Olano-Azkune[3]

[1] Structural Safety Lab, Industry Area, Lab Services Division, Fundacion Tecnalia Research & Innovation, Area Anardi 5, 20730-Azpeitia, Spain, susana.santamaria@tecnalia.com

[2] Fire Safety Lab, Industry Area, Lab Services Division, Fundacion Tecnalia Research & Innovation, Area Anardi 5, 20730-Azpeitia, Spain, arritokieta.eizaguirre@tecnalia.com

[3] Fire Safety Lab, Industry Area, Lab Services Division, Fundacion Tecnalia Research & Innovation, Area Anardi 5, 20730-Azpeitia, Spain, xabier.olano@tecnalia.com

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1 Introduction

The durability of materials used in buildings has been widely studied and, in many cases, there are standards to assess it. However, studies on how pathologies affect the durability and comfort of the building users are not so common. The aim of this article is to explain different pathologies of the building envelope, considering glass as its main element and to analyze the causes of those pathologies, agents involved, and how they have affected durability.

The pathologies of a glazed envelope may be of different natures (Hubbs *et al.*, 2015). Glass breakage is one of the most known failure, but there are other pathologies (such as sealing failure, yellowness or delamination) that have a direct impact on the durability of the building, since they affect the functionality of the building and/or the comfort of the users. It should be borne in mind that the pathologies in this building element usually have the added complexity that the materials and elements that form the envelope solution are many and of a very different nature and function.

The pathologies of a glass building envelope can occur due to the following causes: chemical incompatibility, manufacturing failure/error or because of a product is not suitable for its intended use. Moreover, a pathology can occur in any of the following stages of the building work: design, manufacturing, assembling, on-site execution and while it is in service. In this article, we will only focus on the failure mechanisms during the service period. All these pathologies have a direct impact on the durability of the building envelope. On the one hand, directly on the durability of the materials and on the other hand, indirectly on the durability of the building since the performance are affected.

Different cases of pathologies were analysed and their effects were also assessed. In each case, the technical data sheets available of the materials involved and the information on the design and the expected performance of the constructive solution were compiled. In some cases, the pathologies had caused an irreversible damage, so, the solution had to be drastic; while in other cases, they were detected early enough to propose remedial actions without affecting the final durability of the building.

2 Cases

In this first case study, degradation in the form of a slump of one or both sealing barriers of a double insulating glass unit is noted. Degradation is detected in discrete areas of some of the insulating glass units. When analyzing the units with pathology and their situation in the building, no pattern was

detected and no water leakage was detected in the building envelope. Therefore, the influence of the environmental conditions such as temperature, humidity and radiation was dismissed early in the on-site inspection process. When degradation of a sealant is observed, it is necessary to analyze which agents may be producing that degradation. All the polymeric products contained in the curtain wall were identified and gathered. Sets of specimens were subjected to a chemical compatibility and it was verified that the inner sealing barrier and the weathertightness gasket were highly incompatible.

In this second case, a difference was noted in the perceived luminous radiation coming to the inside in two floors of a building. Two glazing units were removed, and their luminous and solar characteristics were measured in the laboratory. The insulated glazing unit (IGU) was composed by a laminated glazing and a thermally toughened coated glass. After finishing the lab measurements, we noticed that laminated glass panes for both IGUs were the same but coated glass panes were not identical. With those results and the manufacturer collaboration, we reached the conclusion that there was a manufacturing error, meaning that a coating not designed for the thermal toughening process, had been tempered by mistake.

An on-site inspection of the building of the third case showed colour change in two glass products. One of the solutions was a glass-marble-glass composition and the second solution was composed of an exterior glass pane adhered to a pane of marble, which was in turn glued to an aluminium honeycomb panel. The durability of the solutions was evaluated by exposing two samples to ultraviolet radiation. After 2,000 hours of exposure, a considerable change in colour was observed of both panels.

3 Conclusions

To sum up, the pathologies of the glazed envelope may be different in nature and due to different causes, but they can be summed up in three main groups: chemical incompatibility, manufacturing failure/error or because of a product is not suitable for its intended use (Weller *et al.*, 2011).

After having analyzed the different cases, the design phase has been identified as the main stage of the building work in which the pathology could be avoided, followed by the product manufacturing phase. Accordingly, architects/project management or product manufacturers are the main agents causing the future pathology or those responsible for it. It should be added that a wrong assembly does not usually generate a pathology but contributes to its manifestation.

As a result, two main remedial actions that can be implemented during the design, construction or maintenance processes are proposed to avoid the generation of pathologies that affect the durability of the building and their user's comfort. On the one hand, testing the selected products taking into account their intended use is the way to avoid failures before the construction of the building envelop. Most of the pathologies of the glass building envelope can be avoided if the durability of the chosen solution is verified during the design phase, considering the type of use and exposure to which the element will be placed. These previous checks are of particular interest in innovative or unique products or solutions, such as laminated glass products with organic interlayers. On the other hand, factory production controls became essential to avoid failures/errors that can occur in the product manufacturing stage.

ORCID

Susana Santamaria-Fernandez: https://orcid.org/0000-0002-0835-4757
Arritokieta Eizaguirre-Iribar: https://orcid.org/0000-0002-5651-9181
Xabier Olano: https://orcid.org/0000-0002-5647-1923

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