



## Analysis of the present condition and deterioration in the main dome over La Laguna cathedral

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### Summary

The assessment of an existing structure to determine its suitability for present and future use entails different sorts of problems than encountered when designing new structures. The differences revolve essentially around the nature of the information available. In existing structures, deteriorated or otherwise, the accuracy of the models used for such assessments can usually be improved by acquiring more data. The Spanish Technical Building Code defines a procedure for the evaluation of existing structures that includes the same verification format as normally applied for designing new structures, but in which the representative values for the variables and the partial factors may be modified on the basis of updated information. Tools intended for such modifications, developed for the safety assessment of existing sound and deteriorated concrete structures, are applied to the structural assessment of the main dome over La Laguna cathedral, Tenerife, Spain.

**Keywords:** Existing structures; uncertainties; updating; structural reliability; probabilistic methods; partial factors; reinforced concrete; corrosion.

### 1. Introduction

#### 1.1 Context

As a result of extensive damage induced by differential settlements, the former building of La Laguna cathedral was demolished and rebuilt between 1905 and 1913 (Figure 1), using a then novel technology, partially reinforced concrete (RC), which hastened construction and consequently lowered costs. Those advantages came at a price, however: namely, the risks associated with deploying a scantily proven technology. The properties of the materials used (i.e., highly porous concrete with concomitantly low electrical resistivity), which were poorly understood at the time, La Laguna's particularly humid climate, and what would today be regarded as faulty workmanship (e.g. sulfate- and chloride-containing aggregate), lie at the source of the many types of deterioration observed. The outcome was the ultimate need to brace the roof and close the cathedral to the public because it was felt that it could not be safely visited. A thorough experimental and theoretical analysis conducted with modern structural assessment techniques showed that the domes on the low roof (Figure 1a) were structurally safe at the time of the study. Nonetheless, the severe damage to both, the concrete and the reinforcement, the infeasibility of measures able to fully detain ongoing deterioration mechanisms and the technical difficulties entailed in repairing the cathedral as a whole informed the recommendation to demolish and rebuild the whole roof, including the main dome, while maintaining the rest of the structure intact.

In 1999 the historic centre of San Cristóbal de La Laguna, Tenerife, Spain, was declared a UNESCO World Heritage Site. The cathedral is possibly the most prominent of the 400 buildings in this complex and, therefore, is strictly protected. For this reason, the historic monuments protection authority was keen on conserving the main dome, in addition to the façade and other elements such as walls and columns. To that end, the Eduardo Torroja Institute for Construction Science (IETcc) was commissioned to investigate the ongoing deterioration and assess the present and future structural reliability of the dome. Further to the authorities requirements, the criterion applied was a 50-year service life, the period normally adopted for common structures, rather than the minimum 100 years that would seem more appropriate for a monumental building [1]. The reasoning was that new knowledge or techniques might become available in that period of time that would be able to curb ongoing deterioration entirely.