Chapter 42
Agrigento Cathedral: Experimental Campaign and Study of Damage Evolution Addressed to the Assessment of the Collapse Risk

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ABSTRACT

At present Agrigento Cathedral is affected by extensive damage that seems to be mainly due to partial slumping of the foundation soil. The chapter deals with the state of damage that affects the cathedral and the investigation carried out for the mechanical characterization of the construction, the formulation of an FE model and the assessment of the safety level with respect to the service loads and with respect to exceptional loads like seismic ones. In the chapter the details of the above investigation are discussed, consideration also being given to the monitoring carried out in order to understand whether the phenomenon affecting the cathedral is ongoing. The results of the monitoring and the experimental campaign on the structural members are described, revealing an unexpectedly low capacity with respect to service loads. Then a comparison is carried out between the response of the FE model and the experimental observations for the identification of the causes of distress. Finally possible action is discussed.

INTRODUCTION

The rehabilitation of historic buildings involves important activities, from monitoring the state of damage to the formulation of actions in order to improve its capacity and prevent collapse.

Regarding the actions, throughout history, many techniques have been used but today, more than ever, the least invasive ones are preferred. The main objectives are, on the one hand, to safeguard users from danger caused by structural instability and, on the other hand, to ensure that

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the actions give durability and the possibility of using the construction.

In this context, Agrigento Cathedral is an intriguing building because it has long been affected by a rapid increase in its state of damage, characterized by extended macro-cracks along the north aisle that seem to split the structure into two parts, although several actions have been carried out in the last ten centuries.

The construction stands on a hill and the foundation rests on soil having apparently different mechanical characteristics: backfill in the northwest part and calcarenite rock in the remaining part.

The original structure dates back to the tenth century (it still exists and coincides with the current transept) but the present-day construction is the result of different modifications made since the eleventh century. The religious building that has come down to us has a Latin cross plan, along the east-west direction, divided into a nave and two side aisles ending with three apses, for an extension of about 100 meters by 40 meters and about 23 meters in height.

Many times this monument has undergone partial failure and many reconstructions and strengthening actions followed. The failures particularly affected the north side of the structure but the south part too has been affected by a critical damage state, so that it has been closed and reopened to public use several times.

Today the Cathedral is closed and an experimental campaign for its mechanical characterization is in progress to assess the structural capacity and the possibility to give the monument back to the faithful.

This chapter describes the history of the monument in order to understand what type of events have affected the structure during its life, but it also shows the monitoring activity, the damage evolution during a period of two years (2012-2014), the strategy of investigation and the FE modeling. Finally, some action strategies are discussed.

As regards monitoring, electronic and standard crack-meters were installed in order to measure the increase of the amplitudes of the cracks and the increasing speed. Clinometers were also installed to measure the tendency of the walls to lose verticality.

A deep survey of the mechanical characteristics of the materials was performed. A number of site and laboratory tests were carried out, namely:

- Exploratory excavations to investigate the substructure;
- Thermographic analysis of walls for the detection of anomalies, structural discontinuities and hidden connections;
- Removal of plaster for recognition of wall texture and connections between walls;
- Inspection with Ground Penetration Radar (GPR);
- Physical-chemical analysis of mortars;
- Compression tests on calcarenite cores extracted on the site;
- Video inspection of holes in the walls;
- Single flat jack tests for the recognition of the level of the vertical stress state;
- Double flat jack tests for the recognition of the masonry compressive strength;
- Ordinary and diagonal compressive tests on wall samples in a laboratory;
- Measurement of the structural dynamic response.

The data obtained were correlated, allowing the formulation of an FE model that revealed an unexpected risk of collapse due to different causes from those initially considered.

BACKGROUND

The seismic vulnerability of masonry buildings and the evaluation of the risk level connected to seismic events are of great interest all over the