Wood Structure Biodeterioration - A Case Study on a Century Church in Piracaia, Brazil

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Abstract This article describes the results of an evaluation done on the structural timber roof and ceiling of the 19th century Church Matriz Santo Antonio da Cachoeira, located in Piracaia, São Paulo, Brazil, in order to verify its conservation status including: the definition of the geometric and basic structural characteristics, structural anomalies and the biodeterioration of wooden pieces. The analysis carried out, taking into account the inspection data, was based on the following standards: NBR 7190:1997, NBR 6120:1980, NBR 6123:1988 of the Brazilian Association of Technical Standards – ABNT and CEN EN 1995-1-1:2004 ". The survey permitted the authors to conclude that the roof and lining structures are unsafe. Information as to how the conservation and restoration processes should be carried out, in order to assure the building's structural safety, are included.

Keywords structure, anomalies, inspection, biodeterioration, wood, structural analysis, dry wood termites, historic site

1. INTRODUCTION

The Church Matriz Santo Antonio da Cachoeira, located in the city of Piracaia, São Paulo, Brazil, was built by the end of the 19th century and has a central nave, altar, two adjacent side chapels, a tower and a mezzanine. The columns, arches and masonry walls are made of brick clay, coated with mortar. The structure of the roof consists of twelve wooden trusses supported by masonry walls. The arc-shaped wood lining of the central nave of the Church is also supported by the walls of masonry and is connected to the trusses. Plywood painted with the portraits of all the Popes is linked to the structure of the roof (Figure 1).

This article is derived from an evaluation process done in order to analyze the conservation status of the structural timber roof and ceiling of the Church. It describes the results of that process, including the definition of the geometric and basic structural characteristics and anomalies encountered, the biodeterioration of the wooden pieces and the analysis carried out to evaluate structural safety conditions of the roof and ceiling.

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2. INSPECTION AND STRUCTURAL ANALYSES

At first, a diagnosis of the building was done in order to evaluate the condition status of the wooden structures. The diagnosis was done by a multidisciplinary team composed of civil engineers, biologists and architects who performed a detailed examination of the building and its surroundings with the purpose of identifying the main problems, recognize the biodeterioration types present and identify the organisms responsible for them.
Next, data were gathered on the geometry and constructive details of the wooden structures together with a careful observation of mechanical defects and biological deterioration problems. As part of the diagnosis the wooden species used on the structures were identified and this information used to obtain data on their physical and mechanical properties to be used on calculations and structural analysis procedures in order to verify their compliance or not to safety requirements.

3. CONCLUSIONS

It was observed a generalized attack of dry wood termites on the wood structure of the roof, which contributed to significantly reduce the resistance and stiffness of the pieces. It was also noted attack of the same nature on the wood of the ceiling and on the ornamentation pieces found on the interior of the Church.
Numerical simulations indicated that the structural conception of the frames is inadequate, since the responses (bending, horizontal displacements on the supports, horizontal reactions on the walls) are very sensitive to the support conditions, reaching forces and moments in members much higher than those permitted by the standards, mainly in case of little friction. This situation is endangered by the attack of termites.
Considering the above aspects, it can be concluded that the conditions of structural security of the frames are not adequate, with a risk of generalized failure.
The survey permitted the authors to conclude that the roof and lining structures are in an unsafe condition.
Thus, in this type of structure, curved central ceiling, the supports and the wall must have coefficient of friction, for instance with mechanical devices, in order to generate horizontal reactions. In this case the wooden frames will increase the load capacity, because they will behave like arches.

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