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NUMERICAL MODEL TO EVALUATE THE FIRE RESISTANCE IN WOODEN SLABS WITH CAVITIES

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ABSTRACT

The main objective of this paper is to develop a numerical model for thermal analysis of wooden slabs with cavities, when subjected to the fire action. The temperature profiles, the charring depth layer and the charring rate will be determined using the finite element method with ANSYS program. The numerical calculation of the temperature profiles will be obtained through a transient and a non-linear thermal analysis, where the material properties are temperature dependent. These properties were established in accordance with the referenced data and numerically calibrated. Two different models of wooden slabs with cavities were studied. One model characterizes a wood slab with void cavities and other with insulation material. To characterize the fire resistance in wooden slabs with insulated cavities or void cavities, different typical curves of charring depth layer will be obtained. A numerical procedure is proposed to identify the heating action into the slab cavities. All numerical results permit the verification of the fire safety in wooden slabs with cavities.

Keywords: wooden slab, fire, insulated cavities, void cavities.

INTRODUCTION

Wood is a friendly material, attracted by engineers and architects, due the attractive attributes such as architectural features, structural characteristics and also a renewable material. This material when exposed to accidental actions, such as fire action, presents a decomposition process, pyrolysis, and produces a surrounding charring depth layer. On the fire exposure side a charcoal layer, without effective resistance, causes the reduction of the element cross-section. However, this charring depth layer can delay the heating process, from the exposed side, to the wood core section and acting as a good insulating material. Several researchers have presented experimental models and analytical methods to calculate the physical degradation of wood due high temperatures (White, 1999), (Poon, 2003), (Janssens, 2004), (Frangi, 2008). The main objectives of this work are:

- Present a numerical model to obtain the same results from Frangi when uses experimental wooden slabs;
- Evaluate the thermal performance of wooden slabs with insulated cavities or void cavities, when subjected of a fire situation;
- Determine different stages of the charring rate through all wooden slabs;
- Present a numerical model who intends to be a replica of prefabricated wooden slabs common in Nordic countries, and used in residential and commercial buildings;

- Use two different insulated materials (glass fiber and rock wool) in order to evaluate the thermal effect into the wooden slab cavities.

RESULTS AND CONCLUSIONS

This study considers a replica of a prefabricated wooden slab with cavities exposed to fire, with two constructive solutions, figure 1. In the first solution, the slab cavities have an insulation material, and for the second solution the internal slab cavities have no insulation. These models were based on the constructive solution proposed by Frangi. The numerical model proved to be a great importance in the determination of the charring depth layer in wooden slabs with insulated cavities and void cavities. The temperature profiles obtained in transient analysis, as well as the charring rate in different phases in wooden slabs with cavities exposed to fire were calculated using the finite element method with ANSYS program. Two different insulation materials used into the wooden cavities were compared and the mineral wool exerts higher protection in relation to the fiber glass, figure 2a. The results obtained through the proposed numerical model have a good correlation between the values of Frangi and Eurocode 5. As regards with the study of the wooden slab with void cavities, it is possible to conclude that at the end of one hour of fire exposure, the structural resistance vanishes completely, as represented in figure 2b.

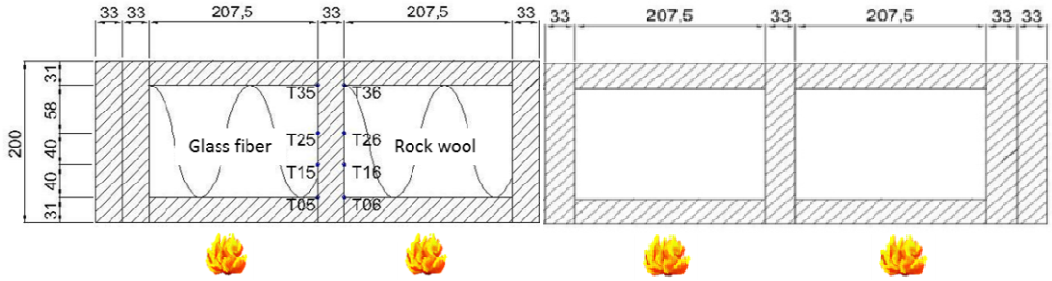

Fig. 1 - Prefabricated wooden slab with insulated and void cavities dimensions in mm.

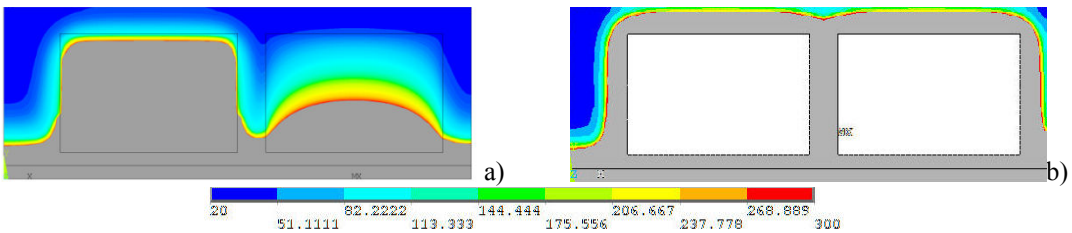

Fig. 2 - Temperatures in wooden slab with insulated and void cavities at the end of 3600s.

REFERENCES

[1]-White RH, Dietenberger MA. Fire Safety, Chapter 17, Wood Handbook: Wood as an Engineering Material, Forest Products Laboratory, USDA Forest Service, 1999.

[2]-Poon L, England JP. Literature Review on the Contribution of Fire Resistant Timber Construction to Heat Release Rate - Timber Development Association, Warrington Fire Research Aust. Pty. Ltd., Project No.20633, version 2b, pp.1-78, 2003.

[3]-Janssens ML. Modeling of the thermal degradation of structural wood members exposed to fire. Fire and Materials, 28, pp.199-207, 2004.

[4]-Frangi A, Knobloch M, Fontana M. Elsevier - Fire design of timber slabs made of hollow core elements. Elsevier - Engeneering Structures, USA, 2008.