NUMERICAL MODEL TO EVALUATE THE PROTECTED AND UNPROTECTED WOODEN SLABS UNDER FIRE

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1-KEYWORDS

Fire behaviour, char layer, charring rate, temperature, wood

2-INTRODUCTION

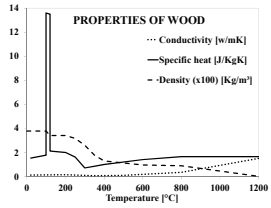
- Wood has been broadly used as construction material due to their availability in nature, variety, lightness, good physical characteristics, excellent architectural, thermal and acoustics characteristics and allowing easy assembly of sets.
- Under adverse work conditions, the material properties might degrade, compromising its performance and safety.
- Numeric and experimental studies have been performed, which objective was to predict the material behaviour, under influence of external factors, as fire situations.
- Wood is considered a combustible material, when it burns, flames are released. However, wood on fire, it presents a peculiar behaviour, since its core may remain unchanged. When being consumed by flames, a char layer formed will condition the heat inside wood, therefore protecting its core.
- The wood charring rate is one of the major parameters used to describe wood behaviour towards fire, as it allows determine the time fire resistance that the structures will performed in site and its structural safety.
- To improve wood fire resistance, insulating materials are used in wood structures. In general, these materials have low thermal conductivity, therefore a reduced heat transfer rate is transferred through the wood member.

3-APLICATIONS

4-WORK DISCUSSION

- The main goal of this study is to evaluate the thermal behaviour of wooden cellular slabs exposed to fire conditions, according the standard ISO 843 curve.
- Different numerical simulations for nonlinear thermal and transient analysis will be obtained, using the finite element method.
- The importance of this study relies on its contribution to an alternative numerical methodology, which allows to determine the safety and fire resistance levels in wooden cellular slabs, with or without insulation materials..

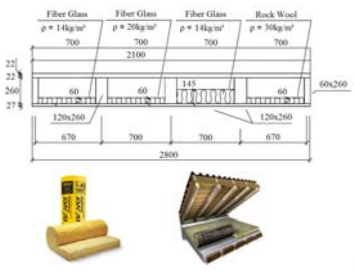
5-THERMAL PROPERTIES



THERMAL PROPERTIES OF INSULATING MATERIALS

	Density [Kg/m³]	Specific Heat [J/kgK]	Conductivity [W/m²K]	Emissivity	Melting temperature [°C]	Difusivity [mm²/s]
Fiber glass	14	1030	0,039	0,750	700	2,0746
Fiber glass	20	1030	0,036	0,750	>1000	1,7475
Rock wool	30	1030	0,04	0,9	>1000	1,2945

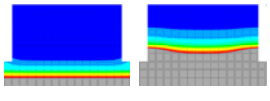
6-DIMENSIONS AND MODELS



MODELS OF STUDY

Models	Abreviação	Considerações
Model 01	n/INS_n/AIR	Without insulation and air
Model 02	FG_14_60_n/a	Fiber Glass = 60 mm, ρ = 14 kg/m³, without air.
Model 03	FG_20_60_n/a	Fiber Glass = 60 mm, ρ = 20 kg/m³, without air.
Model 04	FG_14_145_n/a	Fiber Glass = 145 mm, ρ = 14 kg/m³, without air.
Model 05	RW_30_60_n/a	Rock Wool = 60 mm, ρ = 30 kg/m³, without air.
Model 06	FG_14_60_y/a	Fiber Glass = 60 mm, ρ = 14 kg/m³, with air.
Model 07	FG_20_60_y/a	Fiber Glass = 60 mm, ρ = 20 kg/m³, with air.
Model 08	FG_14_145_y/a	Fiber Glass = 145 mm, ρ = 14 kg/m³, with air.
Model 09	RW_30_60_y/a	Rock Wool = 60 mm, ρ = 30 kg/m³, with air.
Model 10	y/INS_y/AIR	With insulation and air

7-CHAR LAYER AND CHARRING RATE

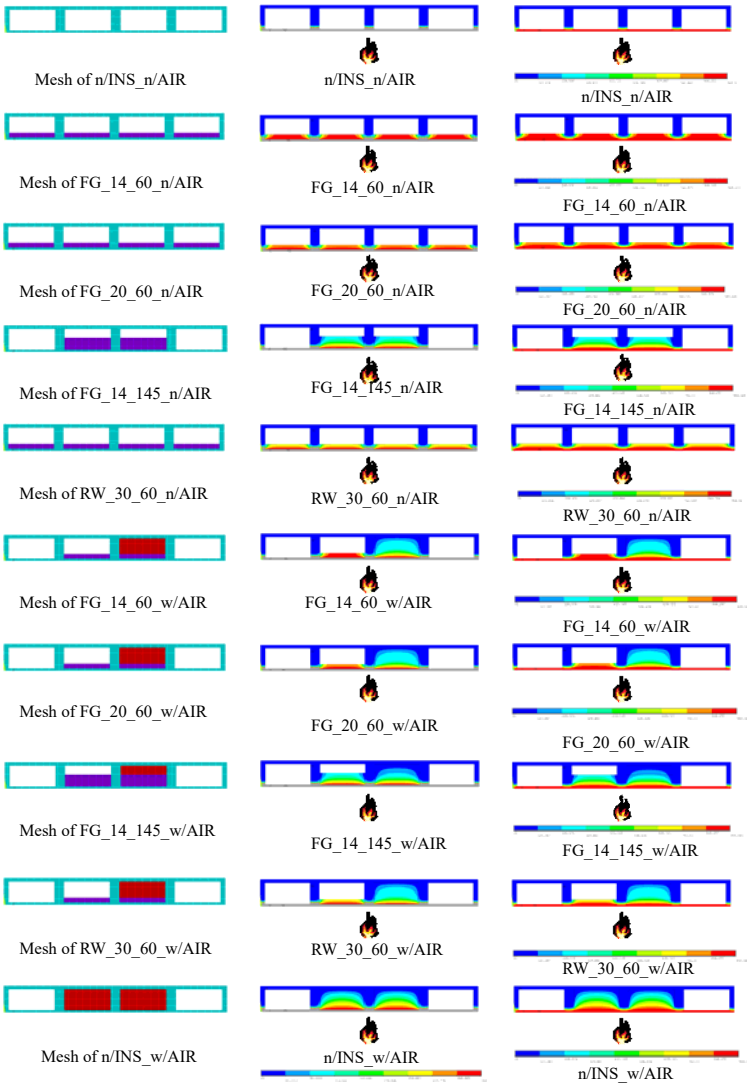


Model S/ISO_S/AR	Average rate between the models	EC5 [14]	Frangi et al [17]	Haddad [10]
0,69	0,642	0,65	0,99	0,74

$\beta_{0,13}$ = 0,646 [mm/min] $\beta_{0,50}$ = 0,679 [mm/min]

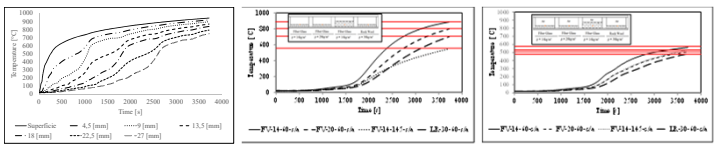
Relation of charring rates to softwood (*spruce*)

8- MESH CHAR LAYER TEMPERATURE PROFILES



- Results permit to determine the temperature evolution and the residual cross-section through the slab element at different time instants for fire situations.
- The final time considered was 3720 [s].
- The red and orange colors show higher temperatures.
- The blue and green colors show lower temperatures.
- Gray color shows the wood char layer.

9-TIME-TEMPERATURE HISTORY



Temperature_n/INS_n/AIR | Non-air insulated models | Models with insulation and air

10-CONCLUSIONS

- Different wooden cellular slabs were developed to identify the best and worst design model.
- Results and comparison between protected and unprotected slabs were obtained.
- The best insulation under fire was glass fiber of density 60 kg/m^3 and 145mm of thickness in wooden slab without air considerations.
- In simulations where mesh air is present, the best thermal insulation was rock wool.
- The simulation with the air effect can greatly change the results.

11-REFERENCES

- EN 1995-1-2:2004. Eurocode 5: Design of timber structures, Part 1-2: General-Structural fire design, CEN, 2004.
- Frangi, A., M. Knobloch, M. Fontana, G. Bochicchio. 2008. “Fire Behaviour of Cross-Laminated Solid Timber Panels”, Zurich. ETH Zuric - Institute of Structural Engineering, Fire Safety Science–proceedings of the ninth international symposium, pp. 1279-1290.

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