

Evaluation of the fire resistance of a sport hall using structural fire engineering



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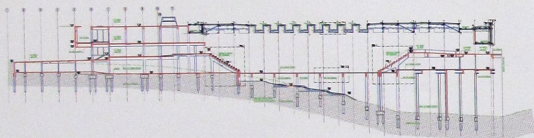
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INTRODUCTION

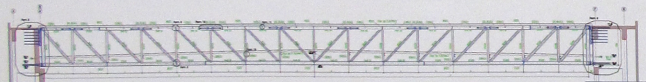
It is the purpose of this paper to present a study on the needs of passive fire protection in the steel roof structure of the Oporto Football Club (FCP) sport hall, to fulfil a fire resistance of 60.

Due to the large dimension of the sport hall a prescriptive approach using the standard fire curve ISO834 revealed to be too severe, quite unrealistic and uneconomical. Indeed the fire load of this type of construction is generally rather small being not possible to reach the high temperatures of the ISO curve. On the other hand a large amount of air is available, which is a second factor for reducing the temperatures in a real fire. The results obtained with the ISO fire curve were compared with the ones obtained using the natural fire, in accordance with the advanced calculation methods included in the recently approved part 1-2 of EC1.

The program Ozone V2.2 was used to simulate the natural fire, and the thermo-mechanic behaviour of the structure was modelled by the finite elements program SAFIR.



MECHANICAL ANALYSIS

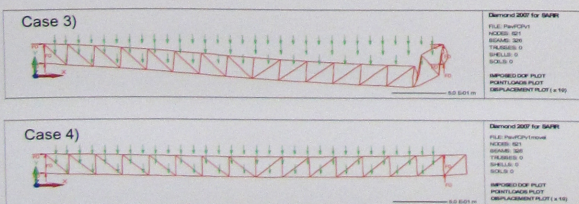


Simplified methods

Profiles	Efforts [kN] Compr. Tension	Critical Temp. (Elefir-EN) [°C]	T _{nat} scenario 2 (Ozone) [°C]	T _{nat} scenario 6 (Ozone) [°C]	Critical time ISO834 [min]	Temp. after 60min of ISO834 [°C]	
HEA280	-110.3	943	435	735	62	938	
HEA260	144.1	899	438	736	47	938	
HEA240	-212.5	774	440	738	29	939	
HEB240	3.74	1195	404	781	320	954	
HEA160	-82	113	808	451	753	27	940
HEA140	-60	89	814	455	765	26	941
HEA120	-40	56	859	457	769	26	941

Advanced calculation methods

- 1) Truss without the possibility of expanding longitudinally subjected to ISO834;
- 2) Truss with the possibility of expanding longitudinally subjected to ISO834;
- 3) Truss without the possibility of expanding longitudinally subjected to scenario 2;
- 4) Truss with the possibility of expanding longitudinally subjected to scenario 2;



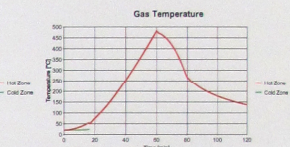
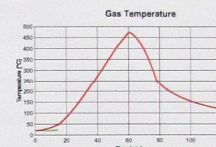
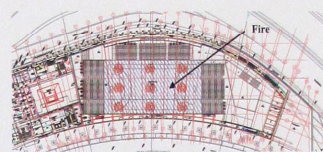
Case study	Collapse time [min]	Reaction [kN]	Displacement [cm]
1) ISO 834	24.8	2100	-
2) ISO 834	26.6	2100	43
ISO 834	57.5	2100	-
3) scenario 2	66.1	2100	-
4) scenario 2	No collapse	-	21

truss protected to hold 60 min of ISO834 fire curve without longitudinal expansion

FIRE SCENARIOS

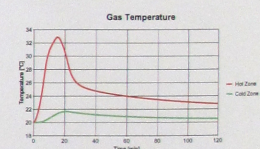
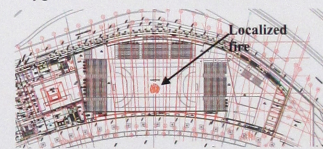
Fires in the entire pitch

- Scenario 0 - standard fire ISO834.
- Scenario 1 - natural fire with a linear openings variation from 10% at 20°C until 50% at temperature of 400°C and after until 100% openings at 500°C and a medium fire grow rate.
- Scenario 2 - natural fire with constant opening area during the fire. Several constant percentage of openings were tested (from 10% until 100%), resulting on the use of the most severe case (60% openings) and a medium fire grow rate.



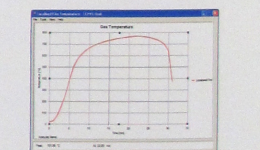
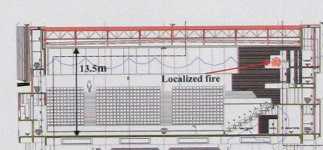
Localized fire in the pitch

- Scenario 3 - The fire area was 9m², corresponding to a diameter of 3.4m, at the pitch level. The opening variation was equal to the one on scenario 1, however due to the large amount of oxygen it was found that the fire is controlled by the fire load not depending on the openings.



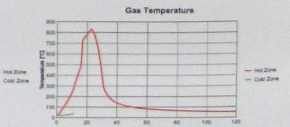
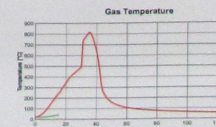
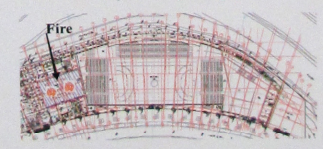
Localized fire in the Media balcony

- Scenario 4 - The fire area was 36m², corresponding to a diameter of 6.8m, at media balcony (10.2m from the pitch level).



Fires in the vip foyer

- Scenario 5 - natural fire with a linear openings variation from 10% at 20°C until 50% at temperature of 400°C and after until 100% openings at 500°C.
- Scenario 6 - natural fire with constant opening area during the fire. Several constant percentage of openings were tested (from 10% until 100%), resulting on the use of the most severe case (100% openings)



CONCLUSIONS

It was shown that the temperatures at the level of the roof are relatively low and no passive protection against fire in the steel structure was needed, as a prescriptive evaluation using the standard ISO834 fire curve would impose.

Adopting the natural fire, was proven that the steel profiles of the truss have a fire resistance higher than the 60 minutes, being even able to not collapse during the entire fire development, if the truss can freely expand in the supports. This can be obtained from the structure configuration or possible yielding of the supports for the horizontal reactions of 2100kN. However this possibility does not require to be used, due to the fact that the structure holds without collapse 66 minutes, enough time for the evacuation of the occupants and for fire brigades intervention.