

Workshop Chania 14-15 October 2011

COST ACTION IFER Integrated Fire Engineering and Response

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Integrated Fire Engineering and Response

Workshop in Chania, 14-15 October 2011

A practical approach to study of fire resistance of a steel structure with open built-up members and columns

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- 1.PRECEDENTS OF THE CASE
- 2.CHARACTERISTICS OF THE BUILDING
- 3.ASSUMPTIONS DONE FOR THE ANALYSIS
- 4.RESOLUTION OF THE MECHANICAL PROBLEM
- 5.RESOLUTION OF THE THERMAL PROBLEM
- 6.CHECK IN ALL MEMBERS OF THE FRAME
- 7.CONCLUSIONS

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Precedents of the case

- The analyzed building is an steel workshop (Industrial Building)
- This building was erected more than 25 years ago
- In that moment, there was no specific rules for fire to apply to this kind of buildings in Spain → Then fire was not taken into account in the design
- In 1996 to renovate the activities permissions, the authorities obligated to the company to be in accordance with the current Spanish standard for this kind of buildings RSCIEI (2005)
- Following RSCIEI it was needed that structure was able to resist 15 min in ISO 834 → R15
- The company contacted to University to study if the current structure could resist R15 or if was needed fire protection.



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Characteristics of the Industrial Building

- Columns → built up and battened members 7m height
- Beam → truss member with built up sections 17.2m luz
- Distance between frames 5m and total length 76.22m
- Total Surface= 1341.5 m²
- Weight = 0.23 kN/m²

Light frame

Bracing Systems



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Assumptions done for the Analysis

- We used the simplified method to proceed in the resistance domain
- We can solve independently the thermal problem and mechanical problem

No interaction between thermal and mechanical actions
 Indirect actions of fire are despit
 Global elastic analysis is done with constant E ctt at 20° to calculate efforts

Solve Thermal Problem → **Resistance & buckling check** → **R15 ?**
Solve Mechanical Problem → **Resistance & buckling check**

Spanish Code RSDE allows the use of EN 1993-1-2

$$N_{t,Rd} = k_{\alpha} N_{pl,Rd} / \gamma_{M2}$$

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Resolution of the Mechanical Problem

- 1- Analysis Model introduced in Software (PowerFrame)
- 2- Applied Loads and Combinations
- 3- Analysis Type
- 4- Flexural Buckling length definitions

- Permanent Loads
- Snow Loads
- Wind Loads
- Case 1
- Case 2
- Crane Loads
- Fire Loads
- Generalized fire ISO 834 15 min

Combinations in Fire Scenario

$$\sum_{i=1}^n \gamma_{Q_i} G_k + \gamma_{Q_P} P + A_1 + \gamma_{Q_i} (V_{1,i} + O_{k,i})$$

Global elastic analysis in Second Order in 2D model

In Plane → Length of each split member
 Out of Plane → Length between restrictions

We didn't find information about how to apply global imperfection in battered columns under fire → We supposed L/500 as usually in normal case

$$\epsilon = l/500$$

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Resolution of the Thermal Problem

- We used a Finite element Software (Physibel) to calculate temperatures in build-up sections

view factor based non-linear radiation
 empirical convection
 in enclosures and at boundaries

view factor based non-linear radiation
 conduction through gas in rest
 in enclosures

$$q_{t,i} = \frac{\sigma(T_i^4 - T_j^4)}{1/\epsilon_i A_i + \frac{1}{A_i F_{ij}} + \frac{1 - \epsilon_j}{\epsilon_j A_j}}$$

$$F_{ij} = \frac{1}{A_i} \int_{A_i} \int_{A_j} \cos \theta_i \cos \theta_j \frac{dA_i dA_j}{r^2}$$

Temperature Results in different cross sections from the frame.

• Special case for battered column

• Only Convection
 • Radiation + convection

AFTER 15 min ISO 834

T^o Av = 708°C
 T^o Av = 674°C
 T^o Av = 590°C
 T^o Av = 632°C

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Check in all members of the frame

• For each beam in the frame is calculated the resistance at the calculated temperature and compared with the efforts in Fire Scenario

$$E_{f,d,j} \leq R_{f,d,j}$$

RED bars not resist R15

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CONCLUSIONS

- 1.Bracing System must be protected because we have taken into account braced points as fixed points.
- 2.Battened Columns can resist R15 without protection
- 3.The superior chord of the beam and some diagonals not resist R15
- 4.Is needed to reinforce that members or apply intumescent coatings or other specific protection material.
- 5.Spanish standard for industrial buildings let to the engineer apply modern concepts of fire engineering

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Tanks for your attention

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