1.2 Assessment of slender external steel columns

Block F., United Kingdom

Buro Happold **FEDRA**

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Assessment of slender external steel columns
Dr Florian Block

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Introduction

- Large university building with internal court yard in the US
- External intumescent paint expensive and high maintenance
- IBC 2003 requires 60 minutes fire resistance to columns supporting roof only and 120 minutes if columns supporting floor

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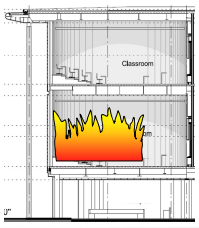
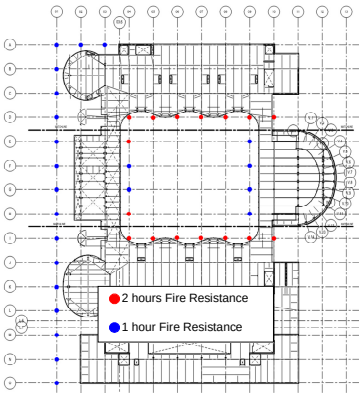
Structural overview

- Column section: HSS18x0.5
- Length: 21m
- Slenderness $\lambda = 127$
- Estimated cost of fire protection per column: $20,000 (2 hours)
- Distance from column to façade: 0.5m – 7.1m





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Approach

- Agree approach with stakeholders
- Define the design fires
- Represent the fire with a simple model
- Perform a heat transfer analysis from the fire to the columns
- Calculate the time depended steel temperature of the column
- Definition of Fire Limit State loading
- Perform a non-linear structural analysis of columns
- Present findings to Code Officials and Fire Marshals


Emirate Football Stadium, London


Royal Ascot Racecourse, Ascot

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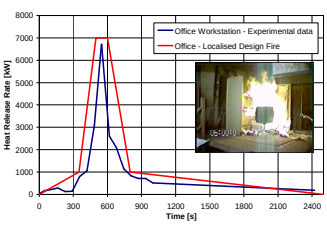
Defining the design fires

Three types of fires are likely in the university building and the court yard

1. Localised sprinkler controlled fire
2. High ventilation sprinkler controlled compartment fire
3. External fire in court yard

Assumptions:

- Sprinklers control spread of fire to adjacent objects but do not influence localised fire
- Localised fire is a 3-panle office workstation
- Temperature of continuous part of flame: 1000°C
- Temperature of intermittent part of flame: 1000°C -> 600°C
- Column is not engulfed



7MW Steady State Fire was used for design

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Represent the fire with a simple model

Select HRR and fire base size

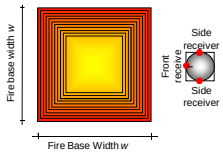
- Calculate flame height using Hekastead equation for rectangular fires
- Assume flame shape
- Split flame into individual slices
- Calculate emissivity of flame slice

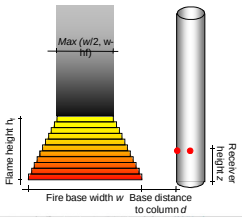
Select a receiver (height, front or side)

- Calculate heat flux to receiver from each flame slice
- Sum up the total heat flux for selected receiver

Select next receiver

Select next HRR and fire base size





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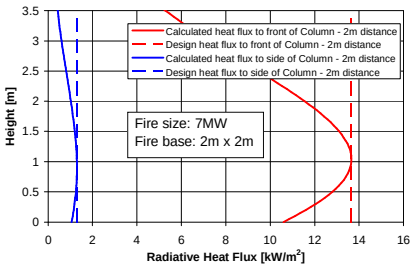
Perform a heat transfer analysis from the fire to column

- The heat flux is calculated for each side of the column separately
- View factors are calculated for each slice of the flame individually
- Circular columns are modelled as square
- Only radiation is considered
- Different distances between the base of the fire and the columns are considered depending on the situation
- Maximum heat flux along the height of the column is used as design value

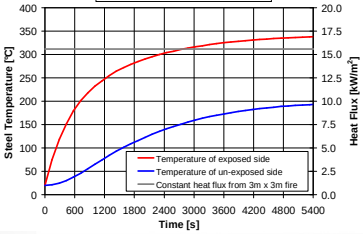


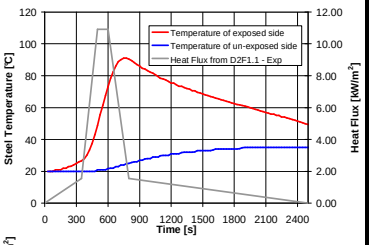
- Note: EC1 considers an uniform heat flux to an external column based on the weighted average of the exposed sides

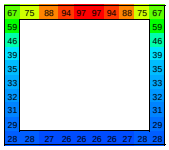
Calculate the time depended steel temperature of the column

- The steel temperature is calculated using the heat transfer software TASEF
- Heat loss of the column to the surrounding air is considered

Fire size: 7MW Steady State
Fire base: 3m x 3m
Distance: 2m



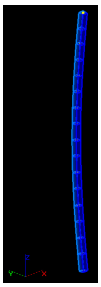


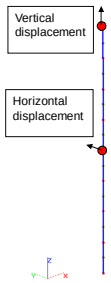


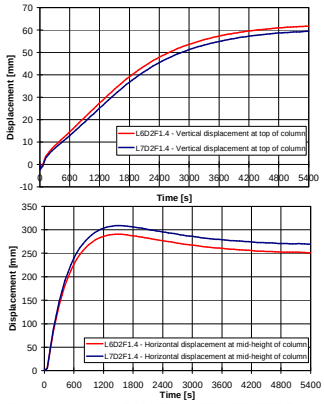
Fire size: Experimental
Fire base: 2m x 2m
Distance: 2m

Perform a non-linear structural analysis of columns

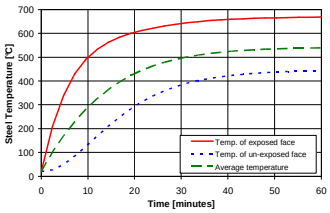
- Vulcan was used for the analyses
- Fire Limit State Loading was used

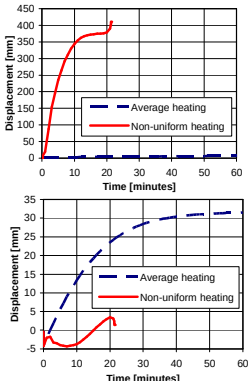






Comparison with the Eurocode approach

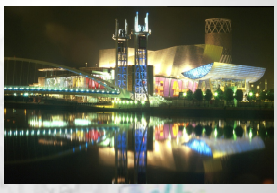


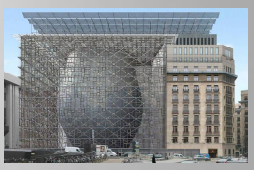


Eurocodes should consider non-uniform heating of external steelwork or propose boundaries of applicability.

Conclusion

- Buro Happold FEDRA has been successfully designing buildings for fire for the last 20 years
- The majority of the external columns will have no applied fire protection
- Significant cost savings
- Less maintenance and better architectural finish
- For slender columns and unrestrained beams the non-uniform heating must be included
- The external steelwork approach in the Eurocode does not include this or highlight the need for it





Buro Happold **FEDRA**

florian.block@burohappold.com

Thank you for your attention!