



# Fire Safety Engineering

## Innovaties over de grens

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# Overzicht

- Innovaties of best practise...-> allebei!
- Introductie en overzicht
- Fire Safety Engineering – Structural fire safety engineering – Waarom?
- Enkele voorbeelden:
  - Bruggen
  - Optopping Londen.
  - Powerhouse

# Arup



1946

Opgericht door Sir Ove Arup

18,000+

Leden

£2.2bn

Omzet (2022/23)

94

Kantoren

34

Landen



Employee owned  
Quality driven

# Onze kennis



**STRUCTURAL  
ENGINEERING**



**MECHANICAL  
ENGINEERING**



**FIRE  
SAFETY**



**ACOUSTICS**



**SUSTAINABILITY**



**GEOTECHNICS**



**ELECTRICAL  
ENGINEERING**



**BUILDING PHYSICS**



**LIGHTING**



**BIM**



**WIND  
ENGINEERING**



**VERTICAL TRANSPORT**



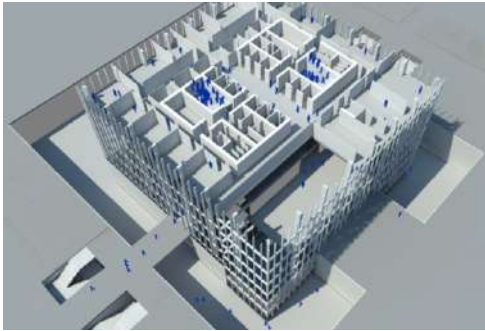
**FAÇADES**



**VIBRATIONS**



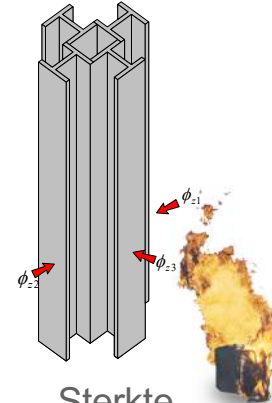
**DIGITAL**



Veilig vluchten



Brandweer inzet



Sterkte  
Constructie bij brand

ARUP



Actieve systemen



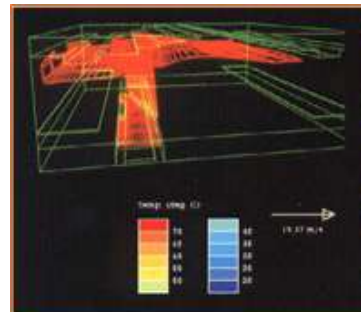
Onderzoek & testen

# Integrale Brandveiligheid



Rijksoverheid

Bouwregelgeving



Rookverspreiding



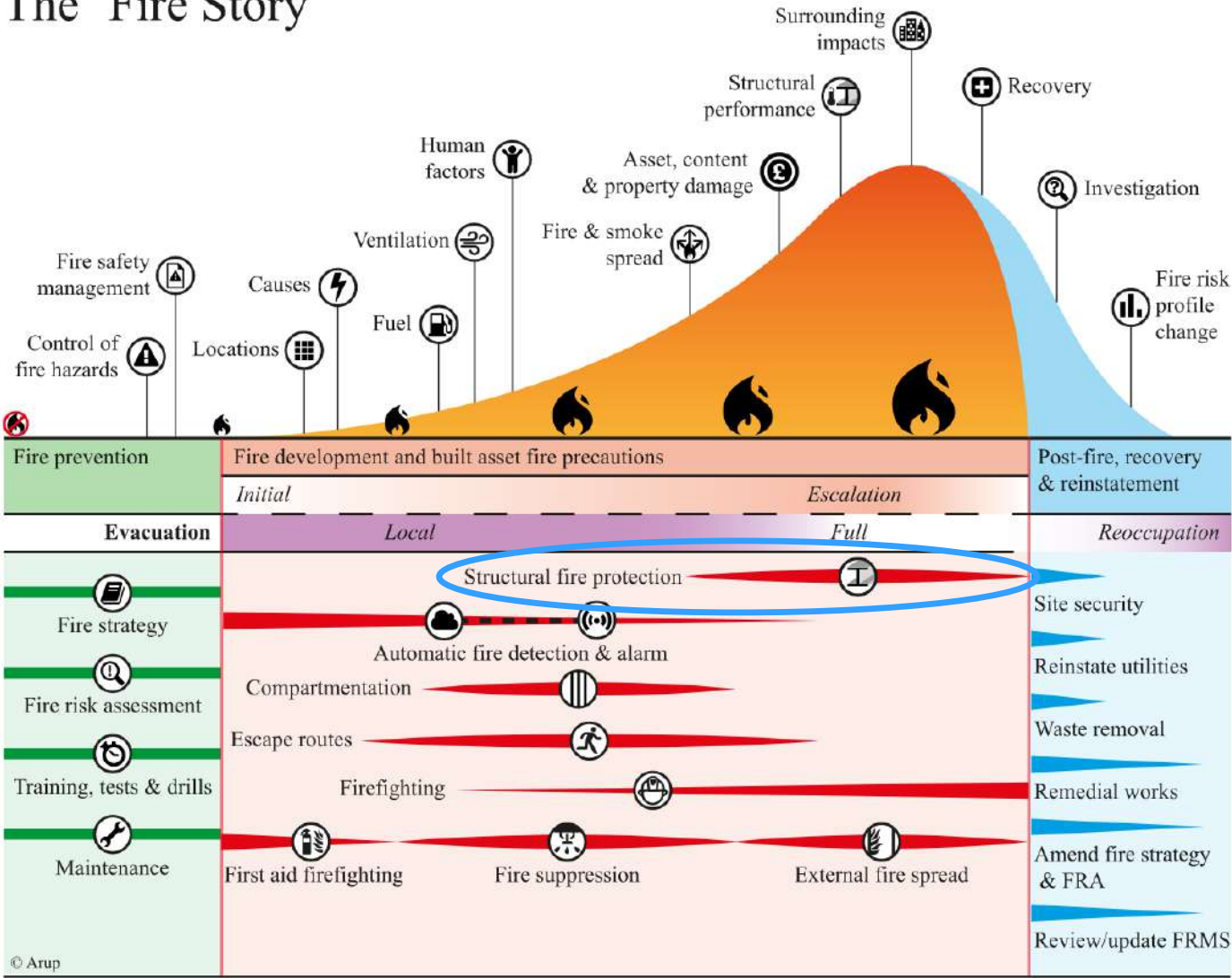
Organisatie & BHV



Brandcompartimenten

# Fire Safety Engineering

## The 'Fire Story'

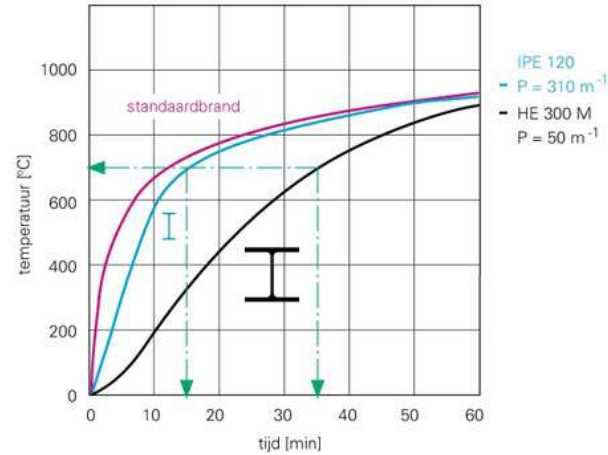


Brandwerendheid bouwconstructies

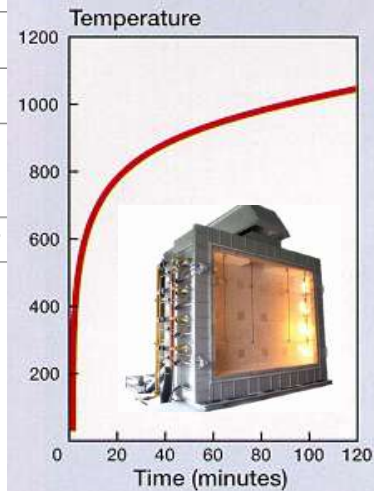
# Traditionele aanpak

Table A2 Minimum periods of fire resistance

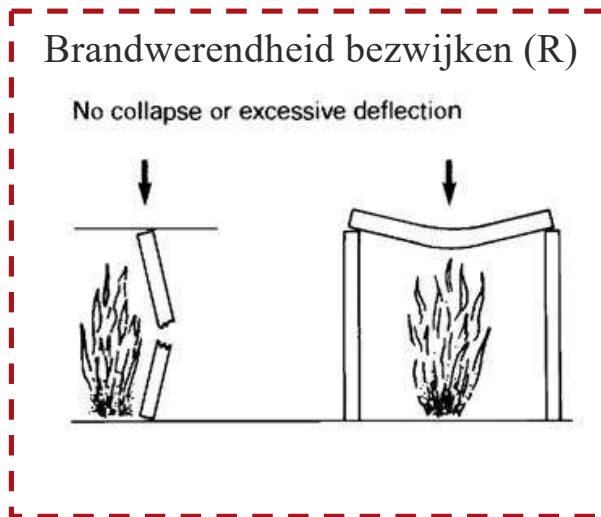
Purpose group of building	Minimum periods of fire resistance (minutes) in a:					
	Basement storey <sup>(B)</sup> including floor over		Ground or upper storey			
	Depth (m) of a lowest basement		Height (m) of top floor above ground, in a building or separated part of a building			
	More than 10	Not more than 10	Not more than 5	Not more than 18	Not more than 30	More than 30
1. Residential:						
a. Block of flats						
- not sprinklered	90	60	30*	60**†	90**	Not permitted
- sprinklered	90	60	30*	60**†	90**	120**
b. Institutional	90	60	30*	60	90	120#
c. Other residential	90	60	30*	60	90	120#
2. Office:						
- not sprinklered	90	60	30*	60	90	Not permitted
- sprinklered <sup>(B)</sup>	60	60	30*	30*	60	120#
3. Shop and commercial:						
- not sprinklered	90	60	60	60	90	
- sprinklered <sup>(B)</sup>	60	60	30*	60	60	
4. Assembly and recreation:						
- not sprinklered	90	60	60	60	90	
- sprinklered <sup>(B)</sup>	60	60	30*	60	60	
5. Industrial:						
- not sprinklered	120	90	60	90	120	
- sprinklered <sup>(B)</sup>	90	60	30*	60	90	
6. Storage and other non-residential:						
a. any building or part not described elsewhere:						
- not sprinklered	120	90	60	90	120	
- sprinklered <sup>(B)</sup>	90	60	30*	60	90	
b. car park for light vehicles:						
i. open sided car park <sup>(B)</sup>	Not applicable	Not applicable	15'+	15'+ <sup>(B)</sup>	15'+ <sup>(B)</sup>	
ii. any other car park	90	60	30*	60	90	



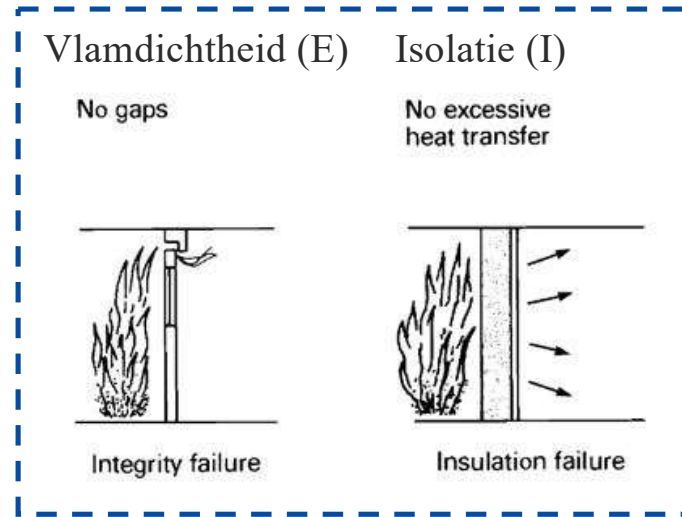
BS476 Part 20



# Brandwerendheid van de bouwconstructies



Draagconstructies



Brandscheidingen



# Constructieve brandwerendheid

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## Regelgeving:

*“Een bouwwerk is bestand tegen brand zodat geen sprake zal zijn van instorting die gevaar oplevert voor het vluchten of voor hulpverlening bij brand, gedurende een redelijke tijd”*

## Aanvullend:

*“Schade beperking & Impact op de bedrijfscontinuïteit”*

Risico gerichte oplossing die past bij het bouwwerk.

# Maar wat is redelijk?!



Bij 300m?



Bij 150m?

Bij een optopping?

> 13m = 2 uur brandwerendheid



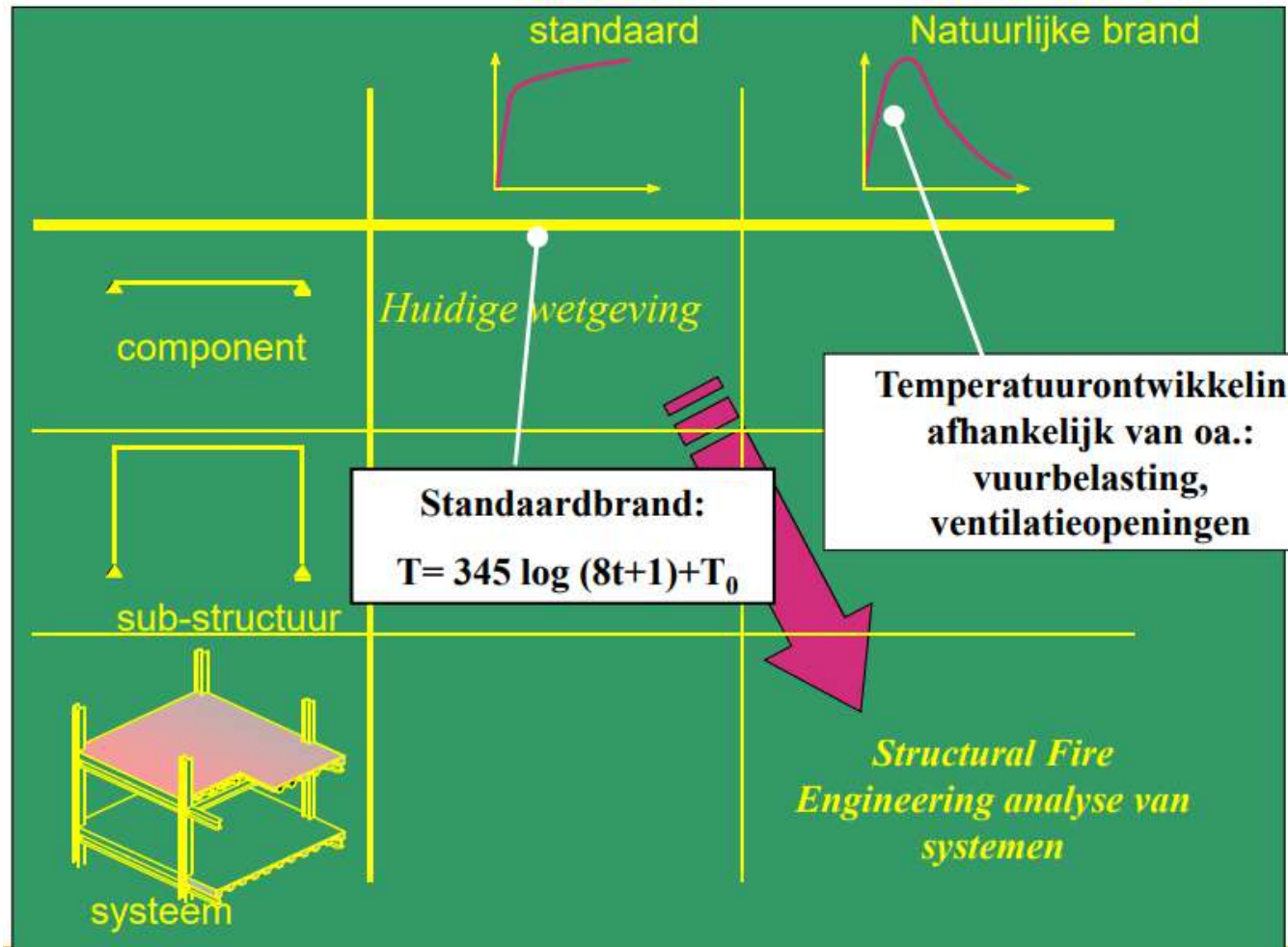
# Waarom?

Omdat...

- we aan de regels moeten voldoen.
- we een veilige bouwconstructies willen maken.
- we risico's analyseren en mogelijk maatregelen nemen.
- we willen slimme oplossingen ook voor 2<sup>e</sup> draagweg en robuustheid.

Maar ook om:

- meer architectonische en creatieve vrijheid te creëren.
- kosten te besparen en minder brandwerende bekleding.
- effectieve, veilige en efficiënte constructies te maken.

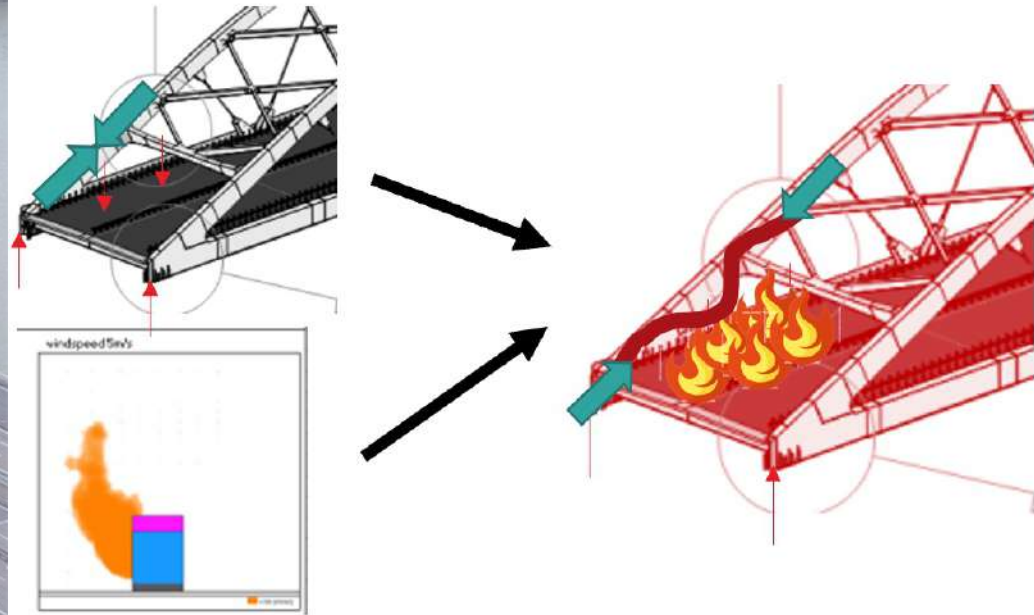


Regel gericht  
 Risico gericht  
 Simpel of meer  
 geavanceerd?

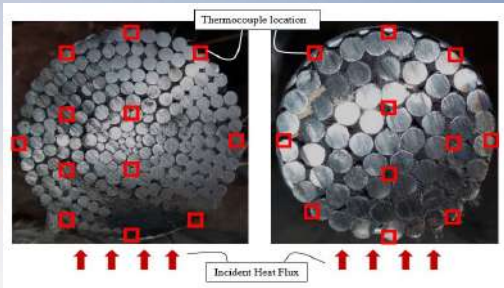


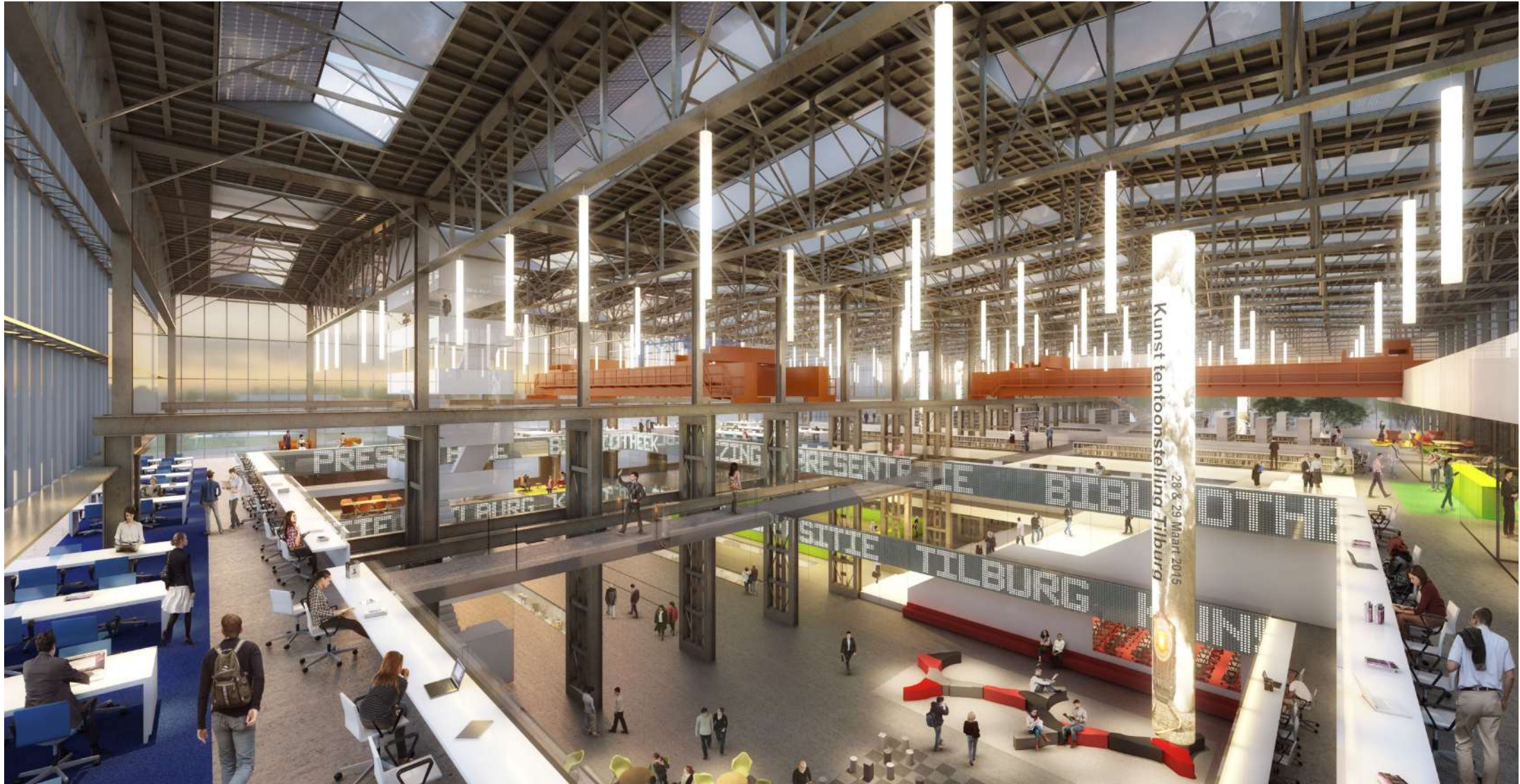
# Infrastructure – digital fire delivery

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CFD & LS-Dyna Structural Fire







# Aanpak

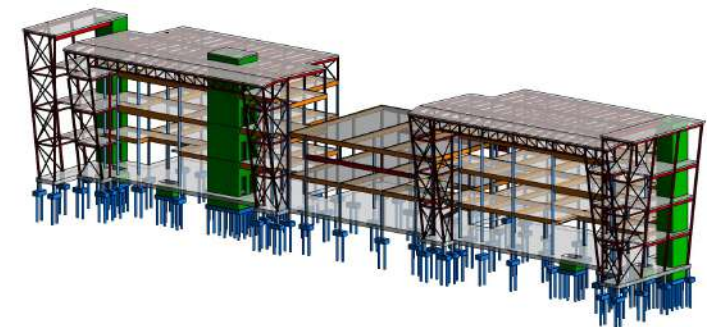
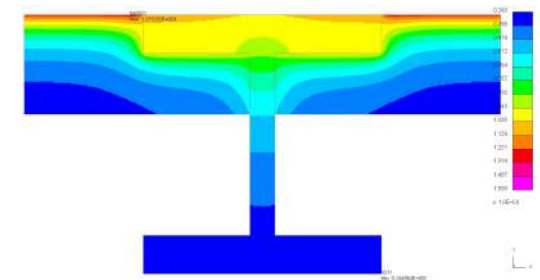
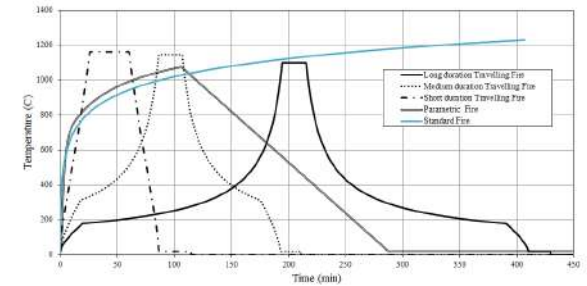
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1. Vaststellen van doelstelling voor constructieve brandwerendheid

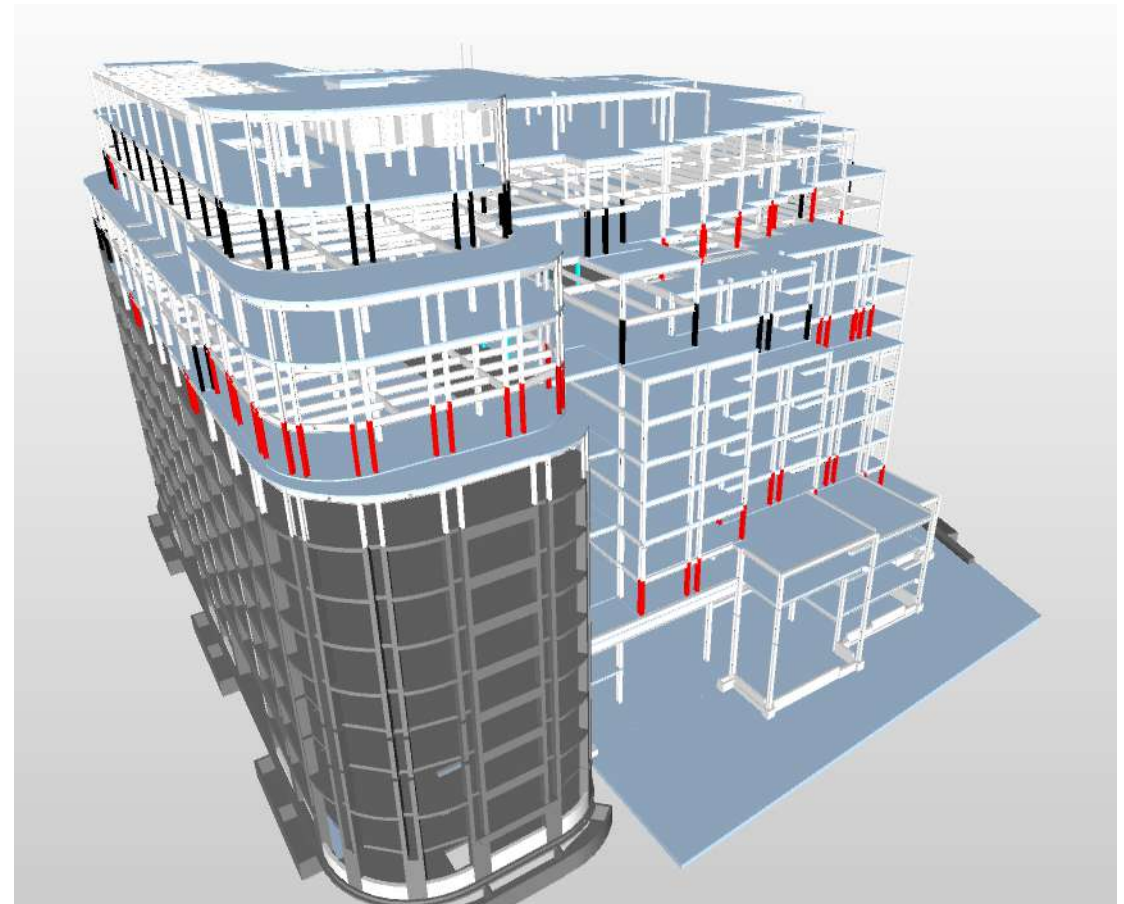
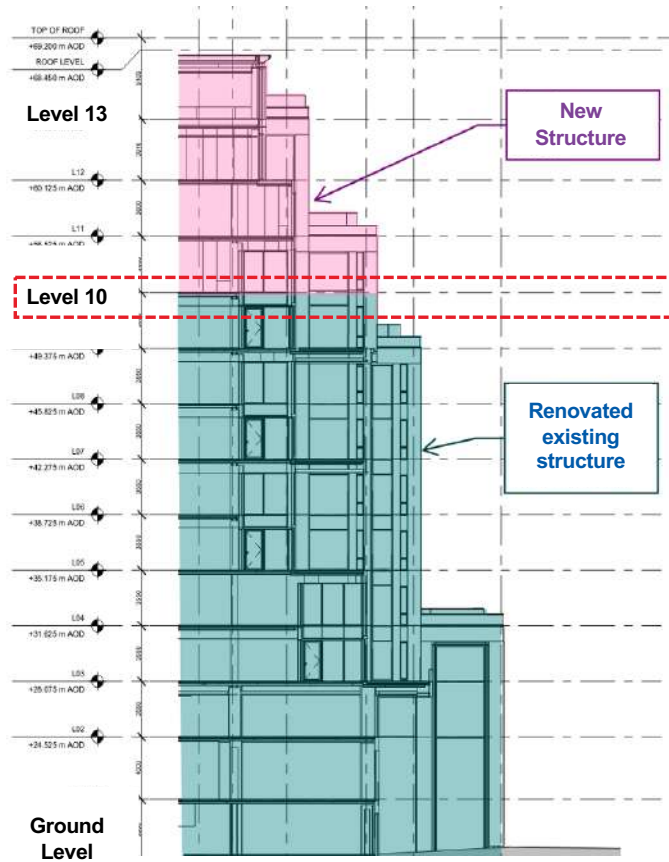
2. Bepalen van brandscenario's en thermische belasting (opwarming)

3. Analyseren van de constructie m.b.v.:

- Tabellen
- Versimpelde rekenregels
- Geavanceerde analyses voor speciale onderdelen



# Optopping in London

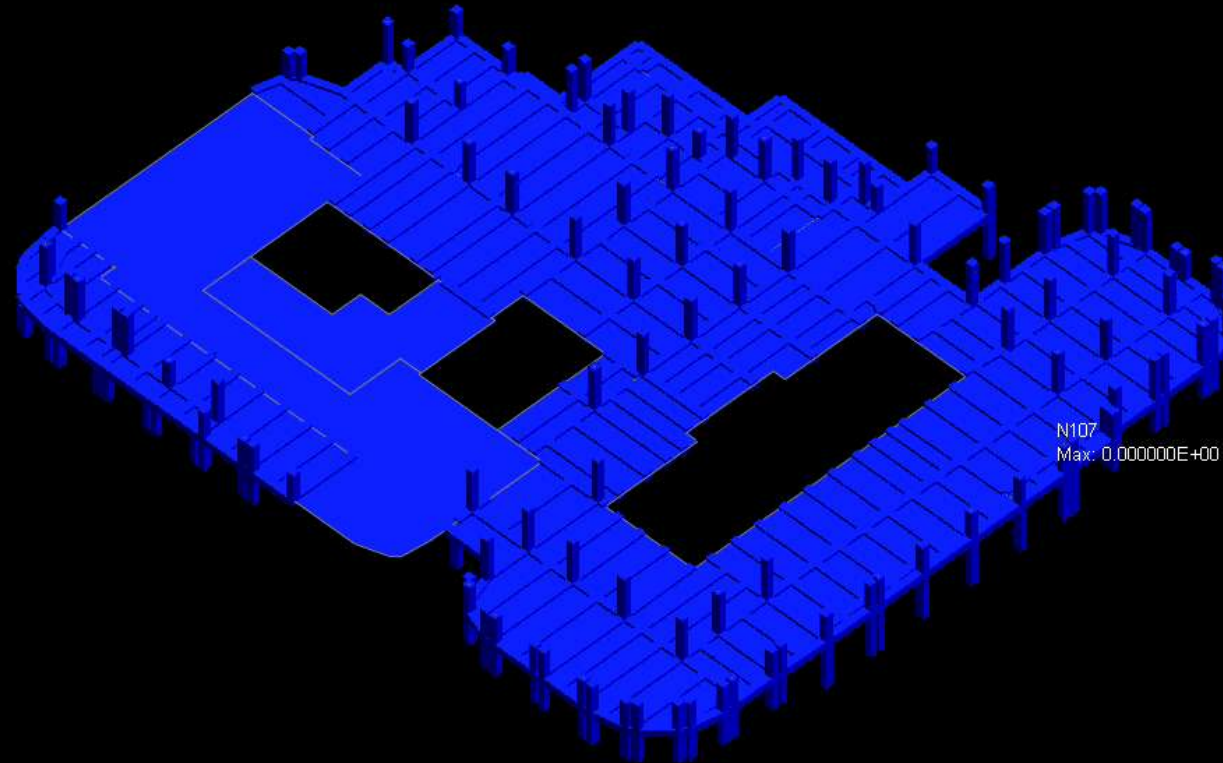


D3PLOT:

1: Max N107 : 0.000000E+00, Min N107 : 0.000000E+00

# Modelling Results

Floorplate behaviour



Resultant Displacement

0.000

0.000

0.000

0.000

0.000

0.000

0.000

0.000

0.000

0.000

0.000

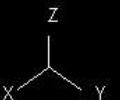
0.000

0.000



m

Overall Displacement



Time (x1000) .000000000

D3PLOT:

1: Max B261 : 0.000000E+00, Min B261 : 0.000000E+00

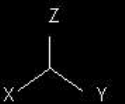
# Modelling Results

Edge Columns

Plastic Strain  
(Ave all pts)

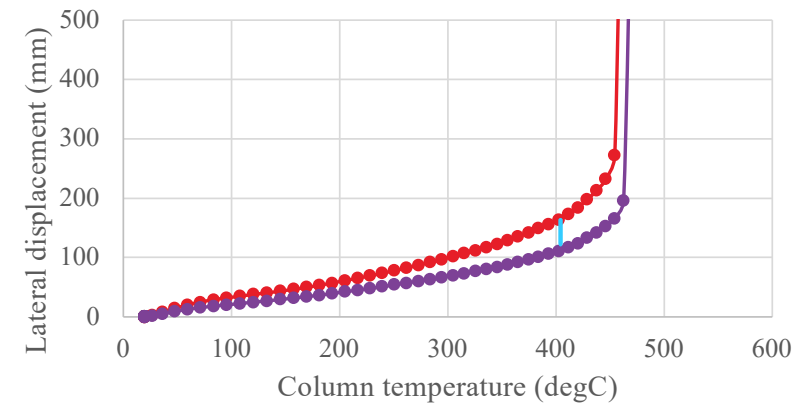
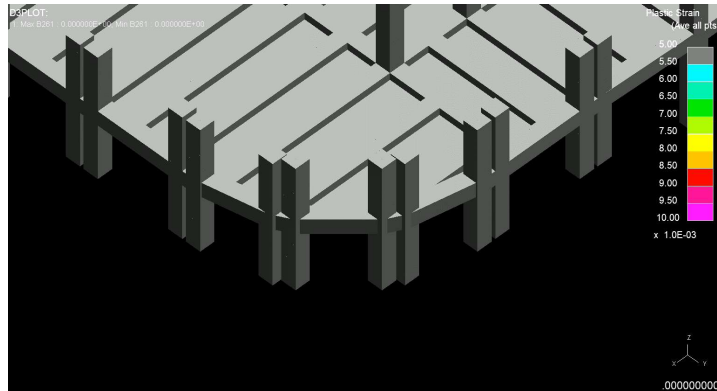


Plastic Strain



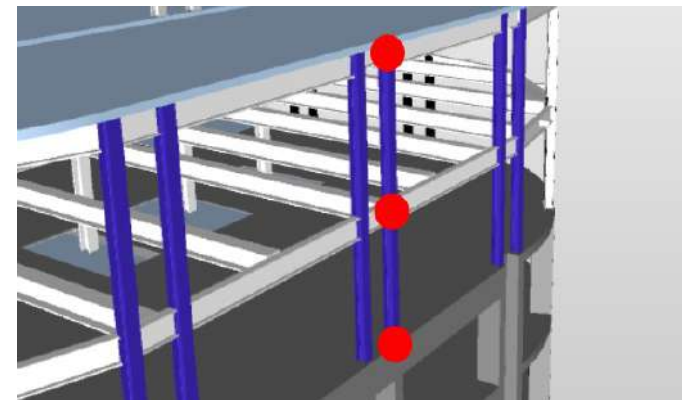
Time (x1000) .00000000

# Resultaten



—●— BS 9999 compliant design    —●— Proposed design

- Inzicht in het gedrag van de opbouw bij brand.
- Kolommen versterkt.
- Geoptimaliseerd ontwerp voor de brandwerende bekleding.



**Retrofit Columns**

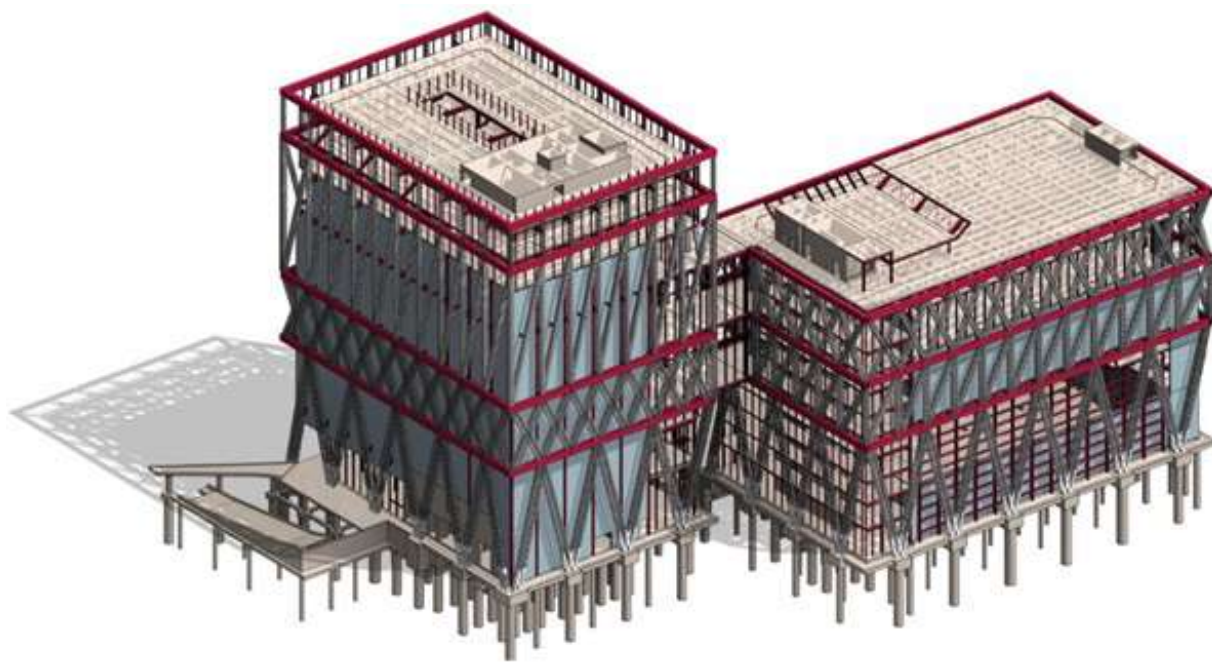
*“the results show some interesting structural behaviour which would not have been apparent using prescriptive methods”*

City of London Building Control

ARUP

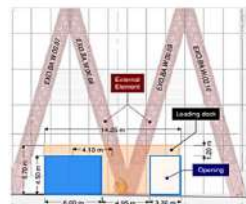
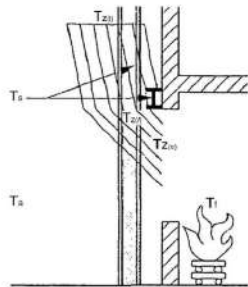
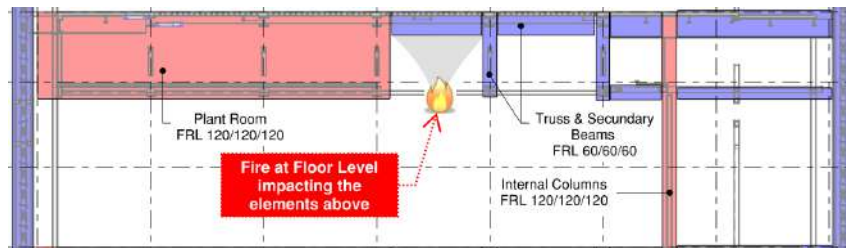
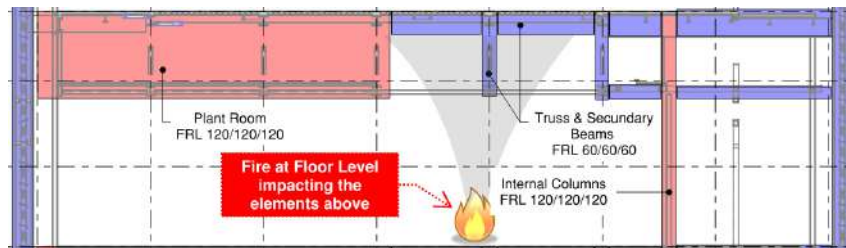
# Case Study Building

Powerhouse Parramatta, Sydney



# Design fire scenarios

Drie voorbeelden



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# Resultaten

- gedrag van de constructie bij verschillende brandscenario's.
- opties voor alternatieve draagwegen.
- optimalisatie van bescherming.





# Fire Safety Engineering

## Innovaties over de grens

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