

PYRO
Engineering



Brandwerendheid tunnels

Rekenmodellen en nieuwe inzichten

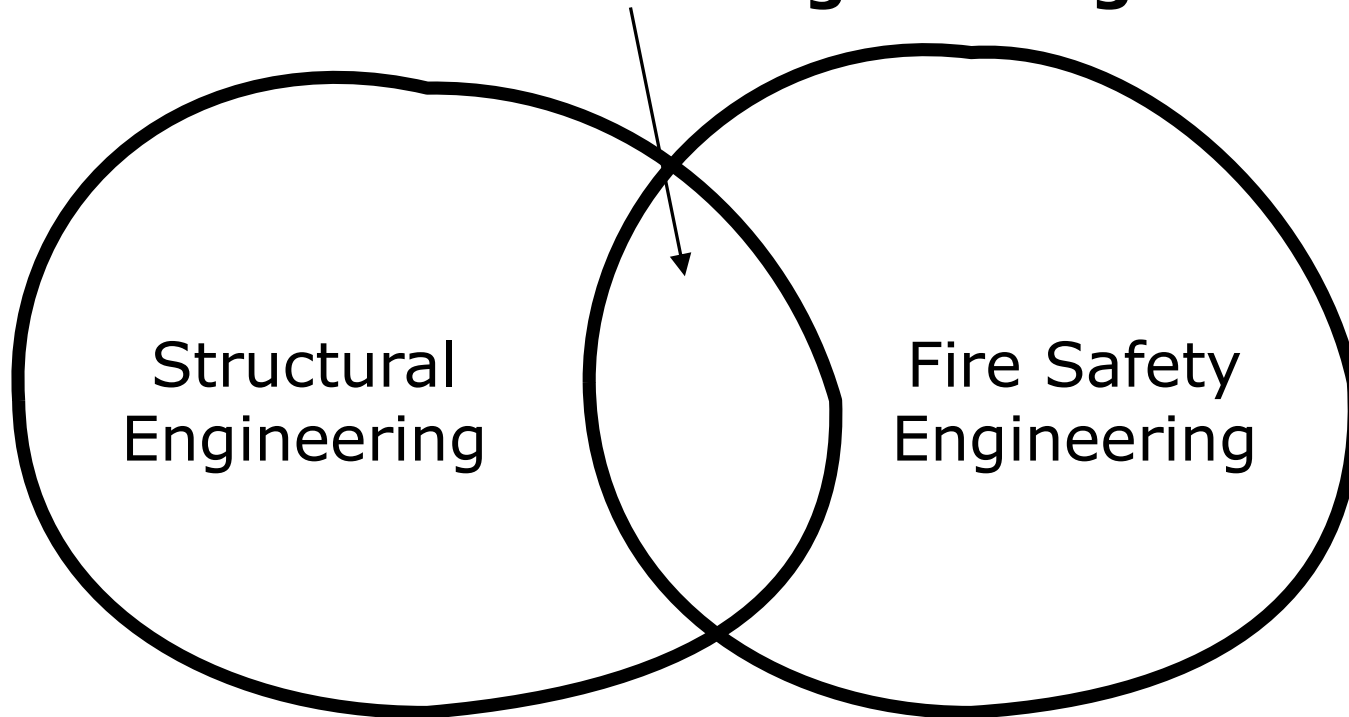
Thomas Thienpont

18 December 2025

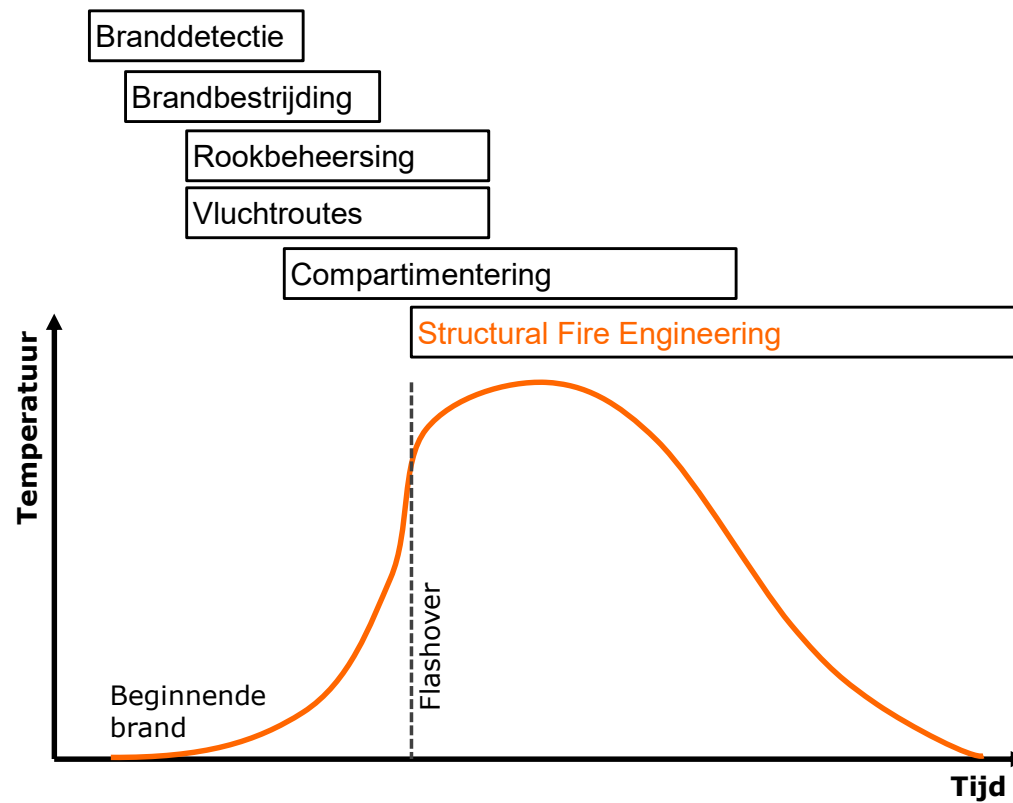
Deel 1

Inleiding

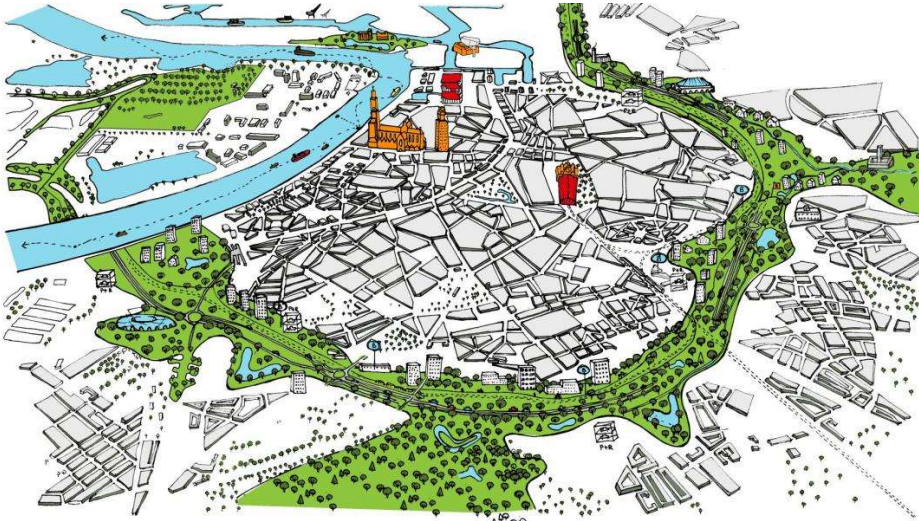
Structural **Fire** Engineering



Structural **Fire** Engineering

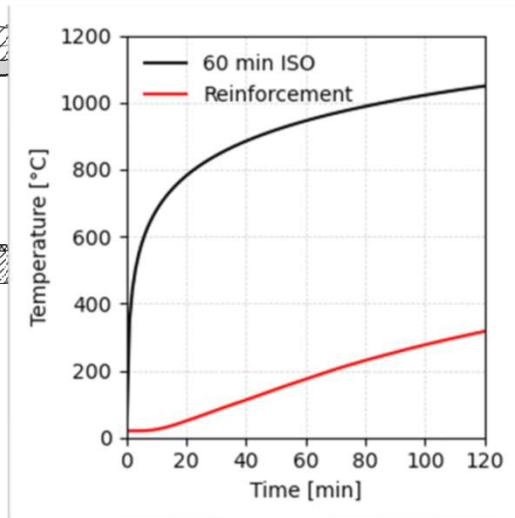
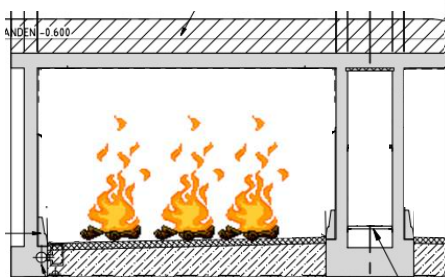


Structural **Fire** Engineering in Tunnels



Structural **Fire** Engineering in Tunnels

Traditioneel ontwerp



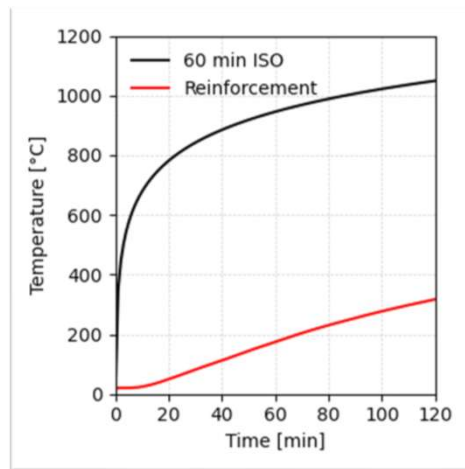
Thermische analyse

Geen informatie over:

- ✗ gedrag tijdens de afkoelfase
- ✗ schade na brand
- ✗ continuïteit van de bedrijfsvoering

Structural **Fire** Engineering in Tunnels

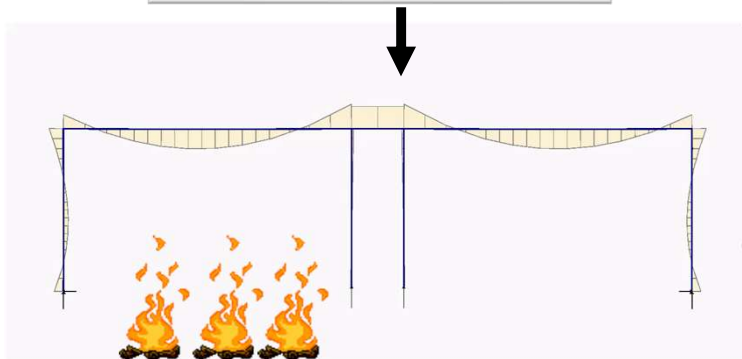
Performance-based ontwerp



Thermische + Mechanische analyse

Informatie over:

- ✓ vervormingen en krachtenherverdeling
- ✓ omvang schade na brand
- ✓ effect van beschermingsmaatregelen
- ✓ effect van spatten beton
- ✓ ...

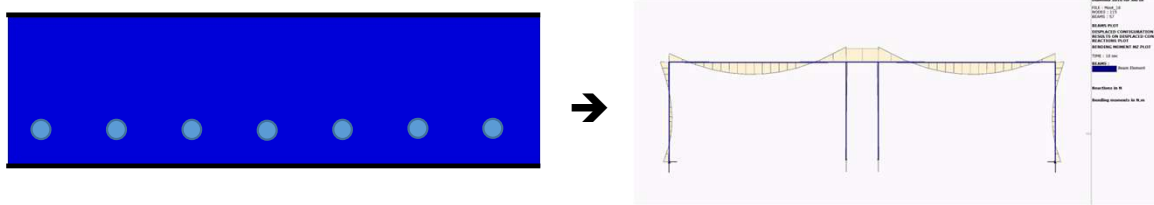


Deel 2

Numerieke modellen

Numerieke modellen

Sequentieel-gekoppelde analyse:
thermische berekening → mechanische berekening



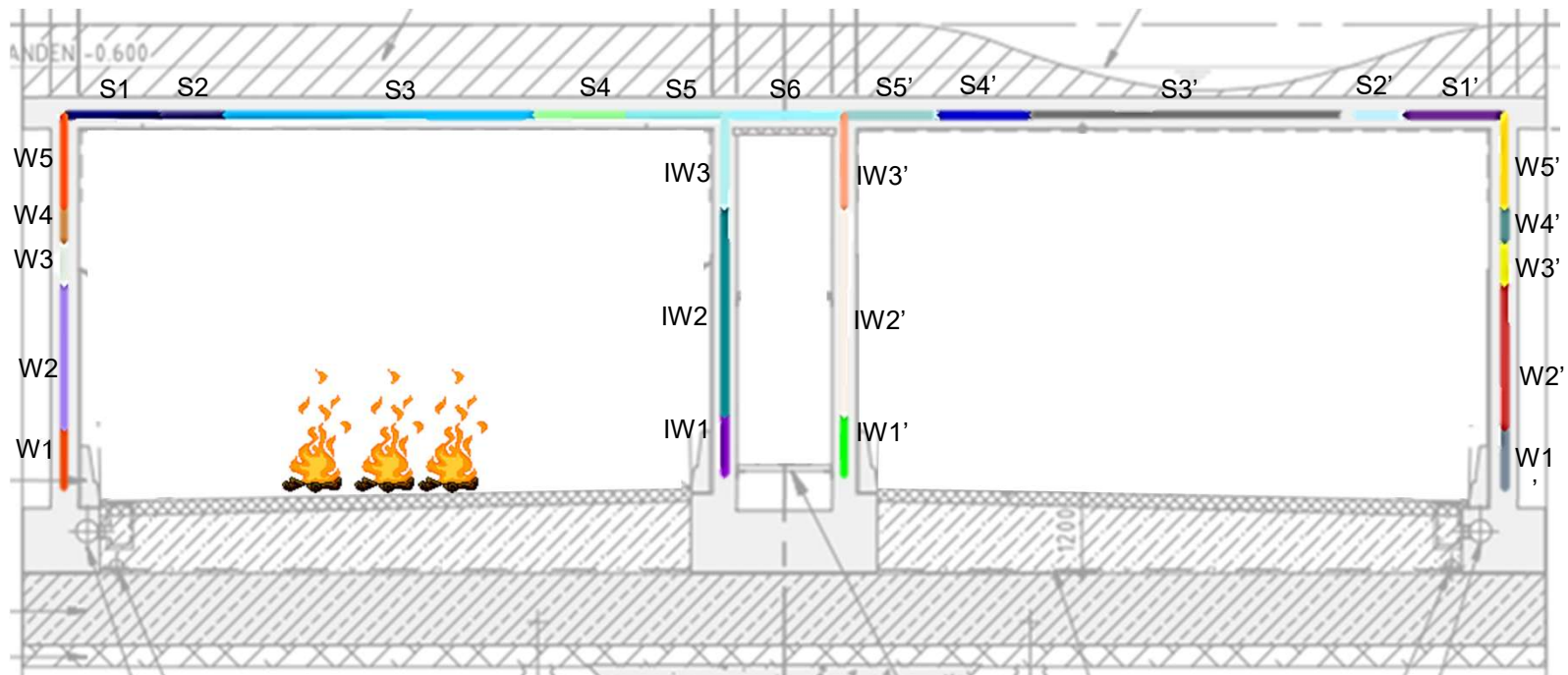
SAFIR + Python codes



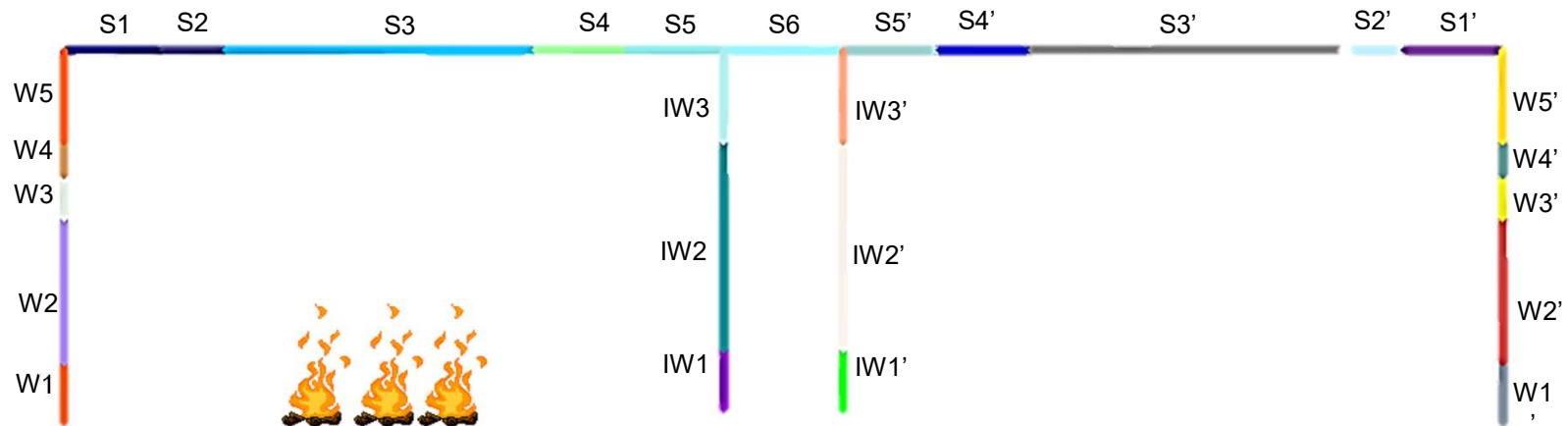
SAFIR®



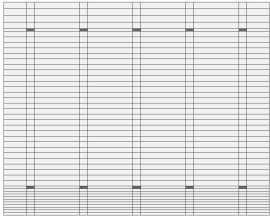
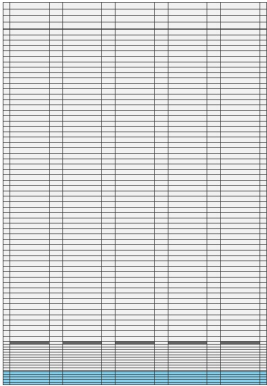
2D staafmodel



2D staafmodel

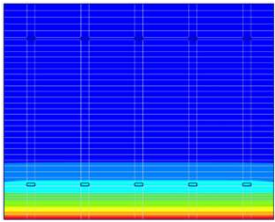
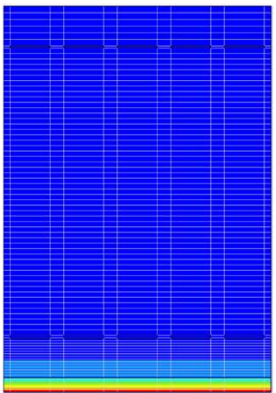


2D staafmodel

Sectie W2	Sectie S2
$A_{s1} = 380 \text{ mm}^2$ (brandzijde) $A_{s2} = 380 \text{ mm}^2$ (koude zijde) $c = 50 \text{ mm}$ $h = 400 \text{ mm}$	$A_{s1} = 1870 \text{ mm}^2$ (brandzijde) $A_{s2} = 1490 \text{ mm}^2$ (koude zijde) $c = 50 \text{ mm}$ $h = 700 \text{ mm}$
Koude zijde  Brandzijde	Koude zijde  Brandzijde



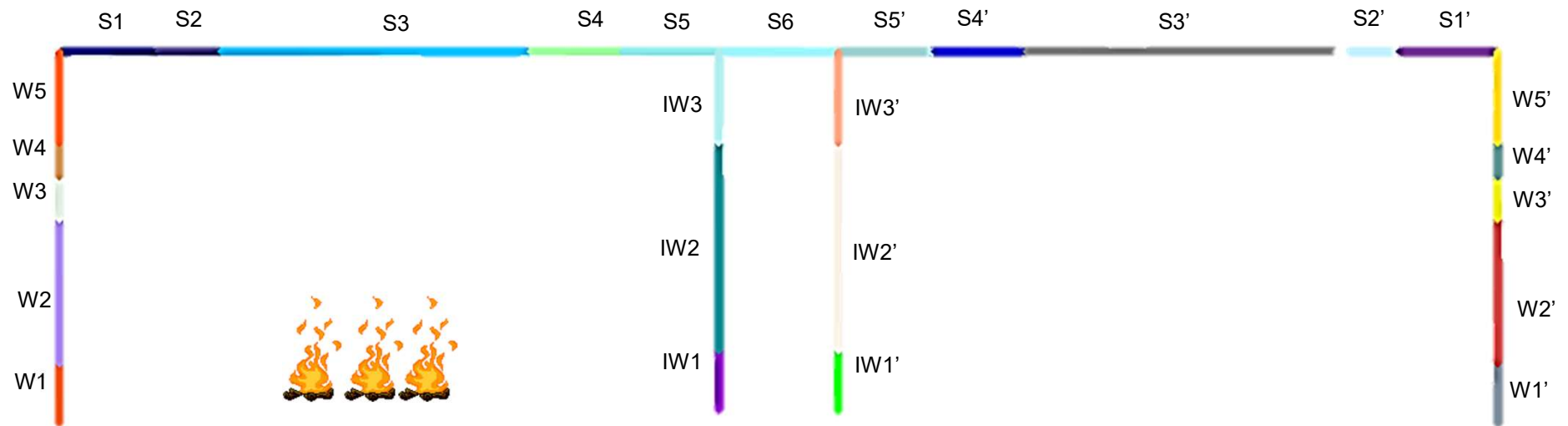
Thermische analyse

Sectie W2	Sectie S2
$A_{s1} = 380 \text{ mm}^2$ (brandzijde) $A_{s2} = 380 \text{ mm}^2$ (koude zijde) $c = 50 \text{ mm}$ $h = 400 \text{ mm}$	$A_{s1} = 1870 \text{ mm}^2$ (brandzijde) $A_{s2} = 1490 \text{ mm}^2$ (koude zijde) $c = 50 \text{ mm}$ $h = 700 \text{ mm}$
Koude zijde  Brandzijde	Koude zijde  Brandzijde



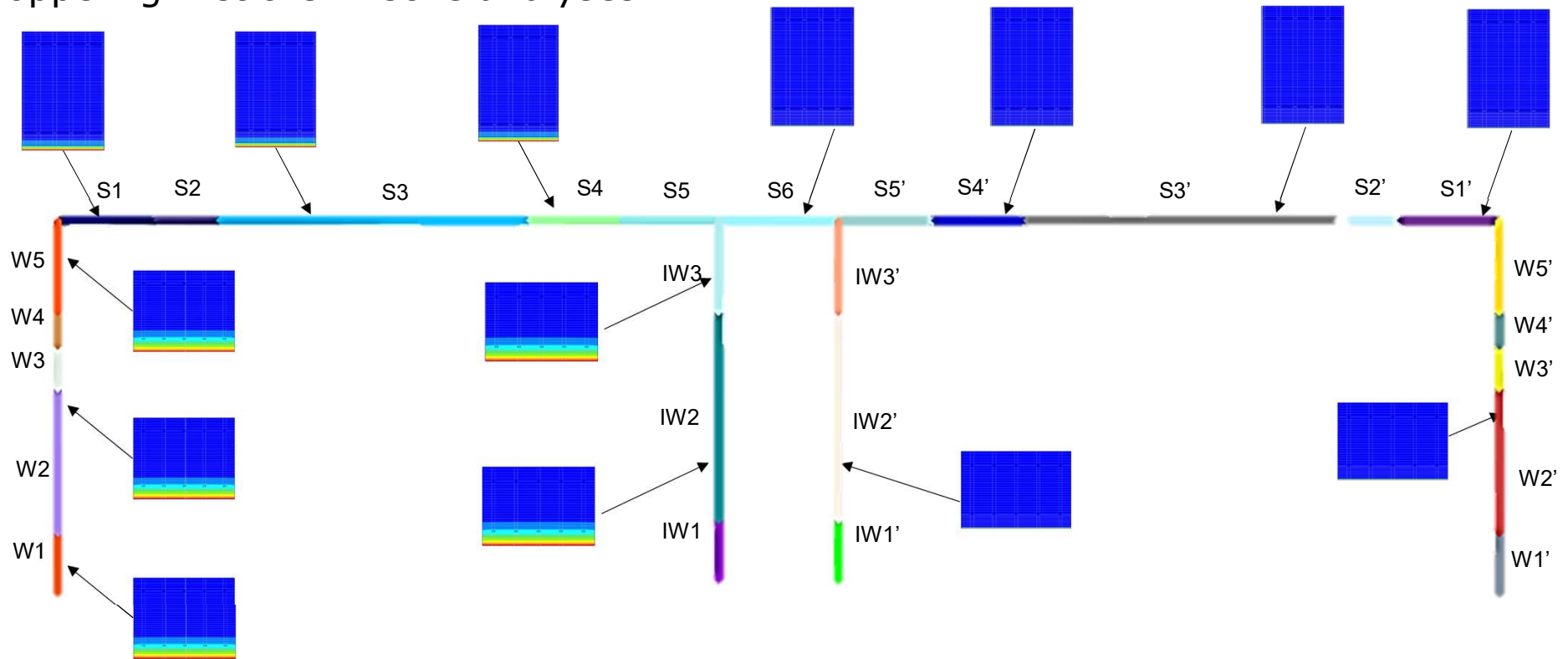
Mechanische analyse

Koppeling met thermische analyses



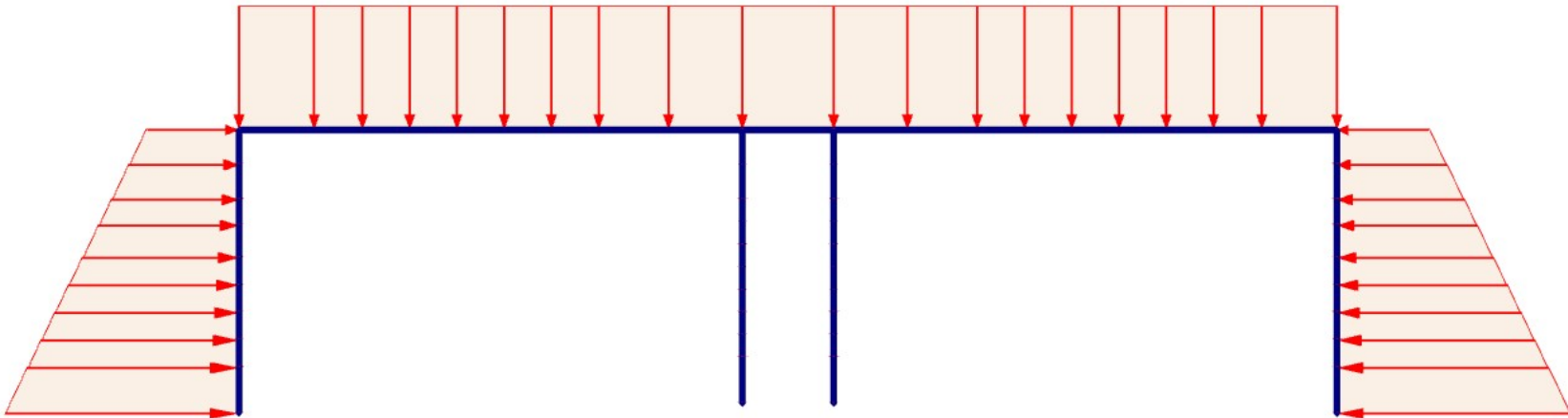
Mechanische analyse

Koppeling met thermische analyses



Mechanische analyse

Belastingen

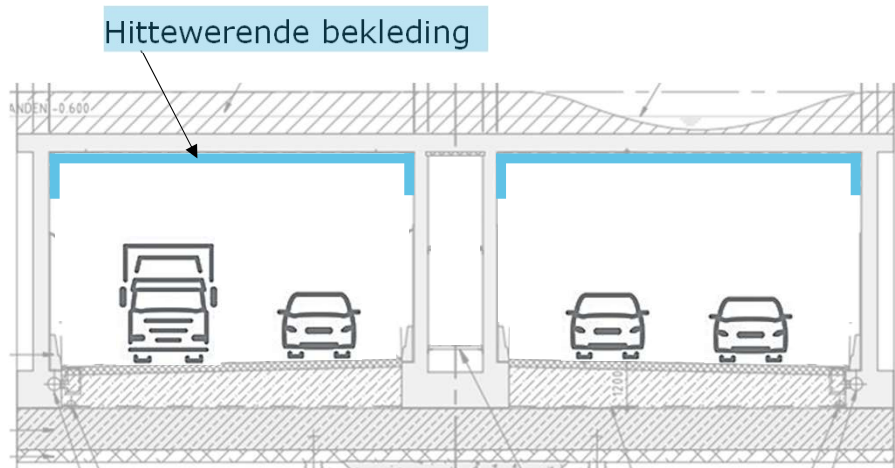


Deel 3

Case studie

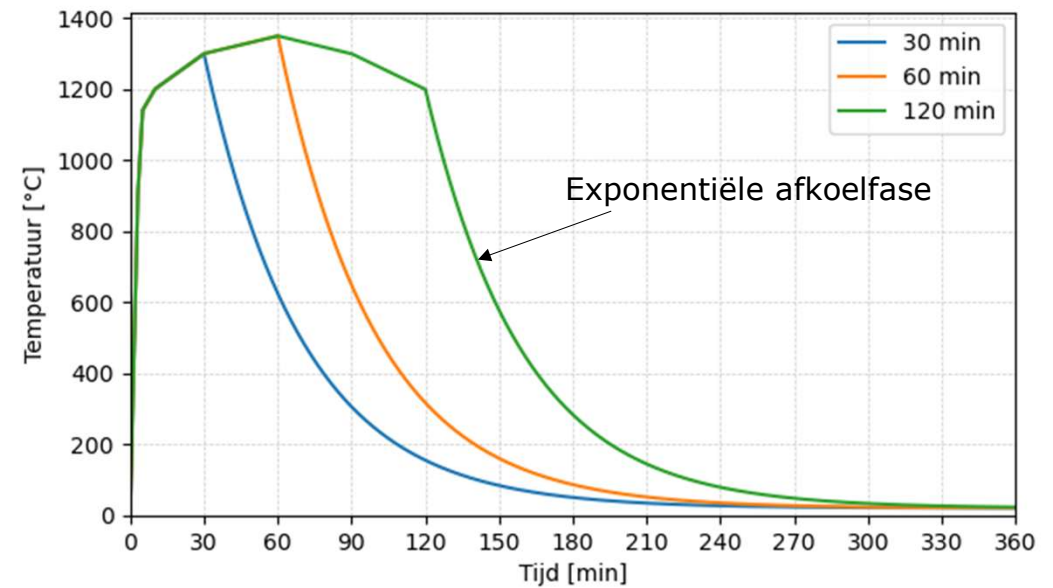
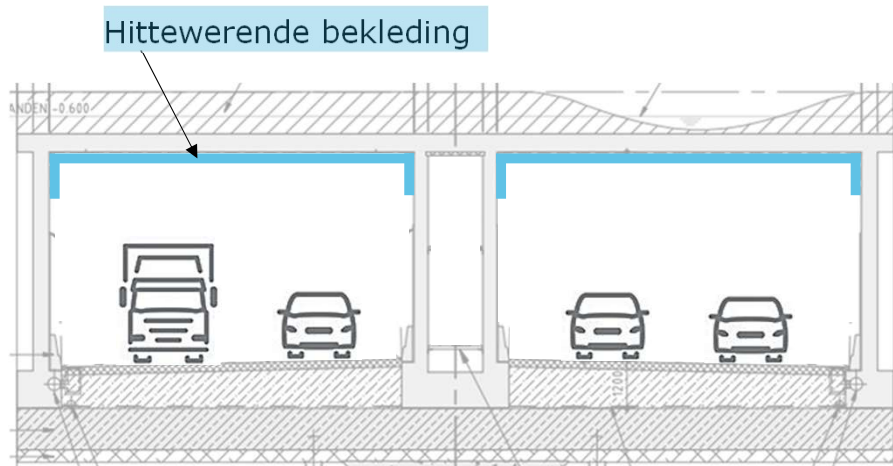
Case studie

Wegtunnel



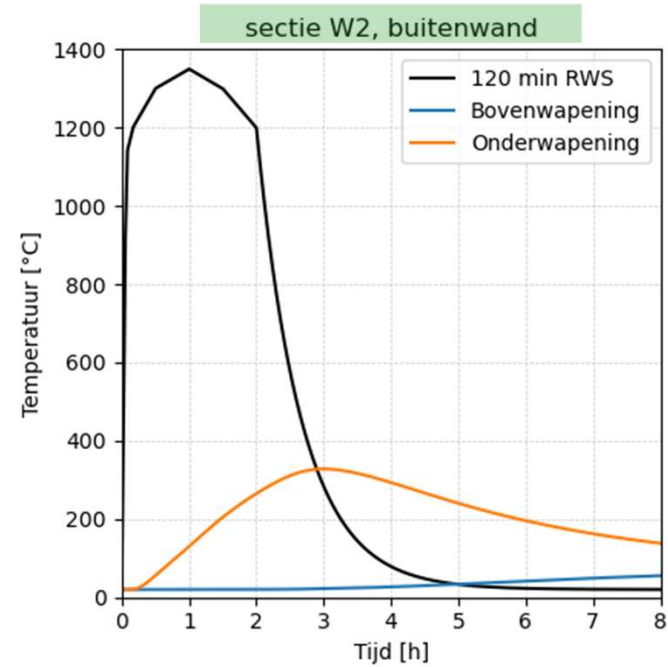
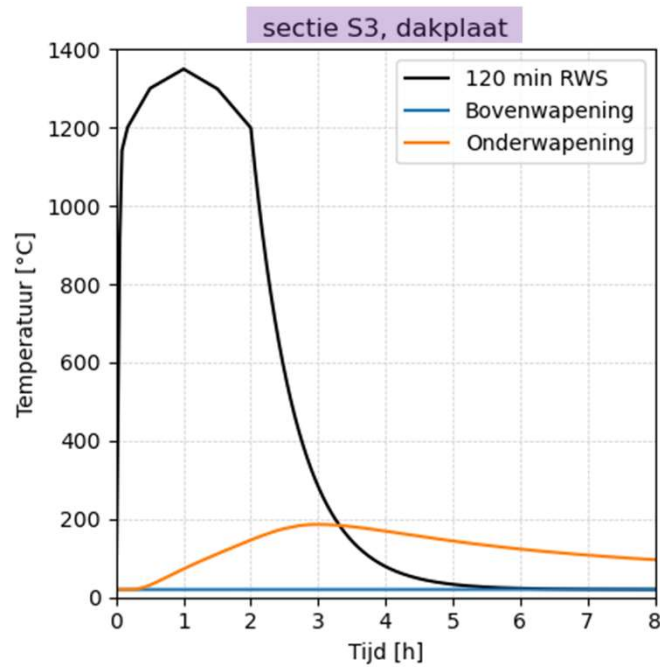
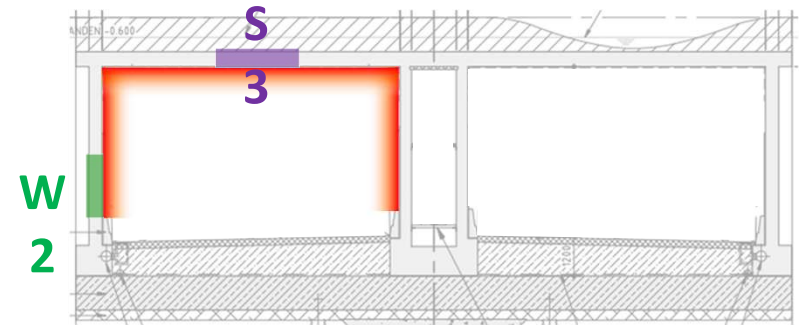
Case studie

Wegtunnel, RWS120 brand links



Case studie

Thermische analyse

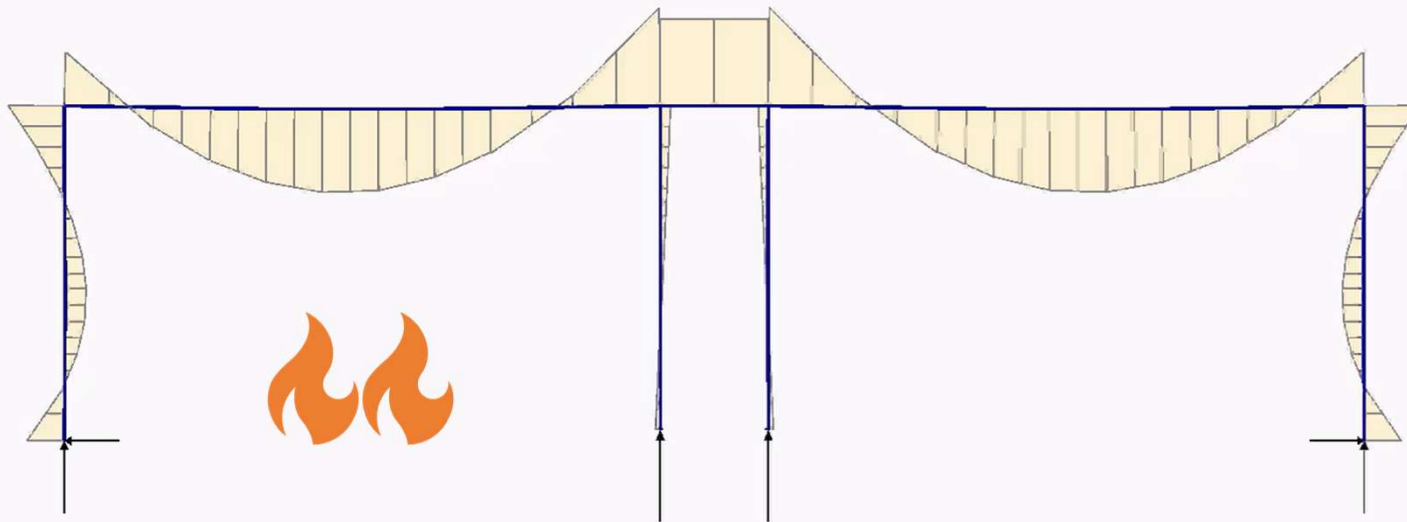


Case studie

Mechanische analyse

Momentenlijn

Vervormingen 10x uitvergroot



Diamond 2016 for SAFIR

FILE : Moot_16
NODES : 115
BEAMS : 57

BEAMS PLOT

DISPLACED CONFIGURATION (x10)

RESULTS ON DISPLACED CONF.

REACTIONS PLOT

BENDING MOMENT MZ PLOT

TIME : 21 sec

BEAMS :

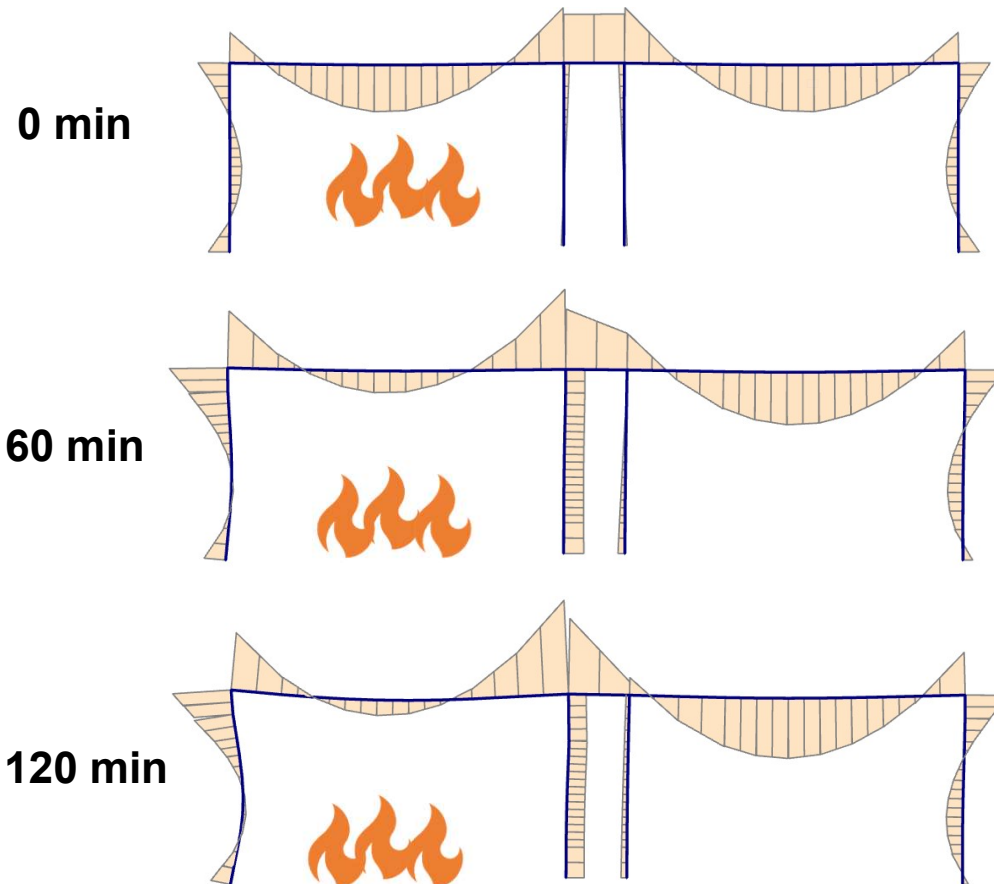
Beam Element

Reactions in N

Bending moments in N.m

Case studie

Mechanische analyse

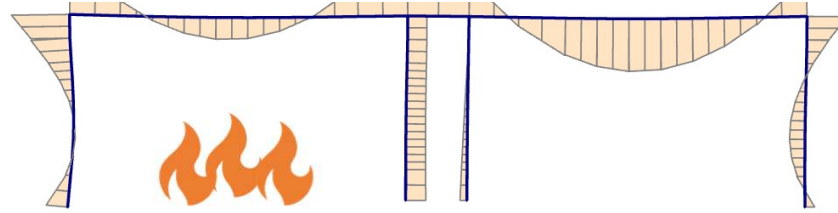


Vervormingen 10x uitvergroot

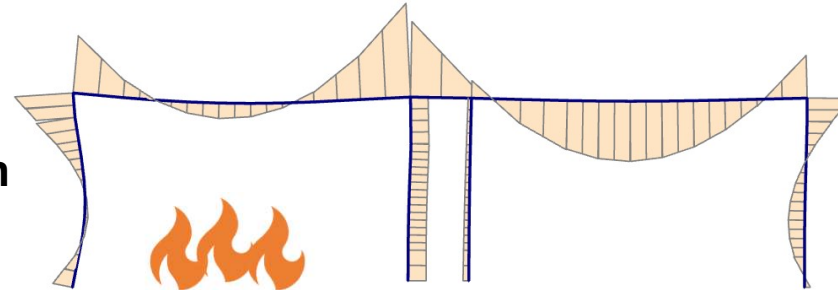
Case studie

Mechanische analyse

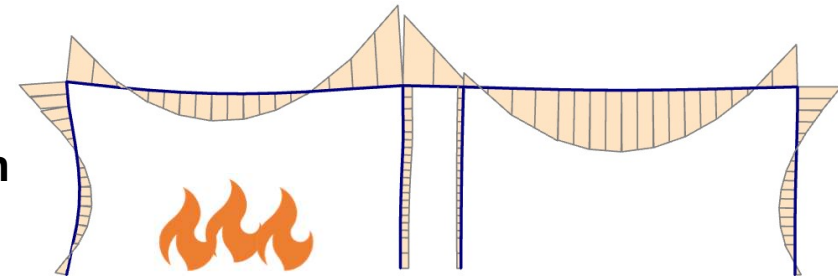
60 min



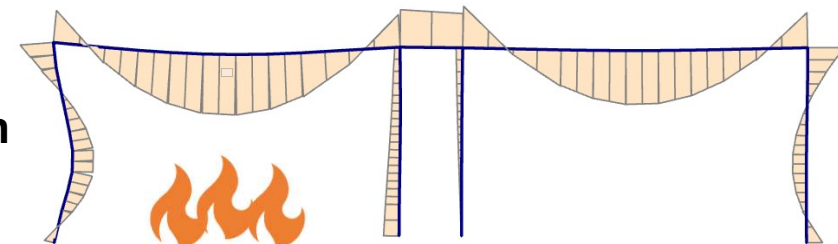
120 min



240 min



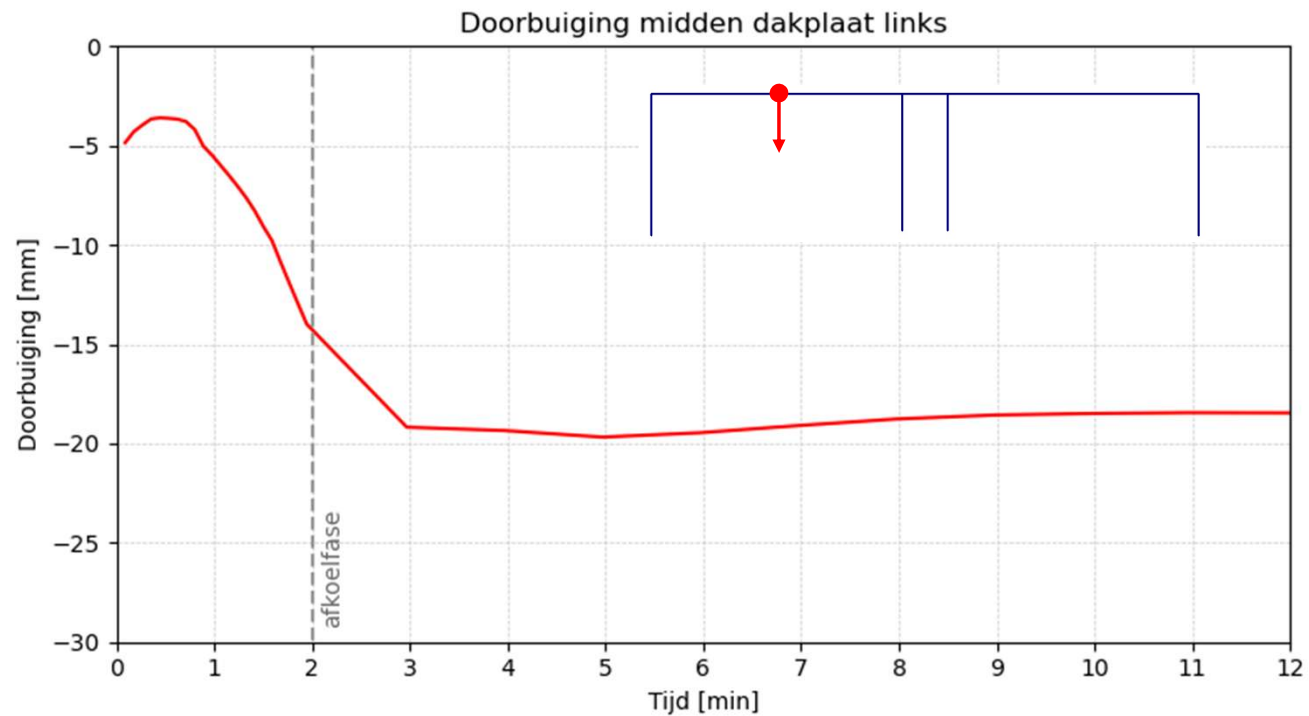
720 min



Vervormingen 10x uitvergroot

Case studie

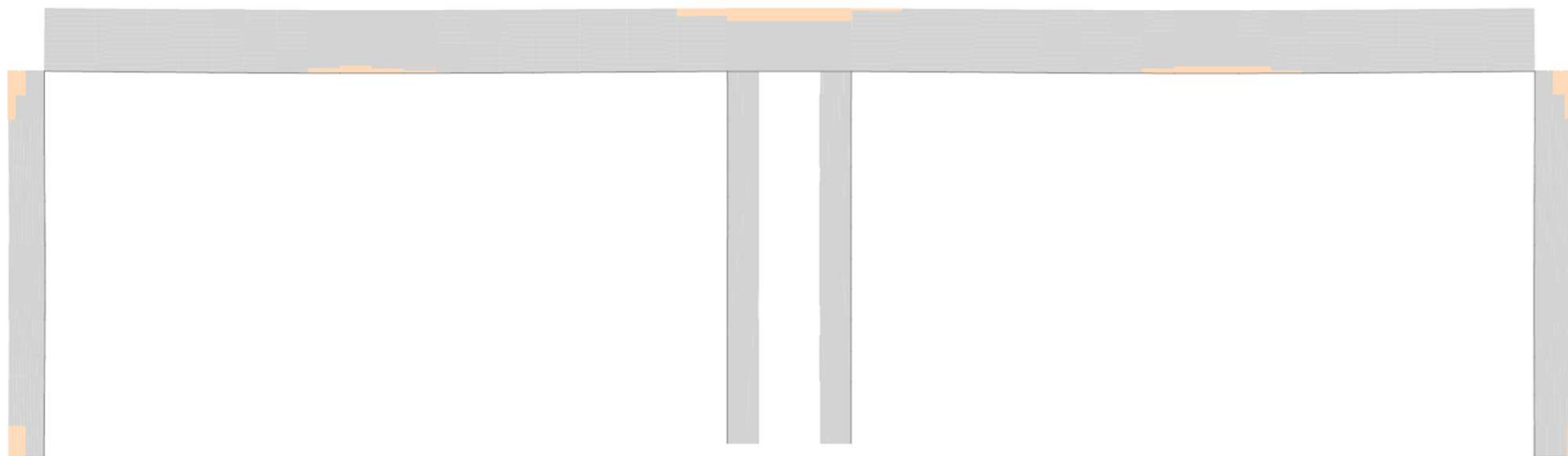
Mechanische analyse: doorbuiging dakplaat



Case studie

Mechanische analyse: schadevorming

Schade na 0 min



Fully cracked Lightly cracked Not cracked

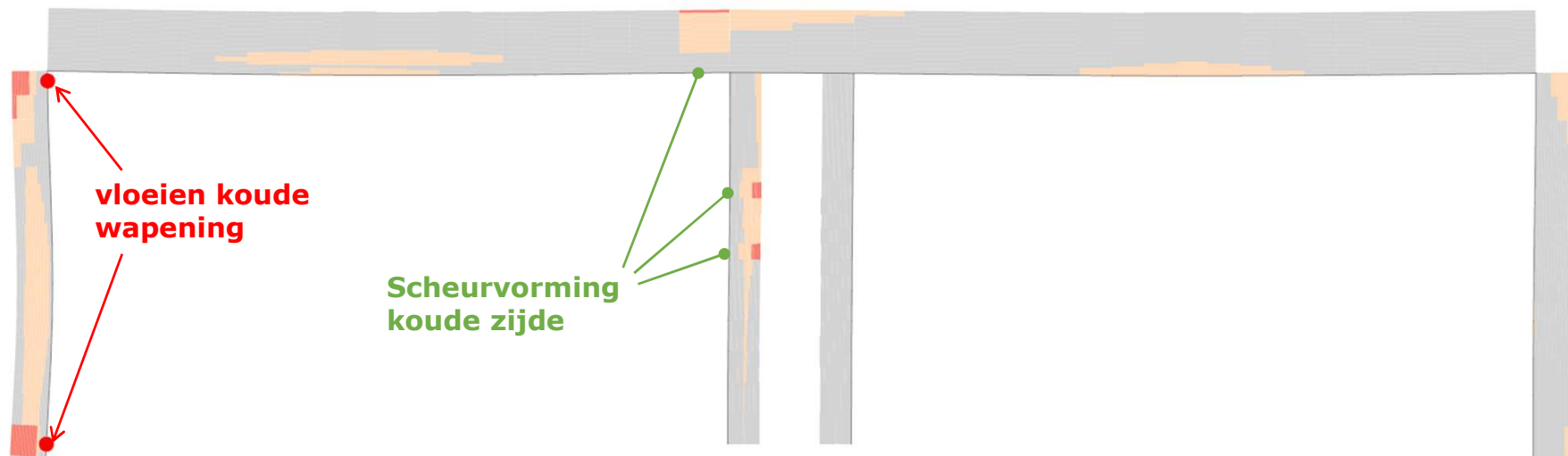
Severely cracked sections: 0m
Plastic steel strain at 0 sections

Vervormingen 5x uitvergroet

Case studie

Mechanische analyse: schadevorming

Schade na 60 min



Fully cracked Lightly cracked Not cracked

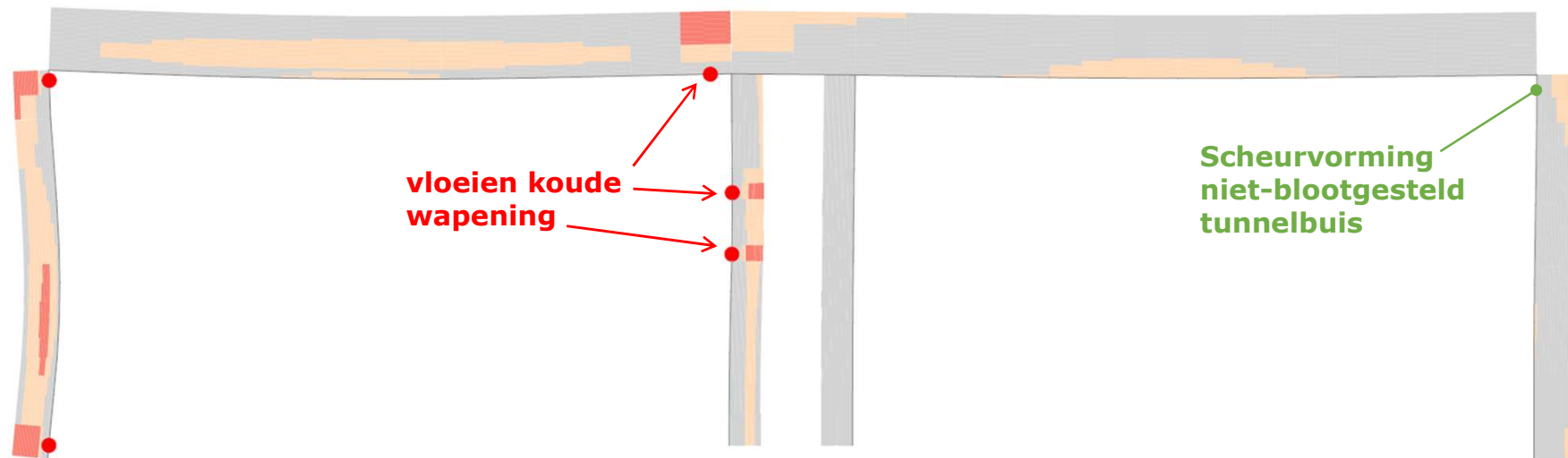
Severely cracked sections: 2.51m
Plastic steel strain at 2 sections

Vervormingen 5x uitvergroet

Case studie

Mechanische analyse: schadevorming

Schade na 120 min



Fully cracked Lightly cracked Not cracked

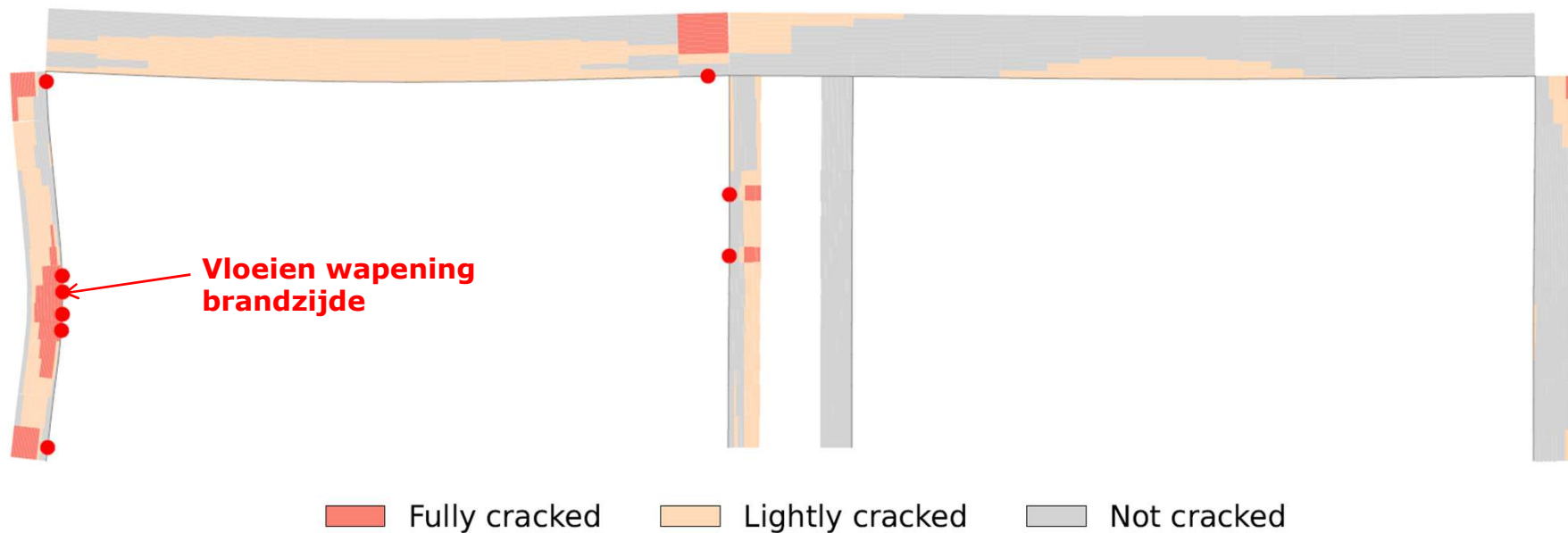
Severely cracked sections: 4.05m
Plastic steel strain at 5 sections

Vervormingen 5x uitvergroet

Case studie

Mechanische analyse: schadevorming

Schade na 720 min



Severely cracked sections: 4.6m
Plastic steel strain at 9 sections

Schade neemt toe tijdens afkoelfase

Vervormingen 5x uitvergroet

Deel 4

Conclusies

Conclusies



Performance-based brandontwerp zorgt voor dieper inzicht (krachtenherverdeling, schade ...)



Tunnelbrand kan leiden tot grote schade aan de koude zijde → duurzaamheidsproblemen



Tijdens de afkoelfase van een brand kunnen structuren verder beschadigd geraken

PYRO
Engineering



UNIVERSITEIT
GENT

Vragen?

Thomas Thienpont

18 December 2025

