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# Concrete renovation and enhancing of fire protection of an existing tunnel with sprayable polymer cement concrete (SPCC)

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# Concrete renovation and enhancing of fire protection of an existing tunnel with shotcrete

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- Tuesday, 05.09.2017 -

## Structure

1. Project introduction
2. Calculation of fire protection
3. Current standards for tunnel fire protection
4. Evaluation of enhancing fire protection systems
5. Application of fire resistant shotcrete

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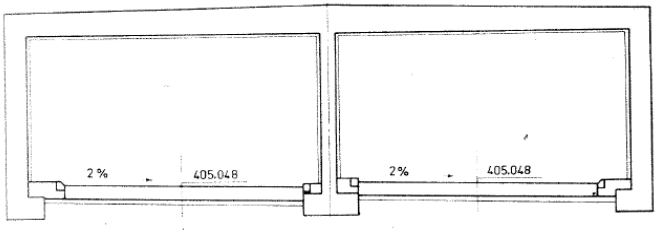
# Project introduction – Tunnel Lüdenscheid

- Historical city center tunnel (1971)
- Length: 342 m
- 2-cell rectangular-frame
- Concrete B300 / B450

→No fire resistance

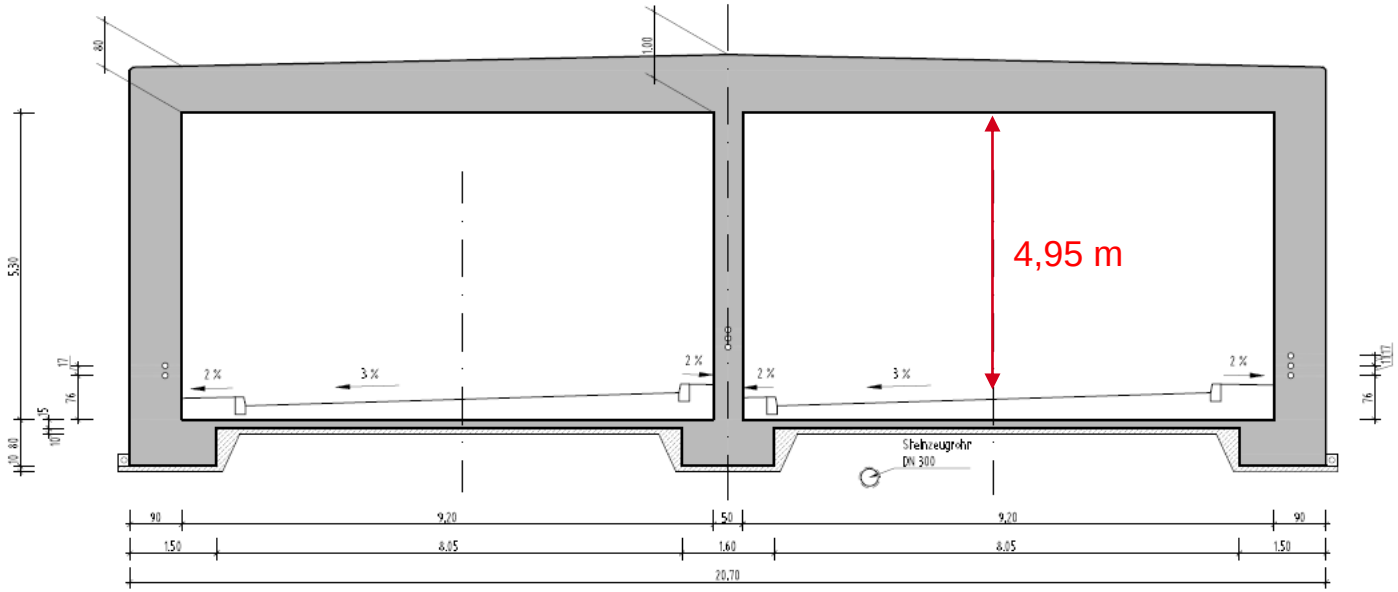
City center above the tunnel

East portal of Tunnel Lüdenscheid




Concrete lining without additional fire protection

# Project introduction – Tunnel Lüdenscheid



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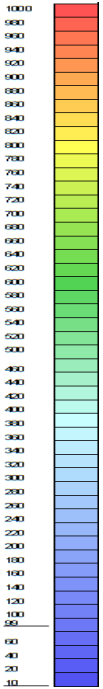
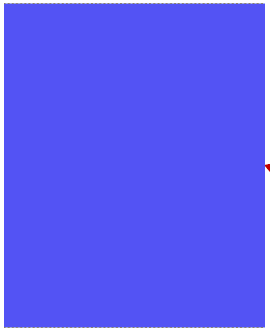
# Calculation of fire protection

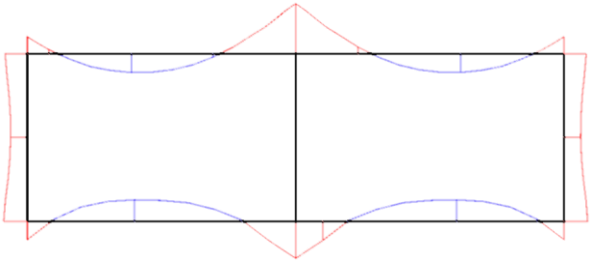
Start, t = 0 min



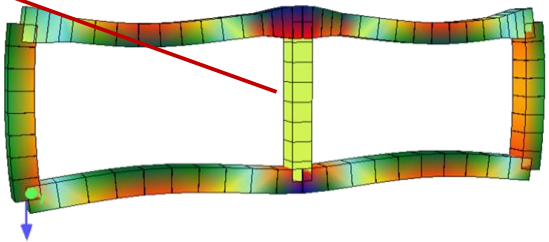

Temperatur development in concrete stucture




Bending moments via Non-linear calculation

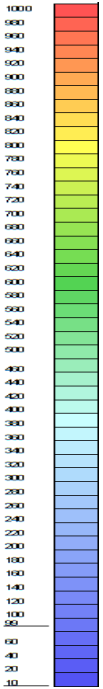


Deformation figure



# Calculation of fire protection

Fire case, t = 1 sec

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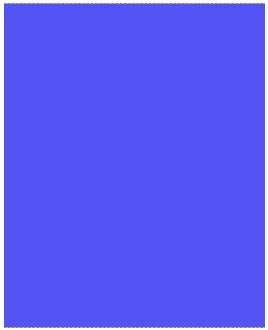
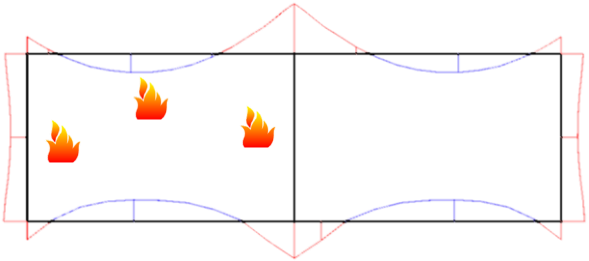
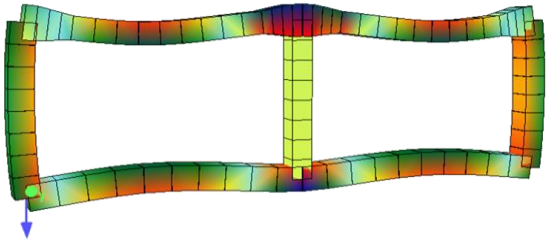



Bending moments via Non-linear calculation

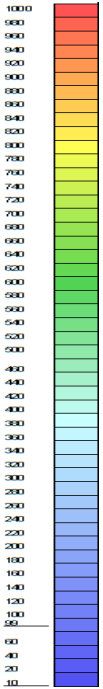


Deformation figure

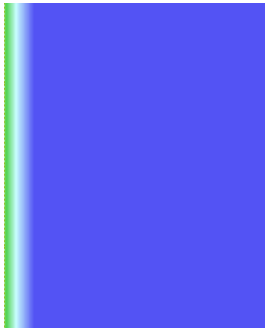


# Calculation of fire protection

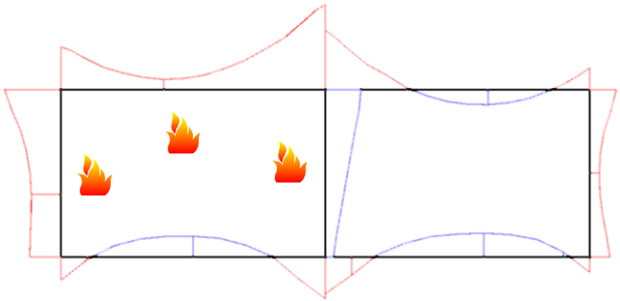
Fire case, t = 10 min



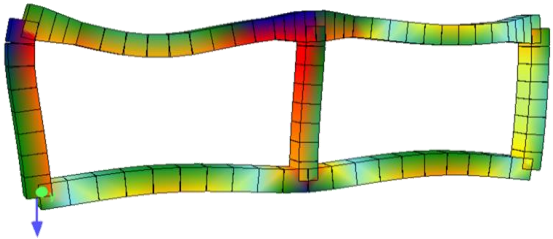

Temperatur development in concrete stucture




Bending moments via Non-linear calculation

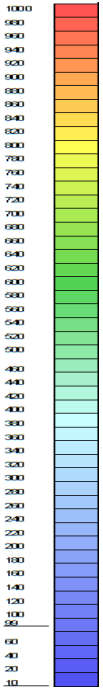


Deformation figure



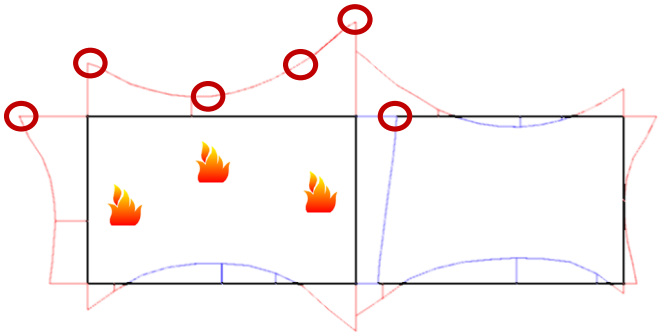
# Calculation of fire protection

Fire case, t = 30 min

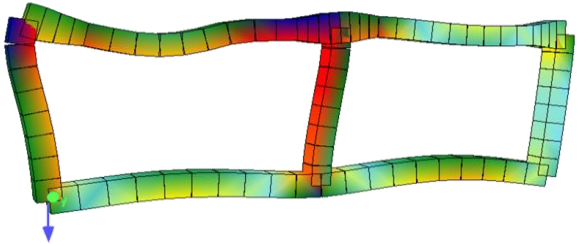



Temperatur development in concrete stucture


Bending moments via Non-linear calculation



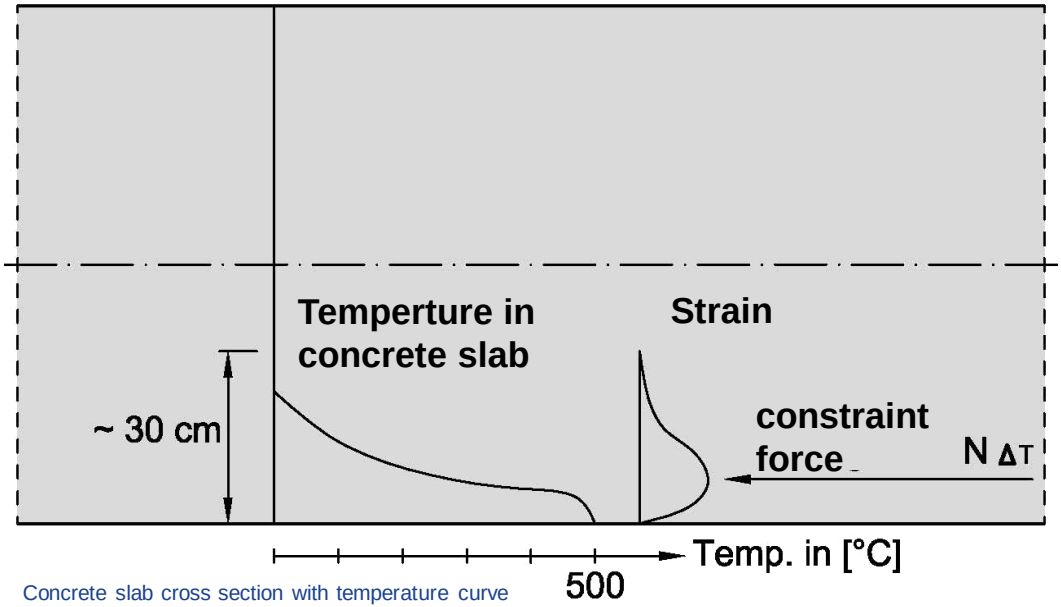
Deformation figure



## Calculation of fire protection

- Hindering of thermal expansion causes huge internal forces

- Internal forces of a concrete slab in fire case



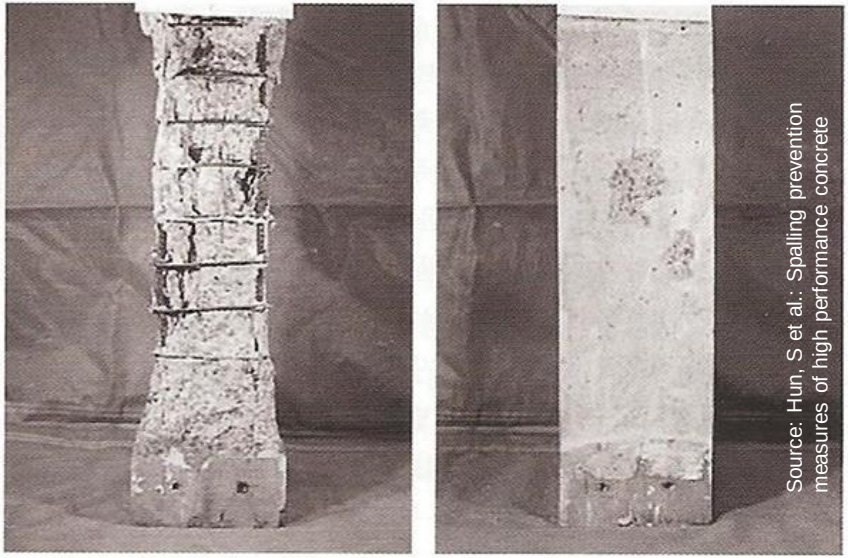

Concrete slab cross section with temperature curve

# Diversion: Heat vs. Concrete

Reinforced concrete:

- Outer Layers heated
- water evaporates
- Spalling occurs

- Exposure of rebars
- Lost strength




Concrete affected by spalling vs. undeformed concrete

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# Current standards for tunnel fire protection

- German standards
  - Structural stability in case of fire
  - Serviceability after fire
  - Structural measures
    - Rebars temp < 300°C
    - $c_{nom}$ = 6cm
    - PP-fibres

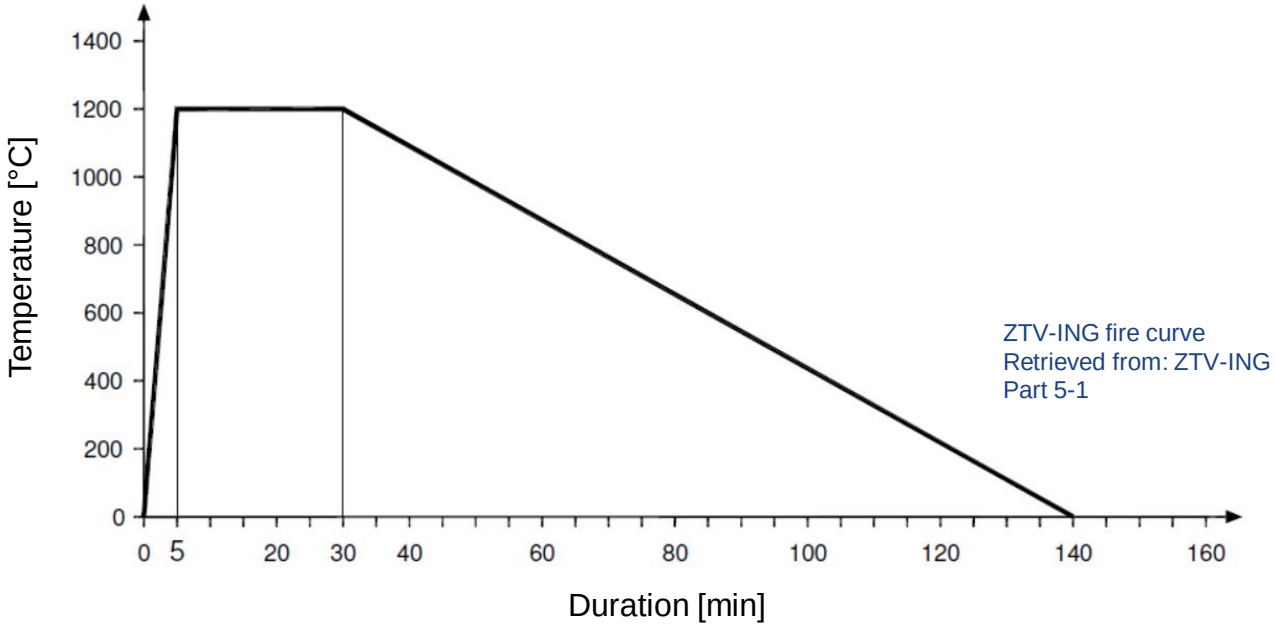
No enhancing fire protection proposals

No European guidelines

No details how to pass fire tests

# Current standards for tunnel fire protection

## Fire curve (ZTV-ING)




ZTV-ING fire curve
Retrieved from: ZTV-ING Part 5-1

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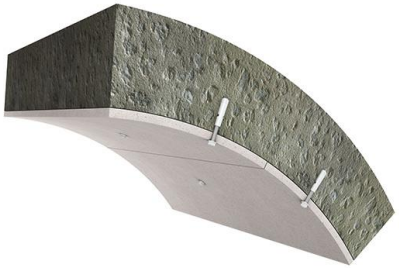
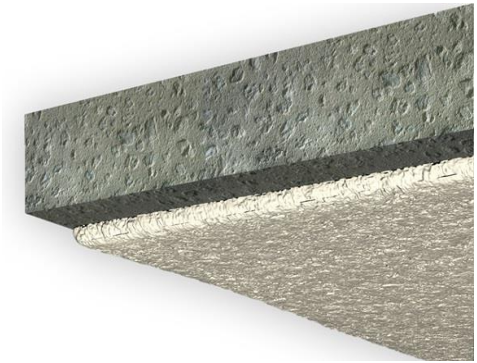
# Enhancing fire protection systems

- V1: Linings
  - Known as fire protection
  - Rigid sub structure
  - Covers cracks
- V2: PCC/SPCC (synthetic compounds)
  - Greater thickness
  - No fire protection experience
- V3: PP-Fibre Shotcrete
  - No fire tests little experiences
  - Realcalisation
- V4: Sprayed on fire protection
  - No European registration for tunnel constructions
  - Minimal thickness



Fire resistance panels



Fire resistance shotcrete

## Version 4 – Spray-Applied Fire Resistive Material

Product: Cafco Fendolite – MII (Promat)

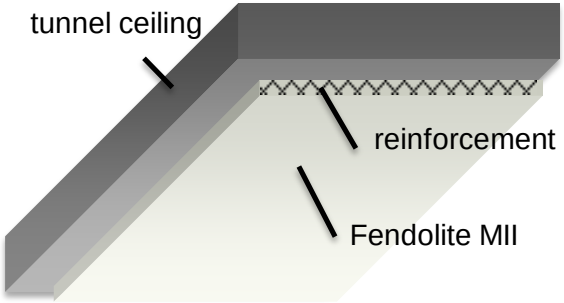
(or similar products)

- Light weight shotcrete
- Components:
  - cement (binder)
  - Vermiculite:
    - Not inflammable
    - Thermally isolating
- Thin layers

# Version 4 – Spray-Applied Fire Resistive Material

## Application

- Bonding Latex
  - Application as adhesive primer
- Mesh reinforcement
  - Tests without reinforcement
  - For long term durability lightweight mesh
- Retaining Anchors
  - Holding reinforement in place




Layer of the fire resistive Shotcrete

Stainless steel mesh as reinforcement

# Version 4 – Spray-Applied Fire Resistive Material

Provide fire protection for structural steel and concrete

Benefits:

- Proven durability
- Also applied in oil and gas industry
- Lightweight
- Leaking spots not covered
- Prevents concrete spalling

Offshore oil platform – potential area of application for fire protection shotcrete

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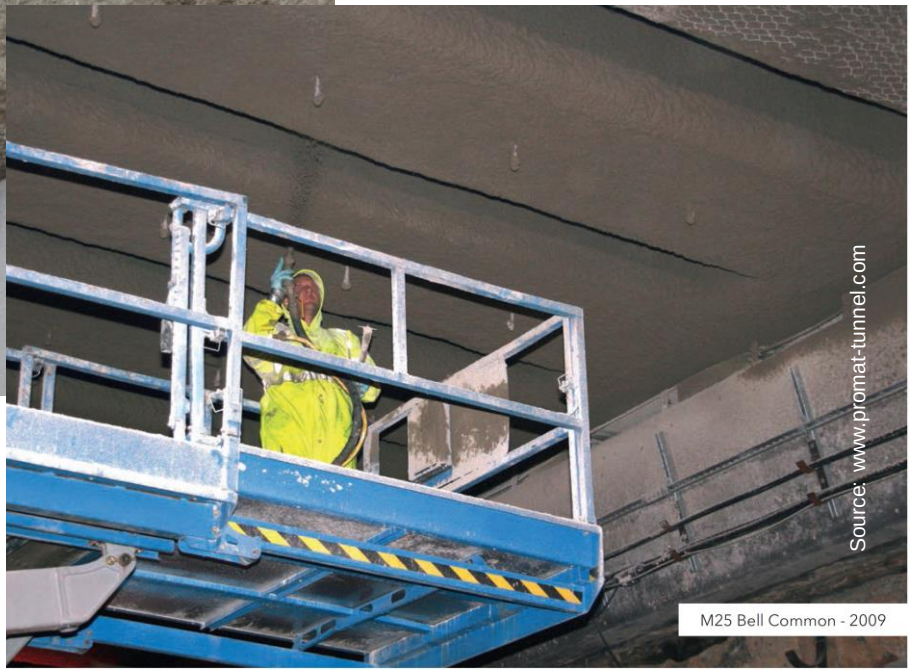
# Version 4 – Spray-Applied Fire Resistive Material

Application of the fire resistive shotcrete

Example of construction in a tunnel in London



# Application in Tunnel Lüdenscheid

- 40 mm sprayable light weight fire protection material
- Ceiling and upper wall areas

- Realkalisation by SPCC
- Lower walls

Application of the fire resistive shotcrete in Tunnel Lüdenscheid


Thank you for your attention
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