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

Stefan Peters  
IMM, Germany, c.peter@imm-bochum.de

U. Versen  
IMM, Germany

Stefan Peters  
IMM, Germany

Follow this and additional works at: http://dc.engconfintl.org/shotcrete_xiii

Part of the Engineering Commons

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

IMM Maidl & Maidl, Consulting Engineers

Stefan Peters M.Sc.

- 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
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
Project introduction – Tunnel Lüdenscheid

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

→ No fire resistance
Enhancing fire protection with Shotcrete
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
Calculation of fire protection

Start, $t = 0$ min

Temperatur development in concrete structure

Bending moments via Non-linear calculation

Deformation figure

80 cm
Calculation of fire protection

Fire case, $t = 1$ sec

Temperatur development in concrete structure

Bending moments via Non-linear calculation

Deformation figure

80 cm
Calculation of fire protection

Fire case, $t = 10$ min

Temperatur development in concrete structure

Bending moments via Non-linear calculation

Deformation figure

80 cm
Calculation of fire protection

Fire case, $t = 30$ min

Temperatur development in concrete structure

Bending moments via Non-linear calculation

Deformation figure

80 cm
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

Source: Hun, S et al.: Spalling prevention measures of high performance concrete
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
Current standards for tunnel fire protection

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

Temperature [°C] vs. Duration [min]

ZTV-ING fire curve
Retrieved from: ZTV-ING Part 5-1
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
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
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 reinforcement in place
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
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
Version 4 – Spray-Applied Fire Resistive Material

Application of the fire resistive shotcrete

Example of construction in a tunnel in London

Source: www.promat-tunnel.com
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

Stefan Peters M.Sc.