



Tunnelling Asia' 2023

International Conference on
Climate Change Resilience and Sustainability
in Tunnelling and Underground Space



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Passive Fire Protection & Light Reflective Coating of Tunnel

by

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Target Market Head – Refurbishment

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November 22-23, 2023, Mumbai, India



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A BRIEF HISTORY OF TUNNEL FIRES

- 177 tunnel fires were recorded since 1866 – first one in UK
- 28 major events from 1949 & 2008
 - >700 deaths
 - >1000 injured
 - > € 1 bn loss
 - > 500 Vehicles destroyed

(a) Gottard Road Tunnel, Switzerland, 2001



(b) Channel tunnel, France, 2008



(c) Yanhou Tunnel, China, 2014



(d) Skatestraum tunnel, Norway, 2015



(e) Rannersdorf tunnel, Austria, 2019



(f) Samae 2 Tunnel, Korea, 2020





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- Fire rises very fast in tunnels.
- Unprotected mass concrete and reinforced concrete tunnel walls are quickly and completely destroyed when exposed to temperatures of over 400°C.
- Temperature can rise up to more than + 1'000°C and can last for hours.



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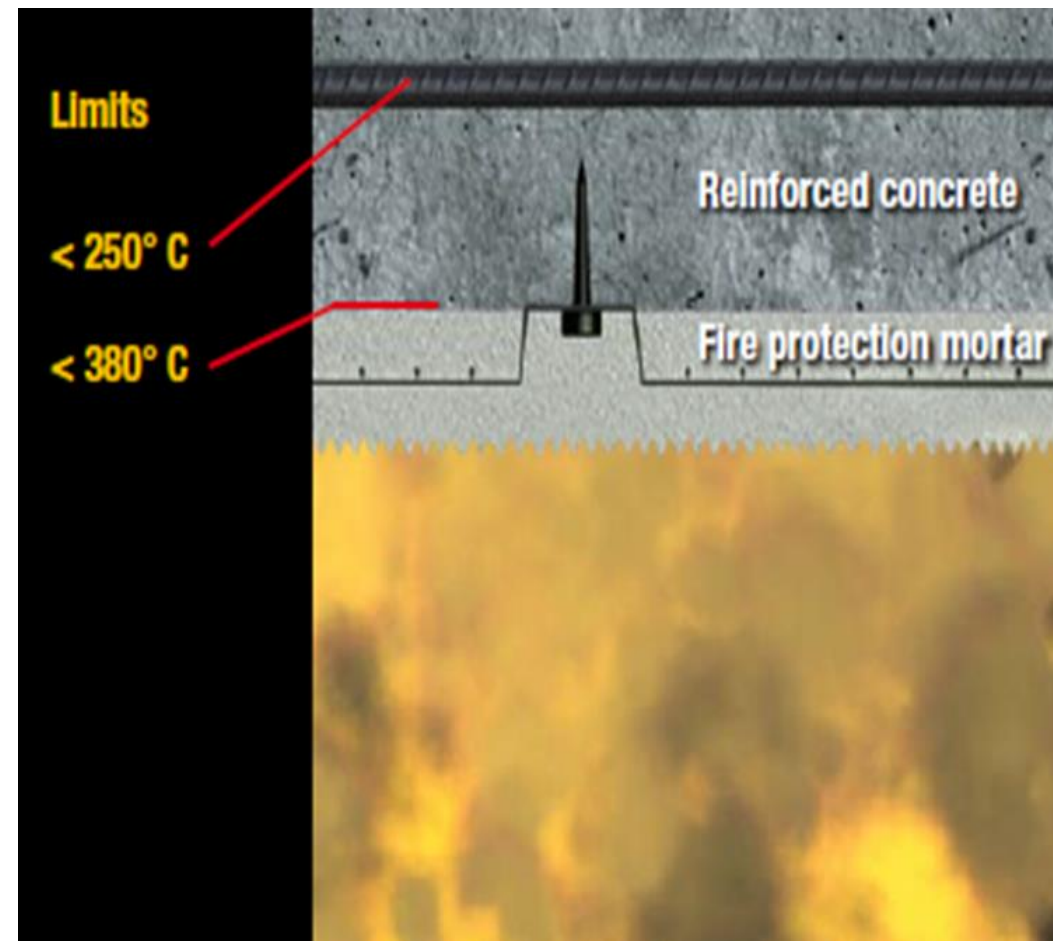
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REQUIREMENT FOR FIRE PROTECTION IN TUNNEL

Passive fire protection systems should meet the following requirements:

- Concrete temperatures during the fire exposure **< 380°C**
- Steel reinforcement temperatures during the fire exposure **< 250°C**
- No spalling during the fire exposure
- No delamination of the fire protection material after the fire exposure test





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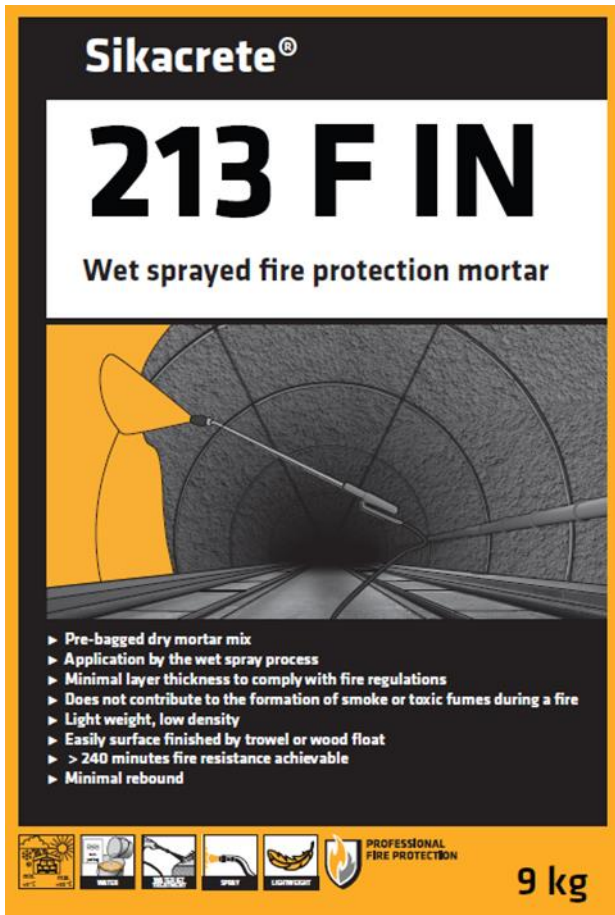
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INNOVATIVE PASSIVE FIRE PROTECTION MORTAR FOR TUNNELS

- Sika developed Cementitious wet sprayed fire protection mortar, containing phyllosilicate aggregates, which are highly effective in resisting the heat of hydrocarbon fires.
- Also suitable for fire protecting all types of reinforced concrete buildings and civil engineering structures including tunnels, FRP (Sika® Carbodur® & SikaWrap®).

TECHNICAL DETAILS

- Reaction to Fire Euroclass A1
- UL Certified
- Complies with RWS Fire Curve





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STANDARD TEST METHOD FOR CEMENTITIOUS, FIRE PROTECTION MORTAR FOR WET SPRAY APPLICATION

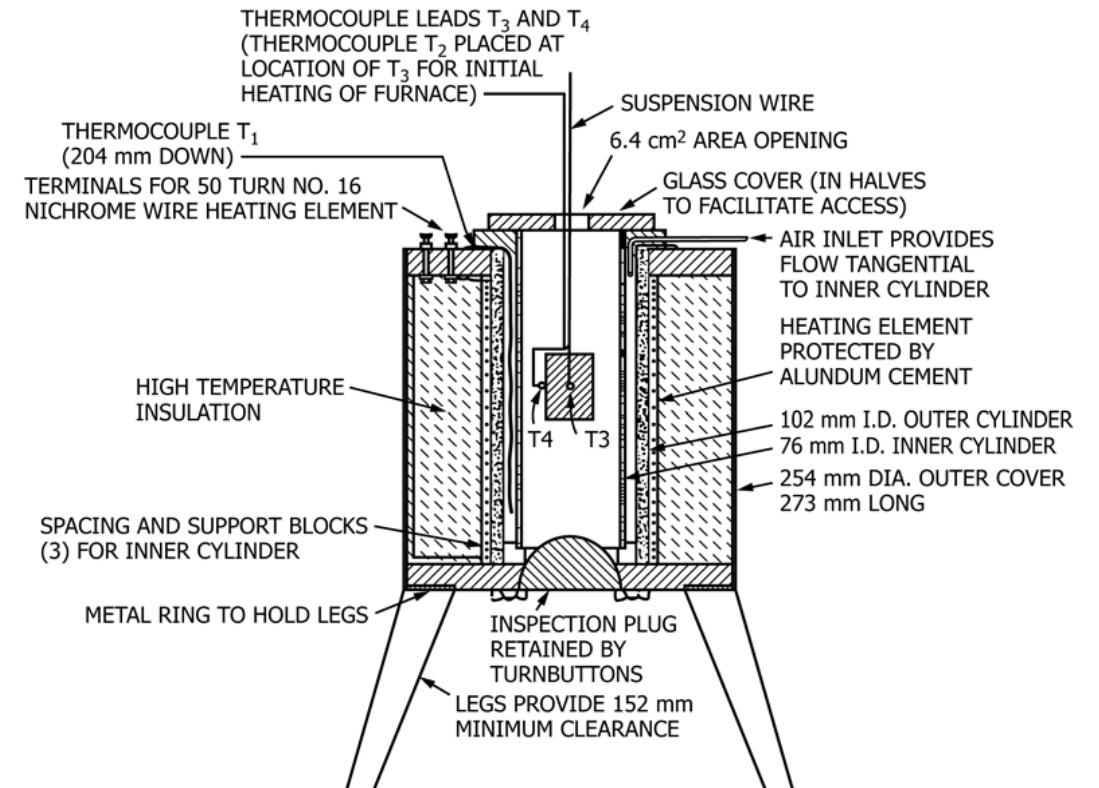
Combustibility Test as per ASTM E136

Standard Test Method for Assessing Combustibility of
Materials Using a Vertical Tube Furnace at 750°C

ASTM E119 for Thermal Conductivity & Specific Heat

ASTM E605 for Density of Sprayed Fire-Resistive
Material (SFRM) Applied to Structural Members

ASTM E736 for Cohesion / Adhesion Strength of
Sprayed Fire-Resistive Materials Applied to Structural
Members





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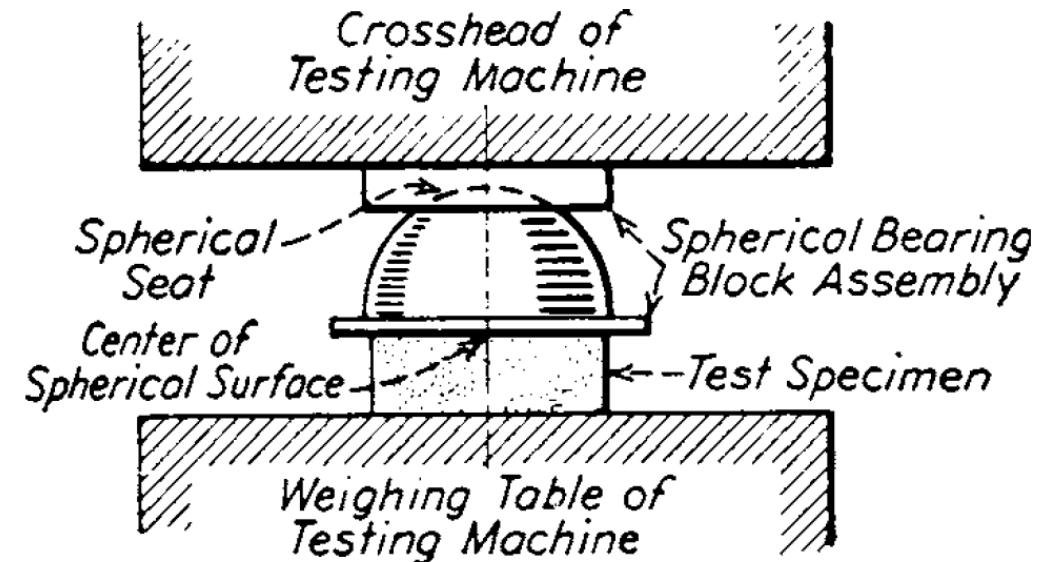
STANDARD TEST METHOD FOR CEMENTITIOUS, FIRE PROTECTION MORTAR FOR WET SPRAY APPLICATION

ASTM E761 for Compressive Strength of Sprayed
Fire-Resistive Material Applied to Structural Members

ASTM E1269 for Specific Heat
Standard Test Method for Determining Specific Heat
Capacity by Differential Scanning Calorimetry

ASTM E759 for Effect of Deflection on Sprayed Fire-
Resistive Material Applied to Structural Members

ASTM E760 for Bond Impact
Standard Test Method for Effect of Impact on Bonding
of Sprayed Fire-Resistive Material





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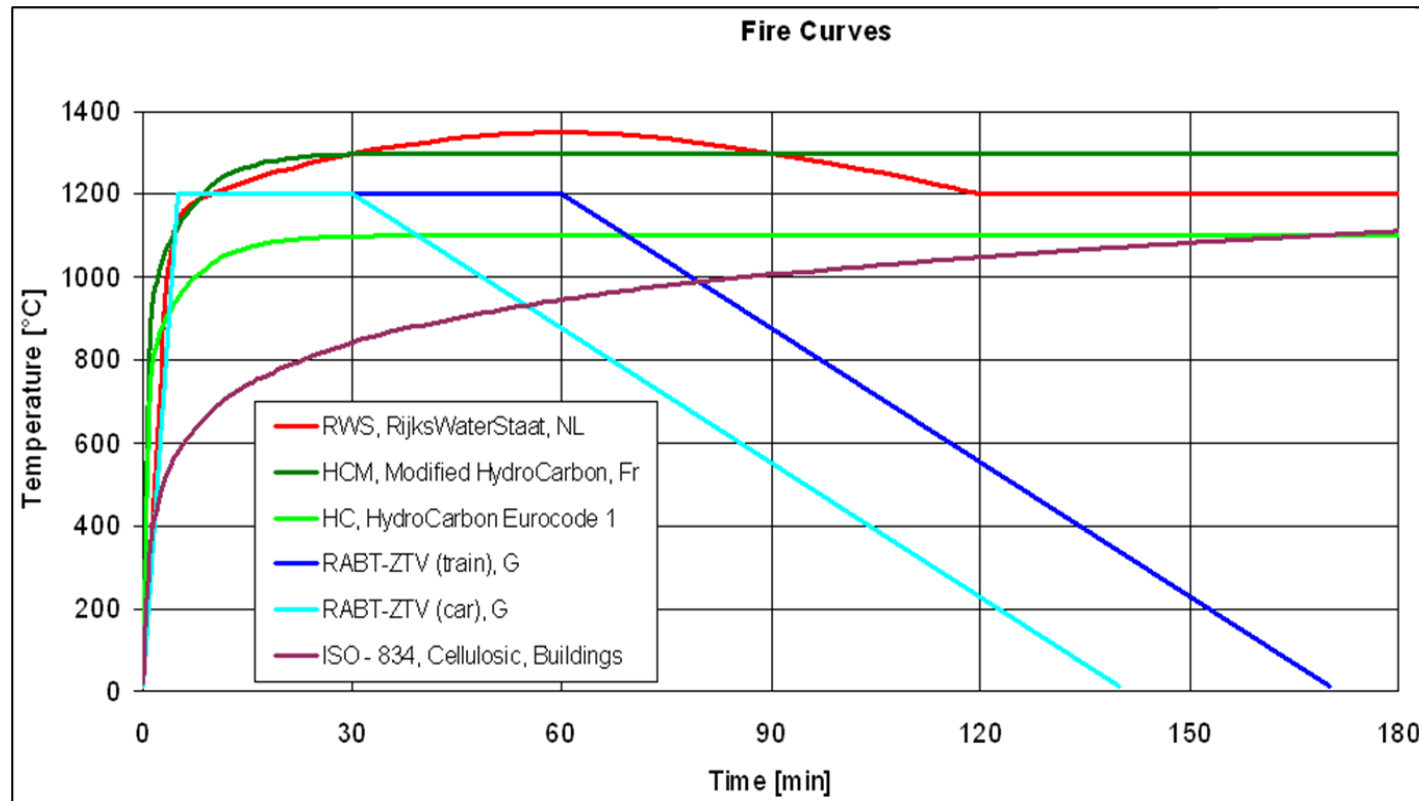
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INTERNATIONAL FIRE CURVES – MOST STRINGENT: RWS



- The most stringent curve is from Netherland, RWS.
- This curve assumes that in a worst-case scenario, a 50 m³ fuel, oil or petrol tanker fire with a fire load of 300MW could occur, lasting up to 120 minutes.
- The RWS curve was based on the results of testing carried out by TNO in the Netherlands in 1979.



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INTERNATIONAL FIRE CURVES – MOST STRINGENT: RWS



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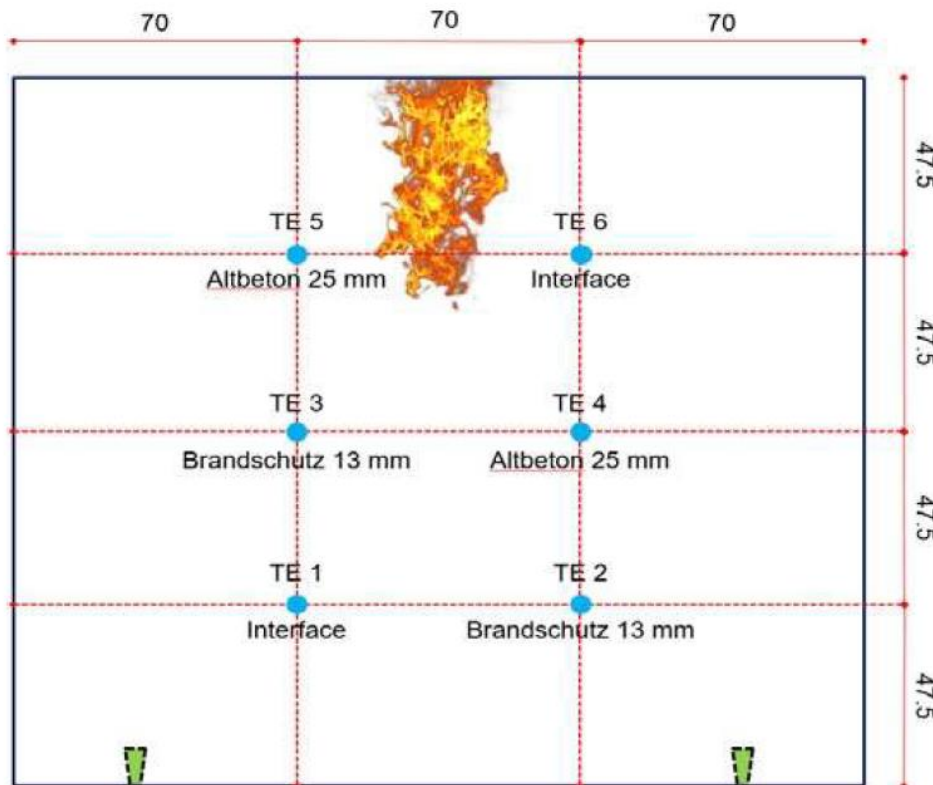
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INTERNATIONAL FIRE CURVES – MOST STRINGENT: RWS



- The furnace used for the fire resistance test has a combustion chamber with an area of 150cm x 150cm and a height of 85 cm.
- The test signals from the 6 sheathed thermocouples inside the test slab and the 4 plate thermocouples in the furnace are converted at a central measuring station and displayed in °C.
- All the temperatures are recorded at 15 seconds intervals.
- The furnace temperature is controlled manually by the operator in line with the specified temperature profile.



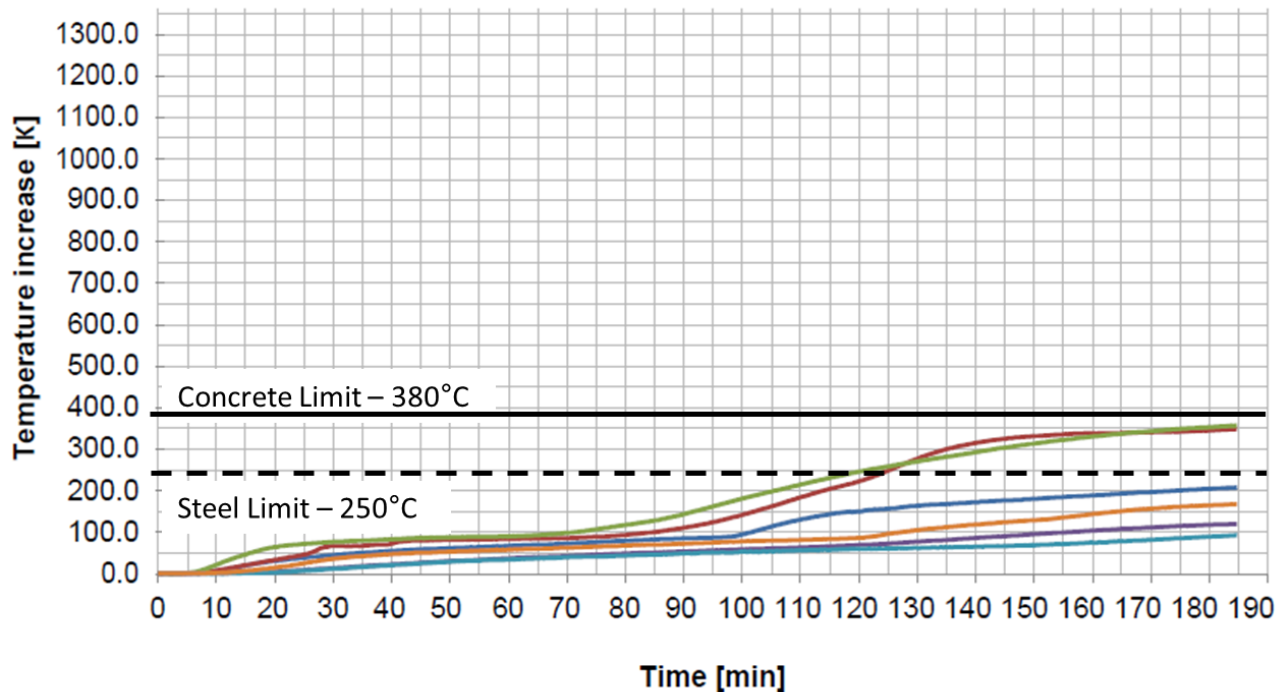
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INTERNATIONAL FIRE CURVES – MOST STRINGENT: RWS

Specimen temperature increase



- TC 1
- TC 2
- TC 3
- TC 4
- TC 5
- TC 6

Thermocouple	Tmax [°C]	Time [min]
TC 1 (Interface)	208	185
TC 2 (At 13mm)	349	185
TC 3 (At 13mm)	358	184
TC 4 (At 25mm)	121	185
TC 5 (At 25mm)	93	184
TC 6 (Interface)	168	185



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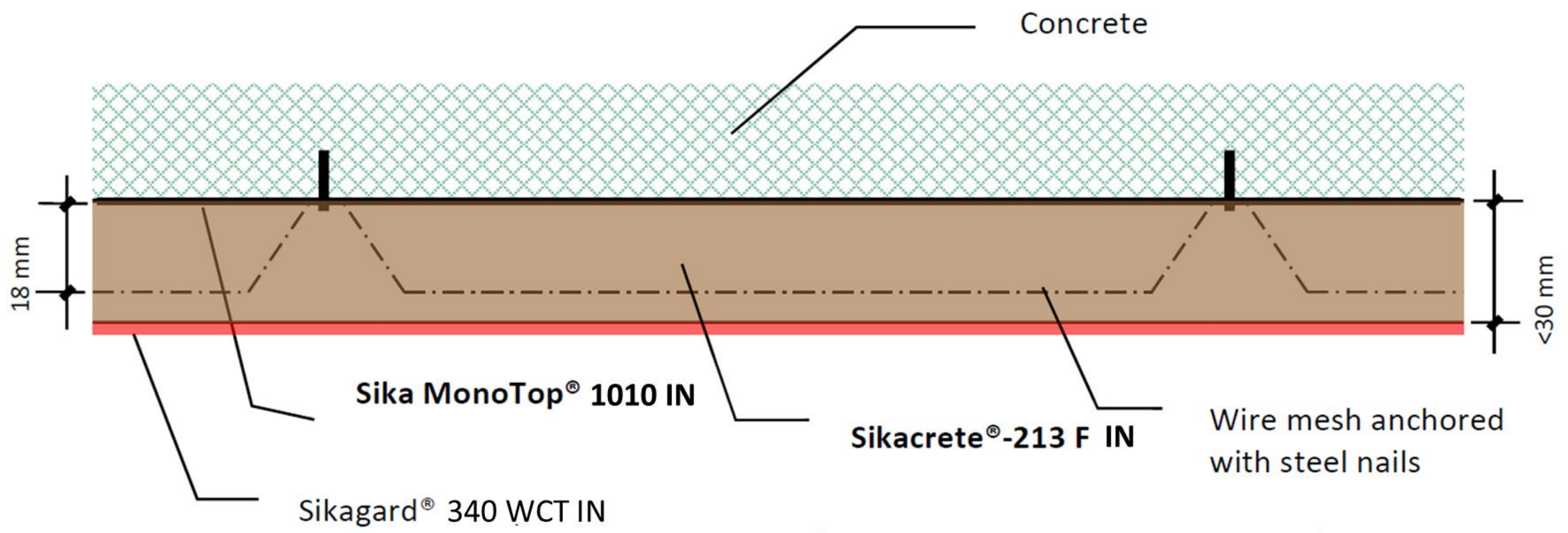
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APPLICATION PROCEDURES – CONCRETE TUNNEL SURFACE





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SIKACRETE – 213 F AT INTERNATIONAL JOURNAL



10/13/21, 4:40 PM Adler Tunnel – Renovation with Fire Protection - tunnel

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tunnel

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05/2012 » Produkte | Products

Fire Protection Mortar

Adler Tunnel – Renovation with Fire Protection

The 5.6 km long Adler Tunnel (1995 till 2000) in the Swiss Jura located between Liestal and Muttanz near Basle constitutes part of the Bahn 2000 project. Cracks in the vault over a length of some 40 m near the portal at Muttanz were perceptible only some 10 years after the 2-track Swiss Federal Railways (SBB) tunnel was commissioned. The cause is the swelling gypsum keuper in the surrounding rock, which has raised the tunnel floor by up to 7 cm in the course of time by continuously absorbing water. As a consequence 6 m high and 3.50 m wide concrete bars were installed in this tunnel section as abutments, which were tensioned using anchors and micro-piling to divert the pressure into the rock.

Requirements

The reinforced concrete bars and the rock anchor heads had to be protected for 60 minutes in accordance with the ISO 834 fire curve in the event of fire so that the tunnel inner shell and abutment zone do not exceed the temperature of 200 °C and the anchor heads 120 °C after this period. In their subsequent operational state the anchor head recesses have to be accessible at all times for monitoring purposes and retensioning the anchors.

A fire protection system was selected for maintaining the clearance profile, which complied with requirements although only 3 cm thick. In addition it had to be capable of withstanding the suction and pressure forces caused by train services in the tunnel, so that a minimal strength of 4 kN/m² is demanded from the fire protection layer. Trains continued operating on a single track throughout as it was not possible to close the tunnel completely in order to carry out the fire protection measures.

Choice of System

The fire protection mortar Sikacrete-213F was applied on account of the requirements posed on fire protection. This is a hydraulically bonded spraying mortar with

https://www.tunnel-online.info/en/artikel/tunnel_2012-05_Adler_Tunnel_Renovation_with_Fire_Protection_1459925.html

10/13/21, 4:40 PM Adler Tunnel – Renovation with Fire Protection - tunnel

Vermiculite used as filler, which affords effective thermal insulation when swollen. This mortar is easy to handle catering for a thin layer thickness and coating; it is tested according to ISO 834 and fulfils the even stricter Dutch dimensioning curve RWS over 2 hours given a layer thickness of only 25 mm.

This fire protection system was also chosen on account of the findings obtained during the extensive fire protection redevelopment of the Wien Mitte Metro station in mid-2009 [4]; 2,200 m² was protected against fire there with Sikacrete-213F given a 25 mm layer thickness in keeping with EN 13501 (REI 180). This fire protection mortar, which is only mixed with water without needing an accelerator, is extremely simple to process.

Executing Construction

First of all the concrete is roughened by high pressure water jet to attain optimal adhesion with the foundation and then wire meshing is placed on the area to be protected. This reinforcement (Bekaert Armanet FP) enhances the service life of the fire protection system – also regarding its resistance to the strain produced by passing trains. Then the fire protection mortar is applied by the wet spraying /thick flow method (screw pump); its surface can be left rough, smoothed or initially coated; in this case the surface was smoothed. Replaceable fire protection plates were installed in the vicinity of the anchor head to facilitate monitoring and retensioning the anchors.

The fire protection mortar was placed section-by-section on account of ongoing train services: first of all in the roof zone and then at the abutments, then the activities were moved to the other track and the other side of the tunnel tackled.

Altogether some 750 m² of Sikacrete-213F was used for the redevelopment scheme. On average 6 kg/m² per 10 mm layer thickness was applied; no accelerator was utilised for this wet sprayed mortar. The fire protection system was applied by Viktor Wyss; the main contractor was the Marti Unternehmung AG and the Basler & Hofmann AG the project compiler for the redevelopment. →G.B.

This article appeared in
tunnel 05/2012

subscription

Content

https://www.tunnel-online.info/en/artikel/tunnel_2012-05_Adler_Tunnel_Renovation_with_Fire_Protection_1459925.html



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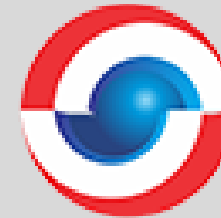
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LOCAL PROJECT REFERENCE BY

BUILDING TRUST



&



Structural Specialities
& Projects (India) Pvt. Ltd.



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PROJECT NAME: SAMRUDDHI EXPRESSWAY TUNNEL (PACKAGE-14)

System Structure

To maintain the structural stability of the Tunnel under a minimum **fire load of 100 MW**, a passive fire protection system **complying to RWS fire curve** was applied over the crown of the tunnel in a layer thickness of 20 mm to get the desired protection.

In addition to passive fire protection of tunnel, a light reflective, durable and washable water-based epoxy topcoat system is applied over the tunnel walls up to a height of 5.75m having gloss performance of 55~60% as per ISO 2813, degree of luminosity of 60%, fire classification of A2-s1, d0 as per EN13501-1.

PROJECT PARTICIPANTS

- Project owner: Maharashtra State Road Development Corporation
- Consultant: EPTISA Servicios De Ingenieria S.L
- Main Contractor: Afcons Infrastructure Limited
- Applicator: Structural Specialities & Projects (India) Pvt. Ltd.



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Wire mesh Installation at Tunnel
Crown



Primer Coat of Sika MonoTop-1010 IN



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Application of Passive Fire Protection Mortar Sikacrete-213 F IN over Tunnel Crown



Sikacrete-213 F IN Passive
Fore protection Mortar

Sikagard-340 WCT IN Light
Reflective Coating



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THANKS