ENGINEERED REFURBISHMENT FIRE PROTECTION MORTAR Sikacrete®-213 F

EFFECTIVE SAFEGUARD YOUR STRUCTURES

BUILDING TRUST

SIKA SOLUTIONS – THE EFFECTIVE FIRE BARRIER

Fire has been a fascinating element for thousands of years. Many achievements in the history of mankind were only possible thanks to its help. When controlled, fire has brought us success and wealth. However when fire is uncontrolled, it hurts us so badly when our achievements of decades are destroyed by it; people are harmed or even lose their lives.

Therefore it is in everyone's interest to be able to control this powerful and elemental force.

Sika offers comprehensive solutions when fire-resistant structures protect commercial, public and private residential buildings from destruction. The cost of effective fire protection usually accounts for only two to three percent of the construction costs. Our products meet the latest standards and have relevant approval.

DESTRUCTION OF CONCRETE AND STEEL CAUSED BY FIRE

DURING A FIRE concrete is continuously eroded and its strength and structure can be completely destroyed. The embedded reinforcing steel is exposed to high heat transfer temperatures inside the concrete and steel loses its static and dynamic load-bearing properties when this heat becomes too great.

In mass concrete and reinforced concrete exposed to fire, as the temperature rises above 100°C, the liquid capillary water (free water) and 'physically bound water' (in gel pores and interstitial layers), changes to water vapor and then steam. As the temperature continues to increase, so does the water vapor pressure in the concrete; at the beginning the steam readily escapes on all sides through the capillary pores and cracks in the concrete without any problems.

However, as vapor continues to form at an increasing rate and steam escapes through the surface facing the flames, the available spaces for continued vapor expansion inside the pores and capillaries of the concrete are filled relatively quickly.

A vapor 'saturation zone' is then created into which additional vapor can no longer enter, therefore as the temperature continues to rise, the vapor pressure in the saturation zone also keeps increasing.

As soon as this pressure is higher than the internal tensile strength of the concrete matrix, the concrete fractures and spalls, a new saturation zone is rapidly created behind the newly exposed concrete surface and this destructive scaling process continues. As a result, concrete is continuously eroded during a fire and its strength and structure can be completely destroyed.

During the fire, the embedded reinforcing steel is exposed to high heat transfer temperatures inside the concrete and steel loses its static and dynamic load bearing properties when this heat becomes too great (above 250°C the tensile strength of the steel is already reduced by around 20%).

FIRE IN A TUNNEL: THE EFFECTS ON REINFORCED CONCRETE

A TUNNEL FIRE is an extreme situation for motorists and passengers, the rescue services, plus the rolling stock or vehicles and the tunnel structure itself.

In the event of a fire in a tunnel, the temperatures rapidly become very high because the heat inside cannot easily escape, therefore the fire spreads extremely quickly and so can soon ignite other carriages or vehicles, as well as their goods and other contents.

Dependent on the type and number of burning vehicles and their loads, temperatures of over 1,000°C can easily develop in the tunnel and this can last for several hours.

The transportation of goods on road and rail networks is subject to many risks. One of the greatest hazards is a fire in a tunnel and the likelihood of this increases the more the volume of traffic multiplies on our roads and railways. The extreme heat, smoke and other fumes generated can greatly hinder or even prevent people's evacuation, early vehicle removal and extinguishing of the fire.

Unprotected mass concrete and reinforced concrete tunnel walls are quickly and completely destroyed when exposed to temperatures over 400°C. In a tunnel fire this means that such an event usually results in the collapse of the tunnel soffit, or even the total collapse of tunnels through unstable geological situations.

In addition to the obvious initial human and economic losses, severe fire damage to a tunnel structure can also cause serious long-term disruption to the traffic flow, together with substantial additional costs to businesses and individuals, since the necessary remedial and rebuilding works will frequently last for several months.

FIRE RESISTANCE TEST

FIRE PROTECTION SYSTEMS

must be subjected to extreme test conditions to confirm their performance capabilities.

The temperature of a fire in an enclosed concrete structure such as a tunnel or an underground car park, can actually reach 1,000°C within the first 5 minutes. Therefore fire protection systems must also be subjected to extreme test conditions to confirm their performance capabilities.

Therefore these are tested in accordance with established International Standards at accredited fire testing institutes and laboratories. The fire exposure levels to which a fire protection system should be tested depends mainly on the volume and type of traffic, plus the proportion of heavy goods vehicles or containers that are anticipated.

PERFORMANCE REQUIREMENTS

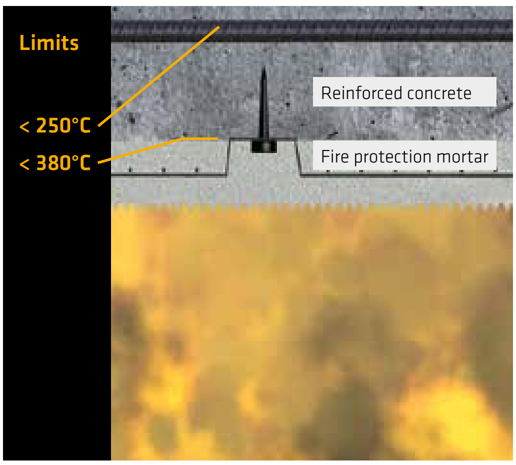
Passive fire protection systems should meet the following requirements:

- 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

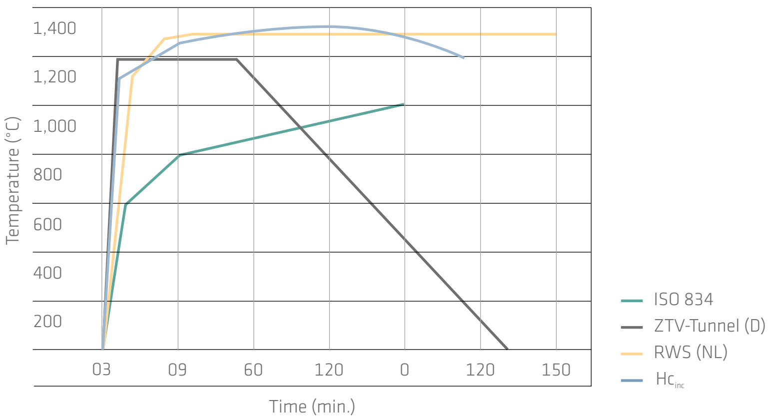
FIRE RATING CURVES

Various fire exposure rating curves are available; the most currently used are:

- ISO 834
- Dutch Rating Curve RWS (Rijkswaterstaat)
- Increased hydrocarbon curve HCinc
- German regulation ZTV-Tunnel



FIRE CURVES

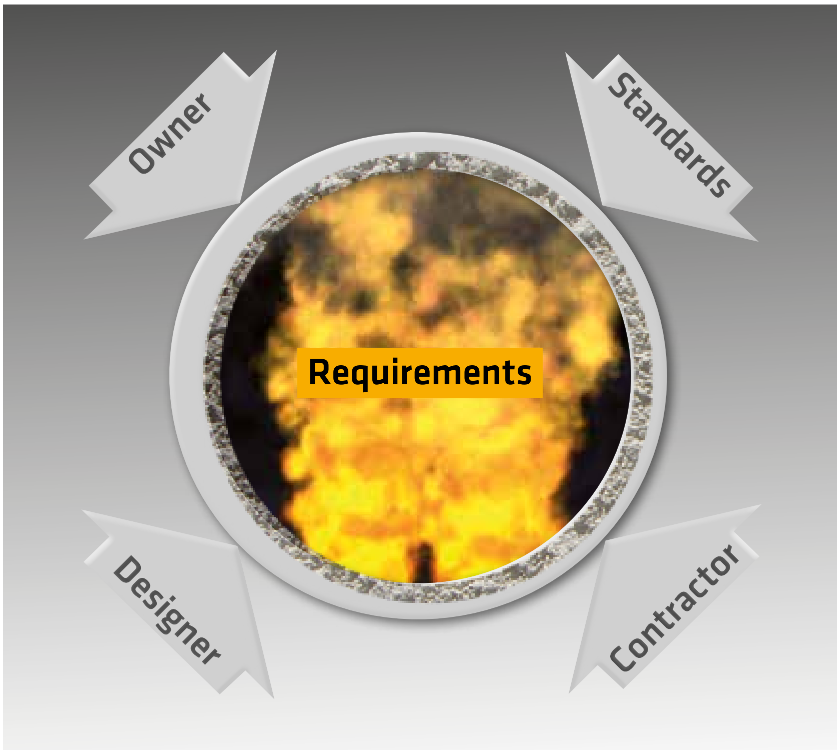


These fire exposure rating curves all simulate the temperature profile of a tunnel fire. The example of the Dutch RWS curve defines the maximum exposure which can be expected in the worst case scenario: This is defined as a fire of a road tanker truck with a load capacity of 50 m³ that is 90% full of liquid hydrocarbon fuel (petrol).

THE REQUIREMENTS FOR A FIRE PROTECTION SYSTEM, especially in a tunnel, are many and diverse.

Technical challenges such as fire resistance, system application details and long term durability must all be overcome and a high cost: performance benefit must be obtained.

The interests of all of the parties involved: authorities (standards), designers, contractors & owners, must define the requirements for fire protection products that are intended for use on specific road and rail structures.



STANDARDS:
Several different fire scenarios are described in International Standards. The European Hydrocarbon Fire Curve increased (HCinc) can be used as an 'umbrella' for all of International Standard fire loads. The HCinc defines a worst case scenario in a road tunnel, where several vehicles are burning simultaneously and the prevailing temperature is 1,300°C, over a period of 4 hours. The fire protection mortar should protect the concrete below it, with the concrete temperature during or after the 4 hours, not being above 380°C and the reinforcement temperature should not be above 250°C. Additional toxic gases should also not be generated by the fire protection mortar itself. The layer thickness required is not defined in this standard.

CONTRACTOR:
Contractors need a fire protection product which can be applied within the limited time stipulated by the designer. The projects requirements must be achievable with relatively low volumes of material (thin layers), and the application must be quick and easy. This means that the system must not be too complicated, so that specialist expertise and equipment are not required.

DESIGNER:
Designers need a system which can be applied in the shortest possible time to keep the refurbishment period to a minimum. The products should ideally also be simple enough not to require specialist expertise. The systems must not need to be applied in very thick layers, because as a general rule structural opening dimensions must not be narrowed and reduced by the refurbishment and fire protection works.

OWNER:
The owner needs a fire protection system which allows minimal tunnel and lane or track closure times for its application during the structures refurbishment; in order to keep the traffic moving and to keep all routes open for as long as possible. The fire protection system must also have long term durability so that any future maintenance requirements are reduced and of course, the system must perform reliably in a fire.

THE FIRE GUARD
Sikacrete®-213 F MORTAR

CEMENT-BASED pre-bagged, dry mix, fire protection mortar for wet sprayed application especially for concrete structures in tunnel construction as a fire barrier.

Sikacrete®-213 F effectively protects concrete from the effects of extreme heat in the event of a fire. The structures only need a thin layer of Sikacrete®-213 F to allow them to survive extensive fire stress and remain undamaged.

Sikacrete®-213 F is a hydraulically bound, fire protection mortar system with vermiculite as its insulating filler component. Vermiculite is a multilayer-lattice silicate material (mica type), which expands at high temperatures.

At temperatures between 700°C and 1,000°C the special Vermiculite, in the form of thin mica discs, expands by up to twenty times its original size, as water naturally bound within it escapes.

ADVANTAGES
Pre-bagged dry mortar mix for application by the wet spray process
- Minimal layer thickness to meet specifications
- Easy to apply

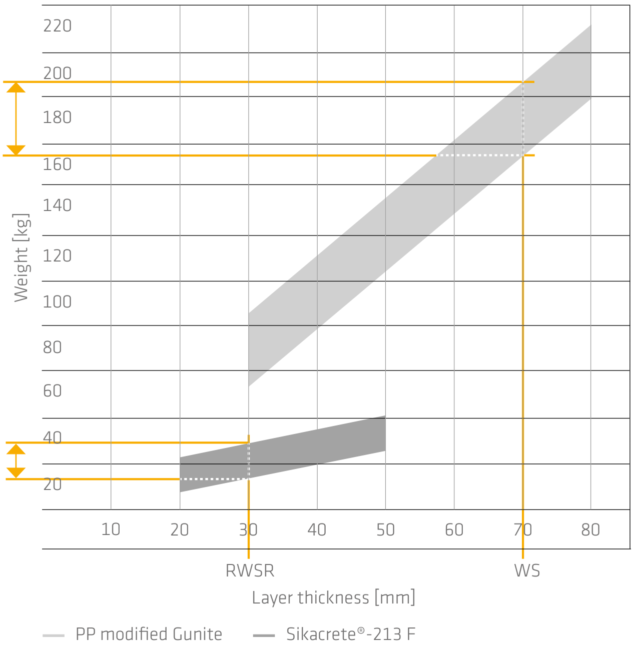
The Sikacrete®-213 F material consumption is also well below the normal consumption of dry-sprayed fire protection mortars, this is due to the special lightweight Vermiculite fillers and its application by the wet spray process.

Sikacrete®-213 F is applied at ~5 to 6 kg/m^2 for every 10 mm layer thickness.

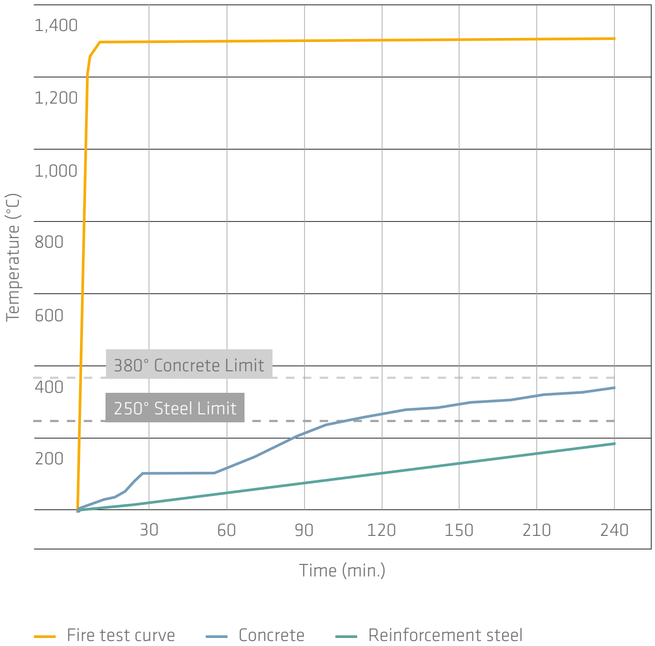
Tests to International Standards show the outstanding fire protection behaviour of Sikacrete®-213 F. Application The different types of applications, exposures and heat stresses on different structures and projects can demand special project specifications and adaptations to be produced. Sikacrete® F systems can easily be adjusted to all of the different conditions required, because where necessary they can be combined with additional reinforcement and surface protection products or systems to provide special solutions.

Sikacrete®-213 F has clearly demonstrated in many different national and international fire tests that it is a fire protection mortar with outstanding properties

MATERIAL COMPSUPTION/m²



HC$_{inc}$ – FIRE TEST: 30 MM Sikacrete®-213 F

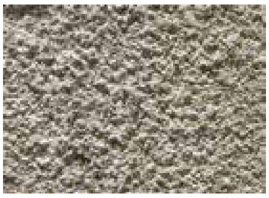


CHARACTERISTICS

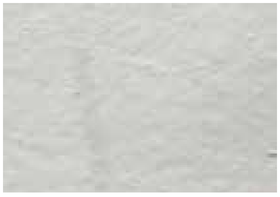
Excellent Performance
- Fulfils International Standards
- Extremely low material consumption
- Thin-layer system

High Workability
- 1 component system
- Fast and easy to apply
- Good surface finishing

ALTERNATIVE SURFACE FINISHES


Rough sprayed.


Trowelled finish.


Trowelled and protected with Sikagard®-Wallcoat T.

PROTECTION OF THE CFRP IN CASE OF FIRE

STRENTHENING SYSTEMS ARE CRUCIAL for structures, especially in case of fire.

The design of a structure is focused on ensuring the necessary strength under the expected loads. For safety reasons, different codes take additional safety coefficients into account, so that the final calculation utilizes load magnitudes higher than the actual ones, and material strengths lower than the real ones. In this way, extraordinary situations which may exceed the common conditions are also taken into account.

Situation	Eurocode 2 (simplification)	ACI 318 (simplification)
Design loads	The expected loads are magnified by means of safety factors: ■ x 1.5 for variable loads ■ x 1.35 for permanent loads	The expected loads are magnified by means of safety factors: ■ x 1.6 for live loads ■ x 1.2 for dead loads
Design strengths	The material's strengths are reduced by means of safety factors: ■ / 1.5 for concrete ■ / 1.15 for steel	The nominal strength of the member is reduced according to defined parameters according to the kind of element and the expected ultimate strains (x 0.65 – x 0.9)

As a consequence of this, the structures must be designed so that they have necessary resistance which is substantially greater than requested to support the anticipated loads. However, under certain circumstances, these conditions cannot be met either as a consequence of a current resistance which is lower than the expected, or through the existence of loads higher than those initially estimated.

Under these circumstances, an appropriate strengthening method must be displayed, so that the structural safety margin required by local legislation is ensured.

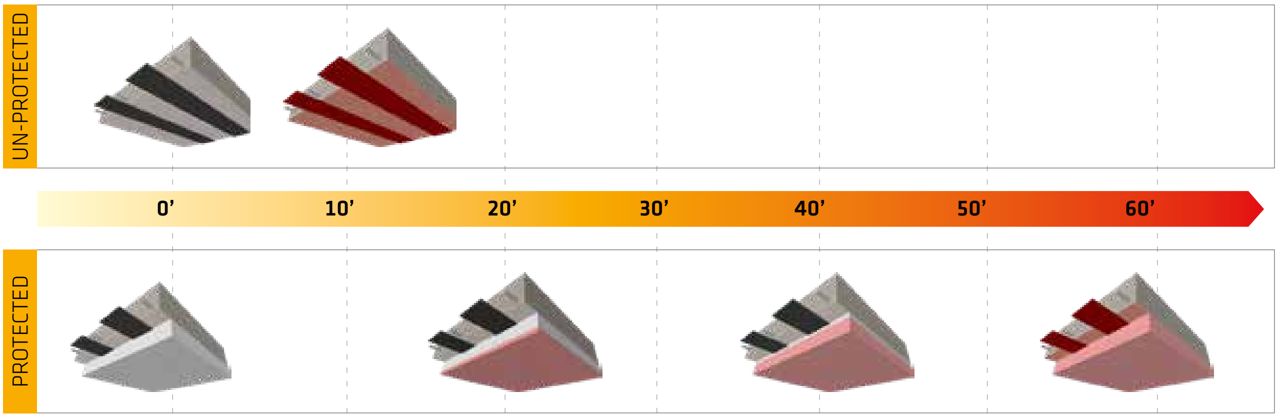
Those systems using CFRP reinforcement methods are a preferred option widely used today by engineers and contractors, since they involve extremely fast and effective solutions in most cases. However, these systems essentially support those loads that are transferred to them via adhesives used for placement. Therefore, in those situations where the rapid heating of the bonding agent can be expected, the integrity of the CFRP solution is constrained to those temperatures below the softening point of the adhesive.

Hence, in a fire situation, the mechanical capacity of the unprotected CFRP laminate will be lost within the first few minutes, so the existing loads must be supported by the original, unstrengthened RC structure. This situation should in theory compromise the integrity of the structural element, but in most cases, this does not happen.

The different existing guidelines take this verification in the calculation process into account. However, the expected loads in case of fire are notably reduced, as a substantial part of the live loads (variable loads) will not be expected in case of fire.

PROTECTION OF THE CFRP IN CASE OF FIRE

Please note that many common solutions for structural protection in case of fire, based on thin mortar layers or intumescent coatings, are often of no use for CFRP laminates, as they are based on thickness with protective capabilities that are not effective to maintain the temperature of the CFRP adhesive below the critical point.



Even in the case of using protective materials applied in a considerable thickness, the expected protection will be restricted to a limited period of time (e.g. 45 – 60 minutes). A long-term protection for the CFRP strengthening (120 – 240 minutes) is not feasible unless extremely costly or complex solutions have been provided. **Short-term CFRP protections do not involve a low fire resistance for the structural member.**

BUILDING (COLUMNS & BEAMS) – FRP PROTECTION

Typical Build-up	Thickness < 30 mm	Thickness > 30 mm	Increased Mechanical Protection*	Humidity	Freeze & Thaw	Mechanical Cleaning
Sika MonoTop®-910 N	X	X	X	X	X	X
Sikacrete®-213 F	X	X	X	X	X	X
Reinforcing mesh	X	X	X	X	X	X
Resurfacing mortar*						X
Sikagard®-705 L/706 Thixo		X	X		X	
Sikagard®-675 W ElastoColor			X	X	X	X

Note*: Resurfacing mortar such as Sika MonoTop®-723 N or equivalent.
Note**: e.g. with increased resistance to mechanical damage as in the case of a column in a car park.

Uncommonly, the mechanical contribution of the CFRP strengthening is absolutely necessary in case of fire. This situation is typically expected in situations where the CFRP contribution assumes a significant part of the resistance (the CFRP increases the original strength significantly).

Under this circumstance, a proper thermal insulation must be displayed. This insulation must comprise insulating mortars (Sikacrete®-213 F) or specific panels which ensure that the temperature in the bonding agent remains below the softening point. This usually involves a substantial thickness for the insulation.

ALSO AVAILABLE FROM SIKA

FOR MORE FIRE STOP SYSTEMS:

WE ARE SIKA
Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, flooring as well as roofing and waterproofing systems.

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