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Heidelberg Materials

The Impact of Concrete on Fire Safety

Heidelberg Materials evoHub

31.03.2026

Agenda

1. Introduction to Heidelberg Materials
2. Concrete in Fire & Safety Testing
3. Design codes & Considerations
4. London Fire Brigade – Commentary on Concrete
5. Spalling of Concrete in Fires

Heidelberg Materials

Heidelberg Materials

Business Overview

Heidelberg Materials is leading the way

- World's first carbon capture cement plant producing **evoZero near-zero cement** – Padeswood cement plant
- World's first **hydrogen trial** at a cement plant – Ribblesdale cement plant
- UK's first **hydrogen asphalt trial** – Criggion asphalt plant
- UK's first use of an **electric paver** on a major road network

About Heidelberg Materials

- Leading supplier of lower carbon heavy building materials to the construction industry.
- Produces aggregates (crushed rock, sand and gravel), asphalt, ready-mixed concrete, cement and GGBS.
- Part of a global company represented in over 50 countries with more than 51,000 employees.
- Committed to decarbonising the built environment/growing the circular economy.
- Develops digital solutions to improve efficiency, productivity and customer service.

No.1
for cement and concrete

No.2
for aggregates

No.3
for asphalt and contracting

Our business

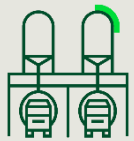
In the UK, Heidelberg Materials is split into five business lines:

- Aggregates (crushed rock, sand and gravel)
- Asphalt and contracting
- Cement
- Concrete
- Recycling

2,000+ Heidelberg Materials-liveried vehicles

25 rail depots and wharves supplied by road, rail and sea

4 marine dredgers



150+ ready-mixed concrete plants

6 landfill sites

3 cement plants

50+ sand, gravel and rock quarries

13 recycling centres

3 grinding plants making Regen GGBS (ground granulated blastfurnace slag)

35+ asphalt plants

8 packed products plants

1 joint venture rail company, Mendip Rail

10+ waste transfer stations

3 hazardous waste treatment sites

Our business

In the UK, Heidelberg Materials is split into five business lines:

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- Asphalt and contracting
- Cement
- Concrete
- Recycling

Supplying essential building materials

Our products are used to help build the infrastructure we need to live, learn, work and travel:

Residential:
Deansgate Square, Manchester

Commercial:
The Shard, London

Hospitals:
Christie Hospital, Manchester

Tunnels:
Thames Tideway super sewer, London

Bridges:
Second Severn Crossing linking England and Wales

Roads:
A414 resurfacing works, Hertfordshire

Power generation:
Hinkley Point C, Somerset

Sea defences:
Marine Parade, Dawlish, Devon

Sport:
Sir Chris Hoy Velodrome, Glasgow

Rail:
Channel Tunnel rail link

Lee Baldwin

Head of Customer Technical Support Concrete

Heidelberg Materials

Why are we here?

The 2017 Grenfell tragedy has resulted in dramatic change across the UK construction industry

- Brought home the importance safety-first design, and the selection the right materials at every stage
- Led to the introduction of new legislative and regulatory frameworks

Ensuring safety in the event of a fire is a moral imperative for everyone involved from design to management of finished project

Concrete in Fire & Safety Testing

Concrete and it’s impact on Fire Safety

One of the most fire-resistant construction materials.

(EN 13501-1:2007-A1:2009) A1 material – the highest grade of fire resistance.

- Non-combustible
- Non-toxic – no release of gases
- Low thermal conductivity - does not easily transfer heat
    - ISO 834/BS476 Fire testing of a concrete beam
    - After 1hr the surface 16mm reached 600oC
    - At the same time, at 42mm depth was only 300oC – halved in an inch!

In most cases, concrete does not require any additional fire protection because of its built-in resistance to fire.

Whether for residential buildings, industrial warehouses or tunnels, concrete can be designed and specified to remain robust in even the most extreme fire situations.

Fire Safety Testing Concrete

IBS – Austria

BRE - Cardington

Fire Safety Testing at BRE, Cardington

Fire Safety Models

ISO: Ventilated, controlled natural fire. 842°C after 30 minutes

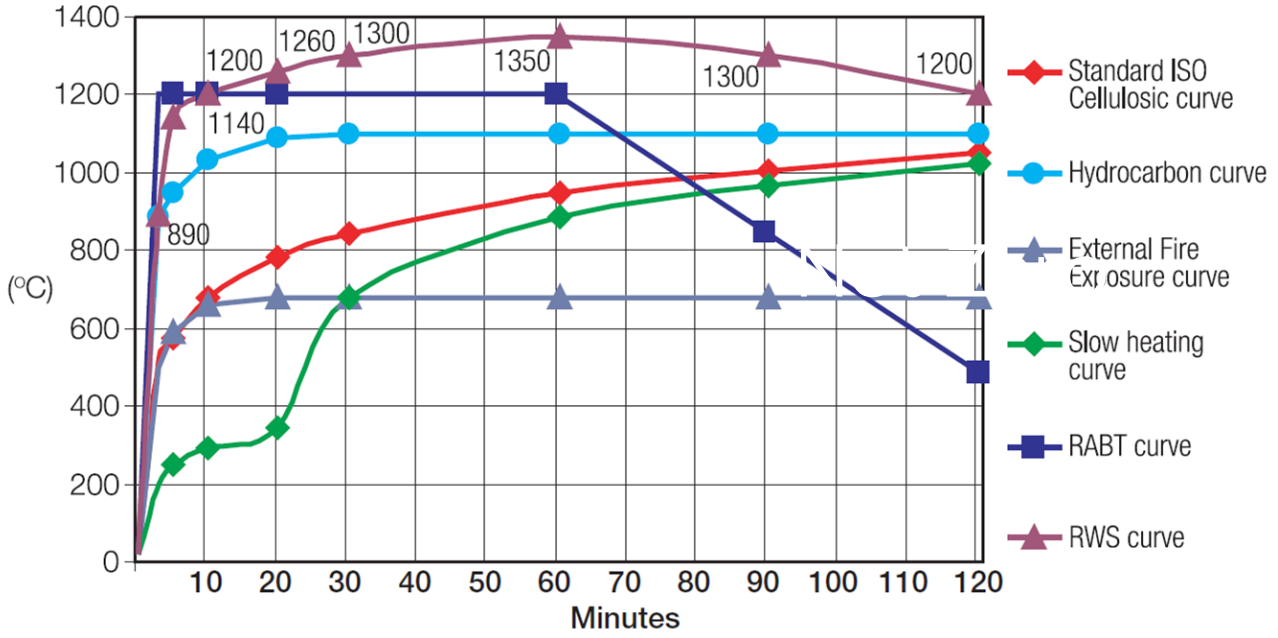
Hydrocarbon: Ventilated oil fire. 1110°c after 30 minutes

External Fire: Open to atmosphere allowing heat dissipation. 680°C after 20 minutes.

Slow growing fire: Initial burn, smoldering and subsequent flash.

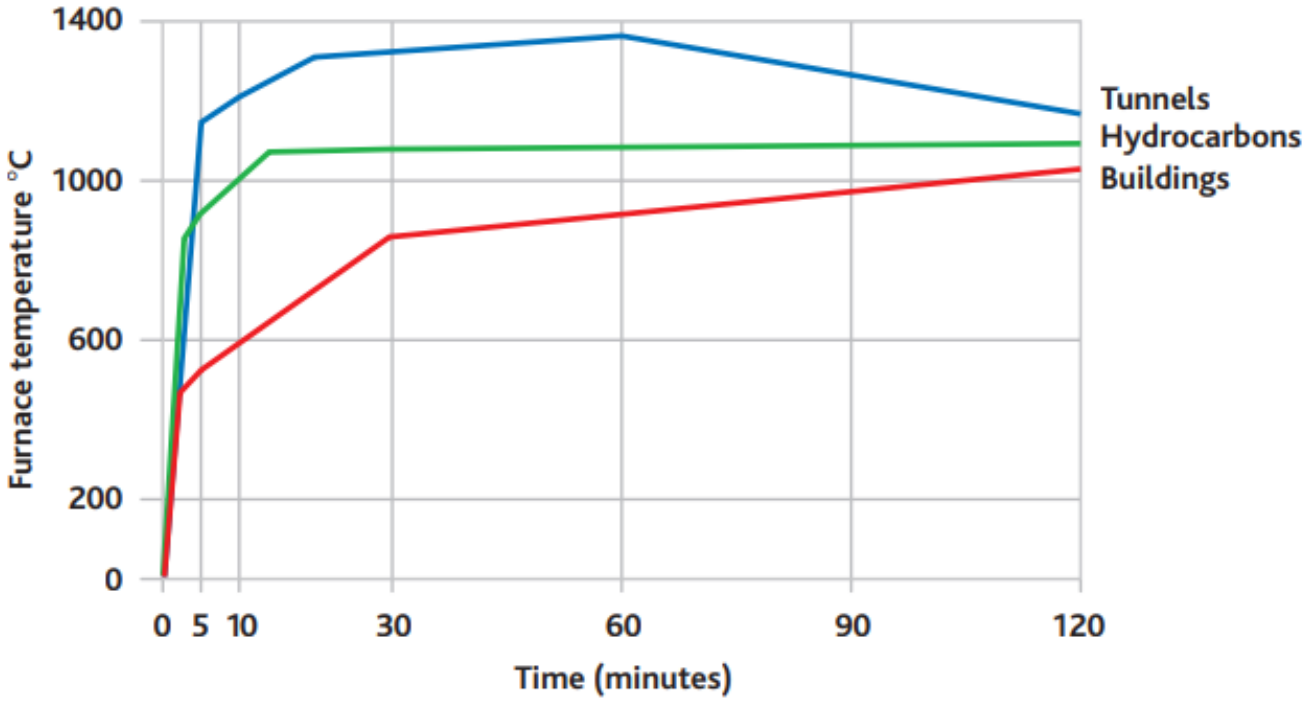
RABT: German Test (AKA Eureka Curve) with rapid temp' rise. 1200°C in 5 minutes

RWSL: Dutch petroleum fire test. 1300°C after 30 minutes



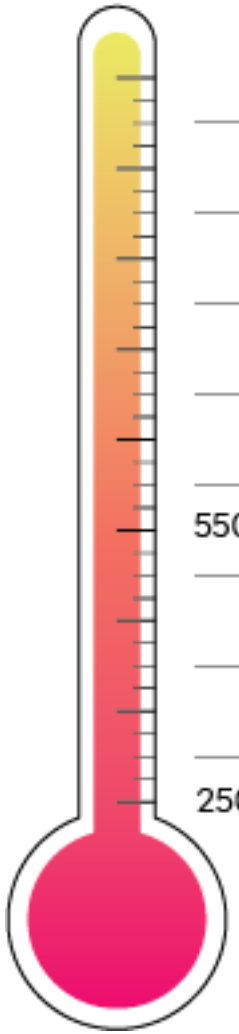
Fire Safety Testing

- CrossRail specification followed the RABT Curve
- Test Panels 1000mm x 800mm x 200mm thickness
- Maximum reinforcement temperature could not exceed 450oC
- Maximum depth of spalling could not exceed 25mm after 48 hours.



Standard fire curves for three scenarios: tunnels, hydrocarbons and buildings.

Concrete in Fire



Temperature °C	What happens
1000	
900	Air temperatures in fires rarely exceed this level, but flame temperatures can rise to 1200 °C and beyond
800	
700	
600	Above this temperature, concrete is not functioning at its full structural capacity
550-600	Cement-based materials experience considerable creep and lose their load bearing capacity
400	
300	Strength loss starts, but in reality only the first few centimetres of concrete exposed to a fire will get any hotter than this, and internally the temperature is well below this.
250-420	Some spalling may take place, with pieces of concrete breaking away from the surface

Design Codes & Considerations

BS EN 1992-1 2004
Eurocode 2: Design of Concrete Structures
Part 1-2: General Rules – Structural Fire Design

- Design of concrete structures to resist both the spread of fire and its effect on structural integrity with increasing temperatures over a defined timescale.

- Standard fire resistance times for structures from 30 minutes to 4 hours.
  - A wider scale within EC2 runs from 15 minutes to 6 hours
- Longer time frames require up to three times the section thickness
- The stronger the concrete, the higher the risk of explosive spalling

Fire Resistance in Structures

Building Regulations 2010 – Fire Safety Approved Document B

(Incorporating 2026 & 2029 changes)

Structures should:

- Retain loadbearing capacity
- Protect occupants from smoke and gasses
- Shield occupants from heat
- Facilitate intervention by fire fighters

Concrete Society Technical Report 68:

- Assessment and repair of fire damaged concrete.

Table B2 Minimum periods of fire resistance

Purpose group of building	Minimum periods of fire resistance[1] (minutes) in a:						
	Basement storey* including floor over		Ground or upper storey				
	Depth (m) of the lowest basement		Height (m) of top floor above ground, in a building or separated part of a building				
	More than 10	Up to 10	Up to 5	Up to 11	Up to 18	Up to 30	More than 30
1. Residential:							
a. Block of flats							
– without sprinkler system	90 min	60 min	30 min†	60 min+§	Not permitted[2]	Not permitted[2]	Not permitted[2]
– with sprinkler system[3]	90 min	60 min	30 min†	60 min+§	60 min+§	90 min+	120 min+
b. and c. Dwellinghouse	Not applicable[4]	30 min*†	30 min†	60 min[5]	60 min[5]	Not applicable[4]	Not applicable[4]
2. Residential							
a. Institutional	90 min	60 min	30 min†	60 min	60 min	90 min	120 min‡
b. Other residential	90 min	60 min	30 min†	60 min	60 min	90 min	120 min‡
3. Office:							
– without sprinkler system	90 min	60 min	30 min†	60 min	60 min	90 min	Not permitted[6]
– with sprinkler system[3]	60 min	60 min	30 min†	30 min†	30 min†	60 min	120 min‡
4. Shop and commercial:							
– without sprinkler system	90 min	60 min	60 min	60 min	60 min	90 min	Not permitted[6]
– with sprinkler system[3]	60 min	60 min	30 min†	60 min	60 min	60 min	120 min‡
5. Assembly and recreation:							
– without sprinkler system	90 min	60 min	60 min	60 min	60 min	90 min	Not permitted[6]
– with sprinkler system[3]	60 min	60 min	30 min†	60 min	60 min	60 min	120 min‡
6. Industrial:							
– without sprinkler system	120 min	90 min	60 min	90 min	90 min	120 min	Not permitted[6]
– with sprinkler system[3]	90 min	60 min	30 min†	60 min	60 min	90 min	120 min‡
7. Storage and other non-residential:							
a. any building or part not described elsewhere:							
– without sprinkler system	120 min	90 min	60 min	90 min	90 min	120 min	Not permitted[6]
– with sprinkler system[3]	90 min	60 min	30 min†	60 min	60 min	90 min	120 min‡

Practical Commentary

L F B Fire Engineering Group

Prescriptive, Conservative Structural Design

A Structure Should:

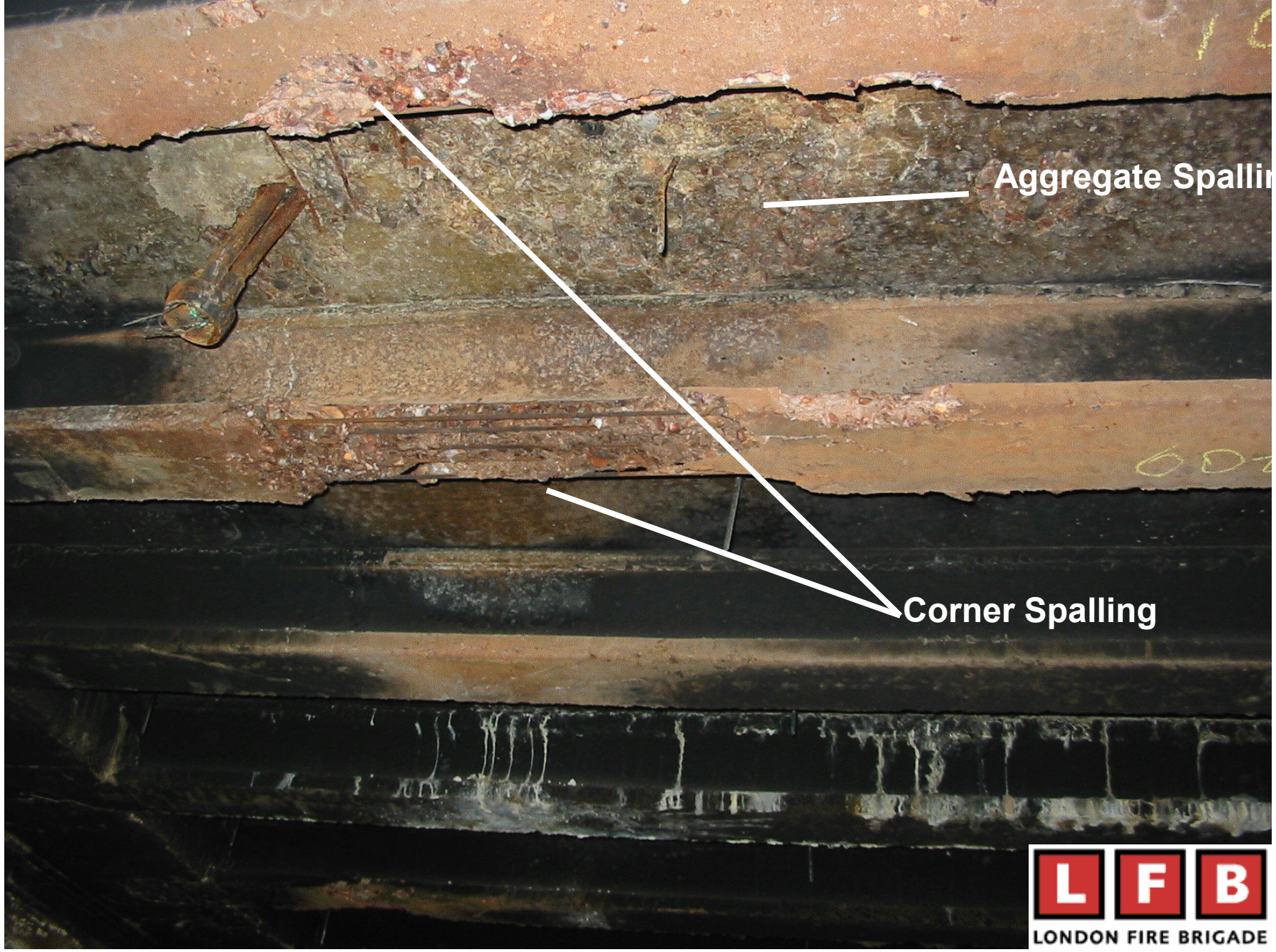
- Not endanger Occupants during evacuation
- Not endanger fire-fighters
  - During Rescue
  - Or during fire fighting

Objective	Requirement	Concrete?
Ensure stability over time	Non combustible elements	Inert & non combustible
Limit spread of fire & smoke	Fire resistant materials	Structural connectivity
Assist evacuation	Stable escape routes	Slipform & Jumpform
Facilitate fire fighting	No burning droplets	Won't melt below 1400°C

L F B Fire Engineering Group

Spalling - Fire Service Observations

- A natural phenomenon observed regularly in fires.
- Potential impact varies from nuisance to serious structural concerns.
  - Aggregate spalling
  - Corner spalling
  - Explosive spalling
- Generally not a fire fighting concern in finished buildings but can be a problem during construction
- Can be induced by fire-fighting jets but situation is usually under (risk assessed) ’control’.
- Tends not to be a critical factor in the safety of non-tunnel structures.



LFB
LONDON FIRE BRIGADE

Concrete Spalling

Mechanism of Spalling

- Spalling is a normal response to high temperatures in a fire,
- There is a difference between spalling (falling off) and explosive spalling
- Directly related to moisture content of a concrete element
- Water, trapped in pores, turns to steam.
- This expansion within the solid concrete builds up pressure until the concrete fails.
- Also affected by rate of heating, reinforcement, loadings, concrete permeability and aggregate properties.
- Higher strength concretes are generally lower porosity and more prone to potential spalling.

Mechanism of Spalling

- Eurocode 2 States: Explosive Spalling is unlikely to occur when the moisture content of the concrete is less than k% by weight. Recommended value for k is 3.
- Above 3%, a more accurate assessment of moisture content, aggregate type, permeability of concrete and heating rate should be considered.
- Four methods of reducing Spalling are given:
    1. Fine gauge (>2mm & 50mmx50mm) mesh at 15mm cover
    2. Concrete with a proven resistance to spalling
    3. Protective Layering
    4. Use of Micro Polypropylene Fibres

Passive Fire Protection – Reduction in Spalling

European **F**ederation of **N**ational **A**ssociations **R**epresenting for **C**oncrete
Specialist Construction Chemicals and Concrete Systems

Passive fire protection can be achieved by one of the following:

1: Integral protection incorporated into the structural concrete
2: Spray applied protective coatings
3: Preformed barrier or board fixed to the concrete surface

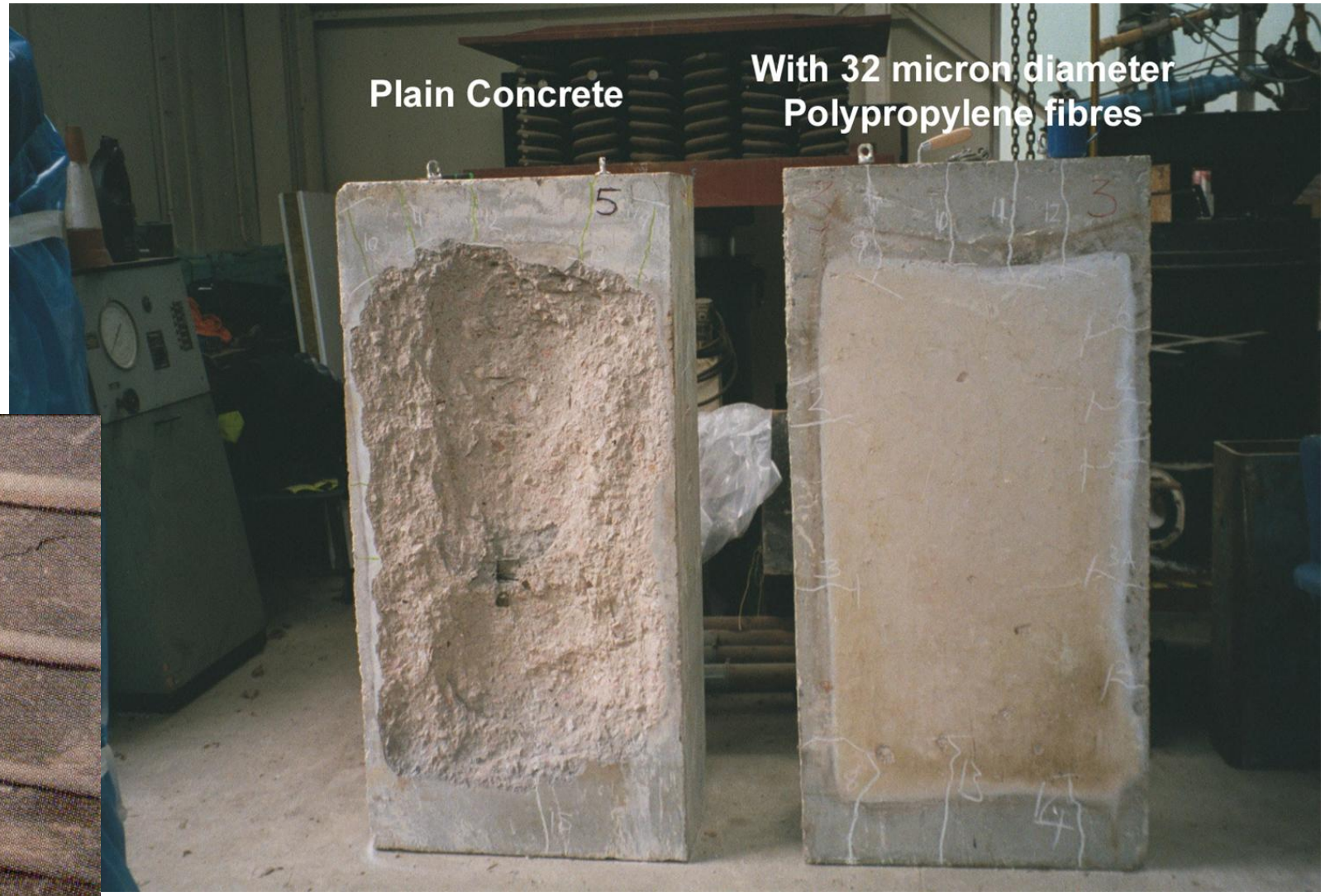
Passive protection minimises temperature rise in concrete and steel to retain structural integrity.

Reduce or eliminate explosive spalling

Explosive Spalling

Explosive Spalling

Spalling in the Channel Tunnel after 1996 fire event



Polypropylene Micro Fibres

- Polypropylene melts at approx. 165°C creating channels and micro cracking within the concrete
- Expanding steam escapes through these channels drastically reducing pressure build up.
- Concrete is often also subject to micro-cracking from this volume change which further opens pathways
- Optimum fibre diameter 32µm in diameter to ensure full melting and increased permeability.
- Melting of thicker fibres still promotes micro cracks but less likely to form pathways
- Melting of thinner fibres generates fewer micro cracks and less pore network.

Spalling reduction with micro fibres

T.N.O Centre for Fire Research – 2006. Large scale polypropylene testing

1kg/m3 Dose

2kg/m3 Dose

3kg/m3 Dose

Crossrail Spalling Tests:

Table 7 Summary of measured loss of section of the test specimen 24 hours after the fire test

Test specimen	Average spalling depth [mm]	Maximum spalling depth [mm]
BFK-11 (1.00 kg/m3)	13.5	35
BFK-13 (1.25 kg/m3)	15.8	23

Fibre Reinforced Concrete in Tunnelling

Is now used globally to reduce the risks associated with fire in tunnel environments

Channel Tunnel Rail Link
UK

Hindhead Tunnel
UK

Elizabeth Line (Crossrail)
UK

Thames Tideway Super Sewer
UK

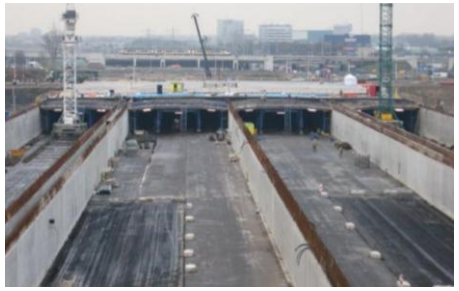
Hinkley Point C
Somerset, UK

Gotthard Base Tunnel
Switzerland

Dublin Port Tunnel
Eire

Brenner Rail Link
Austria

Eastlink Tunnel
Melbourne, Australia

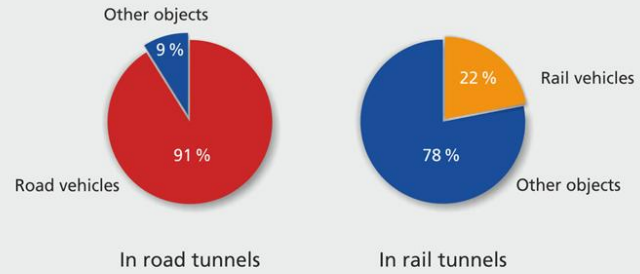


DoDo Tunnel
Utrecht, Holland

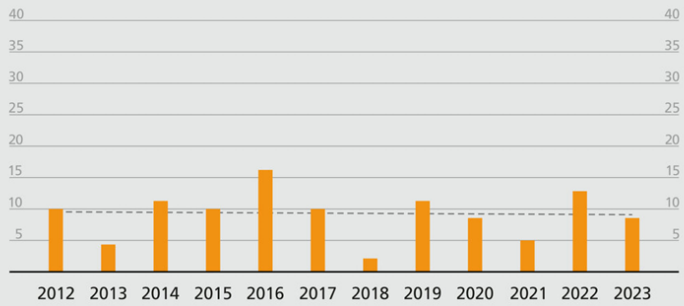
Tunnel Fire Statistics – International Fire Academy (Switzerland)

Continental Europe Statistics from 2012 to 2023

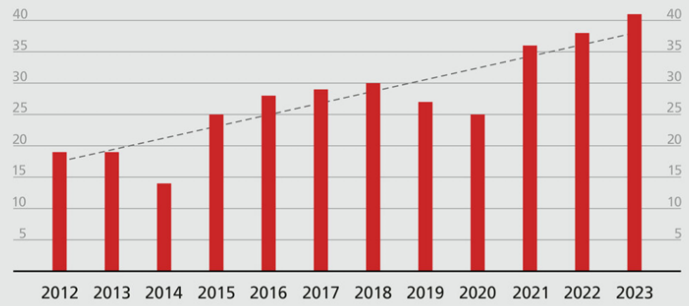
	Switzerland	Germany	Austria	Total
Road tunnel	90	148	93	331
Rail tunnel	6	88	14	108
Total	96	236	107	439
Fires per month	0,7	1,6	0,7	3,0



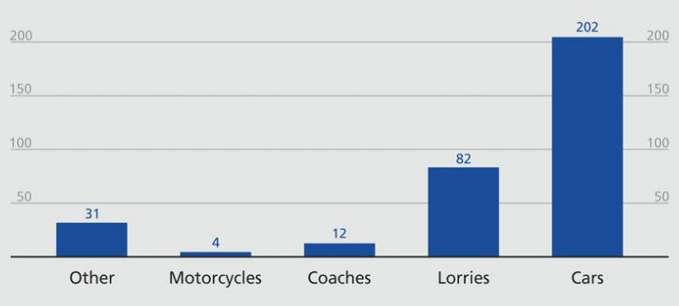
Sources of fire



Fires in rail tunnels

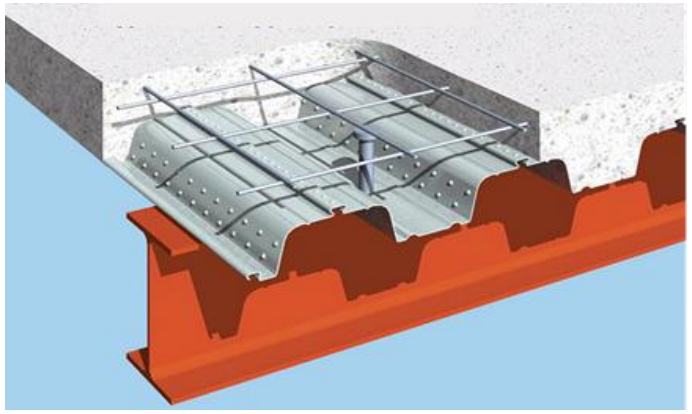


Fires in road tunnels



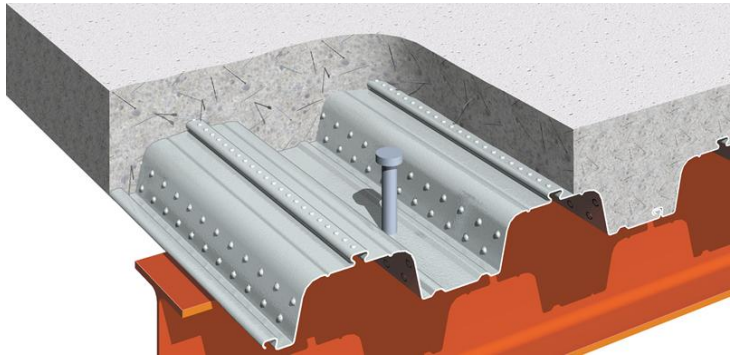
Objects on fire in road tunnels

Steel Fibre Reinforced Concrete in Composite Metal Decks



Steel fibre reinforced concrete has practical and cost benefits over traditional mesh reinforcement.

Full scale fire testing confirms suitability for use in fire protection.



evoBUILD

Low carbon concrete

Heidelberg Materials

Fire safety hand in hand with decarbonisation

- Net zero commitments are becoming a requirement on the majority of new construction projects
  - These require reduction in the project's carbon
- Concretes that perform well in a fire are also readily available in low-carbon formats
- evoBuild, a global brand for low carbon and circular products
- We target **at least 30% CO_2 reduction**
- Movement through the evoBuild increments enables reduction of CO_2.

evoBUILD

gcca Global Cement and Concrete Association

Low Carbon evoBuild Concretes – GWP Mapped Against Global Concrete Ratings

evoBuild low carbon concrete 50

GCCA A1-A3 minimum Grade D

evoBuild low carbon concrete 60

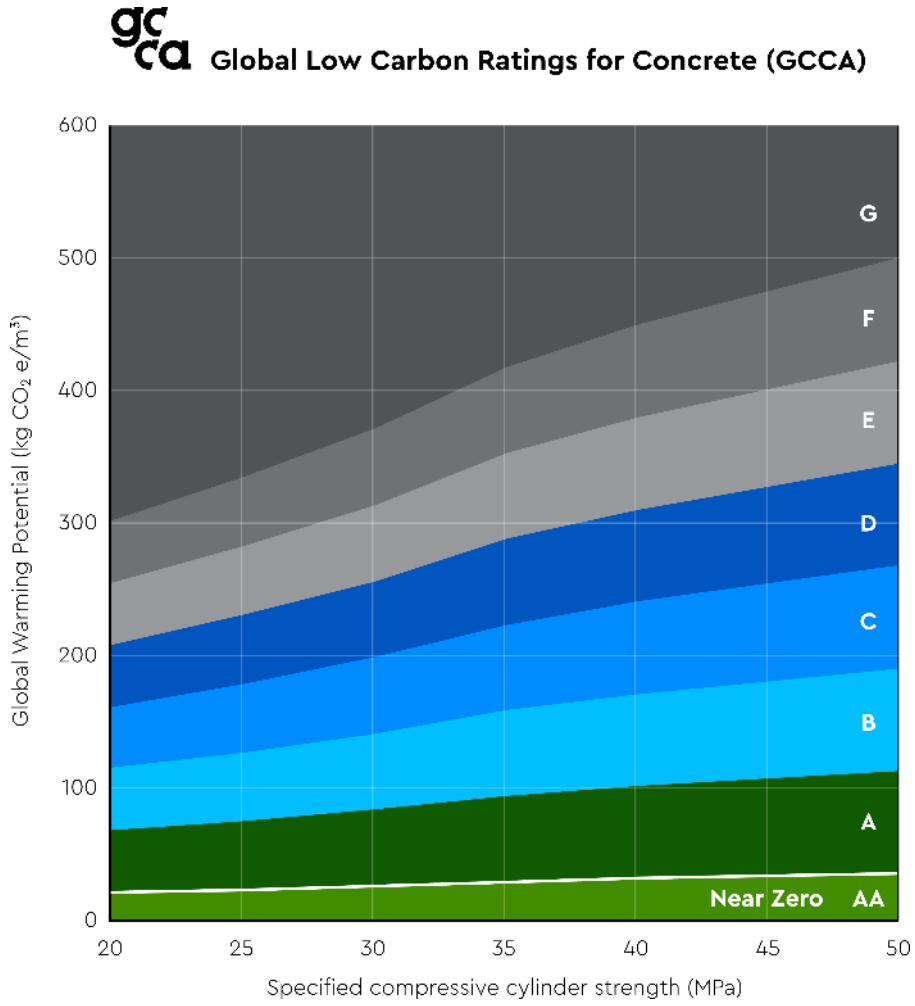
GCCA A1-A3 minimum Grade C

evoBuild low carbon concrete 70

GCCA A1-A3 minimum Grade B

Key benefits:

- Reduces carbon emissions by 50-70% against fixed CO_2/T GCCA reference.
- Verified indicative Global Warming Potential (GWP) values provided
- Behaves like current concretes - unchanged construction process.
- Complies with BS 8500 and BS EN 206-1.
- Available nationally



Conclusions

- 2004 Concrete Society report on over 100 fire damaged structures in the UK
- Most were repaired or could have been. Buildings were usually demolished for reasons other than the fire damage.
- Almost without exception, structures performed well during and after the fire.

- Concrete provides a long term economic advantage in respect of fire resistance. It also provides thermal mass and acoustic insulation, allowing one material to fulfill multiple roles in a structure.

- Polypropylene and steel fibre reinforced concretes give practical advantages during the construction phase whilst retaining safety during service.

NBS

Heidelberg Materials products are now available on NBS Source.

Search. Select. Specify.

Find products like our evoBuild low carbon concrete, fibre-reinforced, high-performance, waterproof and self-compacting concretes.

Search Heidelberg Materials at www.source.thenbs.com.

Thank you for your time.

Any Questions?

If you have any enquiries please contact;

Concrete Technical

- Lee Baldwin – Technical Services Manager
  - lee.Baldwin@heidelbergmaterials.com

Future events at Heidelberg Materials evoHub

- www.heidelbergmaterials.co.uk/en/cpd-registration-evohub