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Reuse of Waste Tyre Fibres for Fire Spalling Mitigation

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Fire-Induced Explosive Spalling



Mont Blanc tunnel after fire
Source: www.phys.tue.nl/

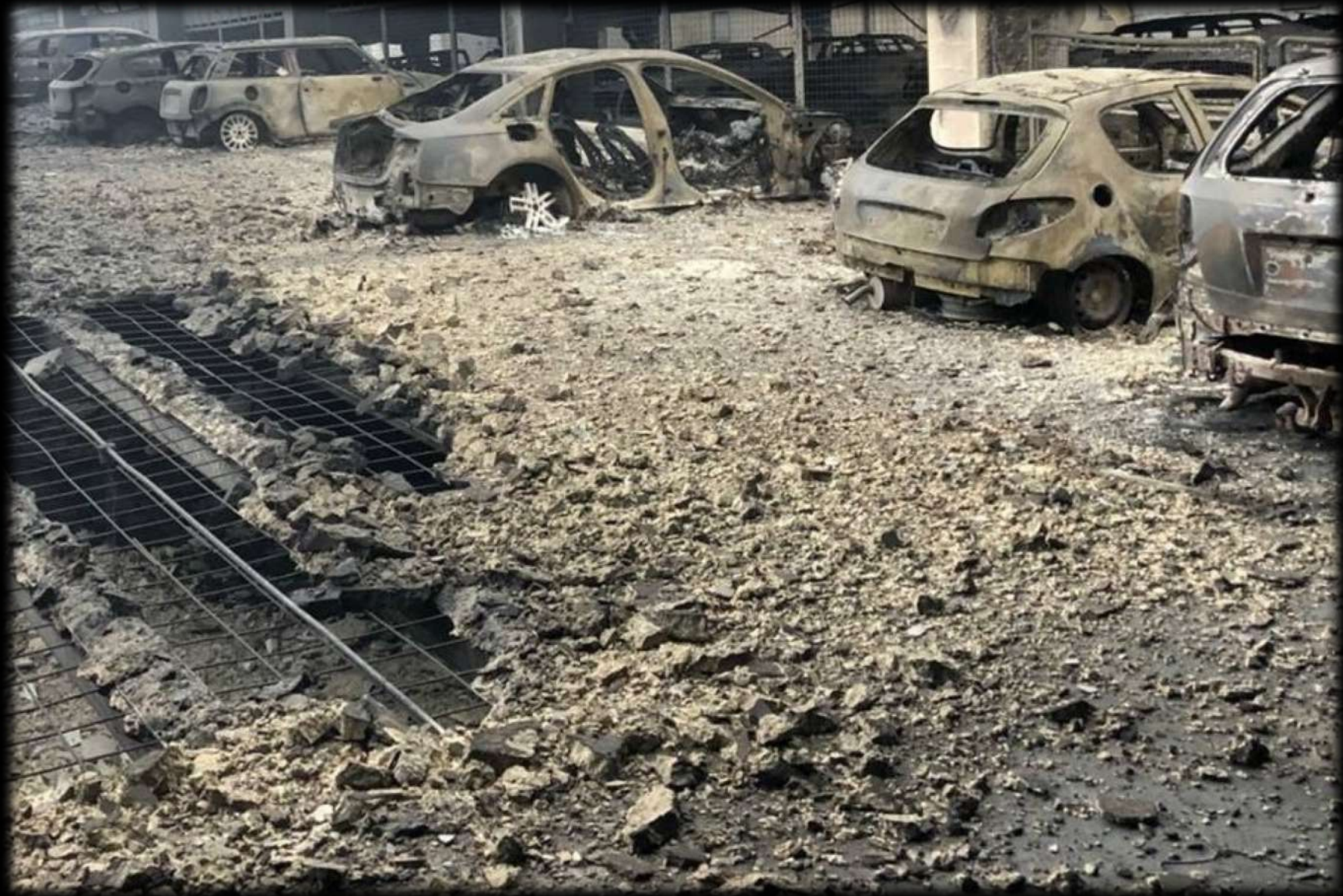


Channel Tunnel fire
Source: www.phys.tue.nl/



Spalling of a building under construction
Source: www.panoramafactory.net

Fire-Induced Explosive Spalling



Liverpool Echo Arena car park fire
Source: www.newcivilengineer.com

Polypropylene (PP) Fibres

Eurocode:

*“Include in the concrete mix more than **2 kg/m³** of monofilament **polypropylene fibres**”*



© www.tunneltalk.com



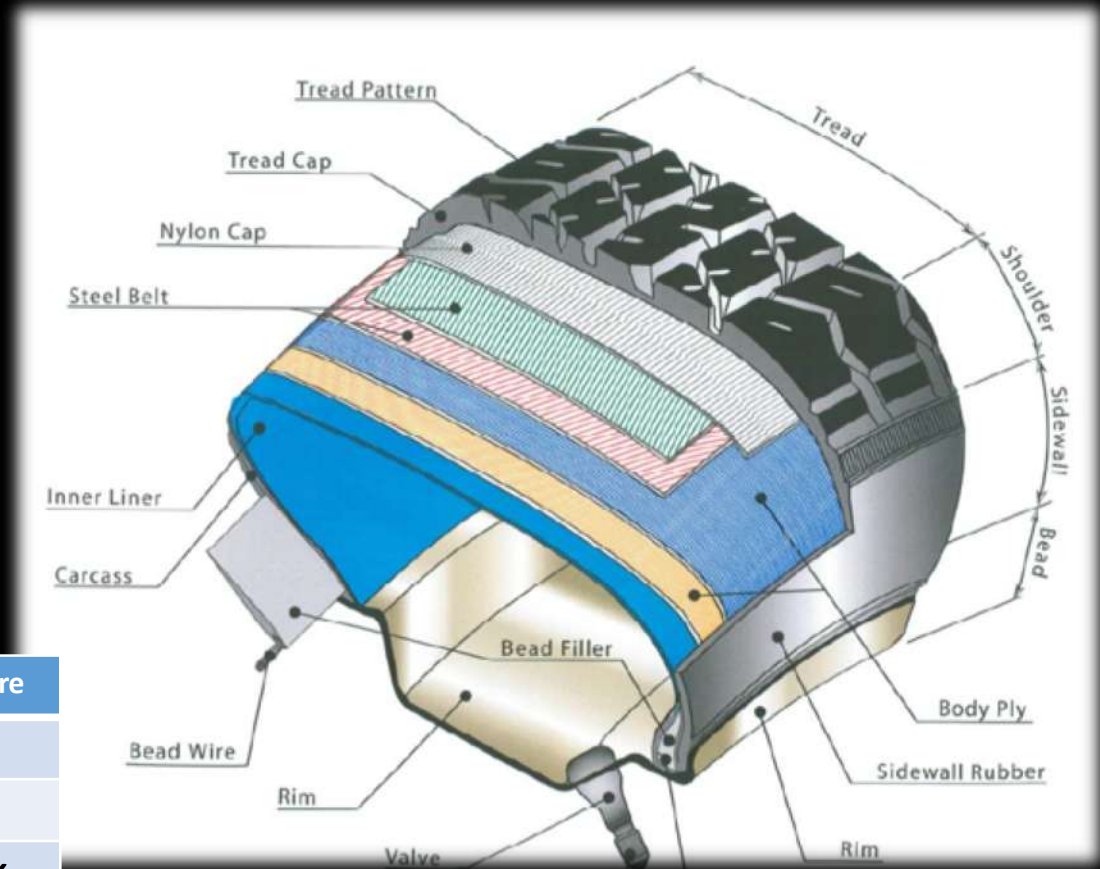
© www.tunneltalk.com



- 1,500,000,000 new tyres each year (worldwide)
- 3,300,000 tonnes of post consumer tyres / annum (in EU alone)



Typical Tyre Composition



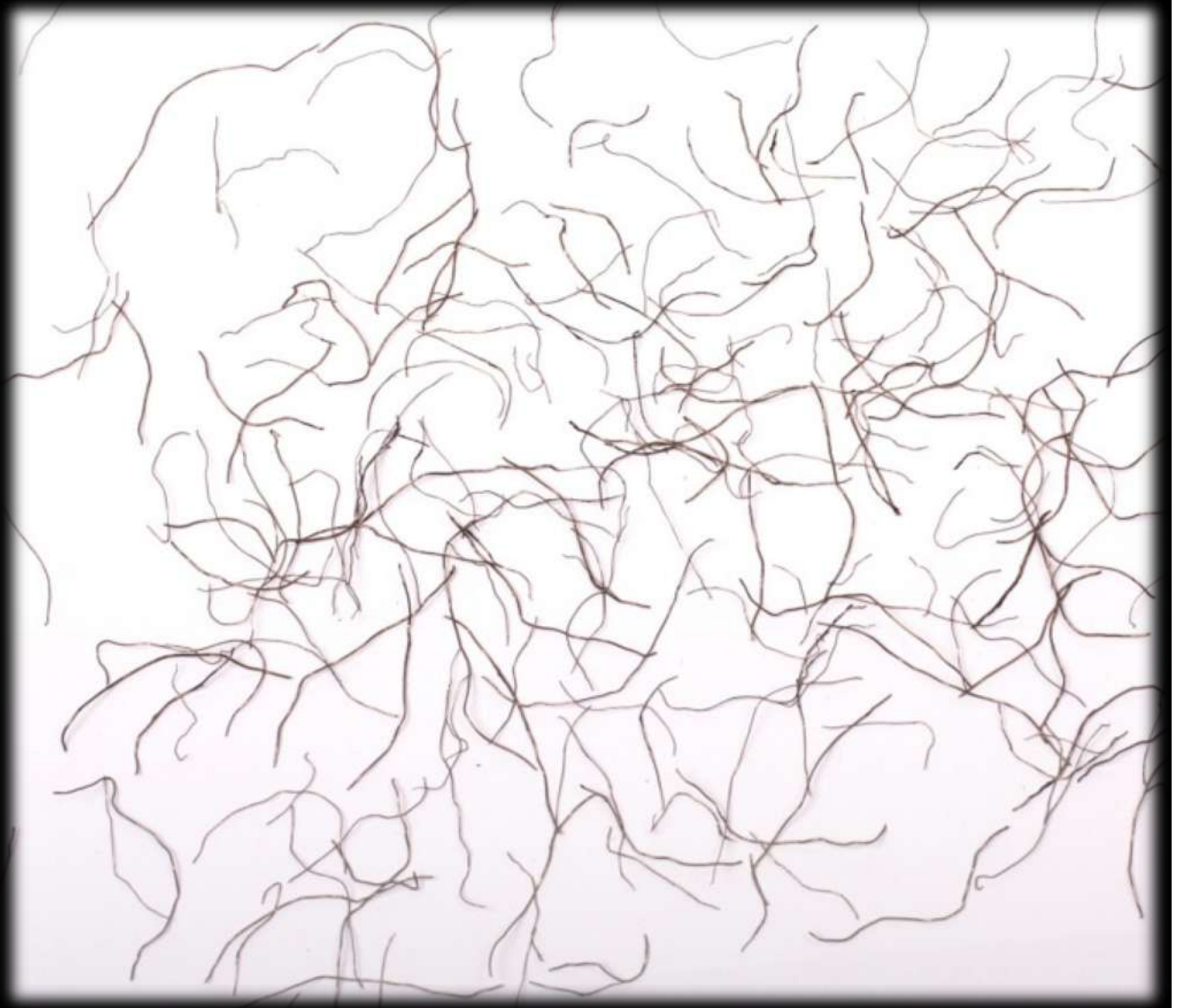
Ingredient	Car Tyre	Truck Tyre	OTR Tyre
Rubber/Elastomers	47%	45%	47%
Carbon Black	21.5%	22%	22%
Metal	16.5%	25%	12%
Textile	5.5%	-	10%
Zinc Oxide	1%	2%	2%
Sulphur	1%	1%	1%
Additives	7.5%	5%	6%

Tyre Recycling



Reused Tyre Steel Fibre

RTSF

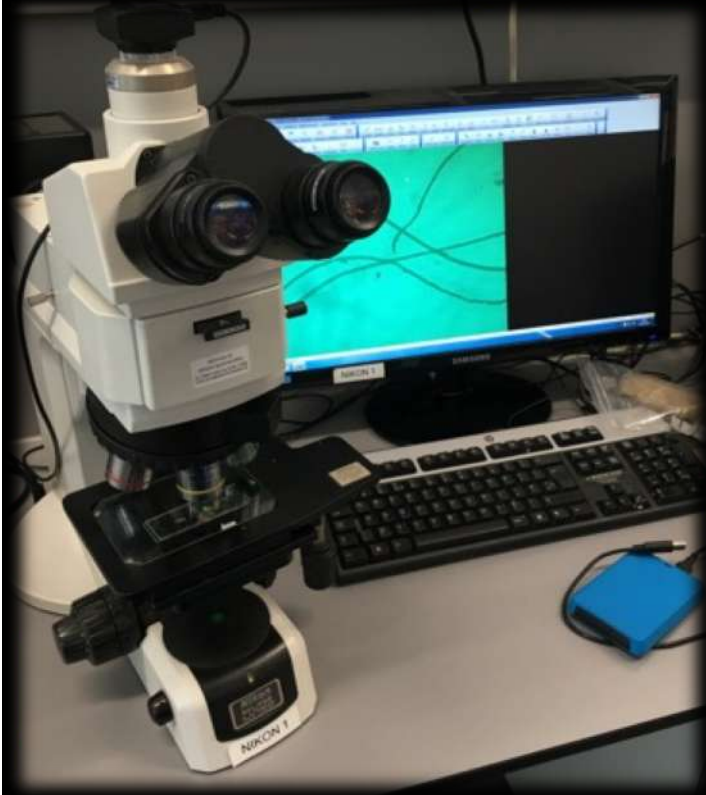


Reused Tyre Polymer Fibre

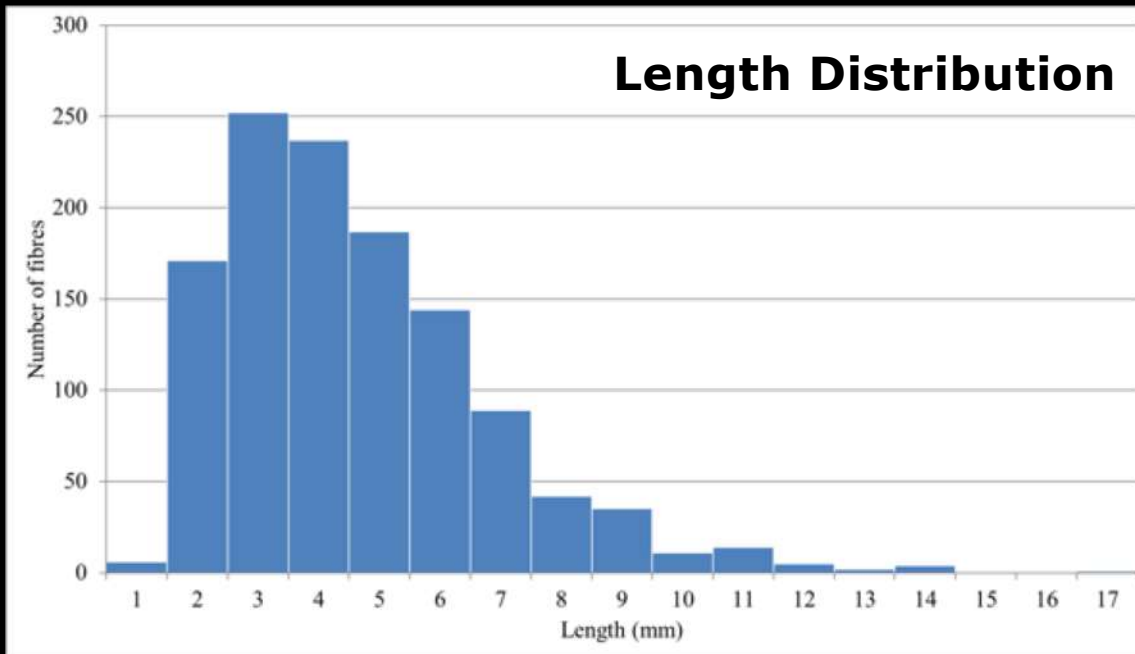
RTPF



RTPF Characterisation



RTPF Characterisation

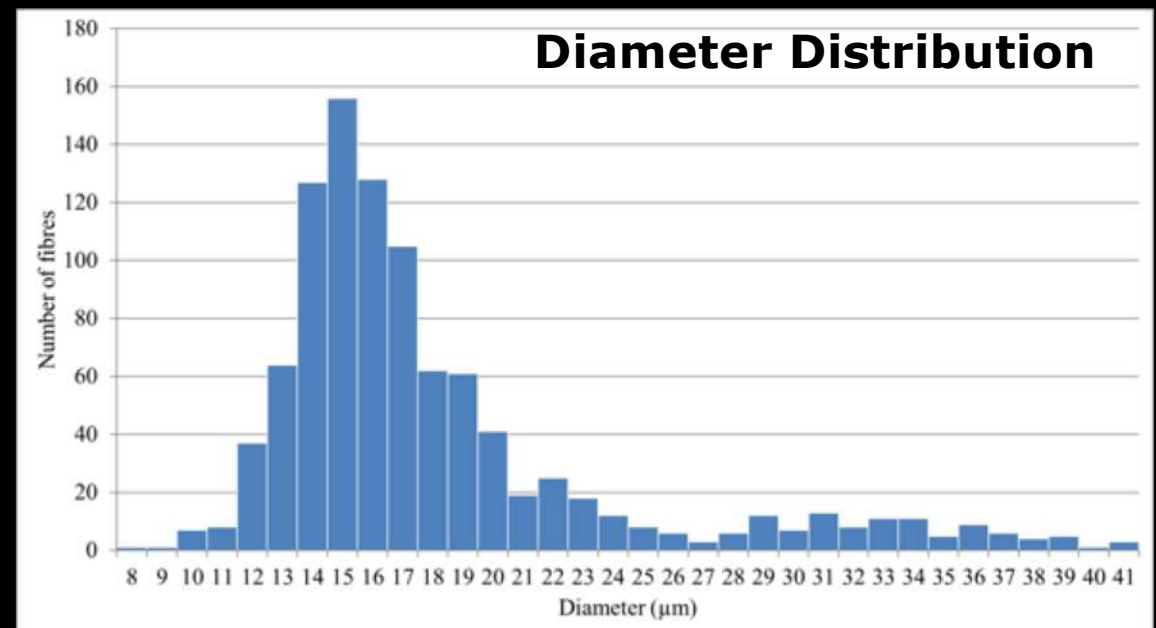


Chemical Composition:

- 60% of PET (polyesters - polyethylene terephthalate)
- 25% of PA 66 (polyamide 66)
- 15% of PBT (polybutylene terephthalate)

Melting temperature:

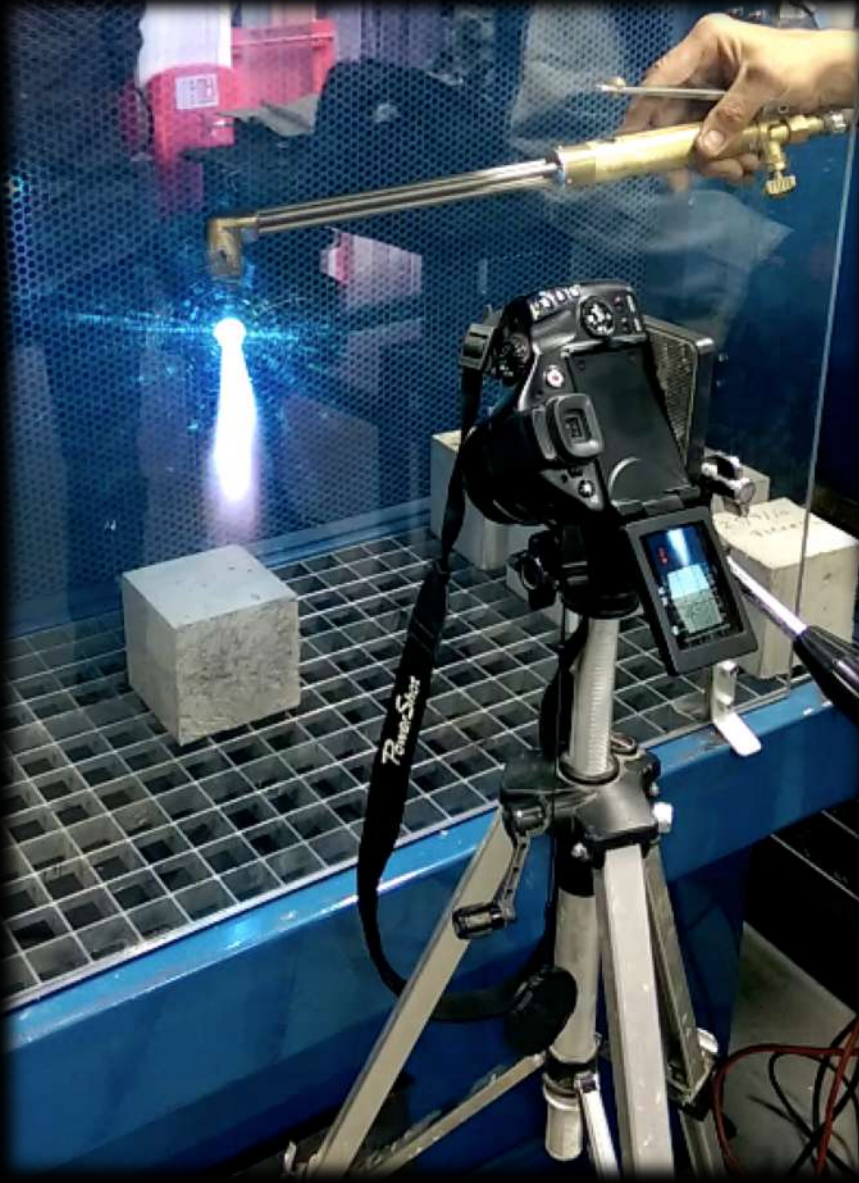
- 200 - 250 °C



RTPF in Fresh Concrete



Fire Spalling Tests



12 cubes

- 6 plain concrete - 2 spalled
- **6 with RTPF (7 kg/m³) - NO spalling**

Fire Spalling Tests

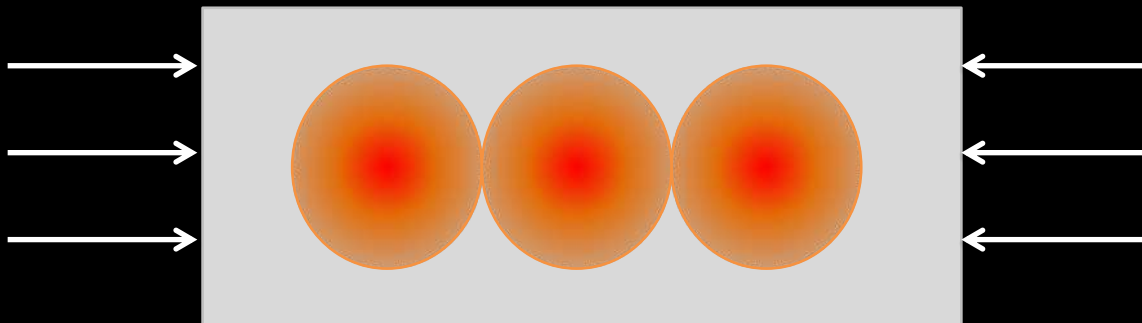


12 slabs (no steel mesh)












- 3 plain concrete
- 3 with 1 kg/m³ RTPF
- 3 with 2 kg/m³ RTPF
- 3 with 7 kg/m³ RTPF

12 slabs (with steel mesh)













- 3 plain concrete
- 3 with 40 kg/m³ RTSF
- 3 with 40 kg/m³ RTSF & 2 kg/m³ RTPF
- 3 with 40 kg/m³ RTSF & 5 kg/m³ RTPF

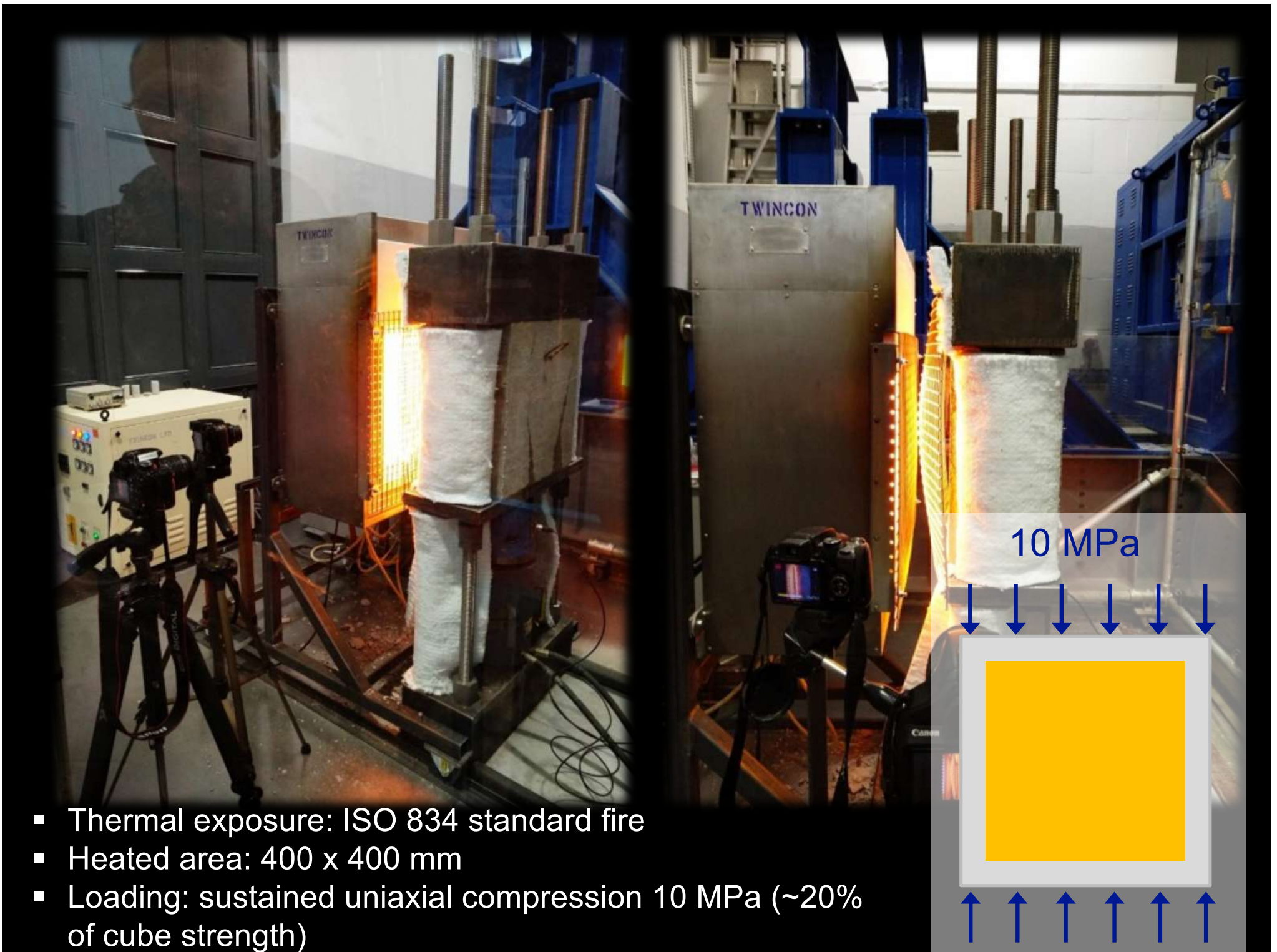


Slab Tests - Series 1

Plain Concrete	1 kg/m ³ RTPF	2 kg/m ³ RTPF	7 kg/m ³ RTPF
		<p data-bbox="1198 542 1534 630">Damaged specimen prior to fire loading</p>	
			
			

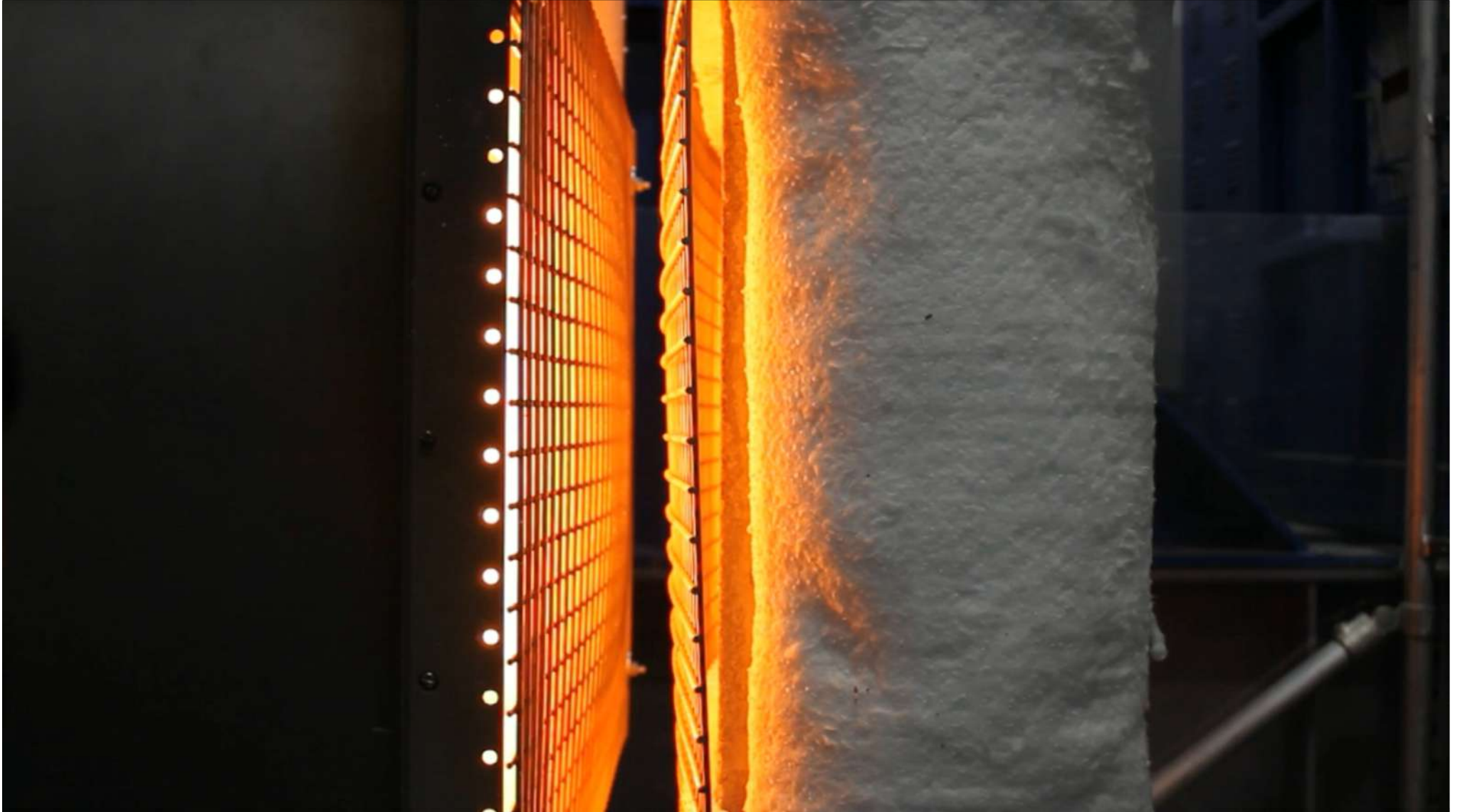
Slab Tests - Series 2

Plain Concrete	40 kg/m ³ RTSF	40 kg/m ³ RTSF + 2 kg/m ³ RTPF	40 kg/m ³ RTSF + 5 kg/m ³ RTPF
			
			
			



- Thermal exposure: ISO 834 standard fire
- Heated area: 400 x 400 mm
- Loading: sustained uniaxial compression 10 MPa (~20% of cube strength)

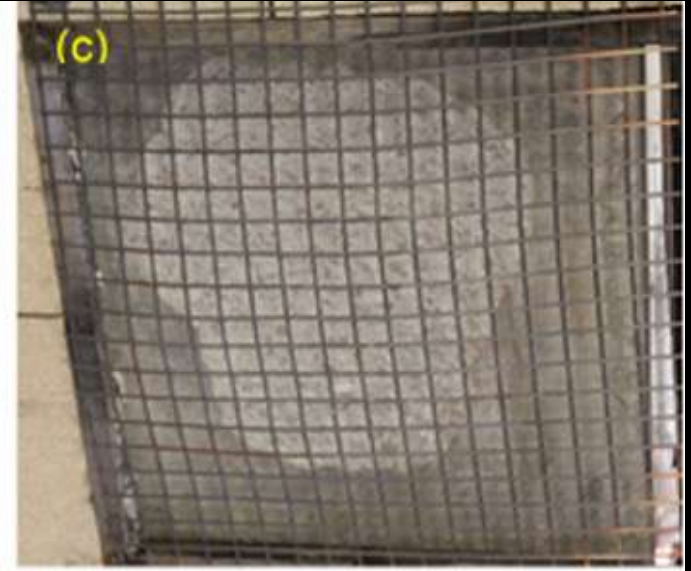
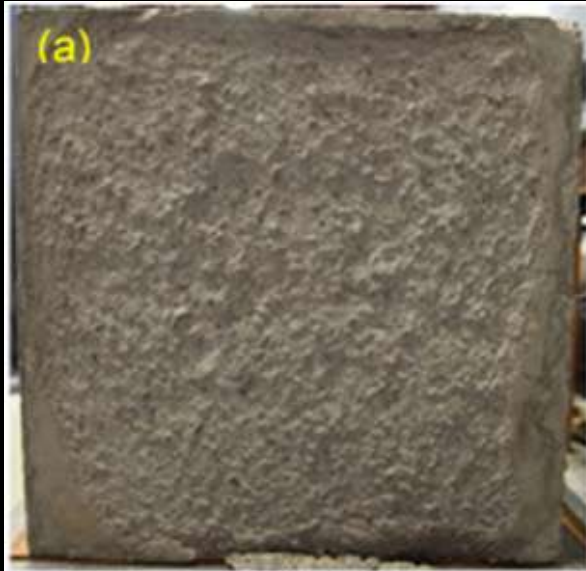
No Fibre: Spalled Violently



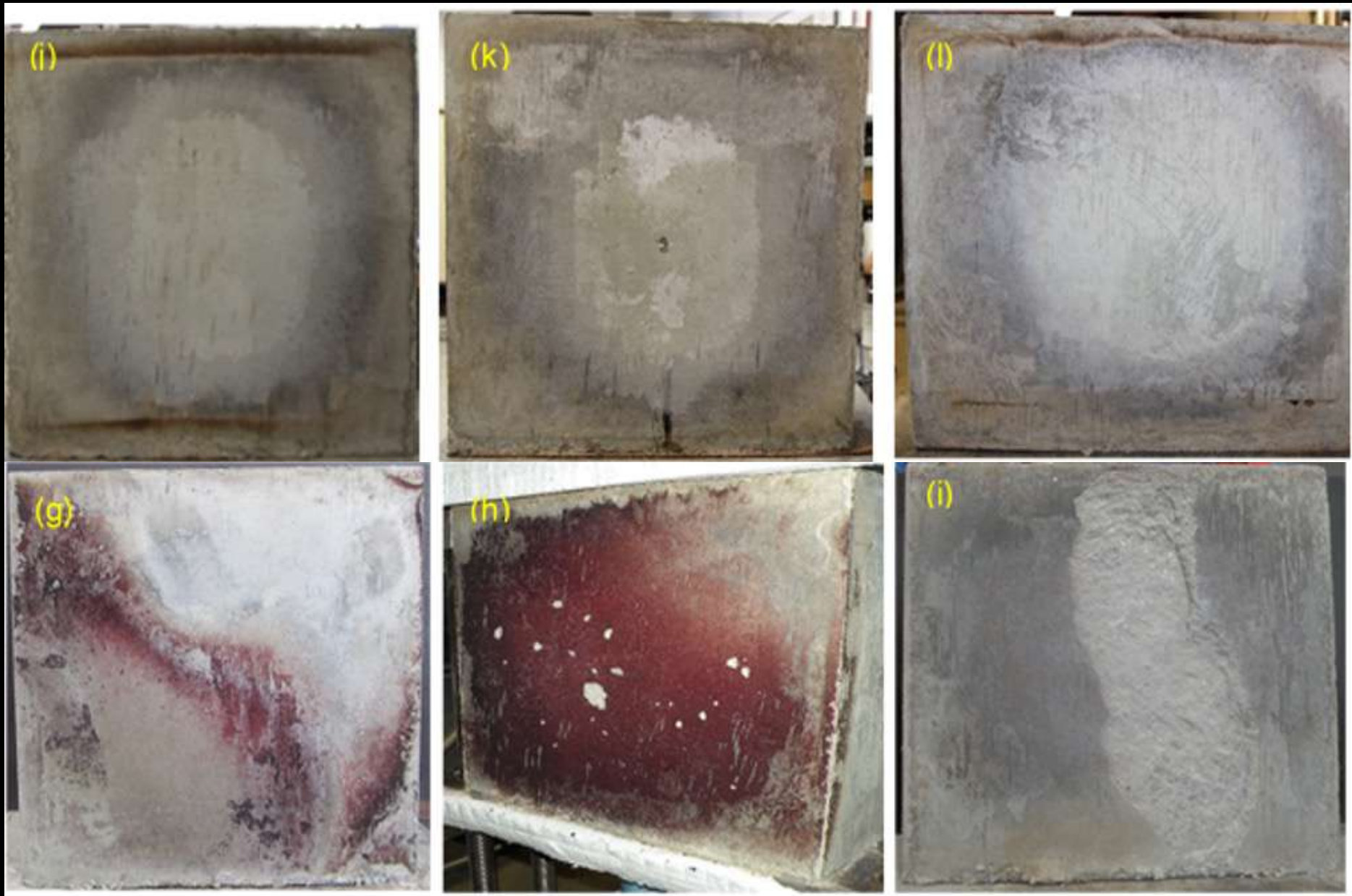
Fire Spalling Tests Using H-TRIS



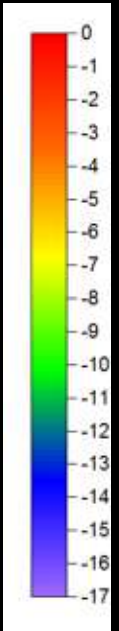
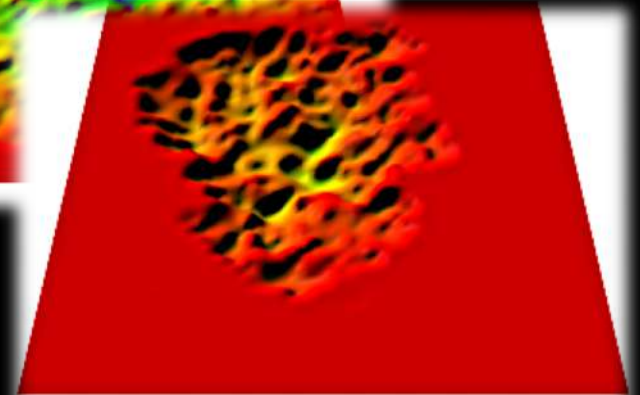
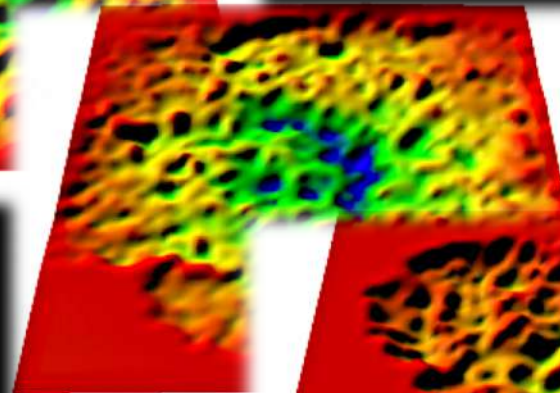
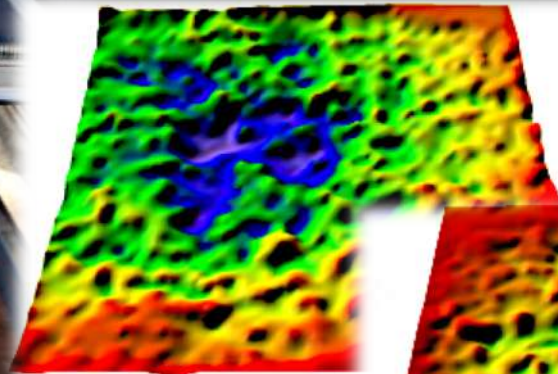
Without Fibre



With Fibre



Spalling Measurement



So Far...

12 cubes

- 6 plain concrete - 2 spalled
- **6 with RTPF (7 kg/m³) - NO spalling**

12 slabs - Series 1

- 3 plain concrete – 2 spalled
- 3 with low RTPF dose (1 kg/m³) - 2 spalled
- **6 with medium & high RTPF doses (2 & 7 kg/m³) - NO spalling**

12 slabs - Series 2

- 3 plain concrete – 2 spalled
- **3 with RTSF – NO spalling**
- **6 with RTSF-RTPF blends - 1 spalled lightly**

12 slabs - Series 3

- 12 plain concrete – all 6 spalled
- **12 with RTPF (2 kg/m³) - NO spalling (1 delamination)**



The University Of Sheffield.



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FIRE SPALLING 2019

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Thank you!

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Innovate UK