Avoids explosive spalling in concrete

IGNIS® Monofilament Fibre
PASSIVE FIRE PROTECTION

Case studies

North Downs Tunnel, Kent
The 3.2 km North Downs Tunnel forms part of the Channel Tunnel Rail Link running from Folkestone, Kent to St. Pancras in London. The primary tunnel lining was made up of sprayed concrete, 1 kg of Ignis PP monofilament fibres were added to the C60/40- concrete secondary lining. The lining was constructed in-situ, forming a sacrificial layer.

De Westerschelde Tunnel, the Netherlands
The client Destrade BV instructed the precast contractors to add 1 kg of Ignis to the C40 concrete. The fibre was included in the concrete sections forming the security exits, safety barriers and connection tunnels.

Dublin Port Tunnel, Ireland
This 4 lane underground highway is designed to take heavy vehicle traffic off the streets of Dublin. A 275 mm thick lining over the tunnels arch is a non-load bearing sacrificial concrete containing 1.5 kg of ignis.

T5, Heathrow Airport
ADfil construction fibres are manufactured by Low & Bonar. The Group is a global leader in high performance materials with operations in 60 countries worldwide and manufacturing in Europe, North America and China. Low & Bonar designs and produces components which add value to and improve the performance of its customer’s products by engineering a wide range of polymers using in-house manufacturing technologies to create films, fibers, geosynthetics, industrial and coated fabrics and composite materials. These materials contribute to a more sustainable world and higher quality of life. The quality systems of Low & Bonar facilities have been approved to the ISO 9001 Quality Management System Standard. The Belgian plant where Ignis fibres are being produced is also ISO 14001 certified (Environmental Management). Low & Bonar is listed on the London Stock Exchange.

De Westerschelde Tunnel, the Netherlands
Dublin Port Tunnel, Ireland
T5, Heathrow Airport, London

North Downs Tunnel, Kent

Westerschelde Tunnel, the Netherlands

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T5, Heathrow Airport, London
Concrete is the most widely used construction material in tunnels around the globe. Due to several tunnel fires in Europe and the increased threat of terrorism, public attention has been focused on the performance of concrete structures both above and below the ground. Passive fire protection that safeguards structural integrity in the event of a fire is of utmost importance for the safety of tunnels. Without such protection, heavy objects and/or hot spalled concrete can pose a serious threat.

### Avoiding explosive spalling

Although concrete is non-combustible and has low thermal diffusivity, it does experience explosive spalling from the build-up of pore pressure and internal tensile stress during a fire. Ignis® polypropylene monofilament fibre, when mixed in concrete, increases its permeability during heating thus reducing pore pressure and avoiding the risk of spalling.

### Breadth of end-uses

Ignis® fibres are applied in a wide range of applications. Examples include sprayed linings, precast segments and shuttering for:

- Road and rail tunnels
- High rise buildings
- Cable tunnels
- Bridges
- Underground/multi storey car parks
- Refractory products

### Mechanism of concrete spalling

**Causes of concrete spalling**

- Temperature rise in concrete
- Moisture starts to vaporise and voids in the concrete build up.
- Moisture cannot escape quickly enough.

**Release of vapour**

- High quality dense concrete means the fibres will disintegrate, creating voids in the concrete.
- When the temperature reaches 360°C, the fibres will melt at 160°C and has low thermal diffusivity, it does not experience explosive spalling.

**Prevention of concrete spalling with polypropylene fibres**

- Hot front quickly overtakes moist front.
- High quality dense concrete means the fibres will disintegrate, creating voids in the concrete.
- When the temperature reaches 360°C, the fibres will melt at 160°C and has low thermal diffusivity, it does not experience explosive spalling.

**Benefits**

- Prevention of explosive spalling
- Enhanced abrasion and impact resistance
- Improved resistance to plastic shrinkage cracks
- Enhanced abrasion and impact resistance

### Technical details

- **Fibre length**: 6 mm
- **Equivalent diameter**: 18 μm
- **Drop mode**: Monofilament
- **Specific gravity**: 0.95 kg/dm³
- **Fibre count**: 718 mio.
- **Specific gravity**: 0.95 kg/dm³
- **Shape**: Monofilament
- **Equivalent diameter**: 18 μm

### Testing

**Proven performance**

Extensive testing at independent laboratories such as TNO (NL) and BRE (UK) has proven that Ignis® significantly enhances the fire rating of concrete structures.

**TNO**

Back in 1999 TNO proved that the use of monofilament fibre gave the best results when compared to fibrillated fibres in avoiding explosive spalling. A year later, the institute used the RWS Fire Curve on a number of concrete samples that contained 1.2 and 3.4 kg/m³ of ignis monofilament polypropylene fibre. The samples were loaded to ± 5 N/mm². The RWS Fire Curve models a severe hydrocarbon fire and after just 15 minutes the temperature was 1200°C. The samples containing 3 kg of Ignis fibre showed no evidence of spalling after two hours of testing.

**BRE**

Samples containing granite aggregates and ignis monofilament polypropylene fibres were exposed to a severe hydrocarbon fire curve that rose to 820°C in three minutes and peaked at 1350°C. The samples were subject to compressive forces during the test; equivalent to the design loadings predicted in the tunnel lining of the Channel Tunnel Rail Link project. The plain control sample suffered extensive explosive spalling up to a depth of 120 mm. The sample containing Ignis fibres showed no evidence of spalling after two hours of testing. Even the mixes containing lightweight aggregate which totally disintegrated during the initial tests, showed no spalling when Ignis fibres were added.

### Table: Comparison of concrete samples

<table>
<thead>
<tr>
<th>Test</th>
<th>RWS Fire Curve</th>
<th>BRE Fire Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>No fibre</td>
<td>1.2 kg/m³</td>
</tr>
<tr>
<td>Test 2</td>
<td>No fibre</td>
<td>3.4 kg/m³</td>
</tr>
<tr>
<td>Test 3</td>
<td>No fibre</td>
<td>6.8 kg/m³</td>
</tr>
</tbody>
</table>

**Ignis® Monofilament Fibres**

Increasing the safety of people and structures

Concrete is the most widely used construction material in tunnels around the globe. Due to several tunnel fires in Europe and the increased threat of terrorism, public attention has been focused on the performance of concrete structures both above and below the ground. Passive fire protection that safeguards structural integrity in the event of a fire is of utmost importance for the safety of tunnels. Without such protection, heavy objects and/or hot spalled concrete can pose a serious threat.