

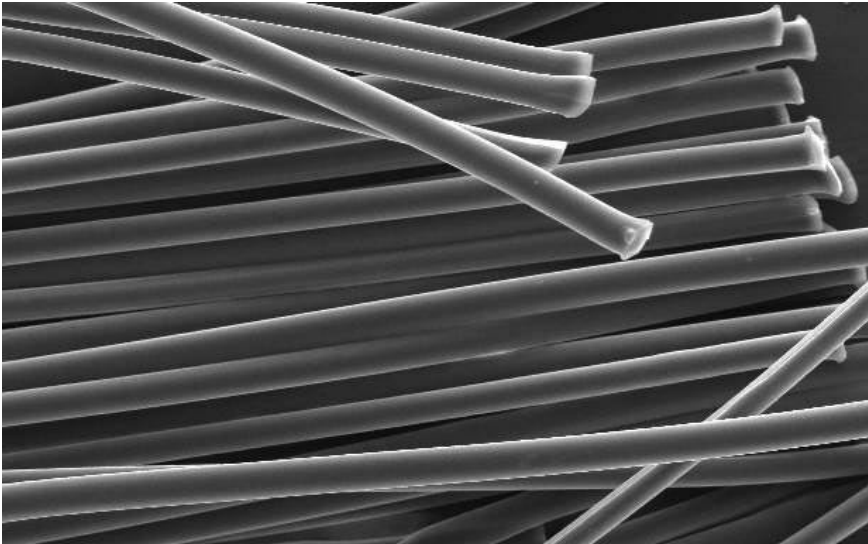
Duomix[®] Fire



**Duomix[®] Fire (M6) polypropylene fibres
to increase fire resistance of concrete**

Duomix® Fire

POLYPROPYLENE FIBRES TO INCREASE FIRE RESISTANCE OF CONCRETE

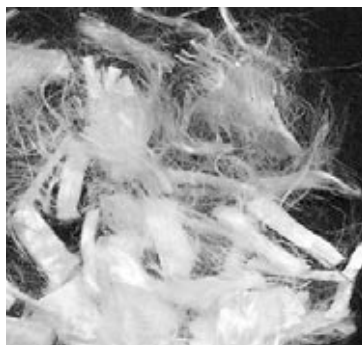


Duomix® Fire (M6), the mono filament fibre with diameters of less than 20 µm and a length of 6 mm.

Duomix® is a strained, mono filament Polypropylene fibre with round cross section, manufactured in the extruding procedure.

Duomix® polypropylene fibres were developed as additives to cement-bound materials. The aim was to preserve the mixing ratio of concrete but to improve the concrete's characteristics, particularly regarding early shrinkage cracks and the absorption of tensions during the hardening (plastic shrinkage phase) should be improved. The result, Duomix® Fire (M6) leads to a decrease in the formation of shrinkage cracks during the production of the construction units themselves.

Recent research proves that the admixture of Duomix® Fire (M6) polypropylene fibres provides an optimally protecting void structure within the concrete. Their refinement, the extremely high number of items and their high surface area impressively increase the concrete's durability in case of fire.



BEKAERT seeks continual co-operation with leading technologists to ensure workability, in particular to optimize consistency and pumpability of the FRC. Our aim is to further improve the required slump, which can be reached by a balanced concrete prescription and, in addition, by special fibre coatings. This coating reduces the required slump and improves the concrete's workability. The use of dosing equipment, cut to the very conditions of the building site, can be clarified individually.

BEKAERT has the finest fibre

Duomix® Fire

2,3 dtex (2,3 g per 10 km fibre)

App. 725 mio. fibres/kg with an overall surface of 600 m²

Length 6 mm

Diameter nominally 18 µm

Elongation at rupture 15 %

Material: Polypropylene

Density: 0.91 kg/dm³

E-module: 3500-3900 N/mm²

Tensile strength: 300 N/mm²

Melting point: 160 - 165° C

Moisture absorption: 0%

Colour: transparent white

Characteristics

Duomix® polypropylene fibres were developed as an enhancement to the **BEKAERT** range of world renowned steel fibres named Dramix®. Duomix® outperforms the requirements of the current guidelines for fibre-reinforced concrete. Duomix® Fire (M6) has proved suitable with all fire curves.

Duomix® polypropylene fibres do not represent a health risk: The nominal dimension lies far over 3 µm, the size regarded as health-endangering.

Applications

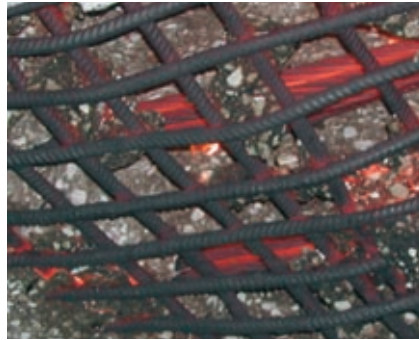
Concrete with Duomix® is used as fibre-reinforced sprayed concrete (FRSpC) or as fibre-reinforced concrete (FRC) poured into a mold.

Packing units: 0.6/0.9 kg water-soluble paper bags in cardboards bundled on pallets, other bundles on request.

Fire-resistant. Sure.

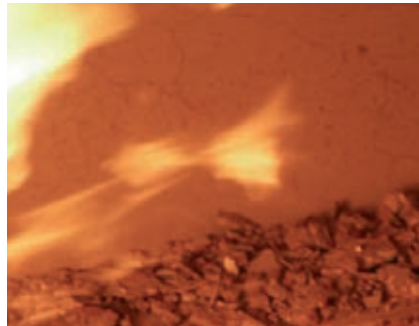
Characteristics and effects of Duomix® Fire (M6)

The impact of fire can inevitably lead to a breakdown of the construction unit caused by huge pieces of concrete spalling. Load-carrying capacity and safety of the structure are lost. The cause: Bound water evaporates, but cannot escape fast enough due to the close concrete structure. The steam pressure inside the concrete increases, and under the rising temperature the outer zones suffer high compression stresses and eventually failure.



WITHOUT Duomix®: Spalling of 25 cm and more - the load-carrying capacity of the unit is not given any longer. **WITH Duomix® Fire (M6):** Spalling of 1 - 2 cm - the reinforcement remains protected.

(Photographs: Road Researchorder No. 3.269 and HL-AG)



DUOMIX® Fire (M6) creates a void structure, as the fibres melt off, so that the vapour can escape before the construction unit fails.

Duomix® Fire (M6) decreases depth and area of spalling in case of fire - practically to zero when compared to fibre-free concrete (infected by fibre dosage, concrete quality and tensile state).

By forming micropores Duomix® lowers the danger of microcracks, which may grow to uncontrollable macrocracks: The reinforcement remains protected even in edges and edge zones.

FRC with Duomix® Fire (M6) minimizes concrete attrition in case of fire, which is limited to a superficial layer of less than 2 cm. Thus Duomix® Fire (M6) ensures that load-carrying capacity and safety of the structure may be retained. Furthermore it can drastically lower the cost of maintenance and re-establishment.

DUOMIX® Fire prevents

- an exposure of the critical reinforcement section.
- reduction of the concrete cross section.
- in many cases even partial spalling.

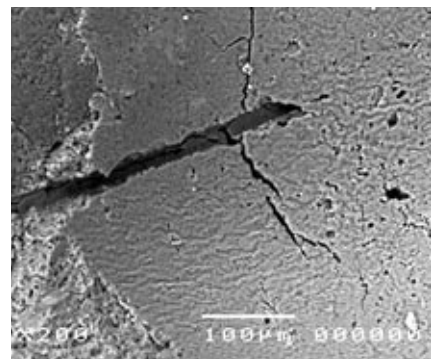
How Duomix® Fire (M6) does this

The control of steam pressure in case of fire unfolds on 3 levels:

- by cross-linking of border zones - enhancement of material transfer and moisture diffusion.
- by micropores formed at the admixed fibres.
- by macropores formed after the fibres melt off.

Particular advantages of the Duomix® Fire (M6) fibres

- They form smaller canals for water diffusion without significantly decreasing the rate of diffusion.
- Due to a higher number of capillary tubes, steam pressure is rapidly compensated, since steam escapes regulated.
- In cross section the large surface of their pores forms optimal diffusion paths.
- They prevent unwanted substance transport in the pores.



Photograph: Road Researchorder No. 3.269 and HL-AG

Already in the preliminary investigations Duomix® Fire (M6) showed impressive results. Therefore in Austria all current research projects will focus further on this fibre type.

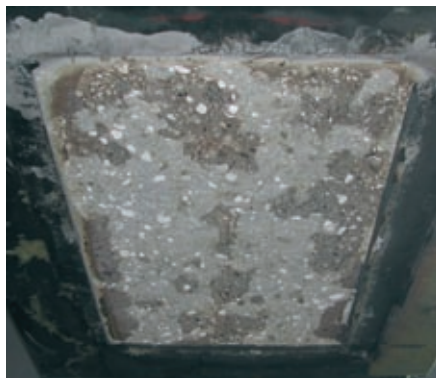
Tested quality

“Fire resistance of fibre-, steel- and prestressed concrete”

Road Researchorder No. 3.269 of the Austrian ministry of logistics, innovation and technology and High Speed Railway organisation (HL-AG):



Fire test with large-scale plates under different stress conditions: WITHOUT Duomix®: The reinforcement lies exposed. WITH Duomix® Fire (M6): Dampness escapes - the sample test specimen stays intact to a large extent.



Photographs: Road Researchorder No. 3.269 and HL-AG

DUOMIX® Fire (M6) is ...

- pumpable, causing no damage to hoses
- easy to work
- distributed throughout the entire concrete matrix
- not visible at the surface
- no risk to health
- 100% alkali-resistant
- chemically inert, compatible and durable
- neither attacked by acids nor by solvents

Concrete prescriptions remain uninfluenced to a very large extent, however, special attention must be paid to the slump. Depending on dosage a loss of slump may be seen, which should be compensated by adding plasticisers.

Despite the loss of slump workability and pumpability of the concrete can be retained. Please contact us!

Fibre performance class BB*

Increase of fire resistance

Spalling in %		
BB-class	Comparable concrete without fibres	Fibre concrete
BB 1G	100 %	< 30 %
BB 2G	100 %	< 2 %

Duomix® Fire (M6) fulfills BB1 and BB2 small samples and BB2G (highest requirement) at large-scale plates (140 x 180 x 30/50 cm) under different compression stresses (0/1.16/6.50/9.00 MPa crosswise, 0.50 MPa lengthwise).

DUOMIX® Fire (M6) ...

- under fire attack forms micro-pores and harmless micro-cracks - the vapour can escape controlled.
- decreases the extent of explosion-like concrete spalling.
- minimizes concrete abrasion down to a maximum depth of app. 2 cm.
- in case of fire the steel reinforcement is protected even in edge zones.
- preserves the ultimate limit state and the serviceability of the construction unit.
- lowers the costs of maintenance and re-establishment to a minimum.

Fibre performance class FS*

Decrease of the formation of early shrinking cracks

Total length of cracks [%]		
FS-class	Comparable concrete without fibres	Fibre concrete
FS 1	100 %	60 %
FS 2	100 %	20 %

Duomix® Fire (M6) fulfills FS2

In normal or high-performance concrete Duomix® causes an evident reduction of early shrinkage cracks. In the early binder phase Duomix® can take up locally arising tensions in the concrete.

* according to Richtlinie Faserbeton (guideline fibre-reinforced concrete) ÖVBB



Duomix® Polypropylene plus Dramix® Steelwire Fibres



FIBREBLEND FOR OPTIMAL FIRE PROTECTION

Fibreblend combines the advantages of Duomix® Fire (M6) polypropylene fibres and Dramix® high tensile steel fibres.

- Duomix® improves the shrinkage behavior in the manufacturing process and ensures serviceability under fire attack.
- Dramix®, in accordance with OEVBB "guideline for fibre-reinforced concrete", works as a statically calculable reinforcement to ensure ultimate limit state performance and serviceability limit state performance.
- Additionally the steel fibres in combination with polypropylene fibres obstruct temperature penetration under fire.
- The use of fibreblend saves working time as well as costs.

Reinforcement and fire protection directly into the mold

Compared to the admixture of 1,5 kg/m³ Duomix® Fire (M6) the use of fibreblend (30 kg/m³ Dramix® RC 80/60 BN and 1,5 kg/m³ Duomix® Fire) significantly reduces temperature penetration.

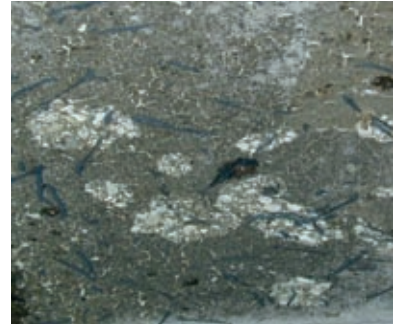
In addition, fibreblend causes a further reduction in the loss of stability under fire: FRC with Dramix® RC 80/60 BN helps to prevent explosive spalling of concrete in a fire situation.

Thus Dramix® protects intact concrete segments against direct firing. Micropores around the steel fibres allow the reduction of steam pressure in case of fire: Improved filtration by cross-linking of border zones, improves diffusion of water and vapor.

Bekaert Know-how: Leadership and competence in one hand

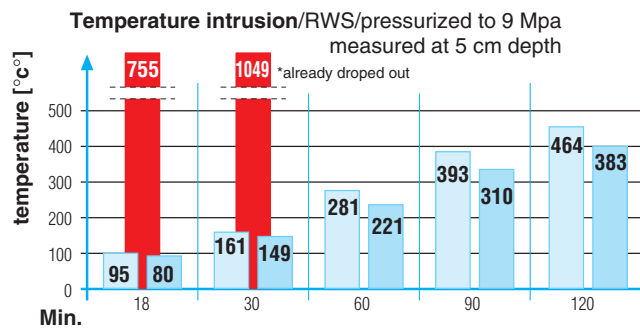
The comprehensive fibre range of **BEKAERT** is the result of intensive research and development, based on the requirements and issues of practical use by industry as well as on innovative deployment. Steel and plastic fibres as well as conventional reinforcing steel are constantly improved, our testing programs seek the optimization of combined applications.

The continuing exchange of experience from our world-wide partnership with universities and research institutes constantly extends **BEKAERT** competence and **BEKAERT** know-how. Our investment in research, development and product innovation make **BEKAERT** a knowledgeable addition to your team.



Economic advantages

The use of composite concrete with Duomix® Fire (M6) and Dramix® results project-related in lower total expenses of installation, a high life span, higher working reliability and reduced costs of restoration after a fire.



Fibre-free concrete
depth of spalling 27 cm
collapse of the component after 18 min.

Fibre concrete
1,5 kg Duomix®
depth of spalling ≈ 2 cm

Fibreblend
1,5 kg Duomix®
30 kg Dramix®
depth of spalling 1-2 cm

Technical advantages

Optimized fire resistance: The combination of Duomix® Fire (M6) and Dramix® significantly reduces spalling: According to test reports up to 98% and more compared with non-fibrous concrete. Required concrete characteristics, such as compressive strength, water resistance, freeze-thaw resistance remain untouched, post-crack resistance and shear strength are even improved by Dramix®.

APPLICATIONS

Concrete with Duomix® is used as fibre-reinforced sprayed concrete (FRSpC) or as a fibre-reinforced concrete (FRC) poured into a mold. Fibre-reinforced concrete can also offer many benefits to high-performance concrete.

Underground engineering:

In particularly critical situations, such as long tunnel tubes, and in inner city tunnels, where several tubes are crossing, or in underpasses of water-courses etc., as

- inner linings
- cover of traffic routes, built in open method
- segmental linings

Building construction:

- additive to increase fire resistance of bearing items
- spun concrete supports and covers



CONSULTING

BEKAERT - Your partner for all questions on fibre-reinforced concrete.

Whether steel- or PP-fibre, we offer you:

- exchange of experience
- aid in decision making in the tendering process (e.g. dimensioning recommendations for steel fibre concrete)
- supply of documents (references, product specifications, test reports)
- selection of the suitable kind of fibre, length and dosage
- concrete prescriptions
- optimal admixture and dosage in the concrete center (safe & economical)
- processing recommendations
- project support from planning to the site installation



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