

# Dramix<sup>®</sup>



**Steel wire fibre reinforced  
segments for  
Tunnel linings**

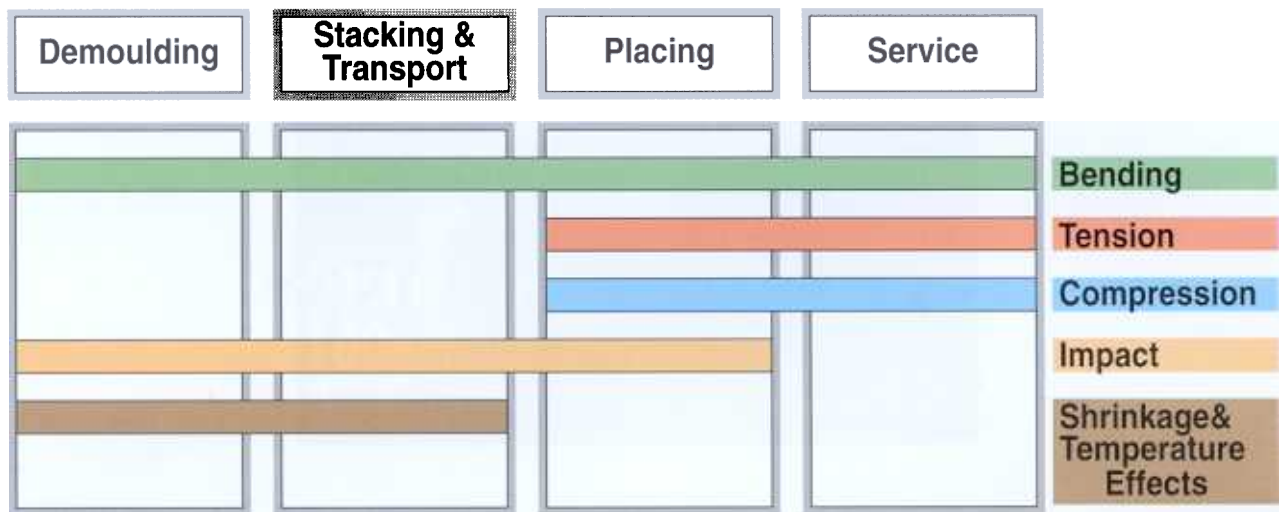
# Dramix® steel wire fibre reinforced segments for tunnel linings



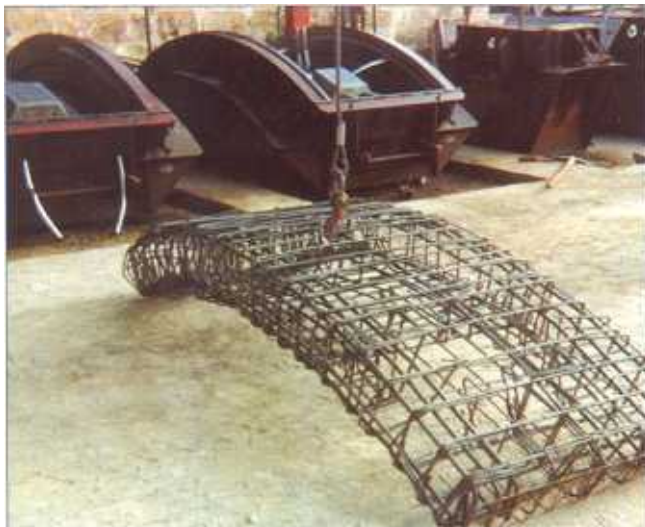
The use of tunnel boring machines together with the installation of reinforced concrete segments allows an important reduction in potential ground settlements, particularly in urban and difficult zones, associated with the complete automation of the boring and lining process. Problems related to the production, installation and durability of conventional reinforced segments favour the potential use of steel fibre reinforced concrete for the manufacturing of tunnel segments.

*Baggage tunnel at Heathrow airport London constructed with Dramix® steel wire fibre reinforced concrete segments.*

## Forces



## Conventionally reinforced segments



### Conventional reinforcement cage

A conventional reinforcement cage consists of rebars fabricated into top and bottom mats, separated by stirrups welded to the mats. The main function of the top and bottom part of the reinforcement cage is to resist the forces related to demoulding, stacking, transportation and site conditions. The edges of the cage resist the forces during installation of the segments. Jacking forces are very often the determining forces in the design.

*A conventional reinforcement cage.*

## Technical constraints

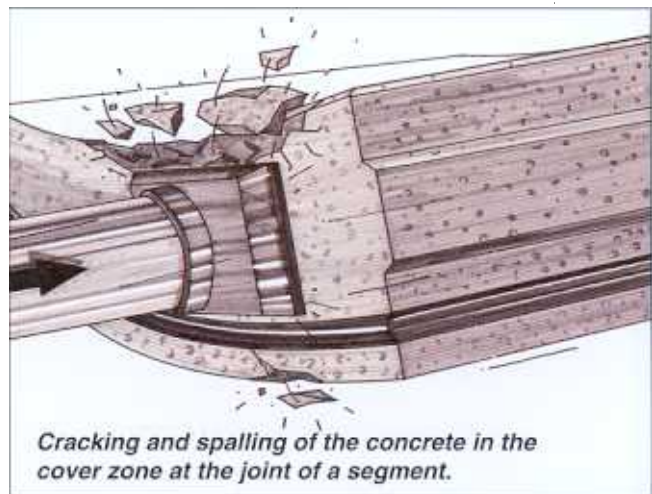
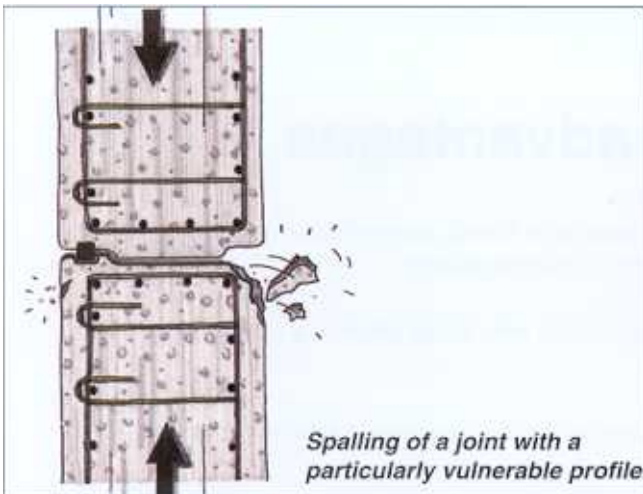
In practice the cage reinforcement proves to be insufficient in many cases. Very often damage at edges and corners occurs.



*Damaged edges of a traditional reinforced segment.*



The minimum required cover, necessary for protection against corrosion, and the particular shape of the edges makes the periphery of the segment particularly vulnerable to damage.



## Practical constraints

- ✓ The construction of the reinforcement cages requires **highly specialised manual labour and equipment.**
- ✓ **Large areas and specialist handling equipment** are required for **storage.**
- ✓ **Fixing the reinforcement cage accurately in the mould is essential** to ensure the required concrete cover.



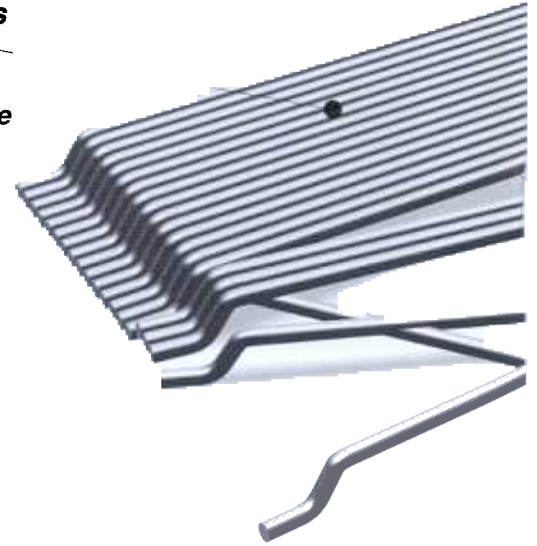
*Supply carousel for cages.*



*Unloading and stacking of reinforcement cages.*

***Dramix® steel wire fibres are glued together in bundles (Bekaert patent) to allow :***

- ✓ *the guarantee of a uniform distribution in the concrete without increasing the mixing-time.*
- ✓ *the possible use of automatic dosing and dispensing equipment.*
- ✓ *the use, when necessary, of galvanised fibres.*



## Technical advantages

- ✓ **Homogeneous distribution.** The Dramix® steel wire fibres, present close to the surface, ensure an excellent reinforcement at the joints of the segments.
- ✓ **Multidirectional reinforcement.** The Dramix® steel wire fibres provide a resistance to stresses in all directions.
- ✓ **Excellent corrosion resistance.** The spalling risk of the concrete is totally excluded.
- ✓ **High impact resistance.** The energy absorbed by the steel wire fibre reinforced concrete during impact is superior to the energy absorption of plain concrete.
- ✓ **Excellent control of shrinkage cracks.**



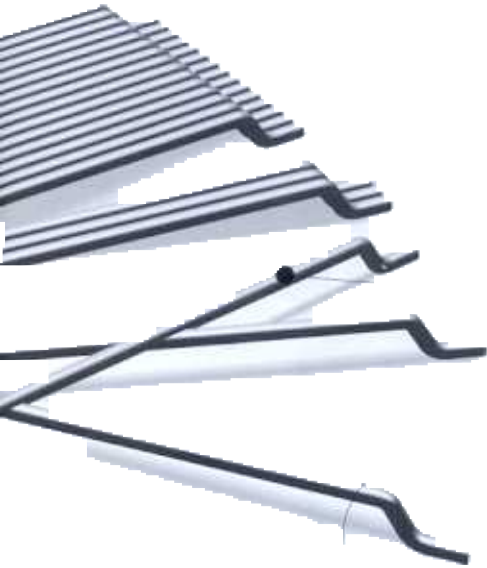
*Automatic dosing and dispensing equipment.*



*Pouring of the steel wire fibre reinforced concrete into the mould.*



*Finis*



- *Drawn steel wire for high tensile resistance.*

*Mechanical anchorage (hooks) at the ends for an optimal pull-out resistance.*

## Economic advantages

- ✓ Reduction in the repair cost of damaged segments during handling.
- ✓ Elimination of manufacturing, handling, storage and positioning of reinforcement cages.
- ✓ Possible use of automatic dosing and dispensing equipment for the Dramix<sup>®</sup> steel wire fibres which can be linked to the control panel of the batching plant.
- ✓ Reduction of the production cycle time resulting in an increase in productivity.



up face.



Demoulding.



Stacking.

## Fibre types



Dramix® steel wire  
fibre bundles

The glueing of fibres together in bundles allows Bekaert to offer a wide range of high and very high performance fibres. The fibre type can vary from project to project.



## Design



### Method

Bekaert has developed a design method to calculate Dramix® steel wire fibre reinforced segments. The design method is based on the German recommendations for steel fibre reinforced concrete 'DBV-Merkblätter Faserbeton - Technologie des Stahlfaserbetons und Stahlfaserspritzbetons Bemessungsgrundlagen für Stahlfaserbeton im Tunnelbau, August 1992'



### Design

A design proposal in Dramix® steel wire fibre reinforced concrete can be provided with no commitment



### Dosage

The required dosage depends on the loads acting on the segments and the fibre type used.

## Packaging



Pallet 1250 kg (50 bags of 25 kg)



Big - bag 1100 kg

# References

Project	country	type	length (m)	internal diameter (m)	thickness (cm)
Fanaco	Italy	water	4.820	3	20
Metrosud	Italy	underground	2.640	5,8	30
Heathrow	U.K.	service	1.400	4,5	15
Jubilee	U.K.	underground	2.400	4,45	20
Essen	Germany	underground	100	7,3	40
Lötschberg	Switzerland	pilot	160	4,5	22



*Transportation of precast segments (Metrosud).*



*Test-ring (Heathrow).*



*Handling of a segment (Heathrow).*



*Installation of the key-segment (Heathrow).*



*Vertical storage of segments (Heathrow).*



*Horizontal storage (Metrosud).*

## @ BEKAERT Service

## Addresses

Should you require further information please contact us for:

- ◆ Technical literature.
- ◆ A design proposal in Dramix® steel wire fibre reinforced concrete.
- ◆ Advice on the production of Dramix® steel wire fibre reinforced concrete elements.
- ◆ Information on the dosing and dispensing equipment for the Dramix® steel wire fibres.
- ◆ Information on Internet:  
<http://www.bekaert.com/building>

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