Environment_Friendly_Solutions_For_Underground_Works

Who Are We

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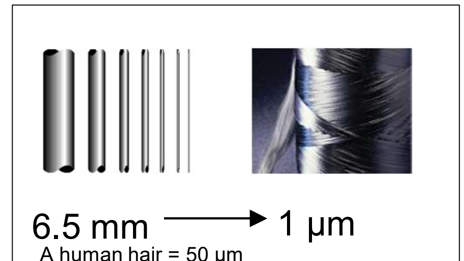
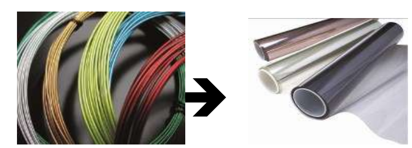
Bekaert In A Nutshell*

- ❑ Founded In 1880 By Leo Leander Bekaert
- ❑ Customers In 120 Countries And In The Most Diverse Industry Sectors
- ❑ Global Manufacturing Platform
- ❑ 28 000 Employees Worldwide
- ❑ Combined Sales Of 4.6 Billion Euro
- ❑ Consolidated Sales Of 3.3 Billion Euro
- ❑ Listed On Euronext® Brussels





From traditional coatings to advanced coatings

- ❑ **Bekaert Is A Worldwide Player Active In Selected Applications**
- ❑ **Based On Our Two Core Competences**
  - ❑ Advanced Metal Transformation
  - ❑ Advanced Materials And Coatings

History

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pioneering

1880
Leo Leander Bekaert starts a small business in barbed wire in Zwevegem, Belgium

1922
First investment abroad: Tréfileries de Bourbourg, France

1948
First investments in Latin America: Argentina and Chile

innovating

1952
Steel cord production start

1964
Establishment of R&D center in Deerlijk, Belgium

1965
Start-up of Engineering facility for machine design and manufacture

growing

Early 1970s
New steel cord plant openings and expansions in US, Brazil, Belgium, Japan

1972
Listing on the Brussels stock exchange to fund continued growth

1975-1977
Establishment of joint ventures in Ecuador and Brazil

diversifying

Early 1980s
Bekaert moves into composite materials, non-ferrous forged products, vacuum coatings and filtration

1988
New plant openings in the US in response to local demand

1990
Bekaert has become a truly international company with 15 000 employees worldwide

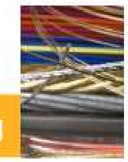
BRIC

1993
Bekaert recognizes China's huge market potential and builds a first steel cord plant in Jiangyin, Jiangsu Province

Mid 90s
Investments and expansions in Brazil, India, Indonesia, China, Peru and Chile

2000-2010
Strong growth in China, Central Europe, and start-up production in Russia

transforming



2013
Bekaert lifts its ambition level and deploys global excellence programs across the business

2014-2016
Bekaert concludes its largest acquisition (Pirelli) and merger (Bridon) ever

2020
Bekaert delivers on all priorities set forth and counters the impact of the pandemic

Bekaert Journey in India

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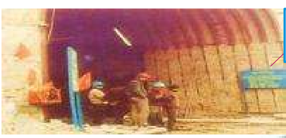
1985

Bekaert entered India market with Dramix® steel fibres, with Tata Steel as an agency agreement in 1985.
First Project – Srisailam Hydro Power.

1995



Nathpa Jhakri hydropower project largest and longest headrace tunnel, and underground power complex.

1996

Marsyangdi hydropower project was one of the notable projects by Bekaert done in Nepal

1998

Tala Hydroelectricity is the biggest hydroelectric joint project between India and Bhutan

1999

1999 completed over 15 Hydro Projects and also Bekaert steel cord plant in Ranjangaon, Pune

2005-07

This partnership continued until 2005. Bekaert made a strong leadership position in the hydropower market. 2007 Bekaert started its own office for building products

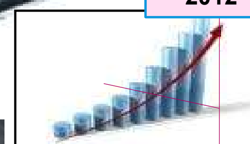
2009

Worked with all major Government bodies in power sector since 1985 including, NHPC, NTPC, NEEPCO, SJVN, etc.

2010

Bekaert continues to enjoy its leadership in the road tunnels sector with major projects like Jaipur tunnel , Rohtang road tunnel and Mumbai-Pune expressway (1998) reinforced with Dramix® SFRS

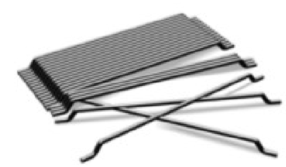
2012



Completed 400+ Projects (flooring + hydro) within a span of 4 years*. 31+ ongoing & completed tunneling projects. Worked with Indian railways, NHAI

2020

Got approval for cast in situ (USRBL)& PSCL Application (Mumbai Metro)



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Steel Fiber Reinforced Concrete Tunnel Linings

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Amit Kaul
Business Development Manager Underground

Introduction

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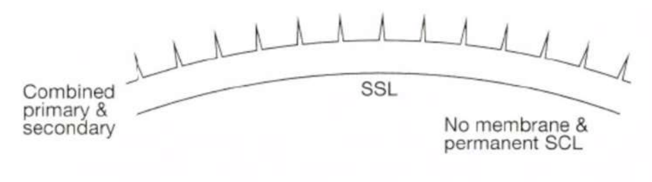
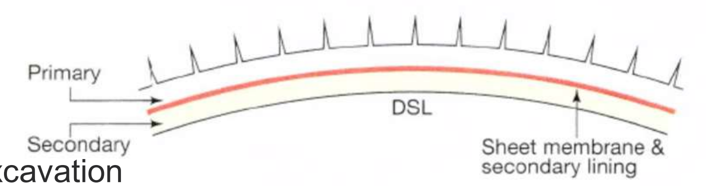
- Typically, The Tunnel Supports (Lining's) Are Broadly Divided Into Two Types:
  - **Single Shell Lining (SSL):**
    - Permanent Sprayed Concrete Lining Consisting Of A Single Layer, Or Several Layers Placed At Different Times:
      - Initial Sprayed Concrete Layer As Sacrificial Layer (5-10 Cm)
      - Primary Sprayed Concrete Layer Immediately Applied
      - Secondary Sprayed Concrete Applied At A Later Stage
      - Architectural Or Protective Finishing Layer (E.G., Case Of Fire)



  - **Double Shell Lining (DSL):**
    - Traditional Tunnel Lining System Consisting Of:
      - Temporary Sprayed Concrete Primary Lining Immediately Applied After Excavation
      - Waterproofing Membranes Installed & Fixed On The Primary Lining At A Later Stage (Separation Layer)
      - Durable Secondary Cast-in Place Concrete Lining Installed At A Later Stage, Incl. Architectural Or Protective Finishing Layer (E.G., Case Of Fire)



Lining Considerations Aspects

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- **Linings Should Perform Satisfactory In The Working Environment During Its Foreseen Service Life:**
  - Long Term Durability
  - Strength Development
  - Predicted Loadings And Load Bearing/ Load Transfer
  - Longevity & Finish
  - Repair & Maintenance
- **Choice of Lining Type Must Consider:**
  - **Constructability…..**
  - **Time Frame….**
  - Required Quality Of Finishing
  - Water Proofing System

Current Practices & Possible Challenges

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- **Cycle Times:**
  - Installation of Reinforcement
  - Concrete Casting (Large Gantries)
- **Space Constraints:**
  - Steel Storage Yards
  - Reinforcement Fabrication Yard
- **Concrete Placement:**
  - **Dense** Reinforcement
  - **Maintaining Proper Cover**
  - Compaction Methods (Shutter Vibrators, etc.?)
- **Post Construction Repairs & Maintenance:**
  - Construction Joints & Honeycombing (Difficulty in Compacting)
  - Small Surface Cracks

Current Practices & Possible Challenges

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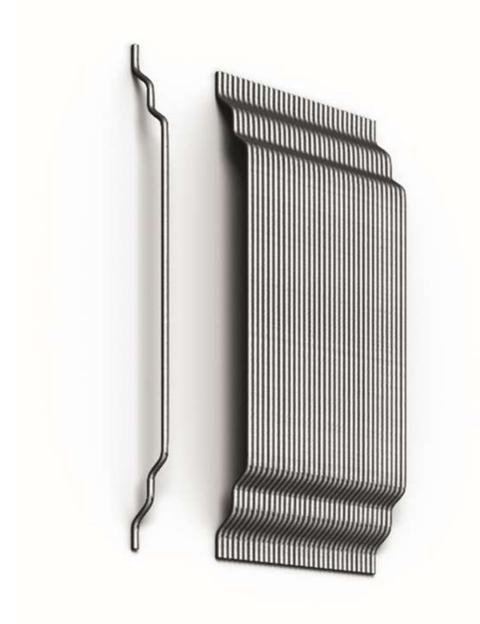
- **Current Systems With Re-bars Have Following Challenges:**
  - Need Large Space For Storing Reinforcement and Fabrications
  - **COVER- >40 MM Most Susceptible ….**
  - Depending Upon Design Requirements Sections Can Have Congested Reinforcement Cages
  - Handling Reinforcement Cages Need Additional Resources (Manpower, Machines, etc.)
  - High Degree of Compaction Needed To Achieve Maximum Density & Especially In Thickly Reinforced Sections (Honeycombing, etc.)
- **Consequences:**
  - Large Area Fabrication Yards Needed
  - Additional Contractors For Bar Bending & Reinforcement Cage Manufacturing
  - Additional Resources for Reinforcement Installation in Gantries
  - Increased Cycle Times

How To Mitigate The Issues….

- By Replacing Steel Re-bars With Dramix® Steel Fibre In Lining

Wt. of Rebar's varies 70- 150 Kg /Cum
*Depending on the Diameter of the Tunnel



Dosage Rates: 5D 65/60BG
25 – 40 Kg/M^3

How Is This Possible……

Understanding Concrete Behavior…

The Principle Of Concrete Reinforcement

- Concrete Is Naturally BRITTLE And Has Low Tensile Strength And Ductility. When Subjected To Tensile Stresses, Unreinforced Concrete Will Crack And Fail.
- In Order To Change This Brittle Behaviour Into A More Ductile Behaviour, Mesh, Rebar Or Steel Fibres Are Added. The Role Of The REINFORCEMENT Is To Increase Load Bearing Capacity And Limit Crack Opening.

How Is This Possible……

Understanding Concrete Behavior…

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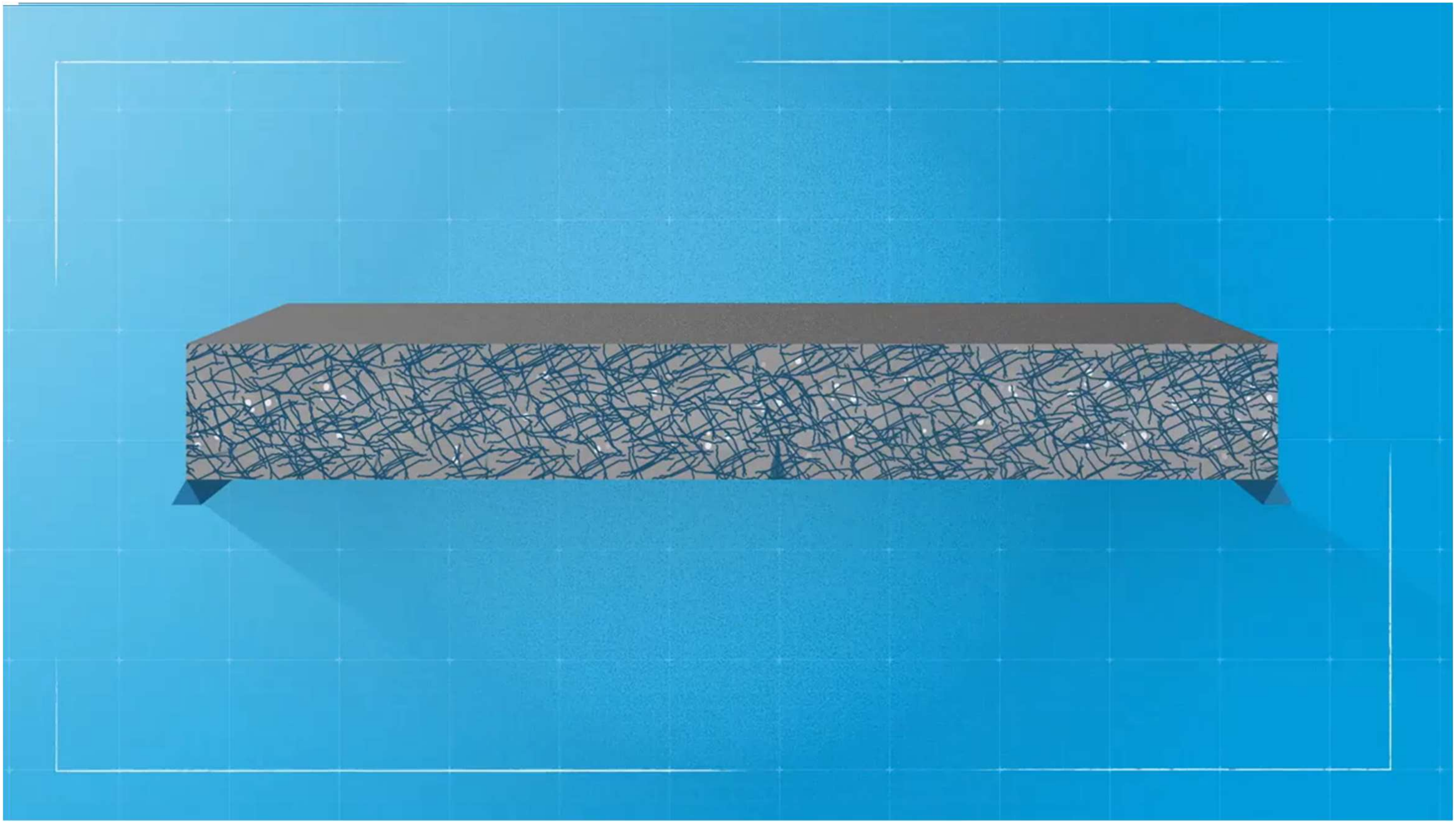
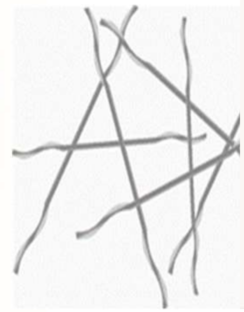
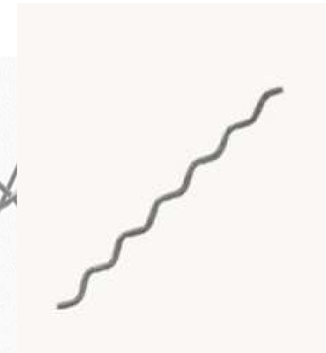
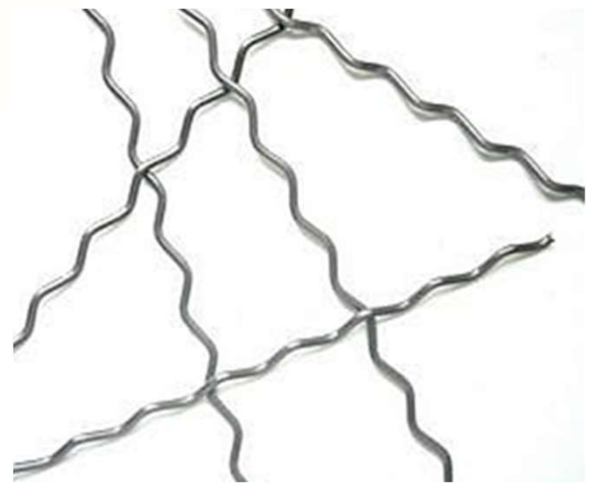
Nothing Is Less True!
Discover Why Steel Fibres Are The Perfect Alternative To Mesh Or Rebar Reinforcement In Many Applications.



Types of Fibres…..

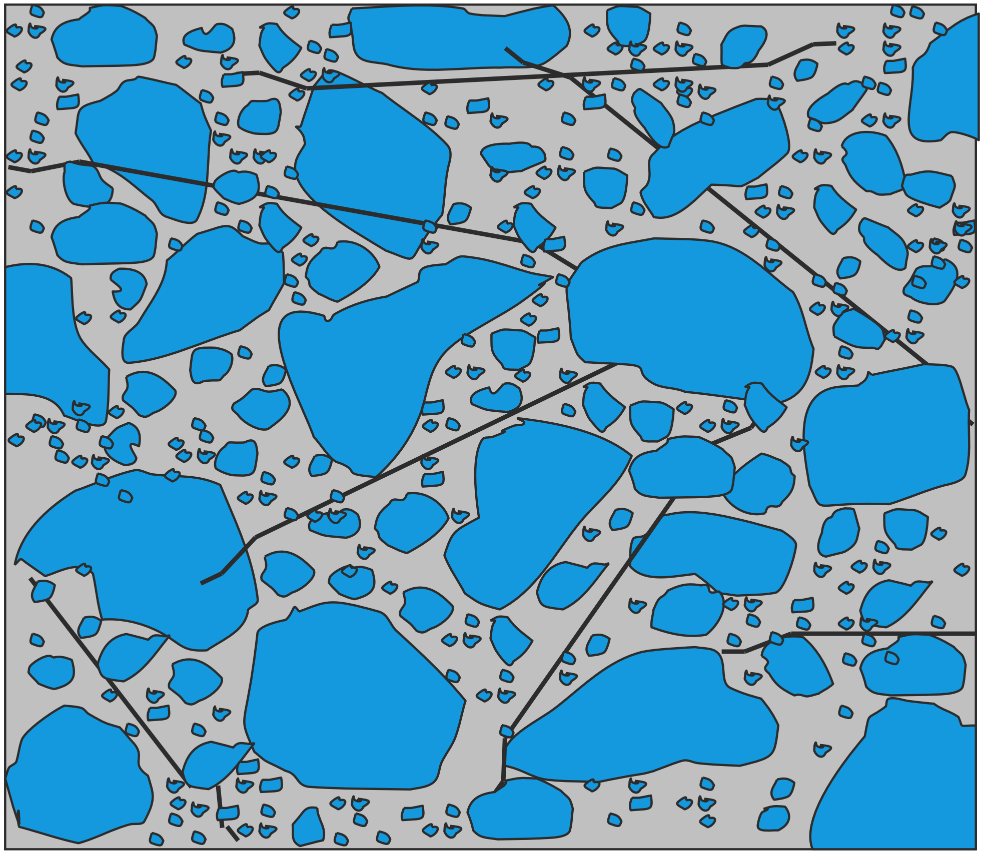
- Different Types Of Steel Fibres
- Steel Fibres For Concrete Appear In All Colors, Shapes, Sizes And Materials.
- The Performance Of Steel Fibres Is Influenced By Different Factors:
  - Wire Strength
  - Shape
  - Wire Elongation
  - Amount Concrete
  - Strength



Introduction to Fibre Reinforced Concrete

- The Fibre-reinforced Concrete (FRC) Is A Composite Material Made Of Basic Concrete In Which A Fibre Reinforcement Is Incorporated And Homogeneously Distributed.
- Steel Fibres Are Discrete, Discontinuous Pieces Of Reinforcement
- Steel Fibres Add Ductility To An Otherwise Brittle Concrete



Why SFRC

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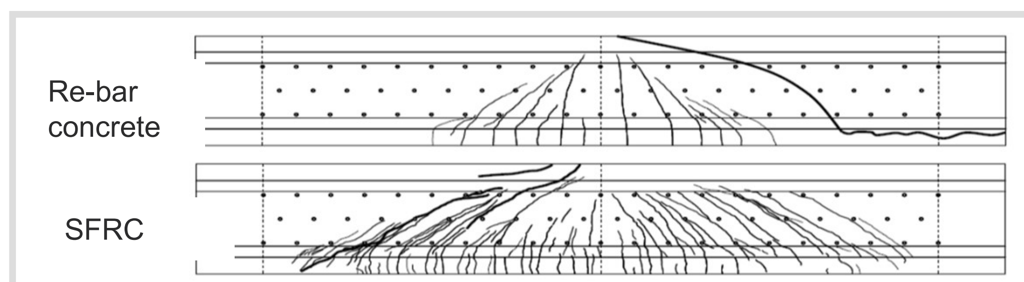
Why SFRC?

- **Constructive**
  - Avoid Conventional Reinforcement (Mesh, Rebars)
  - Labor Reduction
  - Reduction Of Checking Time
  - Reinforcement Correctly Placed
- **Structural**
  - Smaller Crack Width Openings
  - Higher Durability
  - Higher Impact And Abrasion Resistance
  - Higher Fatigue Strength
- **Cracking Control**
  - The Fibers Sew The Cracks And Redistribute The Tensile Stresses In A Larger Concrete Area.
  - Reduce The Crack Width And Spread The Cracking Due To Loads Or Constraints.
  - Prevent Rebar Corrosion, Stop Water Paths, Better Aesthetic Presentation, Prevent Spalling Due To Load Or Impacts.
  - Increase Of Durability.



Results In A Shear Test Of A Full Scale Beam

Why SFRC?

… and for passive fire protection

Fire Damage In Gotthard Tunnel, 2001

Why SFRC?

Plain Concrete
340 Mm Spalling Depth (RABT Fire Curve)

2 KG PP Fibre RC
15 Mm

Advantages of Fibre Reinforced Concretes

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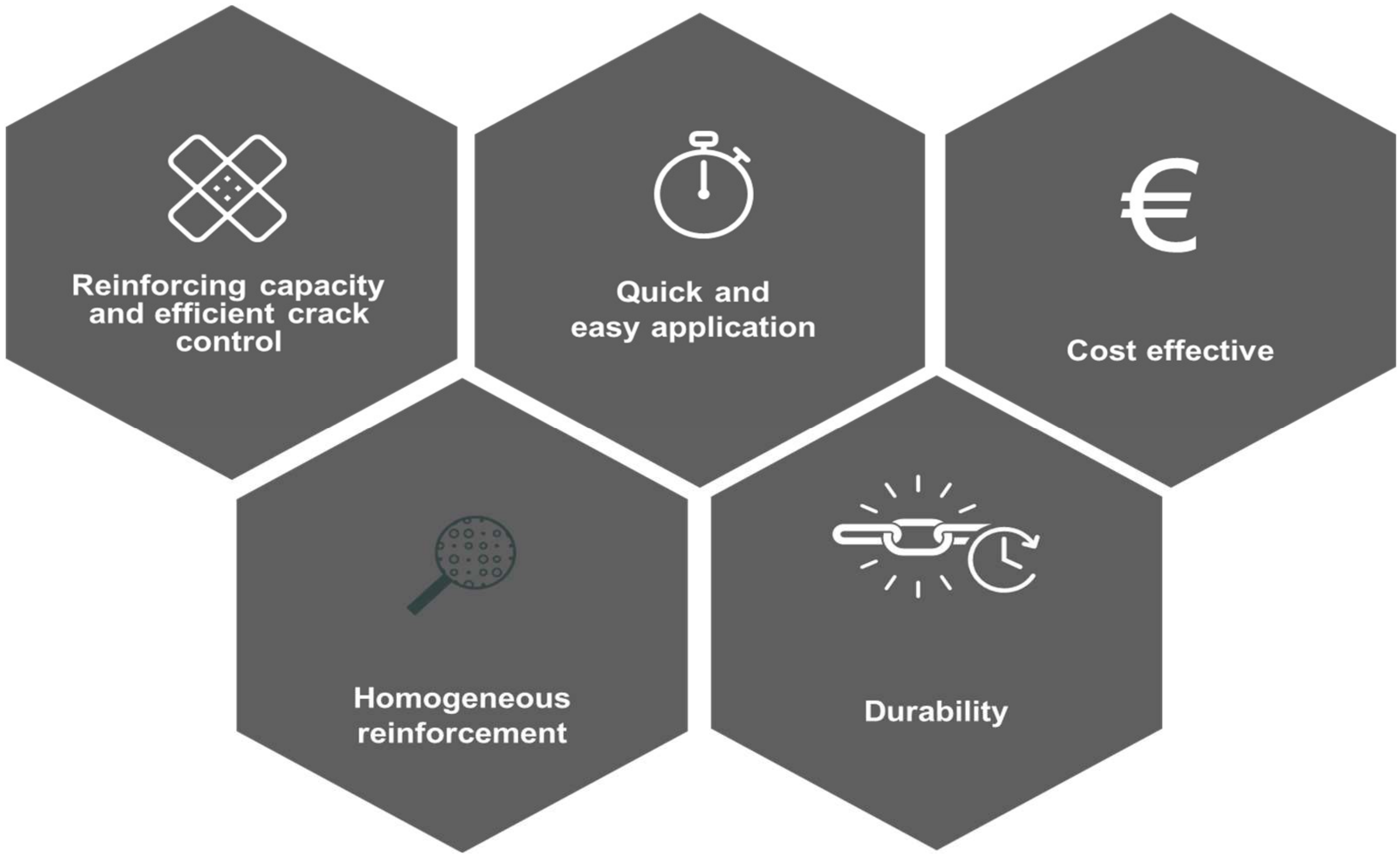
- Five Advantages Of Steel Fibre Concrete Reinforcement



Reinforcing Capacity And Efficient Crack Control

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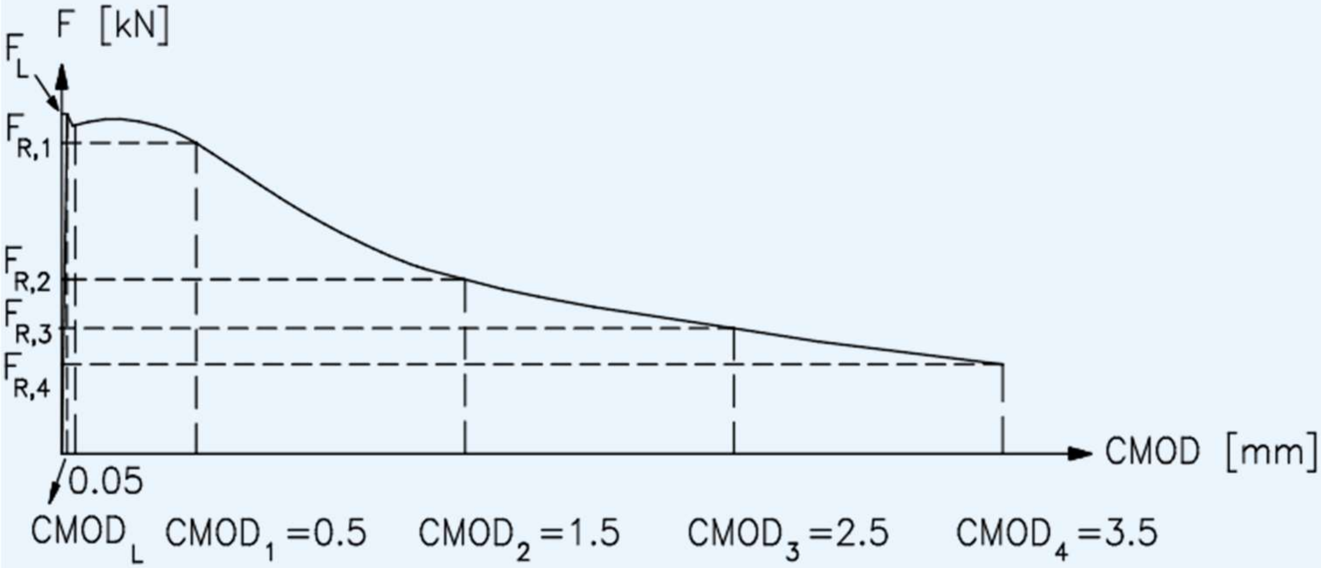
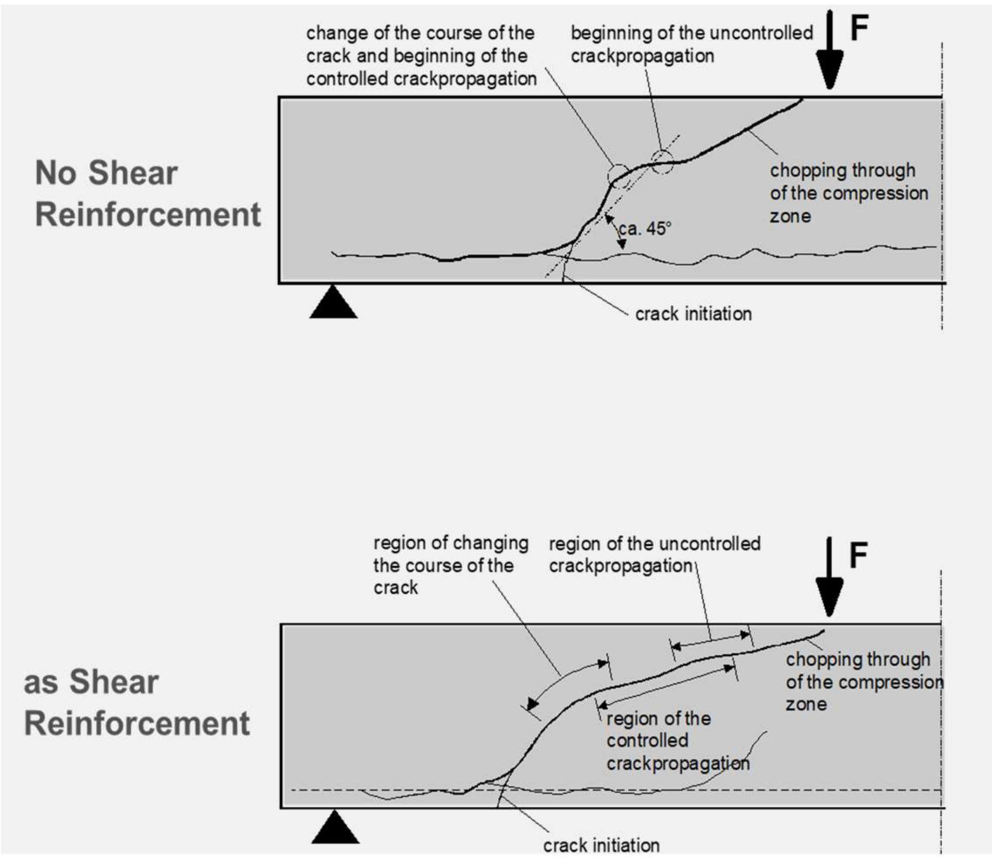
Reinforcing Capacity And Efficient Crack Control

- EN14651- 2005 Beam Test Test Method For Metallic Fibre Concrete - Measuring The Flexural Tensile Strength (Limit Of Prop. (LOP), Residual)



***CMOD:** Crack Mouth Opening Displacement*

Reinforcing Capacity And Efficient Crack Control



- Shear Resistance of SFRC
  - Steel Fibres Can Contribute To The Shear Capacity Of Any Structure By Bridging Of Shear Cracks.

Homogeneous Reinforcement

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Homogeneous Reinforcement

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Homogeneous Reinforcement

Bekaert Invented Glued Fibres In Order To Avoid The Potential For Balling Related To Adding Loose Fibres With A High L/D Radio (And Thus Better Performing) To A Concrete Mix.

Quick And Easy Application

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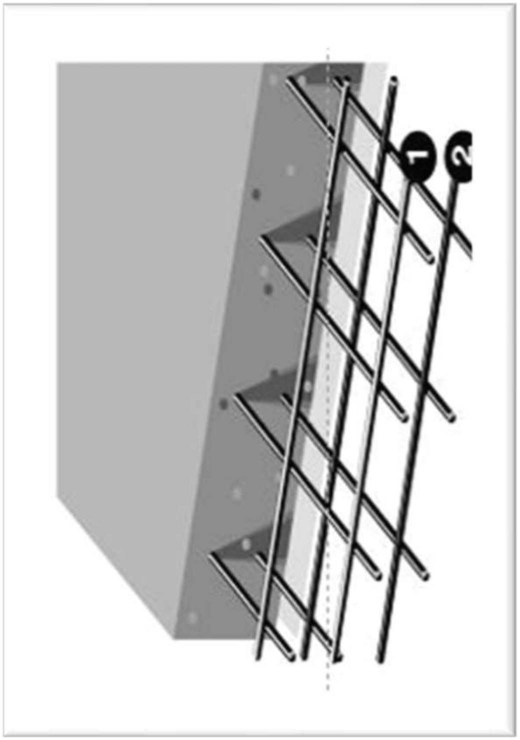
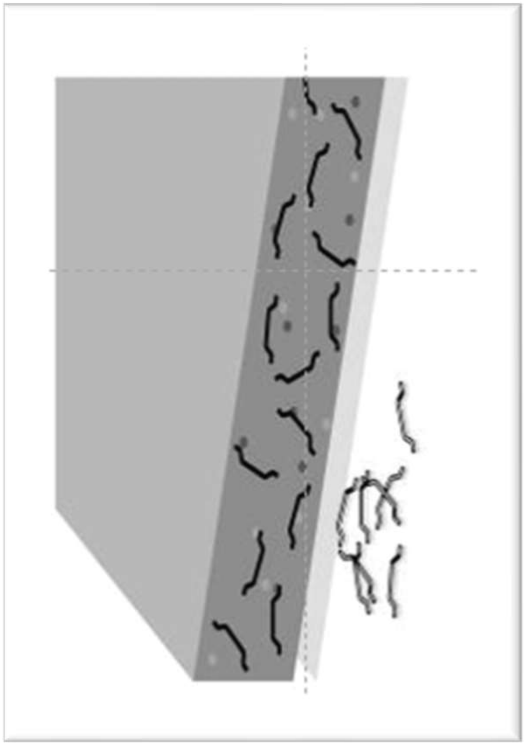
Quick And Easy Application

- Working With Steel Fibres Is Less Labor- Intensive And Helps You Save Time And Money.



- **Steel Mesh Reinforcement**
- Transport The Mesh/Rebar
- Handle And Stock The Mesh/Rebar On Site
- Place The Mesh/Rebar
- Pour The Concrete



- **Steel Fibre Reinforcement**
- Add The Steel Fibres To The Concrete (At The Ready-mix Plant Or Job Site)
- Pour The Concrete

Quick And Easy Application

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- **Safer Jobsite Conditions**
- Using Steel Fibres Enhances The Safety On Your Construction Site. Reinforcement Mesh And Rebar Not Only Hampers Other Work On Your Site, but They Are also, Very Often The Cause Of Accidents And Severe Delays.

Quick And Easy Application

- Steel fibres represent a concrete reinforcement system that is quick and easy to install with:

✓ Less working hours

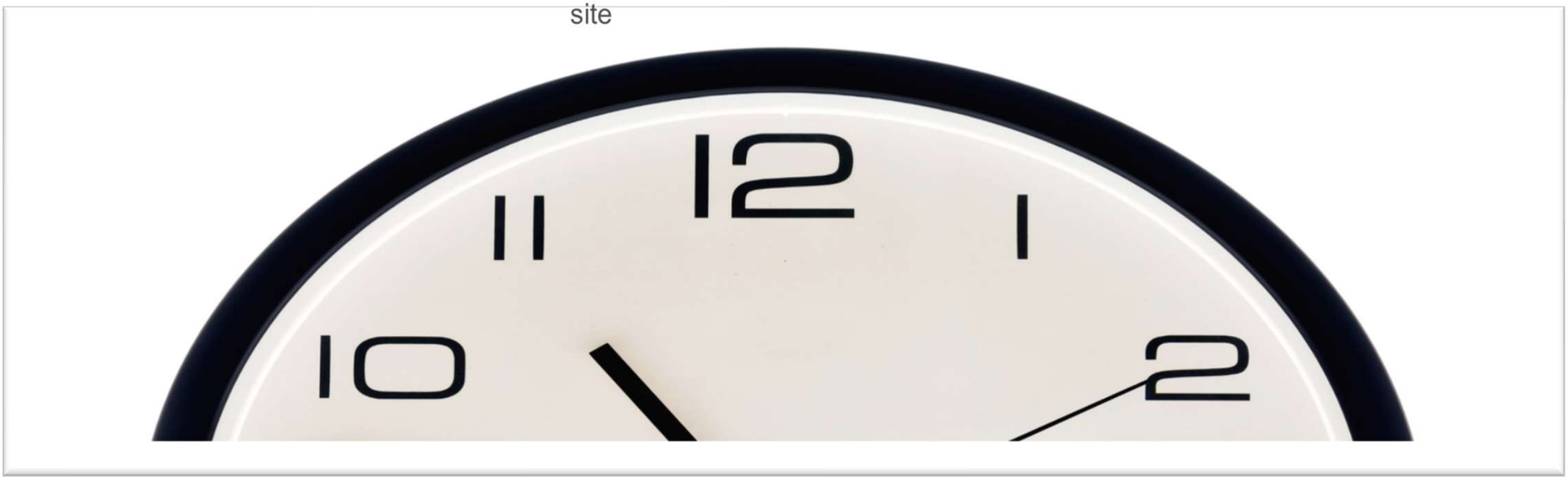
✓ Less stock on site

✓ Less problems

✓ Less risks on accidents on site

✓ Less delay

✓ More flexibility



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Cost Effective

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Cost Economics- Case Reference

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STEEL FIBRE REINFORCED CONCRETE SEGMENTS			
	Unit cost		
	Unit Price Per		
Fibres			
Repair of damaged segments		**…ents for repair**	
% of segments requirin…		…281	
	…t	**Cost/Hour**	
Lab…		18.75	0.94
Co…	0.25	1200.00	15.00
Adr…	0.25	31.25	0.39
	Cost/Segment	**Total cost**	
C… …materials	25.00	7030	1.25
Tot… Cost/Cum Rs			**5617.58**

Saving Per Cu. M Of Concrete = Rs 1112 Or 16%

Cost Economics- Green Solutions…

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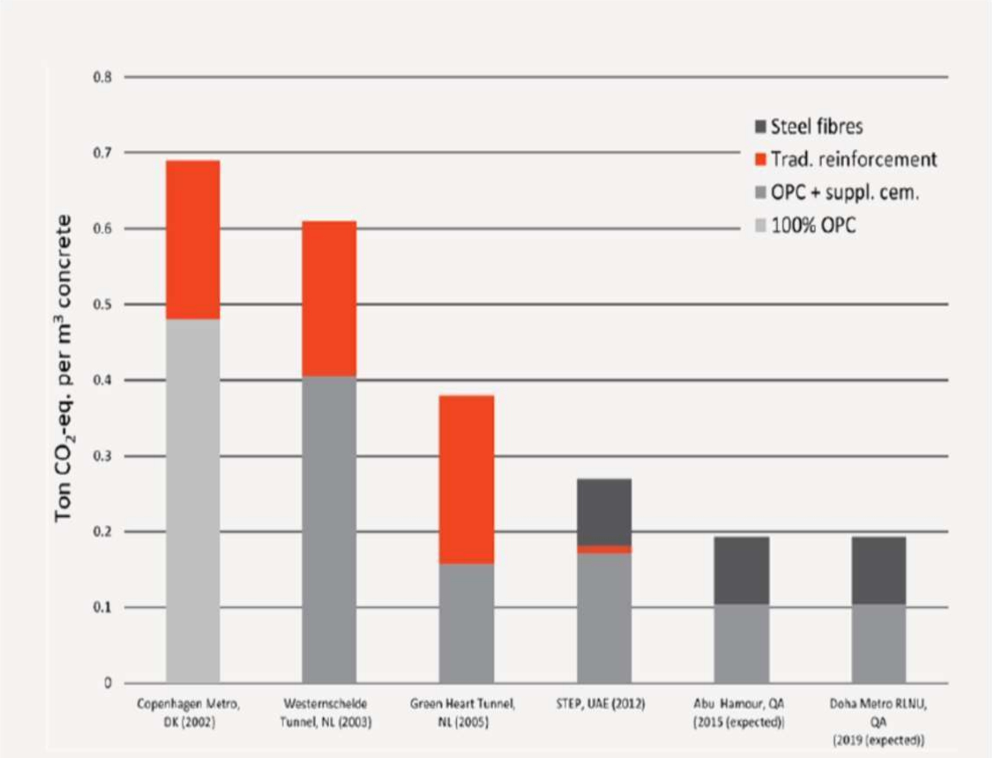
Dramix® Minimizes The Impact On The Environment -Using Less Steel

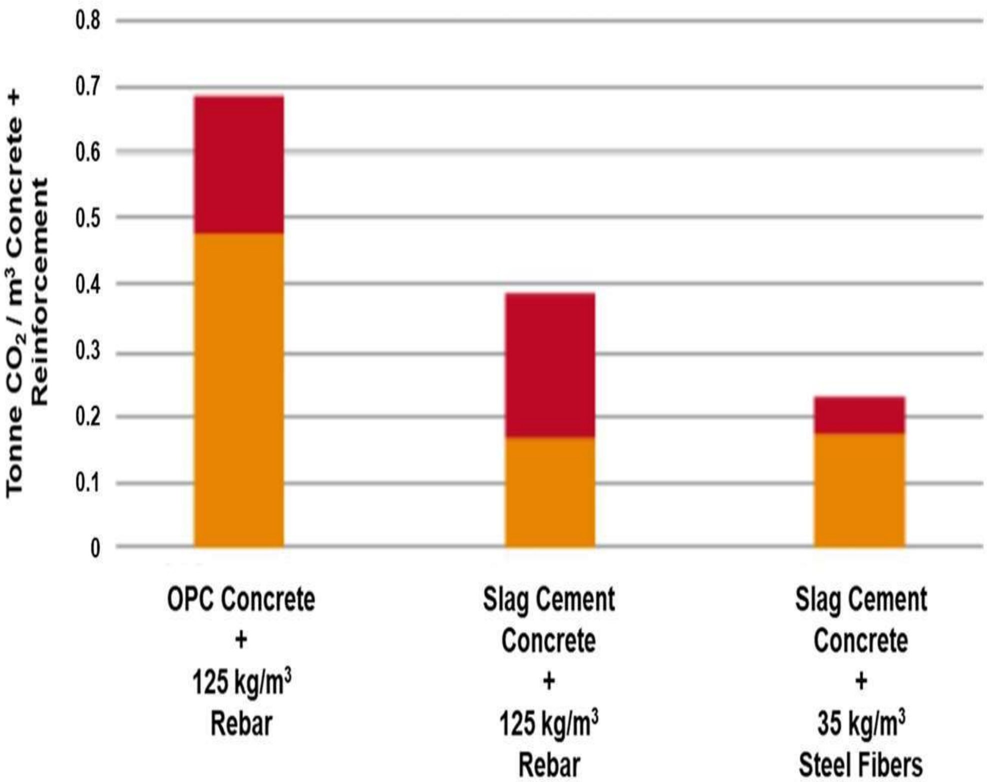
Comparison	Rebar / mesh	Dramix®
Concrete		
Energy consumption (GJ/m³)	2,89	2,89
Reinforcement		
Reinforcement (kg/m³)	100	40
Type	mesh	DRAMIX
Energy consumption (GJ/ton)	22,5	22,5
Energy consumption (GJ/m³)	5,14	3,79
Reduction of energy consumption	26%	



Use Of Fibres: >50% CO2 Reduction

Cost Economics- Green Solutions…

Dramix® Minimizes The Impact On The Environment -Using Less Steel



EPD CERTIFICATE

Basic information

This declaration is the Type III Environmental Product Declaration (EPD) based on EN 15804:2012+A1 and verified according to ISO 14025 by an external auditor. It contains the information on the impacts of the declared construction materials on the environment. Their aspects were verified by the independent body according to ISO 14025. Basically, a comparison or evaluation of EPD data is possible only if all the compared data were created according to EN 15804:2012+A1 (see point 5.3 of the standard).

Life cycle analysis (LCA): A1-A4, C1-C4 and D modules in accordance with EN 15804:2012+A1 (Cradle to Gate with options)

The year of preparing the EPD: 2021

Service Life: not declared by producer, specific calculation in accordance to EN 1990:2004

PCR: ITB-PCR A (PCR based on EN 15804+A1)

Declared unit: 1 kg of steel fibre

Product Standards: EN 14889-1 and ISO 13270–class A & conforms to ASTM A-820

Reasons for performing LCA: B2B

Representativeness: manufactured in Czech Republic, year 2019

Durability

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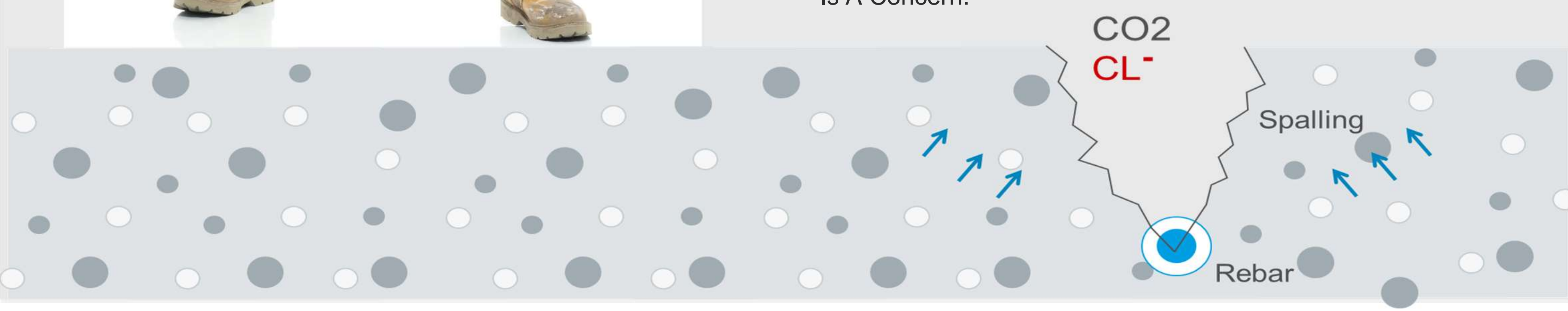
Durability

Even When Steel Fibres Corrode, Due To The Geometry Of The Fibres, The Corrosion Produced Does Not Exert Enough Stresses To Crack The Concrete, Unlike In Rebar, Where This Is A Concern.



Bekaert Support

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Bekaert Support

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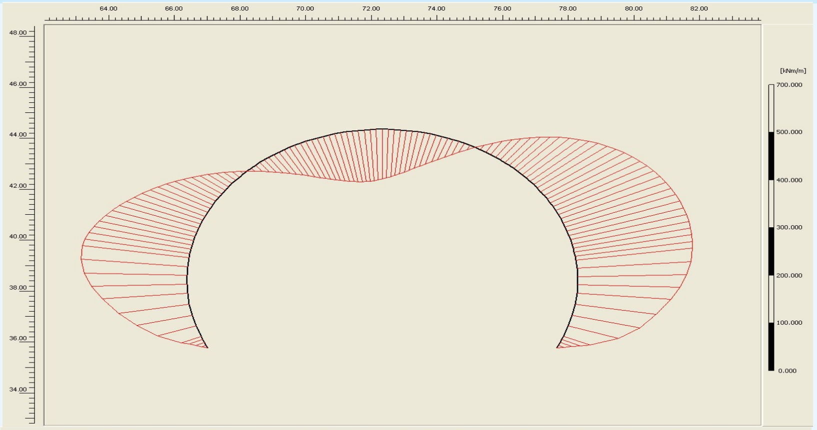
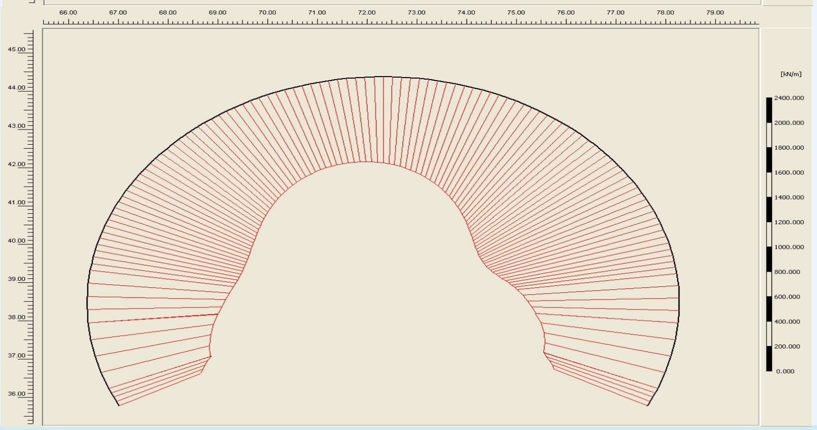
Bending Moments M, Axial Forces N, Shear Forces V

X [m]	Y [m]	x [m]	y [m]	N [kN/m]	T [kN/m]	M [kNm/m]
66,39	37,95	-5,93	-0,53	-808,67	48,17	-139,22
66,54	37,08	-5,79	-1,40	-736,22	55,70	-92,60
66,81	36,24	-5,52	-2,24	-679,65	83,69	-34,69
66,86	36,12	-5,47	-2,36	-650,90	75,38	-24,34
66,96	35,90	-5,37	-2,58	-600,43	63,65	-7,20
68,87	43,28	-3,46	4,80	-754,41	-42,23	39,55
68,60	43,08	-3,73	4,60	-774,64	-45,04	24,73
68,34	42,86	-3,99	4,38	-795,75	-47,50	9,01
68,21	42,74	-4,11	4,26	-806,44	-48,57	0,85
67,97	42,50	-4,35	4,02	-827,82	-50,38	-15,96
67,86	42,38	-4,47	3,90	-838,35	-51,11	-24,57
67,64	42,12	-4,69	3,64	-858,82	-52,19	-42,12
67,44	41,84	-4,89	3,36	-877,85	-52,71	-59,94
67,34	41,70	-4,98	3,22	-886,59	-52,73	-68,89
67,16	41,41	-5,16	2,93	-902,20	-52,24	-86,73
67,08	41,27	-5,24	2,79	-908,89	-51,70	-95,56
66,93	40,96	-5,40	2,48	-919,67	-50,00	-112,86
66,79	40,65	-5,53	2,17	-926,36	-47,22	-129,39
66,73	40,49	-5,59	2,01	-927,94	-45,29	-137,24
66,62	40,17	-5,70	1,69	-927,32	-39,92	-151,77
66,58	40,01	-5,75	1,53	-925,02	-36,14	-158,26
66,50	39,67	-5,83	1,19	-915,76	-24,48	-168,97
66,44	39,33	-5,89	0,85	-900,25	-6,48	-174,47
66,40	38,99	-5,93	0,51	-880,22	11,61	-173,66
66,37	38,30	-5,95	-0,18	-834,42	40,57	-154,76
75,78	43,28	3,46	4,80	-979,14	63,15	-45,05
75,48	43,48	3,15	5,00	-943,73	61,49	-22,02
75,16	43,67	2,83	5,19	-907,96	58,10	0,07
74,99	43,75	2,67	5,27	-890,29	55,90	10,59
74,66	43,91	2,33	5,43	-855,73	50,69	30,26
74,49	43,98	2,16	5,50	-839,05	47,78	39,34
74,14	44,10	1,81	5,62	-807,19	41,74	55,85
73,79	44,20	1,46	5,72	-777,87	35,50	70,09
73,61	44,24	1,28	5,76	-764,36	32,36	76,34
73,24	44,31	0,92	5,83	-739,74	26,07	87,11
73,06	44,33	0,74	5,85	-728,73	22,93	91,63
72,69	44,37	0,37	5,89	-709,47	16,78	98,96
72,33	44,38	0,00	5,90	-694,12	10,69	104,01
72,14	44,38	-0,18	5,90	-688,00	7,64	105,70
71,77	44,35	-0,55	5,87	-678,83	1,62	107,40
71,59	44,33	-0,74	5,85	-675,80	-1,36	107,43
71,23	44,28	-1,10	5,80	-672,88	-7,14	105,86
70,87	44,20	-1,46	5,72	-674,08	-12,80	102,18

X [m]	Y [m]	x [m]	y [m]	N [kN/m]	T [kN/m]	M [kNm/m]
70,69	44,15	-1,64	5,67	-676,17	-15,60	99,55
70,34	44,04	-1,99	5,56	-683,23	-21,03	92,80
70,16	43,98	-2,16	5,50	-688,12	-23,66	88,68
69,82	43,83	-2,50	5,35	-700,50	-28,70	79,03
69,49	43,67	-2,83	5,19	-715,99	-33,48	67,55
69,33	43,58	-2,99	5,10	-724,75	-35,80	61,16
69,02	43,38	-3,31	4,91	-744,02	-40,18	47,15
78,26	37,95	5,93	-0,53	-886,84	-41,91	-153,18
78,28	38,60	5,95	0,12	-942,52	-29,26	-176,72
78,23	39,24	5,90	0,76	-998,42	-13,89	-190,46
78,20	39,40	5,88	0,92	-1013,15	-10,85	-192,46
78,14	39,72	5,82	1,24	-1042,84	-4,34	-194,93





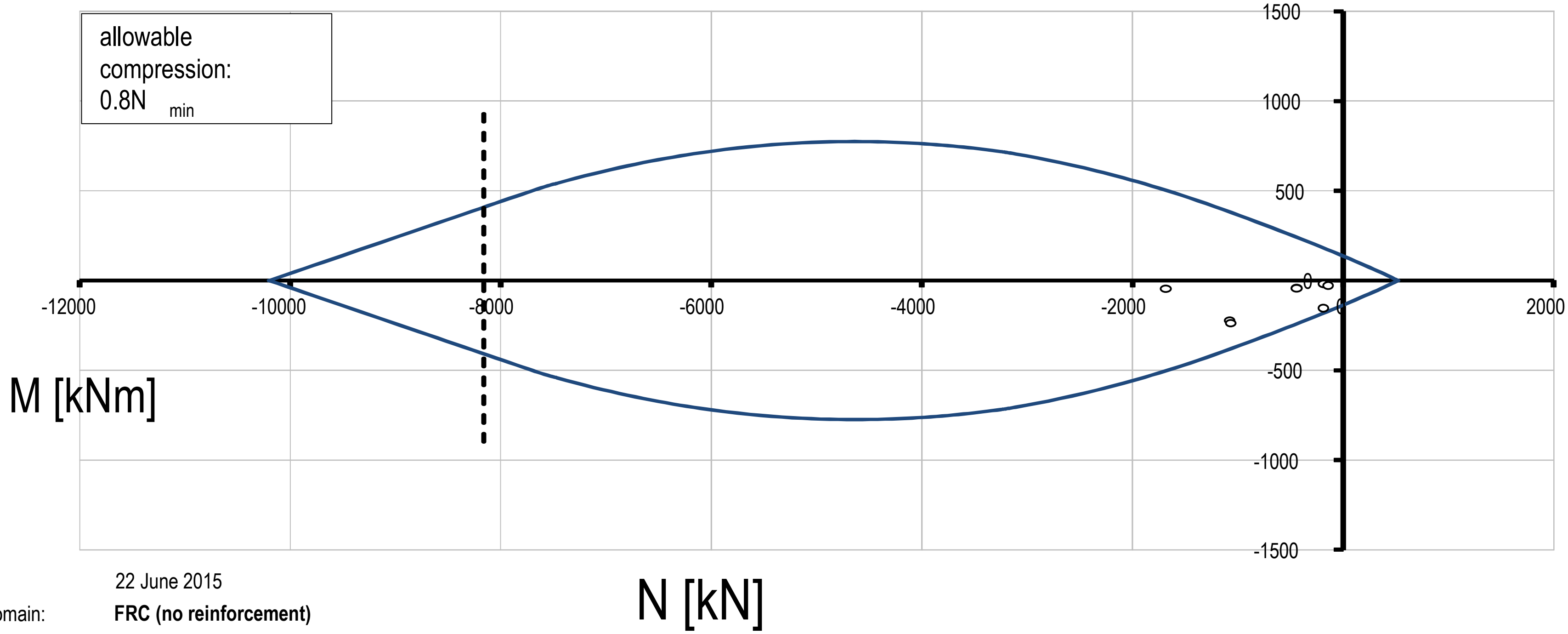
Bekaert Support

Verification Of Safety (ULS)

Project name: 3rd Bridge - Riva Tunnel Final Lining - 5D 65/60BG - km 4+050
Project nr:
Location: Istanbul - Turkey

Contractor:
Author:
Client:
Standard: Model Code 2010

Concrete class: **C30/37**
Fiber type: **5D 65/60BG**
Fiber dosage: **35 kg/mc**



Date: 22 June 2015
Plotted domain: **FRC (no reinforcement)**

References

References….

Bhanupalli Bilaspur Rail Project (Ongoing)

- Client- Indian Railway/ RVNL
- General Consultant- AECOM
- Application : Cast In Place Lining
- Contractor : Max Infra
- Product- Dramix 3D®65/60 BG
- Dosages Used- 45 Kg /Cum
- Grade Of Concrete- M 35
- Thickness- 300 mm

References….

USBRL T48- Gammon, (Ongoing)

- Client- Indian Railway /IRCON
- General Consultant- Lombardi India
- Application : Cast In Place Lining
- Contractor : Gammon India
- Product- Dramix 3D®65/60 BG
- Dosages Used- 45 Kg /Cum
- Grade Of Concrete- M 35
- Thickness- 300 mm to 400 mm

References….

USBRL T49 A- HCC, (Ongoing)

- Client- Indian Railway /IRCON
- General Consultant- Lombardi India
- Application : Cast In Place Lining
- Contractor : HCC
- Product- Dramix 3D®65/60 BG
- Dosages Used- 45 Kg /Cum
- Grade Of Concrete- M 35
- Thickness- 300 Mm

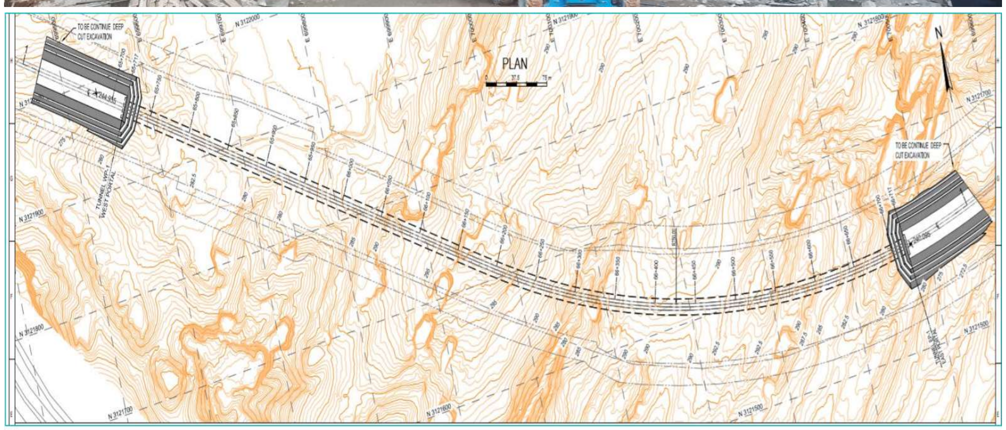
References….

USBRL T1- ABCI, (Ongoing)

- Client- Indian Railway /KRCL
- General Consultant- Geo Consultant
- Application : Cast In Place Lining
- Contractor : ABCI
- Product- Dramix 5D®65/60 BG
- Dosages Used- 25 Kg /Cum
- Grade Of Concrete- M 35
- Thickness- 500 mm

References….

DFCC Project- WDFC Phase-II, Package CTP-14



- Client- Indian Railway
- General Consultant- Nippon Koei / SMEC
- Application : PSCL
- Contractor : Sojitz- L&T Consortium
- Product - Dramix 4D®65/35 BG
- Dosages Used- 25 Kg /Cum & 35 Kg/ Cum
- Grade Of Concrete- C32/40
- Thickness- 225 to 430 mm

References….

UGC 06- Sahar Cross- Over- Mumbai Metro

- Client- Mumbai Metro Rail Co Operation
- General Consultant- MAPLE
- Application : PSCL
- Contractor : J Kumar- CRTG (JV)
- Consultant- Bedi Consulting Ltd
- Product- Dramix 4D®65/35 BG
- Dosages Used- 30 Kg /Cum
- Grade Of Concrete- C32/40
- Thickness- 300 Mm

References….

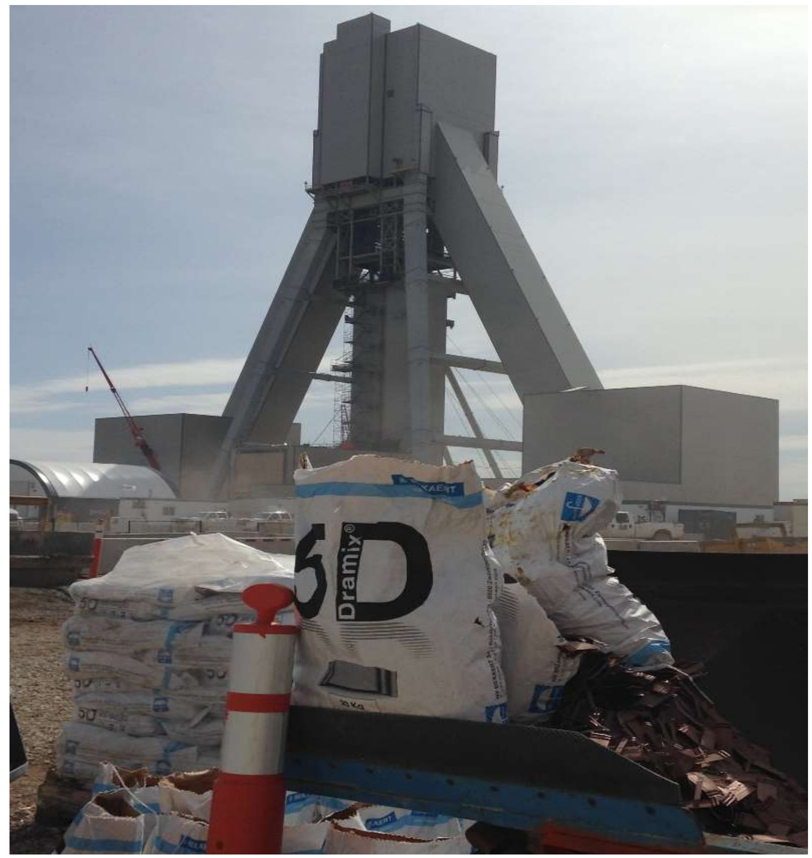
- **Date:** 2014-2015
- **Project Name: Riva Tuneli**– 3rd Bridge Tunnel
- **Tunnel Type**: Highway
- **Client**: Istanbul Municipality
- **Country**: Turkey
- **Contractor**: IC Ictas – Astaldi Consortium
- **Fiber Type**: 5D 65/60BG
- **Dosage Rate**: 20 Kg/Mc
- **Concrete Class**: C30/37
- **Max Diameter**: 22 Meters

References….

- **Lee Tunnel London UK (2015)**
- **Final Lining FRC**
  - Tunnel (Ø: 8.8 M)
  - Designed With MC 2010 By UnPS Traditional Reinforcement Removed, About 15000 Tons
  - Just 2100 Tons Of Dramix® 5D 6560BG @ 40kg/M (67pcy), 60mm Long & 0.90mm Diameter.
  - This Dosing Rate Provided Excellent Bending Hardening Properties To The Concrete Section.
- **3D 65/35 BG For The Shaft Lining**

References….

- Jansen Mine Shafts – Saskatchewan, Canada
- Shaft Basics– Construction:
  - Shaft Walls Range From 800mm Thick Up To 1.1m Thick
  - Interior Diameter Of 8.5 M
  - Shaft Walls Are Slip Formed With A Scheduled
  - Production Of Up To 3m Per Day.
- Concrete Strength 60mpa
- Dosage Rate 40kg / M^3



References….

Project list - Cast in Place / Final Lining

Year	Project	Tunnel Type	Country	ØExt (m)	Thickness (mm)	Fiber type	Concrete Class (Cxx/yy)	SFRC only	Combined solution	Client/contractor
2021	T-1 USRL	Rail	India	6	350	Dramix5D65/60 BG	M 35			Indian Railway
2020	Yusufeli Road Deplacement	Road	Turkey	11,5	400	5D 65/60BG	C30/37			Limak Construction
2020	Sydney Metro Civil Works	Metro	Australia			4D80/60BG	C40/50			Holcim
2020	Thames Tideway West Hammersmith Connector Tunnel	Sewage	UK	4	300	5D6560BG	C50/60			Client Thames Water - Contractor BMB JV
2020	Thames Tideway West Hammersmith Connector Shaft	Sewage		27	600	5D6560BG				Client Thames Water Contractor BMB JV
2020	Tunnel Diel	Rail	Slovakia	10	600	DRAMIX® 5D 65/60BG	C30/37			Tubau
2020	T 49 of USRL	Rail	India	6	200	Dramix3D65/60	C28/35			India Railway
2019/ 20	Hammersmith Connect Tunnel Shaft London	Sewage				5D6560BG	C50/60			Thames Tideway West / Thames Water
2019	Hammersmith Connector Tunnel London UK	Sewage	UK	4,5	35	5D6560BG	C50/60			Thames Tideway West / Thames Water
2019	Northern Marmara Highway Extension	Road	Turkey	24	600	4D 65/60BG	C30/37			Cengiz-Limak-Kolin-Kalyon JV
2019	Ayvacık Road	Road	Turkey	11,5	400	5D 65/60BG	C30/37			Kalyon AS
2017	Honaz Road	Road	Turkey	11,5	400	5D 65/60BG	C30/37			Özce Construction
2016	Jansen Mine Production & Service Shafts - Initial & Final Linings	Mining	Canada			Dramix® 5D 6560BG				Ledcor, Redpath, Thyssen
2016	Hanlan	Hydro	Canada			Dramix® 3D 6535BG				
2016	Astra Zennica	Utility	Great Britian		175	3D6560G	C50/60			Joseph Gallagher Ltd
2015	Riva Tunnel, Northern Marmara Highway	Road	Turkey	22	600	Dramix® 5D 6560BG	C30/37			IC İçtaş-Astaldi JV
2015	Konak Tunnels/İzmir	Road	Turkey	11,5	400	Dramix® 5D 6560BG	C30/37			Ege Asfalt
2014	Lee Tunnel - Thames Tideway Project - 5 no Shaft Lining	Sewage	United Kingdom			Dramix® 3D 6535BG	C50/60			Thames Water
2014	Lee Tunnel - Thames Tideway Project - Final Lining	Sewage	United Kingdom			Dramix® 5D 6560BG	C50/60			Client - Thames Water
2013	Göktas HES/Adana	Hydro	Turkey	9	500	Dramix® 3D 8060BG	C25/30			Bereket Enerji
2008	Arpa HES/Artvin	Hydro	Turkey	4,5	300	Dramix® 3D 6560BG	C25/30			B&M Engineering
2006	Craviale/Turina	Road	Italy			Dramix® 3D 6560BG				
2001	Kakegawa No. 1 - Twin Tunnel	Road	Japan	15	500	Dramix® RC-65/60-BN	C30/37			Maeda
1996	The Brunel Tunnel	Metro	Great Britian		200		C40/50			London Underground Ltd
1995	Tarvisio tunnel (UD)	Rail	Italy							FF.SS.
1994	Highway Torino – Bardonecchia – Bussoleno (TO)	Road	Italy							ANAS-SITAF
1994	Piano del Campo Hidraulic tank (Palermo)	Hydro	Italy							Cons. Bonifica Belice
1994	Rosamarina DAM (PaLERMO – t. Imerese)	Hydro	Italy							Reg. Sicilia
1993	Electric power station	Hydro	Italy							Enel (Torino)
1992	Fresh water tunnel Blufi	Hydro	Italy							Ente sviluppo e
	Thames Tideway West Hammersmith Connector Shaft Works	Sewage								

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infobuilding@bekaert.com

Available Resources….

BEKAERT
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- 400+ Projects References
- Established Design Codes/Guidelines
- Accepted Testing Methodologies
- Environmentally Friendly

Conclusion….

Conclusion….

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- **The Principle Of Steel Fibre Concrete Reinforcement In A Nutshell:**
- **Elimination Of Traditional Reinforcement (Mesh Or Rebar)**

  → Faster & Safer Construction

- **Homogeneous Distribution**

  → Uniform Reinforcement Of Your Concrete Structures

- **Redistribution Of Stresses**

  → High Ductility & Increased Load Bearing Capacity

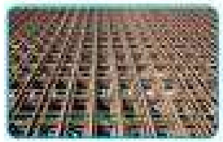
- **Excellent Crack Control**

  → A Significant Reduction Of Concrete Cracking And Spalling Of Segments

- **Optimal Resistance** Against Impact And Dynamic Loads

Right Fibre For The Right Application….

…& All Fibres Are Not Same…

Material	Steel Mesh / Steel fibre  	Micro / Macro Polymer Fibre Extruded polypropylene / polyethylene  
Typical length of fibres Typical diameter of fibres	30-60 mm 0.5 - 1.0 mm	**micro**: 6 - 20 mm **macro**: 30 - 65 mm **micro**: 0015 - 0.030 mm **macro**: 0.5 - 10 mm
Young's Modulus Tensile strength	210000 MPa 500 - 2000 MPa	3000 - 10000 MPa 200 - 600 MPa
Density	7850 kg/m³	910 kg/m³
Melting Point (°C)	1500°C	165°C does not reinforce
Creep behaviour in tension (Tg glastransition temperature)	+370°C	-20°C

And It's Green….

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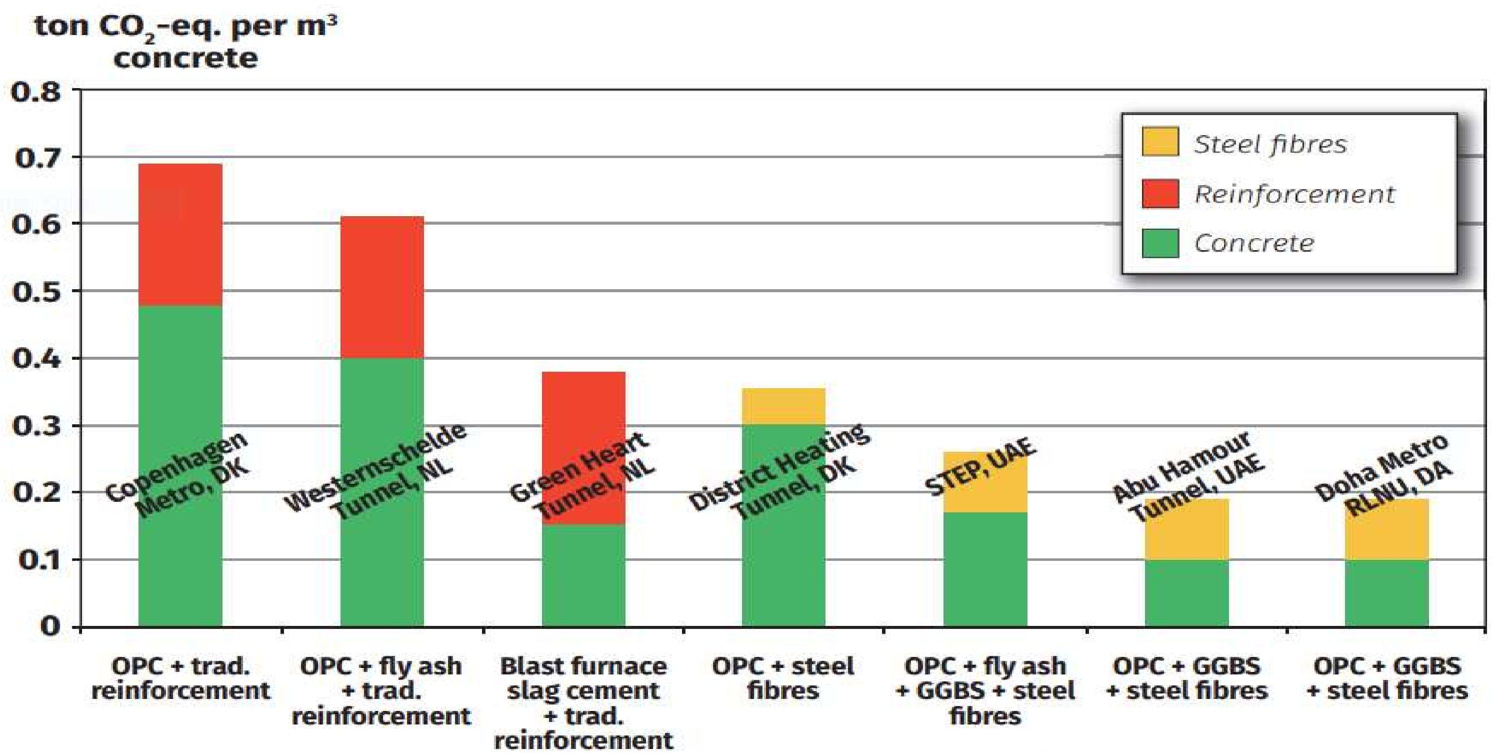

Comparison Of Embodied CO2 For Different Types Of Binder And Steel Reinforcement Used For Various Major Infrastructure Projects (Edvardsen et al)

Thank You So Much

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FIRST LINING/TEMPORARY SUPPORT

Spray Concrete

3D Dramix®

→ 3D Dramix® 65/35BG CE ASTM A820

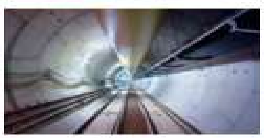
→ Synmix®

FINAL LINING

Spray Concrete Lining
PS anti spalling

4D Dramix®

→ 4D Dramix® 65/35BG CE ASTM A820



Precast Segments

4D Dramix® +

→ 4D Dramix® 80/60BG CE ASTM A820

Duomix® M6 Fire

FINAL LINING

Cast in place
Inner Lining

5D Dramix® +

→ 5D Dramix® 65/60BG CE ASTM A820

Duomix® M6 Fire

Thank you!

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dramix

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