

ArcelorMittal Fibres



ArcelorMittal

Sustainable steel fibre reinforced concrete for the tunnelling industry



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Optimised concrete tunnel lining solutions for every project

ArcelorMittal Fibres is working with Engineers, Tunnelling Contractors and Ready Mix companies on some of the most challenging tunnelling projects in the world.

Our partnerships with clients responsible for major engineering and construction projects, are transforming the reinforced concrete industry and creating a better built world; a world that is being constructed more quickly, more safely, more efficiently and more sustainably.

ArcelorMittal Fibres, part of the ArcelorMittal Group – the metals and mining industry leader, is an industry expert and global provider of reinforced concrete solutions.

For more than three decades, ArcelorMittal Fibres has been working with tunnelling specialists to develop and improve concrete tunnel lining performance.

From our five production facilities in the UK, Luxembourg, Poland, Morocco, and Bosnia and Herzegovina, we develop, manufacture and supply high quality steel fibres to construction markets around the world.

STEEL FIBRE REINFORCED CONCRETE SOLUTIONS FOR TUNNEL LINING APPLICATIONS

Our long-standing experience, combined with our ongoing commitment to the development of the best performing steel fibres, has enabled us to develop a comprehensive range of advanced steel fibres for use in tunnel lining applications.

OPTIMISING PERFORMANCE STANDARDS

ArcelorMittal Fibres has developed steel fibre reinforced concrete solutions for the construction of tunnel linings in tunnelling and mining projects around the world. We are dedicated to optimising performance standards for:

- › Precast tunnel lining segments
- › Cast in place tunnel linings
- › Sprayed concrete linings

OUR STEEL FIBRE REINFORCED CONCRETE SOLUTIONS ARE WIDELY USED ACROSS:

- › High-speed train tunnels
- › Subway tunnels and stations
- › Railway tunnel refurbishments
- › Road and motorway tunnels
- › Cross passages
- › Fresh water supply tunnels
- › Waste water tunnels
- › Combined sewer overflow tunnels
- › Stormwater tunnels
- › Utilities tunnels
- › Mining
- › Slope stabilisation

ArcelorMittal Fibres

The first-choice provider of steel fibre reinforced concrete solutions.

ACCESS TO A GLOBAL RESEARCH & DEVELOPMENT NETWORK

Operating for all ArcelorMittal Group units, ArcelorMittal Fibres benefits from the Group's worldwide research and development resources. This is the cornerstone of sustainable development and innovation and it ensures the continuous renewal of ArcelorMittal's product offer.

OUR EXPERTISE

OUR HANDS ON APPROACH enables us to support our partners and ensure the success of every tunnel construction project.

OUR SOLUTIONS deliver exceptional levels of added value to the design of steel fibre reinforced concrete tunnel linings.

OUR EXPERTISE continues to grow, with over 35 years working with our partners to build better concrete tunnel linings.

Supporting you from start to finish

The right advice. The right fibres. The right solutions.

ArcelorMittal Fibres do much more than manufacture and supply a comprehensive range of high quality steel fibres.

We support you to ensure the success of your project from start to finish.

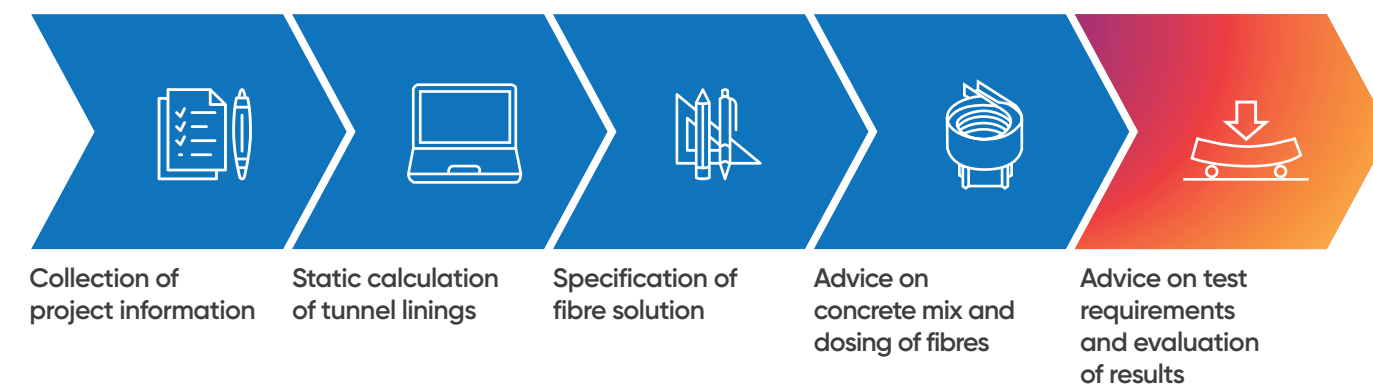
WE OFFER EXPERTISE ON:

- › Design and calculation of steel fibre reinforced concrete tunnel linings
- › Setting up your project specification
- › The most appropriate fibre type to comply with the specification
- › Optimum dosage rates to guarantee performance
- › Concrete mix design optimisation
- › The supervision of performance tests
- › On-site support and advice on dosing and mixing

Our team of experienced Engineers and Sales Managers will give you all the support your project needs from conception to project completion.

We are here to support and assist you at every stage.

How we create our fibre solution:



To discuss the optimum solution for your next project, please contact our team at fibresupport@arcelormittal.com

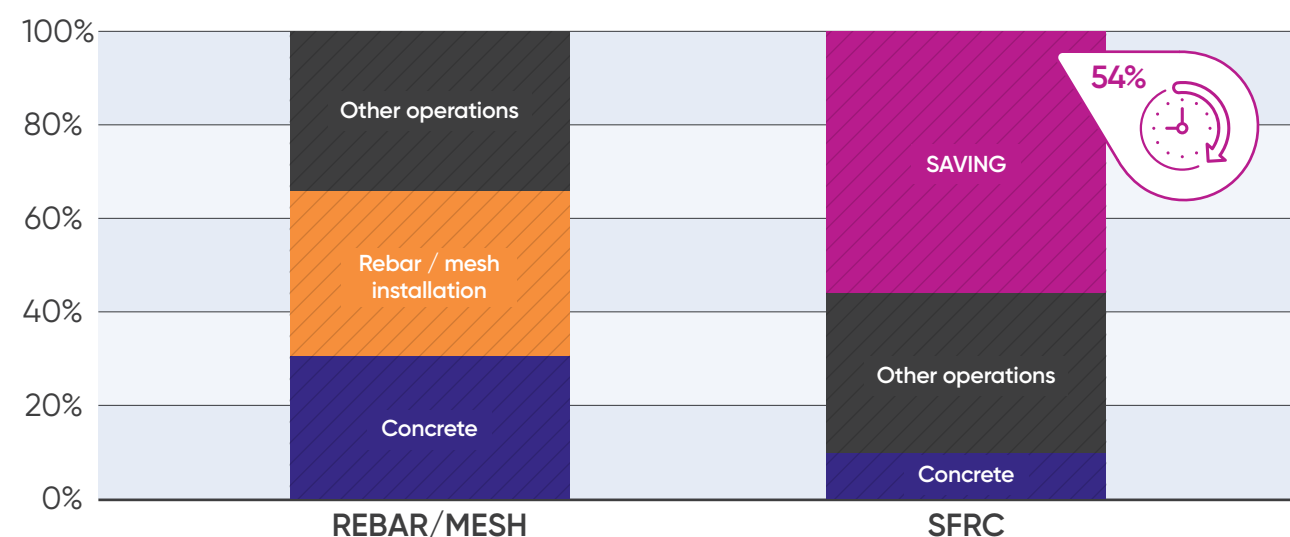
Significant time and cost savings

The use of steel fibre reinforced concrete can result in significant project savings in both time and cost.

For sprayed concrete and cast in place applications, using steel fibre reinforced concrete can save up to **54%** on installation time compared to traditional reinforcement.

The cost savings for steel fibre reinforced concrete tunnel lining projects are significant and can range from **23%** for sprayed and cast in place applications, to **39%** for tunnel lining segments.

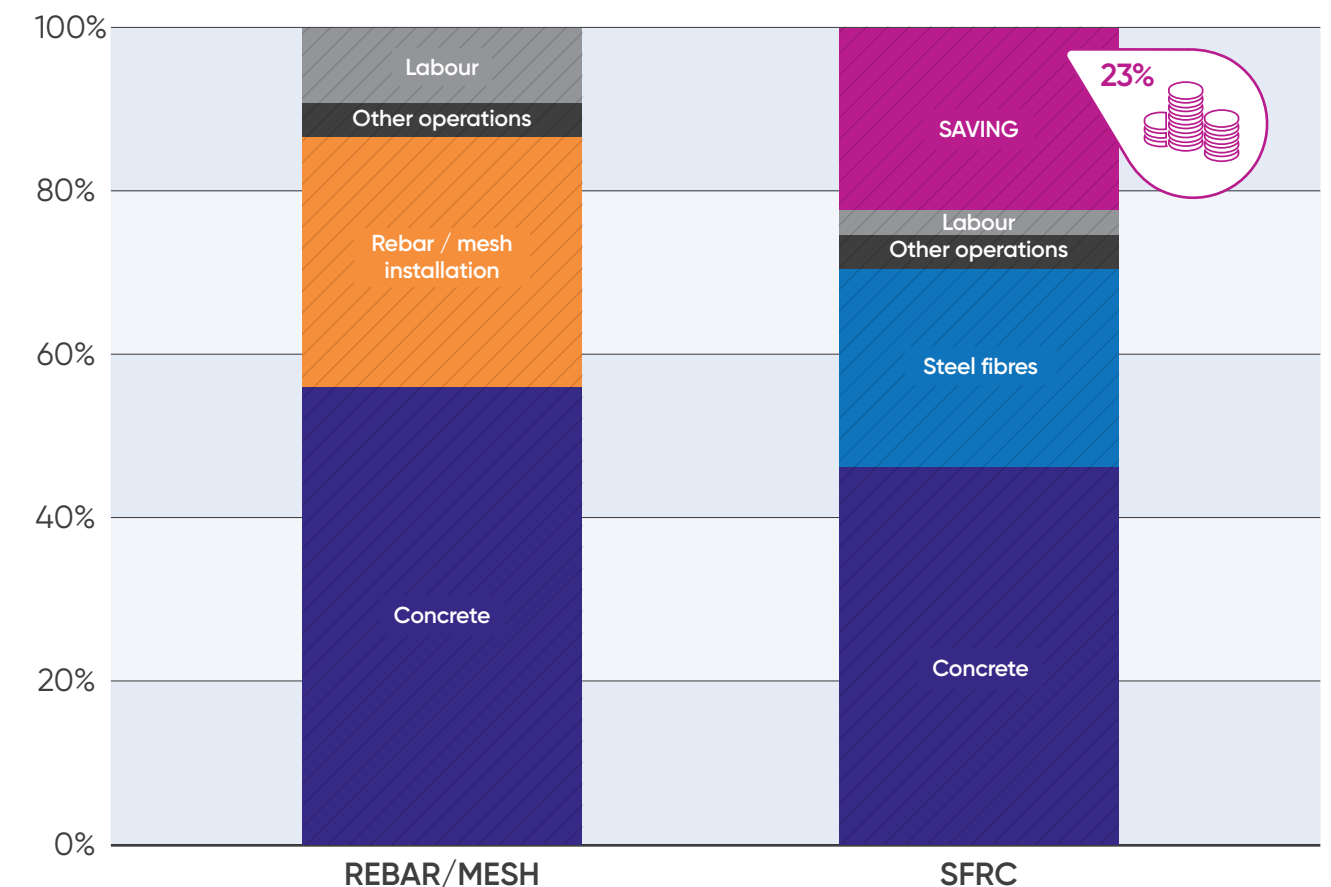
TUNNEL LINING - TIME SAVINGS



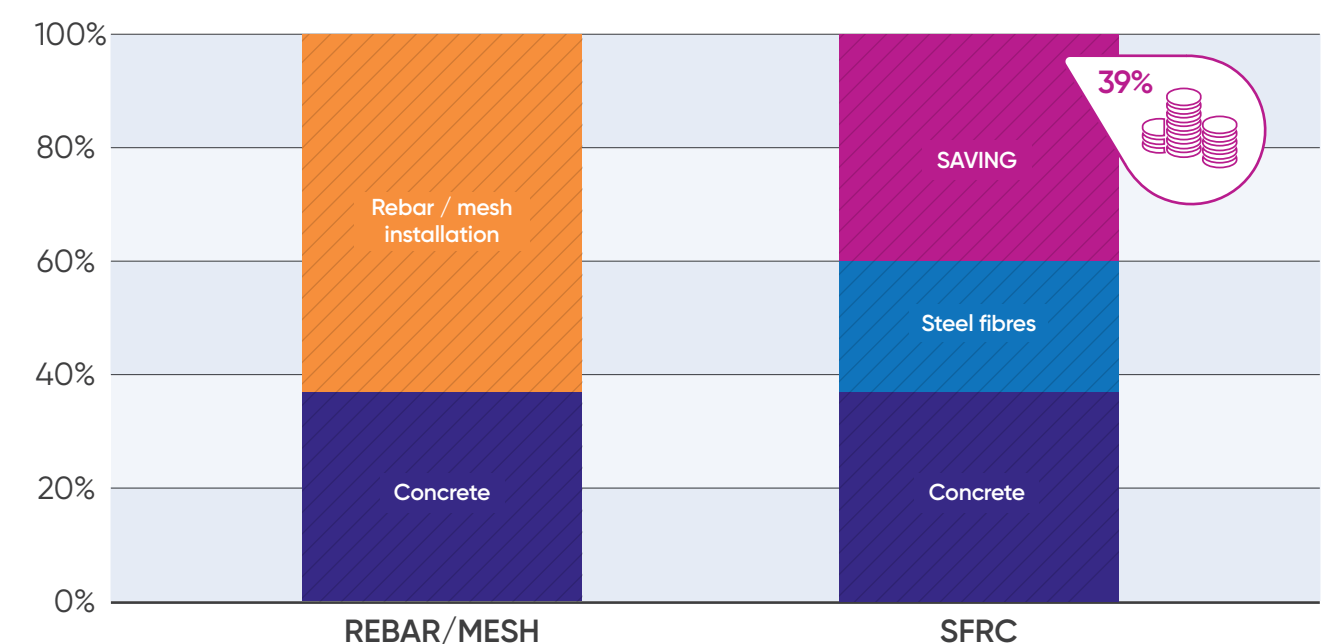
Benefits and advantages:

- › Optimisation of concrete thickness
- › Traditional reinforcement can be totally or partially replaced
- › Reinforcement correctly placed, no cover limitations
- › Improved impact resistance for handling and placement
- › Reduced segment damage and replacement
- › Enables easier concreting
- › Reduced rebound
- › Increased safety on site

SPRAYED & CIP – COST SAVINGS



TUNNEL LINING SEGMENTS – COST SAVINGS



Quality and durability

The lining of a tunnel is typically designed to provide a service life of at least 100 years, meaning durability is of paramount importance to guarantee serviceability and safety requirements.

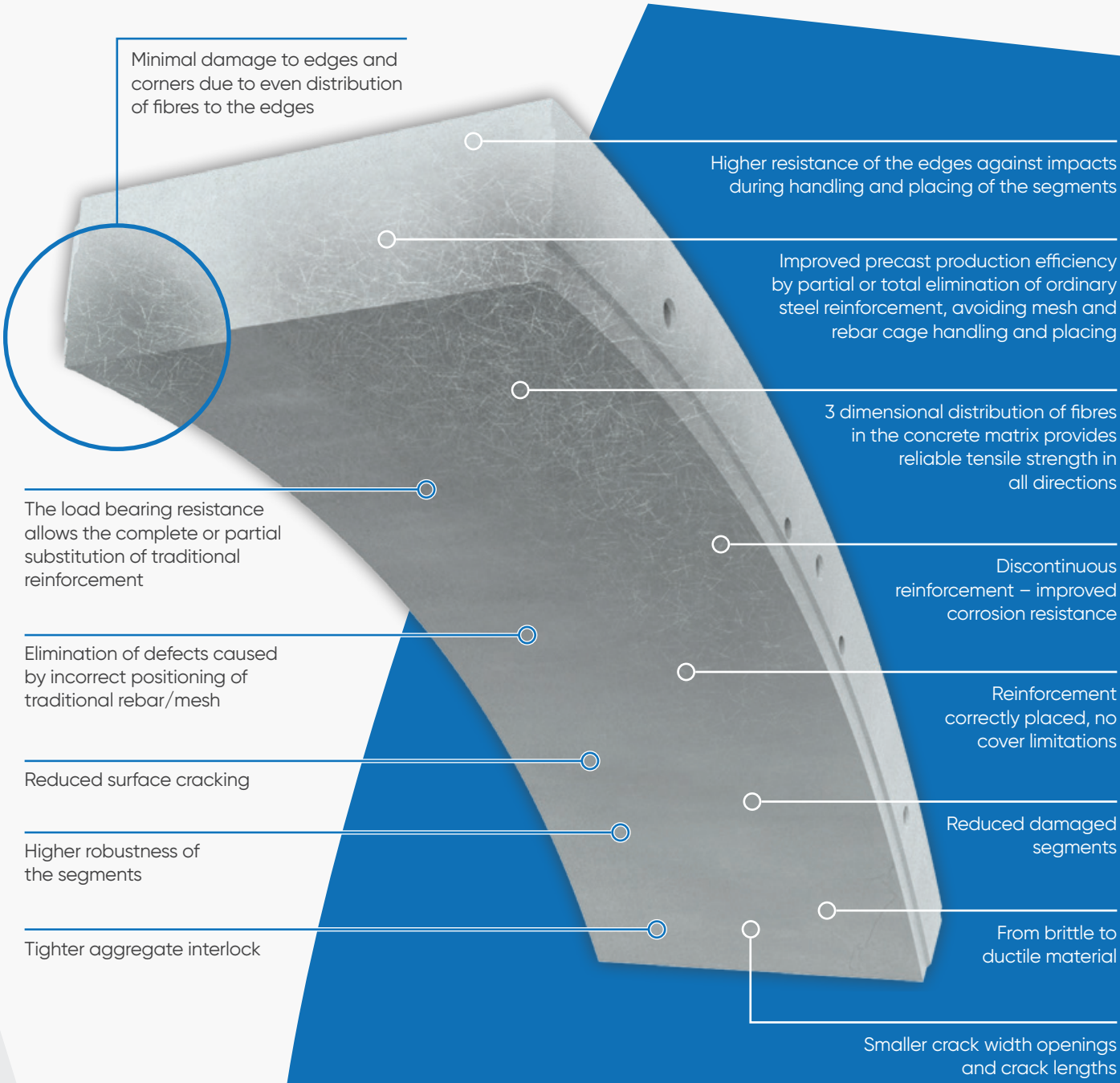
Steel fibre reinforced concrete is a composite material made of basic concrete in which steel fibre reinforcement is incorporated and homogeneously distributed. The addition of steel fibres in concrete controls plastic and hydraulic shrinkage cracking, and considerably improves the concrete post-cracking behaviour.

Steel fibre reinforced concrete ensures the reinforcement is correctly placed with no cover limitations, improves corrosion resistance, and provides uniform reinforcement protection throughout the concrete, including the edges.



Precast segments and cast in place linings

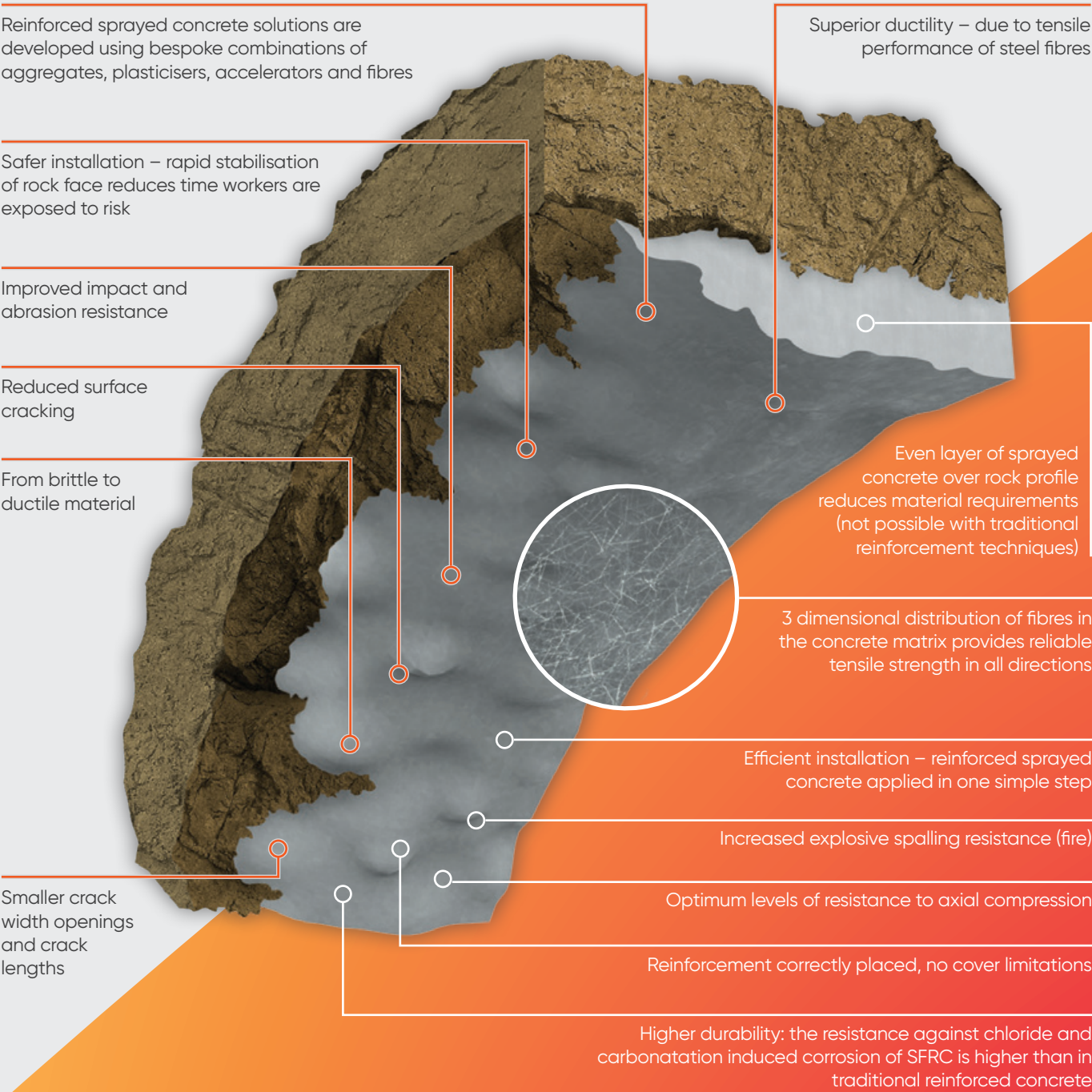
The load bearing resistance allows the complete or partial substitution of traditional reinforcement.



Quality and durability

Reinforced sprayed concrete solutions

Sprayed concrete solutions for temporary and permanent applications



The right advice,
the right fibres,
the right solution

Our technical engineers are dedicated to the success of your project.

Contact us today. Let's talk tunnels.
fibresupport@arcelormittal.com

Building for tomorrow

Designing and building concrete tunnel linings with a lower carbon footprint.

At ArcelorMittal, we strive to contribute to a more sustainable world through the production of smarter steels. Our innovative manufacturing process, which uses recycled steel that is processed with renewable energy, drastically reduces carbon emissions. The result is a range of cleaner steels that are stronger and reusable, contributing to a brighter and more sustainable future.

Our drive towards net zero, combined with our experience in delivering optimised solutions for the tunnel construction industry, is enabling us to assist our customers in meeting the world's rapidly changing building requirements, and the need to create a more sustainable future.

Our advanced steel fibre reinforced concrete solutions allow Developers, Engineers and Contractors to optimise the design of concrete tunnel linings, allowing for material savings, compared to traditional reinforced concrete tunnel linings, resulting in important reductions in the carbon footprint of construction projects.

We are working closely with Developers, Project Owners, Engineers, and Contractors to support their ambitions to reduce the carbon footprint of their projects.

Our Engineers and Sales Managers will provide expert support to those designing and building concrete tunnel linings, providing the right advice and the right solutions to reduce the carbon content of each project.

Using the correct solution for your concrete tunnel lining will have a major impact on the carbon footprint of your project.

XCarb®

Recycled and renewably produced

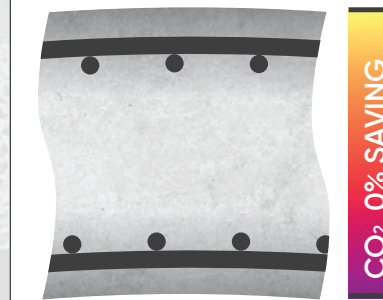
XCarb® recycled and renewably produced steel fibres, manufactured with recycled steel and 100% renewable electricity, provide an exceptionally low carbon footprint.

CO₂ savings with ArcelorMittal Fibres

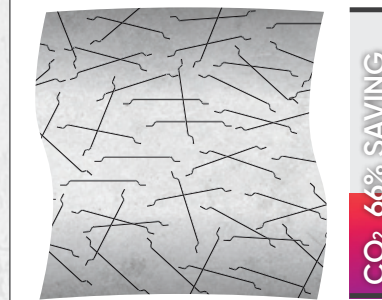
Traditional rebar/mesh reinforcement compared to steel fibre reinforced concrete in tunnel lining segments.

By replacing traditional rebar/mesh reinforcement (assuming 120kg/m³) with ultra-high strength steel fibres (40kg/m³), the carbon footprint of tunnel lining segments can be reduced by more than 66%. Choosing XCarb® recycled and renewably produced steel fibres, can increase the CO₂ saving further up to 89% compared to traditional rebar/mesh reinforcement.

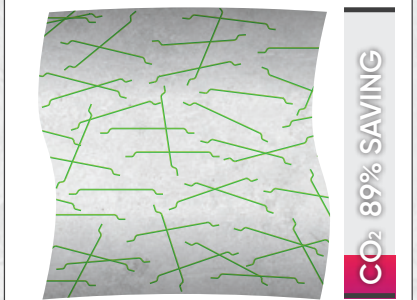
Traditional rebar/mesh reinforced concrete TLS



Steel fibre reinforced concrete TLS



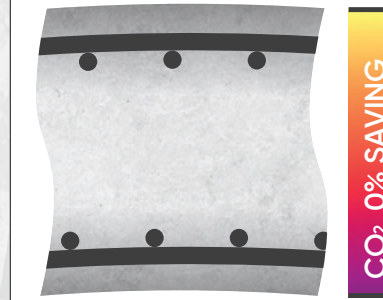
XCarb® recycled and renewably produced steel fibre reinforced concrete TLS



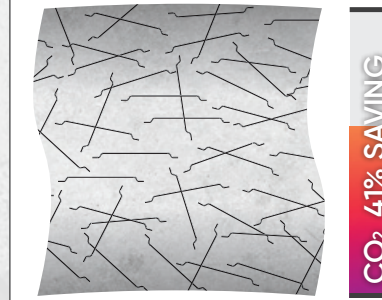
Traditional rebar/mesh reinforcement compared to SFRC in sprayed and cast in place linings.

Replacing traditional rebar/mesh reinforcement with steel fibres can reduce embodied CO₂ by more than 41%. By using XCarb® recycled and renewably produced steel fibres, CO₂ savings can rise to 82%, compared to traditional rebar/mesh reinforcement.

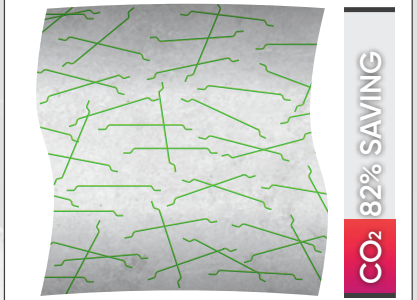
Traditional rebar/mesh reinforced sprayed and CIP concrete



Steel fibre reinforced sprayed and CIP concrete



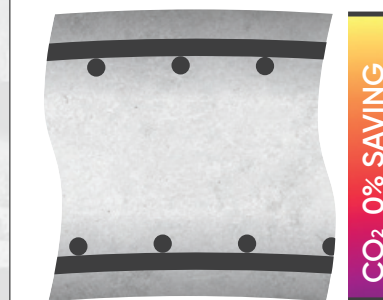
XCarb® recycled and renewably produced steel fibre reinforced sprayed and CIP concrete



Additional CO₂ savings

Depending on project conditions, the use of SFRC in sprayed concrete solutions can reduce the thickness of the concrete required by up to 20% as there are no cover limitations and less rebound. This thickness reduction results in even further CO₂ savings compared to traditional mesh reinforcement.

Traditional mesh reinforced sprayed concrete



Steel fibre reinforced sprayed concrete



XCarb® recycled and renewably produced steel fibre reinforced sprayed concrete

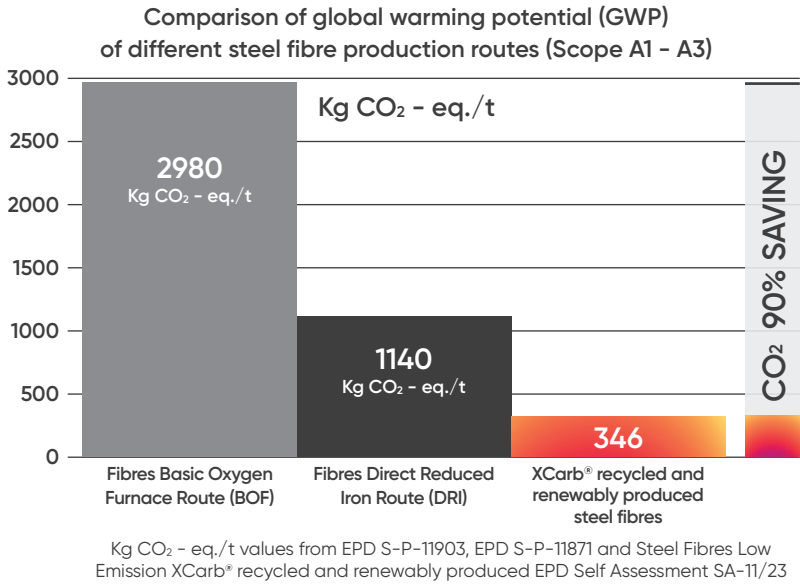


XCarb[®]

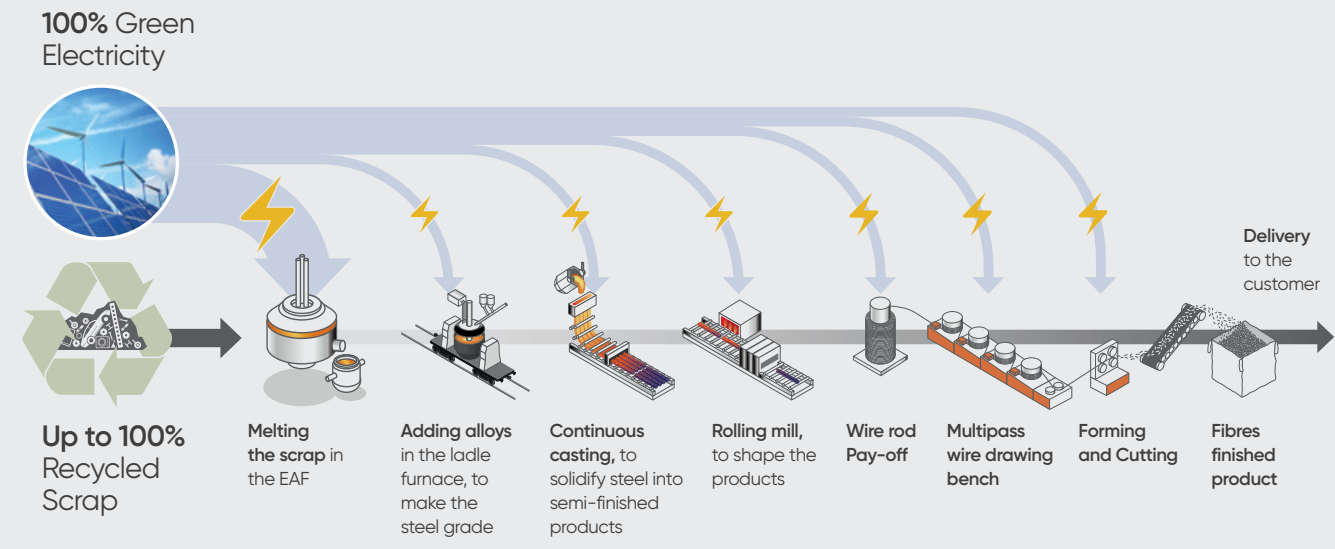
Recycled and renewably produced

ArcelorMittal Fibres have developed a new generation of steel fibre. XCarb[®] recycled and renewably produced steel fibres are manufactured with recycled steel and 100% renewable electricity. XCarb[®] recycled and renewably produced steel fibres further reduce the carbon footprint of construction projects, leading the way towards carbon neutrality.

XCarb[®] recycled and renewably produced steel fibres can reduce embodied carbon by up to 90%, compared to conventionally produced steel fibres, leading the way to carbon neutrality.



XCarb[®] recycled and renewably produced steel fibres process



RENEWABLE ENERGY

All of the electricity needed to transform the scrap into XCarb[®] recycled and renewably produced steel products comes from renewable sources such as solar and wind power.

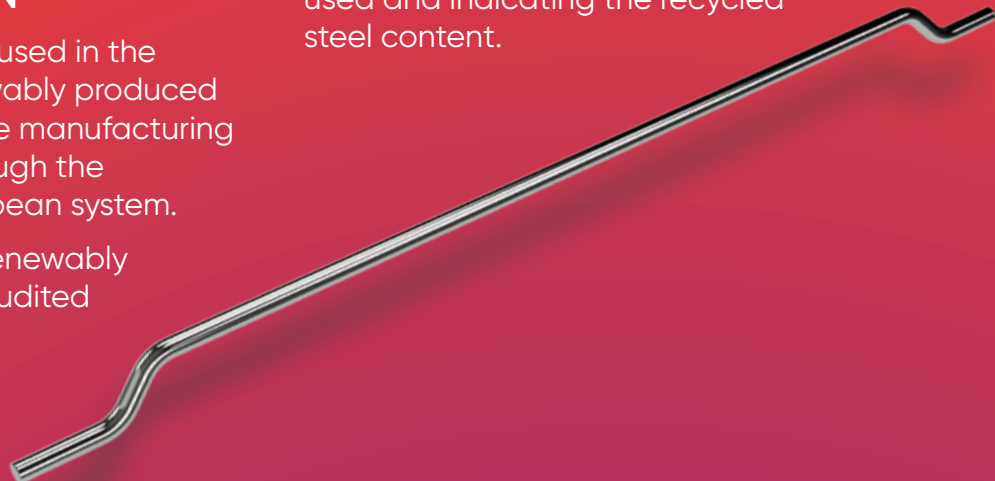
GUARANTEE OF ORIGIN

The origin of the electricity used in the XCarb[®] recycled and renewably produced steel-making and steel fibre manufacturing process is guaranteed through the "Guarantee of Origin" European system.

The XCarb[®] recycled and renewably produced order system is audited by a third party.

DEDICATED PRODUCTION CERTIFICATE

Each tonne of steel fibres produced under the XCarb[®] recycled and renewably produced label will have a dedicated production certificate showing the kg of CO₂/tonne (Scope A1 - A3) of steel used and indicating the recycled steel content.



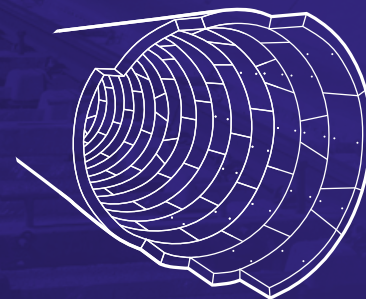
ArcelorMittal tunnel lining solutions

ArcelorMittal Fibres offer steel fibre reinforced concrete solutions for three key tunnel lining construction techniques. The technical design and support service offered by our Engineering team, ensures the optimal solution for each tunnel construction method is achieved on every project.

PRECAST TUNNEL LINING SEGMENTS

Steel fibre reinforced concrete segments for TBM excavated tunnels.

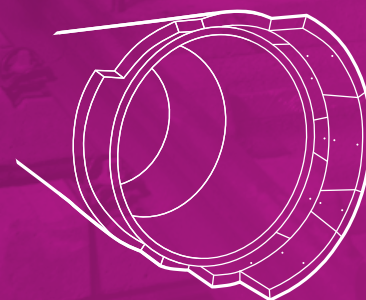
Precast concrete segments form rings to line the wall of the tunnel. Tunnel lining segments are cast to the specified rectangular, trapezoidal, hexagonal or rhomboidal shape design, and are suitable for temporary and permanent lining applications.



CAST IN PLACE TUNNEL LININGS

Steel fibre reinforced concrete cast in place for secondary and final tunnel linings.

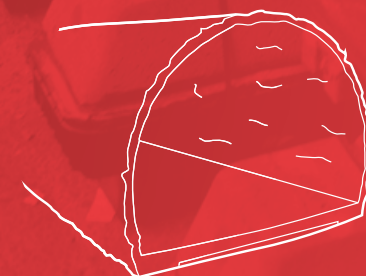
Cast in place steel fibre reinforced concrete is suitable for NATM and TBM tunnel excavation methods and can be used as permanent tunnel linings for both sprayed concrete and precast segment construction methods.



SPRAYED CONCRETE LININGS

Sprayed concrete reinforced with steel fibres for temporary or permanent tunnel lining applications.

Steel fibre reinforced sprayed concrete is a versatile reinforcement method for NATM excavated tunnels and can be used as a stand-alone method, or in combination with cast in place solutions.



FIBRES IN ACTION

HS2 16km twin bore tunnels lined with steel fibre reinforced concrete

HS2 is Britain's new high speed rail line that will link London and the Midlands and represents the largest infrastructure project in the UK to date. The high speed line will pass through 105km of tunnels and over 15km of viaducts, delivering faster journeys on more trains with more seats.

The 16km long, north and southbound twin tunnels, excavated 90 metres beneath the Chiltern Hills, through a mix of chalk and flint, are lined with a primary lining constructed using precast concrete tunnel lining segments reinforced with steel fibres.

112,000 tunnel lining segments were manufactured in the purpose built concrete production facility at the south portal, and reinforced with 15,200 tonnes of ArcelorMittal HE++ 90/60 steel fibres. The high performance HE++ 90/60 steel fibres provide optimum levels of residual flexural strength for the reinforcement of tunnel lining segments.

Each ring consists of 7 segments and measure 9.1m diameter x 2m wide x 400mm thick with a concrete volume of 382,000 cubic metres.

The UK manufacturing of the steel fibres, enabled reinforced tunnel lining segments to be manufactured in close proximity to the tunnels, significantly reducing the CO₂ impact of the project.

ArcelorMittal provided the necessary on-site technical expertise, and the production and logistical support to enable contractors to meet the highest quality standards and a demanding construction schedule. Our Technical Support Team have been on hand every step of the way, from providing important technical advice on dosing and mixing and assisting with the production start up process, to ongoing support, ensuring project progress.



Precast tunnel lining segments

High-speed train tunnels | Subway tunnels and stations | Motorway and road tunnels | Cross passages | Fresh water supply tunnels | Waste water tunnels | Combined sewer overflow tunnels | Stormwater tunnels | Head race tunnels

Solution description

Steel fibre reinforced concrete tunnel lining segments find their application in tunnels that have been excavated using a Tunnel Boring Machine (TBM) and are mainly suitable for permanent tunnel lining applications.

TBM's are specialised machines that excavate the tunnel by using a rotating cutting head to break through soil, rock, and other ground conditions. Once the TBM has passed a section, concrete precast tunnel lining segments are installed to provide structural stability to the tunnel. Tunnel lining segments are cast to the specified rectangular, trapezoidal, hexagonal or rhomboidal shape design, and form rings to line the wall of the tunnel.

The use of steel fibres as the reinforcing method within the concrete mix, brings three dimensional distribution to the reinforcement. This distribution delivers a number of advantages to the robustness and durability of the tunnel lining. The concrete matrix is provided with reliable tensile strength in all directions through the three dimensional distribution of the fibres, with high load bearing resistance being achieved.

Our well established range of high performance, HE++ ultra high tensile strength steel fibres mixed with a high strength concrete (C45/55 min) achieve outstanding levels of residual flexural strength for the reinforcement of tunnel lining segments. This high strength performance allows

tunnels with an internal diameter of up to 12m to be designed with steel fibres as the sole reinforcement method.

The introduction of our new generation HE3+ ultra high strength steel fibres with a tensile above 2400 MPa, increases the boundaries of what can be achieved with steel fibre reinforced concrete even further.

Tunnel lining segments reinforced with steel fibres, significantly increases health and safety on site as the risks associated with the manufacture and installation of reinforcement cages in the segment production process, are completely removed.

Benefits and advantages

- › Reinforcement correctly placed, no cover limitations
- › Improved precast production efficiency as mesh and rebar cage handling and placing is not required
- › Higher resistance against impacts during handling and placing of the segments
- › Smaller crack width openings and crack lengths
- › Higher durability: chloride and carbonatation induced corrosion resistance of SFRC is higher than traditional reinforcement
- › Time and cost saving.



A selection of the major tunnel lining segments projects supplied

LOCATION		PROJECT	FIBRE	TONNES	CONTRACTORS / SUBCONTRACTORS
	UK	HS2 Chiltern Tunnels, Central Section C1	HE++ 90/60	15281	Align JV, Tarmac
	UK	HS2 Long Itchington Wood Tunnels, Northern Section N1	HE++ 90/60	1200	BBV JV, Pacadar
	UK	Thames Tideway Central Tunnels	HE++ 90/60	3600	Ferrovial Agroman Laing O'Rourke JV, Pacadar
	UK	Crossrail London – Crossrail Running Tunnels – East	HE++ 90/60	4900	Dragados Sisk JV
	UK	Crossrail London – Crossrail Thames Tunnel	HE++ 90/60	1100	Hochtief Murphy JV
	France	Grand Paris Express Line 16 Lot 2	HE++ 90/60	5600	Webuild & NGE JV, GIE Alliance
	France	Grand Paris Express Line 18 Lot 1	HE++ 90/60	4600	VINCI and SPIE JV, Stradal
	France	Grand Paris Express Line 16 Lot 3	HE++ 90/60	2500	Razel-Bec, SEFI Intrafor, Fayat Metal JV, GIE Alliance
	Qatar	Qatar Rail, Doha Metro Red Line South	HE++ 90/60	7520	QDVC JV
	Poland	Świnoujście Road Tunnel	HE++ 90/60	1266	Gulermak, PORR, Cemex
	Czech Republic	Ejpovice Railway Tunnel	HE+ 1/60	3600	Metrostav
	New Zealand	City Rail Link – Auckland	HE++ 90/60	735	Link Alliance JV, Wilson Group
	Spain	Mularroya Water Tunnel	HE++ 90/60	1000	Acciona – Sacyr JV, Acciona

12,700 tonnes of steel fibres for the Grand Paris Express

12,700 tonnes of ArcelorMittal HE++ 90/60 high quality steel fibres are being used in 28km of tunnel lining segments beneath the city of Paris.

PROJECT TITLE:	Grand Paris Express
CLIENT:	Société du Grand Paris
CONTRACTOR:	Line 16 Lot 2: Webuild & NGE JV, GIE Alliance Line 16 Lot 3: Razel-Bec, SEFI Intrafor, Fayat Metal JV, GIE Alliance Line 18 Lot 1: VINCI and SPIE JV,Stradal
TLS PRODUCER:	Line 16 Lot 2: GIE Alliance Line 16 Lot 3: GIE Alliance Line 18 Lot 1: Stradal

LOCATION:	Paris, France
WORKING ENVIRONMENT:	Subway
DISTANCE:	Line 16 Lot 2 – 10.7km Line 16 Lot 3 – 5.5km Line 18 Lot 1 – 11.8km
INTERNAL DIAMETER OF THE TUNNELS:	8.70m
DURATION:	2021 - 2023
ARCELORMITTAL FIBRES PROPOSED:	12,700 tonnes of HE++ 90/60 for tunnel lining segments to include: 5600 tonnes of HE++ 90/60. Line 16 Lot 2 2500 tonnes of HE++ 90/60. Line 16 Lot 3 4600 tonnes of HE++ 90/60. Line 18 Lot 1

"ArcelorMittal HE++90/60s enabled us to achieve the high level of concrete performance requested by our client, fully meeting our expectations in terms of quality monitoring and traceability. ArcelorMittal provided us with a flawless service on the Grand Paris Express, ensuring steady supplies at all time, which is of paramount importance on these ambitious projects"

Jean Luc Valin, Stradal Precast Plant Manager

THE SOLUTION

ArcelorMittal's technical engineers provided detailed guidance throughout the project, including the early development of the project specification, the optimisation of dosage rates, the supervision of performance tests, the installation of dosage equipment and continuous technical support. In total, ArcelorMittal manufactured and delivered 12,700 tonnes of HE++ 90/60 steel fibres.

THE RESULT

Grand Paris Express project will have a positive impact on the urban environment, extending the French capital's metro and light rail network by 200 kilometres, with 68 stations. Improving connections between the centre of Paris and the surrounding suburbs, the Grand Paris Express is set to improve the local economy and passenger mobility, whilst reducing vehicular traffic and air pollution.

ArcelorMittal Fibres is a major contributor to the development of urban mobility infrastructure projects, supporting worldwide initiatives to reduce traffic and pollution with the supply of steel fibre reinforced concrete solutions.



THE CHALLENGE

Grand Paris Express is the new metro and light rail network beneath the French capital region. Contracted to provide technical support on the steel fibre reinforcement of precast tunnel lining segments, ArcelorMittal were required to deliver 12,700 tonnes of HE++ 90/60 steel fibres and oversee dosing, mixing and quality testing procedures at each stage of the steel fibre reinforced concrete tunnel lining segment production process.



HE++ 90/60

Cast in place tunnel linings

High-speed train tunnels | Subway tunnels and stations | Motorway and road tunnels | Cross passages | Fresh water supply tunnels | Waste water tunnels | Combined sewer overflow tunnels | Stormwater tunnels | Head race tunnels

Solution description

Cast in place steel fibre reinforced concrete is used in secondary and final tunnel lining applications.

This reinforcing method is suitable for tunnels excavated using both NATM and TBM techniques, and can be used as permanent linings for both sprayed concrete and precast segment tunnel construction.

The cast in place process takes place after the tunnel excavation and support work has been completed, and sits on the inside of the primary tunnel lining.

Steel fibre reinforcement improves both the efficiency and the safety of the cast in place technique as it removes the process of cage and mesh installation in what can often be a limited space area.

Cast in place is commonly used as permanent lining with sprayed concrete in road tunnel applications, and as secondary linings in water/waste tunnel applications to mitigate the risk of seepage and improve performance flow where precast segments have been used for primary linings.

Our well established range of high performance, HE++ ultra high tensile strength steel fibres achieve outstanding levels of residual flexural strength for the reinforcement of cast in place linings.

The introduction of our new generation HE3+ ultra high strength steel fibres with a tensile above 2400 MPa, increases the boundaries of what can be achieved with steel fibre reinforced concrete even further.

Benefits and advantages

- › Improved durability and better crack control
- › Faster, easier and safer construction process
- › Concrete can be pumped even from long distance
- › Reduced number of workers required on job site
- › Integrated automatic dosing system.



A selection of the major cast in place projects supplied

LOCATION	PROJECT	FIBRE	TONNES	CONTRACTORS / SUBCONTRACTORS
 UK	Thames Tideway Eastern Tunnels – Secondary Linings	HE++ 90/60	1500	Costain, VINCI, and Bachy Soletanche JV, Heidelberg Materials
UK	Thames Tideway Central Tunnels – Secondary Linings	HE++ 90/60	1800	Ferrovial Agroman and Laing O'Rourke JV, Heidelberg Materials
 Singapore	Deep Tunnel Sewerage System 2, Lot T-08	HE+ 1/60	1350	Penta-Ocean and Koh Brothers JV

Cast in place secondary tunnel lining improves performance for Thames Tideway

ArcelorMittal Fibres cast in place tunnel linings.

PROJECT TITLE:	Thames Tideway
CLIENT:	Tideway (Bazalgette Tunnel Limited)
CONTRACTOR:	Ferrovial Agroman UK and Laing O'Rourke Construction Joint Venture (FLO JV)
CONCRETE PRODUCER:	Heidelberg Materials
LOCATION:	London, United Kingdom

WORKING ENVIRONMENT:	Up to 60m below ground and under the River Thames
INTERNAL DIAMETER OF THE TUNNELS:	Central Tunnels – secondary lining of 7.2m internal diameter East Tunnels – secondary lining of 7.2m internal diameter
DURATION:	2016 - 2024
ARCELORMITTAL FIBRES USED:	HE++ 90/60. Central Tunnels 1800 tonnes HE++ 90/60. East Tunnels 1500 tonnes
DOSAGE:	30kg/m ³

"ArcelorMittal provided another brilliant service. The HE++ 90/60 fibre was an integral part of the high strength, high performance concrete required by the client. Not only that, ArcelorMittal were always on hand to provide technical support where required."

James Lloyd, Heidelberg Materials



THE CHALLENGE

The Thames Tideway tunnels have been excavated through highly variable strata and there is significant geological faulting in the area. The traditional configuration of variable shaped precast tunnel lining segments means that the entire interior surface of the tunnel lining is divided with longitudinal and circumferential joint seams. In the case of the Thames Tideway there was a risk that the water would seep through the primary lining. Furthermore, the combination of many joint seams and the multitude of joint connector cavities located around the perimeter of each tunnel lining segment, results in a surface that is not smooth and continuous. Overtime, this irregular surface will act as a catalyst for the build up of effluents on the walls of the tunnel, impeding the flow of sewage to the treatment works, and causing back up.

THE SOLUTION

To address the dual issues of water seepage and the discontinuous interior surface texture of the precast TLS lining, a cast in place secondary lining was used.

Following the completion of a significant proportion of the primary precast TLS lining, preparatory works for the secondary cast in place lining began. The secondary cast in place lining was cast using a bespoke travelling shutter system serviced by a pump supplied with C50/60 concrete by remixer wagons. The concrete, mixed with ArcelorMittal Fibres was pumped directly into the formwork via ports. HE++ 90/60 steel fibres dosed at 30kg/m³ were used.

THE RESULT

The cast in place lining required careful planning in order to streamline the construction process throughout the project. The use of this established cast in place method presented few challenges and consistent production rates were maintained throughout the construction.

HE++ 90/60



Sprayed concrete linings

High-speed train tunnels | Subway tunnels and stations | Motorway and road tunnels | Mining | Cross passages | Fresh water supply tunnels | Waste water tunnels | Slope stabilisation | Combined sewer overflow tunnels | Stormwater tunnels | Head race tunnels

Solution description

Sprayed concrete reinforced with steel fibres can be used for temporary or permanent tunnel lining applications.

Steel fibre reinforced sprayed concrete is a versatile reinforcement method for NATM excavated tunnels and can be used as a stand-alone technique, or in combination with cast in place solutions.

Sprayed concrete has traditionally been used as a temporary lining for stability in NATM excavated tunnels, but the development of steel fibre technology and the introduction of high performance steel fibres for sprayed concrete applications, has broadened the capabilities of what is possible with steel fibre reinforced sprayed concrete.

The three dimensional distribution of fibres in the concrete mix, provides multi-directional tensile strength, offering a more robust and durable solution than traditional mesh reinforcement. The sprayed concrete technique allows the even application of the reinforced concrete that follows the contours of the excavated tunnel.

Our well established range of HE+ (very high), and HE++ (ultra high) tensile strength steel fibres, are enabling sprayed concrete solutions to be utilised as permanent tunnel lining solutions. The introduction of our new generation HE3+ ultra high strength steel fibres with a tensile above 2400 MPa, increases the boundaries of what can be achieved with steel fibre reinforced concrete even further.

The use of sprayed concrete steel fibre reinforcement significantly increases site safety as the high risks involved with the placement and fixing of reinforcement in a newly excavated and potentially unstable environment, are completely eliminated through the rapid stabilisation of the area.

Benefits and advantages

- › Reduction of construction time and labour costs
- › Saving of material costs by optimisation of cross section (reduction of thickness, material excavated and transported, less rebound)
- › Increase of working safety
- › More compact lining
- › Integrated automatic dosing system.



A selection of the major sprayed concrete projects supplied

LOCATION	PROJECT	FIBRE	TONNES	CONTRACTORS / SUBCONTRACTORS	
	Finland	Kehärata Rail Tunnel Helsinki-Vantaa Airport	FE 60/36	1000	Skanska, SRV, Rudus Oy
	Finland	Länsimetro Helsinki-Espoo	FE 60/36	3000	Skanska, Lemminkäinen, Rudus Oy
	Spain	High Speed Railway Line Cordoba/Málaga Túnel Álora-Túnel El Espartal	FE 67/30	1200	Ferrovial
	Switzerland	Alp Transit Gotthard, Bodio 553 Fondazioni Speciali	FE 67/30	700	Pizzarotti, Muttoni, Ferrari
	Norway	Storberget Rail Tunnels	HE 55/35	1000	NCC, NorBetong AS
	Norway	Skillingsmyr Rail Tunnels	HE 55/35	1000	Veidekke, NorBetong AS
	Norway	E134 Gvammen Road Tunnel	HE+ 55/35	1000	NCC, Ferdigbetong
	Spain	High Speed Railway Line Madrid, Valencia, Villagordo, Venta del Moro, Naharros	HE 55/35	1300	Acciona Infraestructuras
	UK	Crossrail C-510, Liverpool Street and Whitechapel Stations	HE 55/35	4800	BBMV-Balfour Beatty,Morgan Sindall, Alpine Bemo, Vinci
	UK	Crossrail C-305, Eastern Running Tunnels	HE+ 55/35	1000	DSJV- Dragados Sisk
	Sweden	Västlänken - Deletapp Korsvägen, Rail Tunnel	HE 55/35 GL	1050	Thomas Betong, NCC
	Luxembourg	A7 Highway Road Tunnel, Luxembourg Tunnel Arge Grouft (TAG)	HE 75/35	3831	Félix Giorgetti, Galère, Max Bögl, Wayss, Freytag, Ingenieurbau
	Luxembourg	A7 Highway Road Tunnel, Luxembourg Arge Tas Tunnel Stafelter GBR	HE 75/35	1514	Félix Giorgetti, Galère, Max Bögl, Wayss, Freytag, Ingenieurbau

Safer and faster: The new E134 route between Gvammen and Århus

Relocation of the E134 through a tunnel between Gvammen to Århus will successfully shorten the E134 route by approximately 11km. In addition, the new road, with very little gradient, reduces driving time for heavy vehicles by about 18 minutes, making the journey both safer and faster.

PROJECT TITLE:	Drill and Blast tunnel, E134 Gvammen-Århus
CLIENT:	Ferdigbetong A/S
CONTRACTOR:	NCC Norway A/S
LOCATION:	Telemark Fylke, Norway
DEVELOPER:	Statens Vegvesen. Norwegian Road Administration

LENGTH:	11.7km of which 9.4km is tunnel
SPEED LIMIT:	80km/h
ROAD WIDTH:	10 metres
DURATION:	2014 - 2018
ARCELORMITTAL FIBRES PROPOSED:	1,250 tonnes to include:
	650 tonnes of high tensile HE 55/35, 1200 N/mm²
	600 tonnes of very high tensile HE+ 55/35 GL, 1800 N/mm²
DOSAGE:	Between 23kg/m³ and 28kg/m³

"In addition to what the ArcelorMittal higher performance HE+ 55/35 fibre is bringing to the concrete, the lower dosage rate has had a big influence on the daily work at the concrete ready mix plant. With 30% less fibres, we found the process of mixing and dosing the fibres considerably easier. The reduced dosage rate also positively affected the whole supply chain with less deliveries and less stock required at our mobile concrete plant in the remote Notodden location."

Øyvind Alseth, Manager, Mobile Concrete plants, Ferdigbetong AS



THE SOLUTION

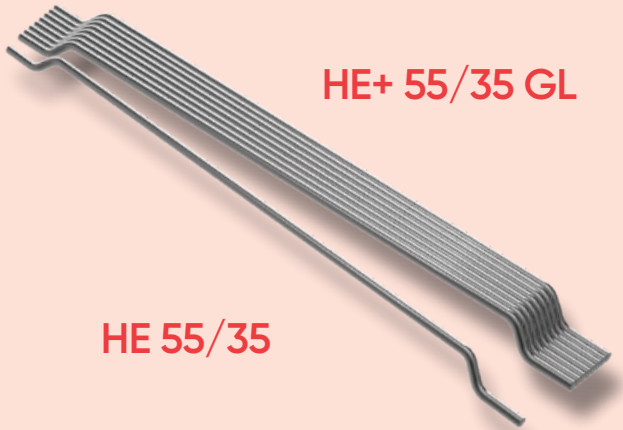
Due to the HE 55/35 fibre's long history of delivering highly efficient reinforced sprayed concrete solutions in environments similar to the E134 tunnel, the HE 55/35 fibre was an obvious choice as it exceeded the Gvammen - Århus project's stringent quality and performance standards. ArcelorMittal HE 55/35 steel fibre reinforced concrete not only re-stabilised the subterranean environment, but it also demonstrated how the hooked end design, with its high tensile strength, enabled contractors to use fewer fibres, with no compromise to performance and strength.

THE CHALLENGE

The Gvammen-Århus tunnel runs predominantly through quartzite. The thickness of the overburden in many sections of the tunnel is more than 1000 metres, resulting in high rock stress and a real danger of rock burst. The tunnel is constructed using a Drill and Blast method and reinforced with ArcelorMittal steel fibre reinforced sprayed concrete.

WE CONSTANTLY STRIVE TO IMPROVE OUR PRODUCTS

During the course of the project, our ongoing development of a new breed of steel fibre resulted in the launch of the HE+ 55/35 GL. In combination with successful tests at SINTEF Certification Institute in Oslo, we were able to demonstrate the HE+ 55/35 GL, with 1800 N/mm², could achieve the same performance levels as the HE 55/35, using a 30% lower volume of fibres. We supplied the HE+ 55/35 GL as a glued fibre which provides greater workability and delivers an even distribution of the fibres throughout the concrete mix. Switching from the HE 55/35 to the HE+ 55/35 GL represented an important reduction in dosage rates and the client was able to see highly beneficial efficiency savings on the project.



ArcelorMittal Fibres at a glance.

The right advice. The right fibres. The right solution.

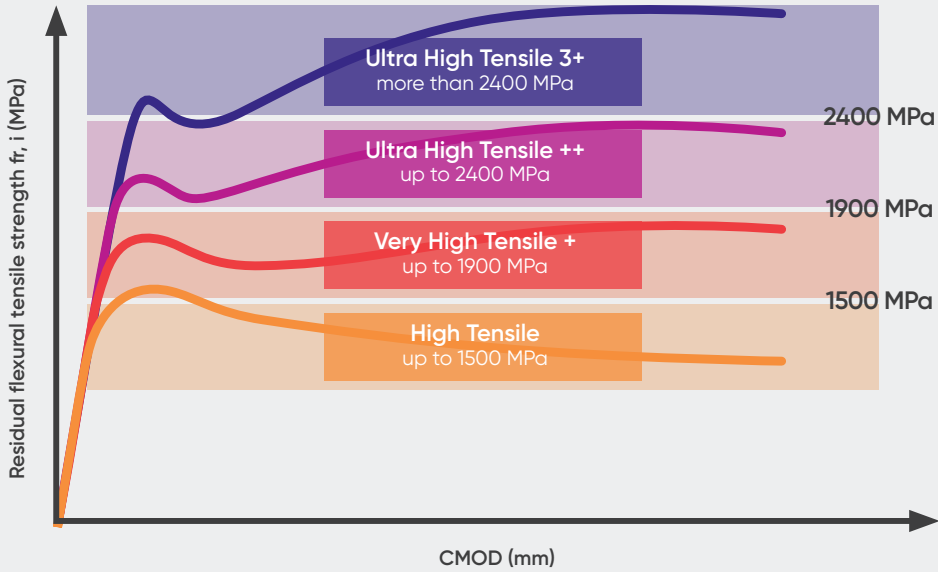
Solutions	High Tensile Strength	Very High Tensile Strength	Ultra High Tensile Strength	
	Standard 1200 MPa to 1500 MPa	+	++	3+ > 2400 MPa
Sprayed concrete lining				
Cast in place lining				
Precast tunnel lining segments				

Our different levels of wire tensile strength are dedicated to different levels of expected performance of the concrete element reinforced with our steel fibres.

The High Tensile Strength steel fibres, made with a wire tensile strength ranging from 1200 MPa to 1500 MPa (2 to 3 times the tensile strength of normal rebars), are proposed in sprayed concrete tunnel linings where the concrete performance and ductility requirements are corresponding to lower level of loadings. The recommended concrete strength class is min C30/37.

The Very High Tensile Strength steel fibres (tensile strength between 1500 MPa and 1900 MPa) are used in sprayed concrete linings and cast in place where the loadings are higher. The recommended minimum concrete compressive strength class is min C35/45.

The Ultra High Tensile Strength steel fibres (tensile strength 1900 MPa to 2400 MPa and more) are recommended for cast in place and tunnel lining segments where the compressive strength of the concrete is min C45/55 and a bending-hardening behaviour is required, so that the peak strength exceeds the first crack strength.



HE

Hooked End fibre range



THE HOOKED END FIBRE RANGE IS AVAILABLE WITH: High, Very High and Ultra High Tensile Strength wire qualities

TENSILE STRENGTHS:
Available as **Standard**, **+**, **++** and **3+**

LENGTHS:
Available in **35mm** to **60mm**

DIAMETERS:
Available in **0.55mm** to **1.00mm**

HE Glued

Hooked End Glued fibre range



THE HOOKED END GLUED FIBRE RANGE IS AVAILABLE WITH: High, Very High and Ultra High Tensile Strength wire qualities

TENSILE STRENGTHS:
Available as **Standard**, **+** and **++**

LENGTHS:
Available in **35mm** to **60mm**

DIAMETERS:
Available in **0.55mm** to **0.75mm**

PACKAGING OPTIONS

Our steel fibres are available in a range of packaging options dependent on the fibre type and the volume of fibres required. **For full details please contact our support team: fibresupport@arcelormittal.com**

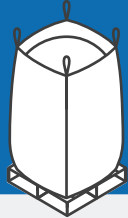
10kg, 20kg and 25kg boxes
on pallets



2x500kg big bags/pallet
Nett weight 1000kg



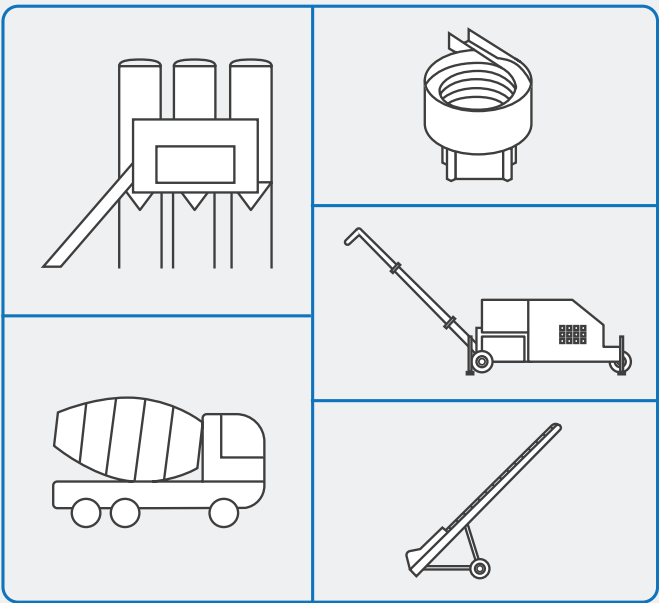
1000kg big bag/pallet
Nett weight 1000kg



DOSING AND MIXING

A wide range of solutions, with automatic dosing equipment, blast-machines and conveyor belts are available.

Our complimentary on-site support and technical advice service on mixing and dosing equipment, can help you decide on the right on-site dosing and mixing to suit your project.



Why choose ArcelorMittal Fibres?



Expert support



Fibre performance



Packaging options



Reduced carbon footprint for your project



Materials origin and traceability



Comprehensive product range



Guaranteed quality



Your reliable project partner



Vertically integrated business model

TECHNICAL AND ENGINEERING SUPPORT

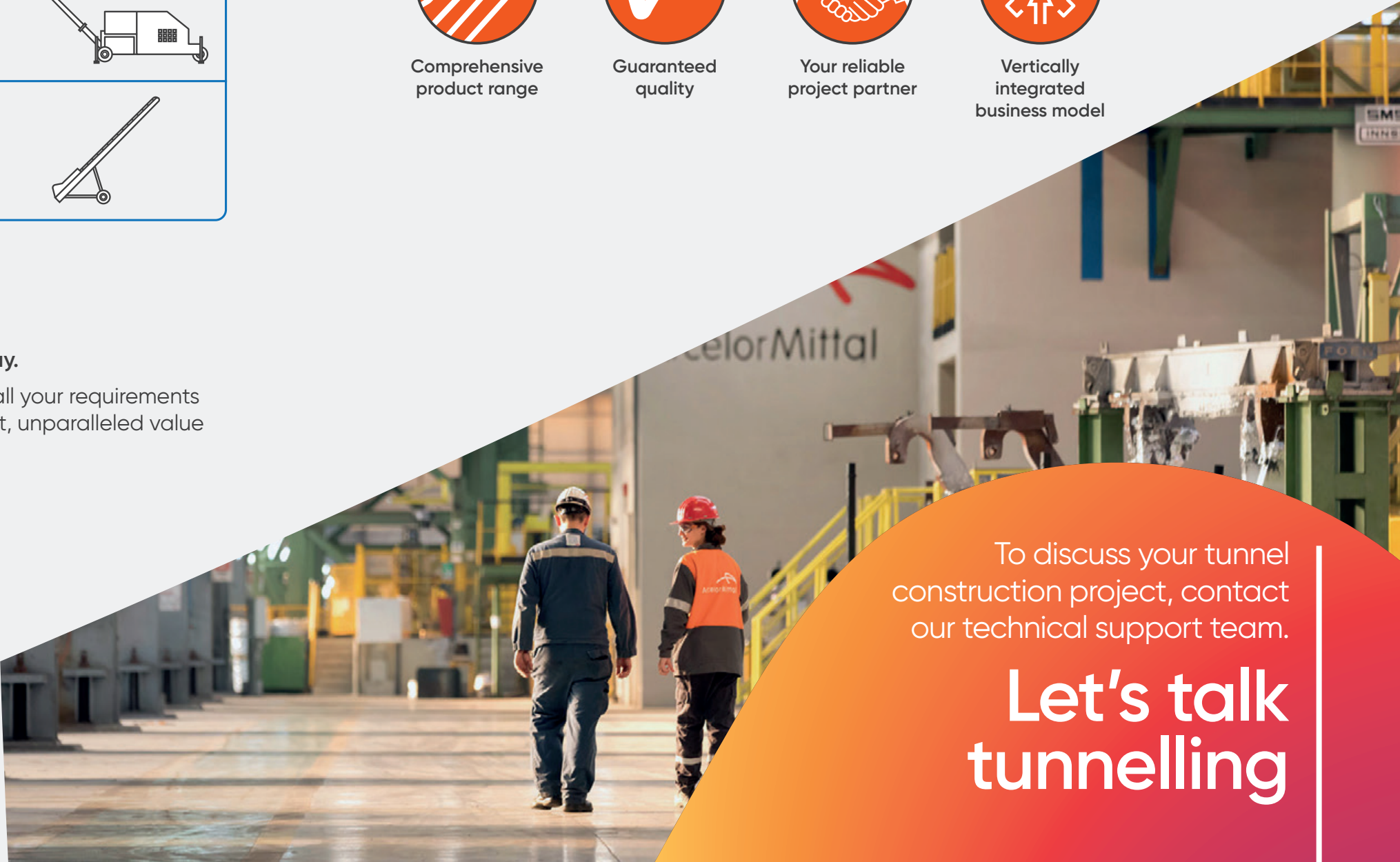
Our technical experts will advise and support you every step of the way.

We will ensure that your steel fibre reinforced tunnelling project meets all your requirements including material tracking and traceability, a reduced carbon footprint, unparalleled value and, of course, fully optimised steel fibre reinforced concrete solutions.

For further details please contact our support team:
fibresupport@arcelormittal.com

To discuss your tunnel construction project, contact our technical support team.

Let's talk tunnelling





The world is building on our expertise

ArcelorMittal Fibres operates internationally. We provide steel fibre reinforced concrete solutions for the tunnel construction industry and participate in some of the world's major tunnelling projects.

Let's talk tunnelling



ArcelorMittal

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