7 STAR advanced
GFRP BUILDING SOLUTIONS

in collaboration with

ARMASTEK RUSSIA ™

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7 STAR advanced
GFRP BUILDING SOLUTIONS

Unleashing the Power of GFRP: A Revolution Beyond Steel

Strength, Durability and Sustainability, Demonstrated !

- **2X** STRONGER THAN STEEL
- **80%** LIGHTER THAN STEEL
- **30%** SAVINGS
- **NO** CORROSION
- **NO THEFT** IN TRANSIT / AT SITE

SCOUTBOOK

GFRP, a revolution beyond steel highlights the emergence of Glass Fiber Reinforced Polymer (GFRP) as a potentially transformative material in various industries, promising advancements that go beyond the conventional uses of steel. With potential benefits, innovations, and paradigm shifts that GFRP could bring to the forefront. Let's delve into the explanation:

Issues with **TMT Bar**

Here are some common issues faced with TMT bars:

Corrosion

TMT bars are susceptible to corrosion when exposed to moisture, chemicals, or saline environments. Corrosion can weaken the bars and lead to structural integrity issues over time.

Increasing Cost

The cost of TMT bars has been subject to fluctuations due to factors like raw material prices, transportation costs, and market demand. This volatility can impact project budgets and overall construction expenses.

Theft in Transit / Site of TMT Bars

TMT bar theft, a significant industry concern, occurs during transit or on construction sites, impacting manufactures and companies with reported cases upto 30%. Due to high market value and unsecured routes, TMT bars are vulnerable to theft during transportation. On-site storage challenges, inadequate fencing, and remote locations make construction sites prime targets. Stolen bars often end up in the black market, causing financial losses.

Scrap Generation

During construction, TMT bars may require cutting and bending to fit specific structural requirements, leading to scrap generation. The disposal of this scrap can be a concern and add to waste management challenges.

Cutting of Opening in Concrete Structures

Incorporating openings, such as doorways or windows, in concrete structures with TMT bars can be labor-intensive and time-consuming. Special tools and techniques are often required for precise cutting, adding to construction complexity.

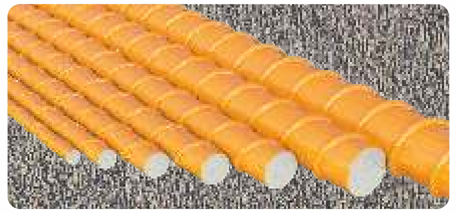
Labour Intensive

Handling and installing TMT bars can be labor-intensive, especially in large-scale construction projects. The bending, cutting, and placement of bars demand skilled labor and may increase construction timeframes.

Introducing GFRP Bars, Mesh & Bent Elements

GFRP, or Glass Fiber Reinforced Polymer, is a composite material that has gained significant attention in the construction industry. It is made by reinforcing plastic resin with fine glass fibers, resulting in a lightweight yet durable material. GFRP offers several advantages over traditional construction materials, such as steel, like high strength, corrosion resistance, and design flexibility. It has found application in various structural elements, such as reinforcing bars, grids, panels, and profiles. With its exceptional properties, GFRP is revolutionizing the way we build, providing sustainable and innovative solutions for a wide range of construction projects.

GFRP bars, mesh, and beam elements are key components in the construction industry, revolutionizing the way structures are built. GFRP, or Glass Fiber Reinforced Polymer, is a composite material that combines the strength of glass fibers with the versatility of polymer resins.

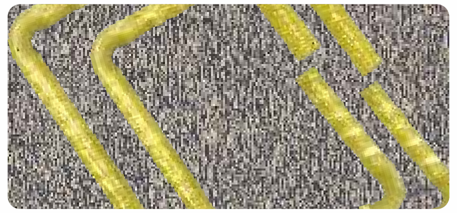


GFRP BARS

GFRP bars are used as an alternative to traditional steel reinforcement bars (rebar) in concrete structures. They offer excellent corrosion resistance, as they are not susceptible to rust or chemical degradation. GFRP bars are lightweight upto 80% lighter than TMT bars, making them easier to handle and transport, and they have a high strength-to-weight ratio, providing comparable or even superior structural performance to steel.

GFRP MESH

GFRP mesh, also known as fiberglass mesh, is a sheet of interwoven GFRP strands. It is used for reinforcing concrete slabs, walls, and other structural elements. GFRP mesh offers the same benefits as GFRP bars, including corrosion resistance, lightweight, and high strength.



GFRP BENT ELEMENTS

GFRP (Glass Fiber Reinforced Polymer) bent elements refer to structural components made from a composite material that combines glass fibers and a polymer resin matrix. These elements are custom-made and designed with specific bends, angles, or curves to suit various construction and infrastructure applications.

Advantages of GFRP Bars, Mesh, and Bent Elements:

2X

Stronger than Steel

Glass Fiber Reinforced Polymer (GFRP) is considered to be significantly stronger than conventional materials like steel in certain aspects due to its unique composition and properties.

Upto 80% Lighter than TMT Bars

GFRP bars, mesh, and bent elements are custom-made to precise dimensions, reducing waste and minimizing rebar scraps during construction.

Upto 30% Savings as Compared to TMT Bars

GFRP bars can offer cost savings of up to 30% when compared to traditional TMT bars, making them a cost-effective alternative.

No Theft in Transit / Site of TMT Bars

As GFRP Rebars have specific application and no resale value in the open market, they are not prone to theft of TMT bars during transit or theft at site. This will further help reduce project costs by lacs of ₹.

Saving in Overlapping Cost of TMT Bars

GFRP elements do not require overlapping as traditional TMT bars do, resulting in cost savings on materials and labor.

Reduction of Rebar Scraps

GFRP bars, mesh, and bent elements are custom-made to precise dimensions, reducing waste and minimizing rebar scraps during construction.

Rust Proof

Unlike steel bars, GFRP bars are rust-proof, ensuring a longer lifespan and minimizing maintenance needs.

Highly Chemical Resistant

GFRP is highly resistant to chemical corrosion, making it ideal for use in aggressive environments or marine structures.

20 Times the Fatigue Resistance of steel

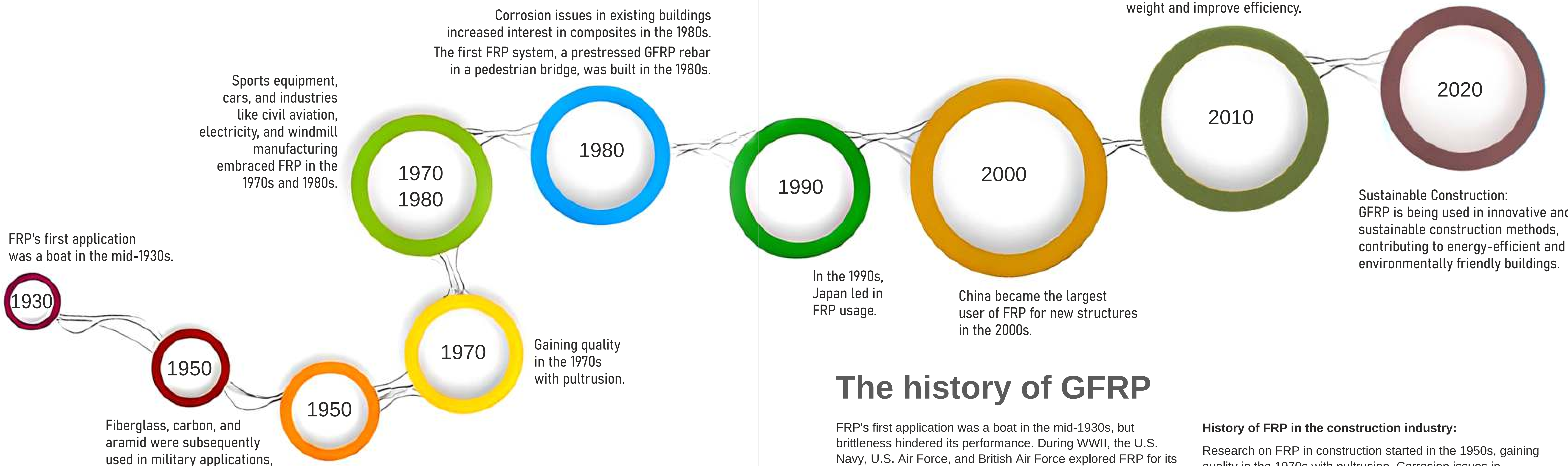
GFRP has 20 times the fatigue resistance of steel, making GFRP more durable under cyclic loading-420, 684 cycles for GRP compare to 23,162 cycles for steel.

No Problem with Tunnel construction

GFRP's non-conductive and corrosion-resistant properties make it well-suited for tunnel construction, where such characteristics are crucial.

GFRP & TMT Bars

Can be used together in construction.



The history of GFRP

FRP's first application was a boat in the mid-1930s, but brittleness hindered its performance. During WWII, the U.S. Navy, U.S. Air Force, and British Air Force explored FRP for its lightweight, nonconductive, and corrosion-resistant properties. Fiberglass, carbon, and aramid were subsequently used in military applications, including ships and aircraft.

Civil uses of FRP began after WWII in oil pipes due to their noncorrosive behavior. FRP use expanded to various applications, with the marine industry becoming a major consumer. Sports equipment, cars, and industries like civil aviation, electricity, and windmill manufacturing embraced FRP in the 1970s and 1980s

History of FRP in the construction industry:

Research on FRP in construction started in the 1950s, gaining quality in the 1970s with pultrusion. Corrosion issues in existing buildings increased interest in composites in the 1980s. The first FRP system, a prestressed GFRP rebar in a pedestrian bridge, was built in the 1980s. In the 1990s, Japan led in FRP usage, while China became the largest user of FRP for new structures in the 2000s. CFRP gained commercial success in the 1990s, becoming the primary application for strengthening existing structures.

Design codes and standards related to the use of GFRP (Glass Fiber Reinforced Polymer) reinforcement in different countries:

USA

ACI 440.1R:
Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars

AASHTO LRFD:
Bridge Design Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railing

EUROPE

FIB Task Group 9.3 - Bulletin 40 - FRP Reinforcement in RC Structures

CANADA

CAN/CSA S806:
Design of Buildings with Fibre Reinforced Polymers

CAN/CSA S6-06:
Canadian Highway Bridge Design Code

SAUDI ARABIA

ACI 440.1R:
Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars

INDIA

AASHTO (2018), FDOT / 2021, SA/2006. Ac1440

As per Indian Road Congress

PARAGUAY

NORMA PARAGUAY
NP 17 09 1 19

SWITZERLAND

FIB BULLETIN NO. 40

NORWAY

22-A 98741
Structural-Eurocrete Modifications to Ns3473 when using FRP Reinforcement.

ITALY

CNR DT 203/2006
Structural-Guide for the Design and Construction of Concrete Structures Reinforced with Fiber-Reinforced Polymer Bars.

UKRAINE

NBV 2.6-185-2012
Structural-Guidelines for the design and manufacture of concrete sructures with non-metallic composite reinforcement on the basis of basalt and glass fiber rovings.

REP. OF BELARUS

1103-98
Structural-Glass-fiber plastic reinforcement. Technical requirements.

JAPAN & CHINA

NO. 30

JAPAN-CONCRETE ENGINEERING SERIES 23

Structural-Recommendation for design and construction of concrete structures using continuous fiber reinforcing materials (Design)

RUSSIA

GOST 31938-2012

These design codes and standards provide guidelines and specifications for the use of GFRP reinforcement in various structural applications. They offer detailed information on material properties, design methodologies, construction practices, and performance criteria when incorporating GFRP composites in concrete structures and bridge decks. By adhering to these codes, engineers and construction professionals ensure the safe and efficient use of GFRP materials while promoting the advancement of sustainable and innovative construction practices.

Many more countries namely GERMANY, NETHERLANDS, NEW ZEALAND, AUSTRALIA, THAILAND, BRAZIL, KOREA, SINGAPORE, AZERBIAJAN have been using GFRP for infrastructure construction purposes since 1990s.

भारतीय मानक
Jbejbo!Tuboebse

IS 18256 : 2023

कंक्रीट प्रबलन के लिए काँच रेशा प्रबलित पॉलिमर (जीएफआरपी) के ठोस गोल सरिए — विशिष्ट

Solid Round Glass Fibre Reinforced Polymer (GFRP) Bars for Concrete Reinforcement — Specification

ICS 83.120; 91.100.30

मानकः पथप्रदर्शकः
Hkkjrh; ekud C;wjks
CVSFBV!PG!JOEJBO!TUBOEBSET
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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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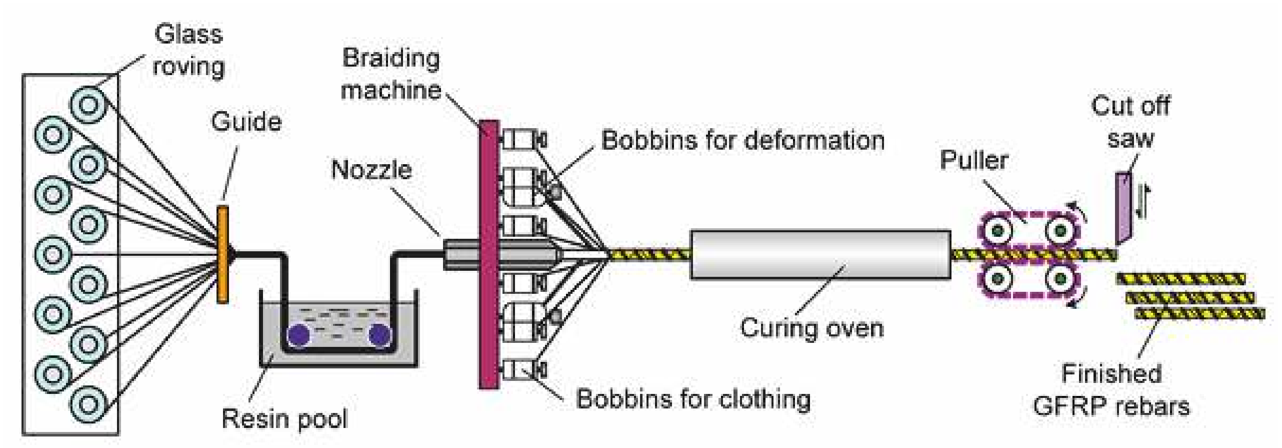
GFRP or Glass Fiber Reinforced Polymer, is made through a manufacturing process that involves the following steps:



Glass Fiber Production: The process begins with the production of glass fibers. Glass filaments are formed by melting glass at high temperatures and drawing it through fine openings, creating continuous strands. These strands are then coated with a sizing agent to improve their bonding with the polymer matrix.

Matrix Preparation: The polymer matrix, typically made of polyester or epoxy resin, is prepared by mixing the resin with other additives such as curing agents, fillers, and pigments. The specific formulation of the matrix depends on the desired properties and application of the final GFRP product.

Fiber Impregnation: The glass fibers are carefully arranged into a desired pattern or orientation and then impregnated with the liquid polymer matrix. This impregnation process ensures that the fibers are thoroughly coated and bonded with the matrix material.

Curing: Once the fibers are impregnated, the GFRP composite is subjected to a curing process. Curing involves applying heat or chemical reactions to initiate the polymerization of the resin. This step solidifies the matrix, resulting in the formation of a rigid and durable composite structure.

Shaping and Molding: The cured GFRP composite can be shaped and molded into the desired form. This can be done through various techniques such as compression molding, vacuum bagging, or resin transfer molding. The shaping process ensures that the GFRP composite takes on the desired dimensions and geometry.

Finishing: After shaping, the GFRP composite may undergo additional finishing processes. This can include trimming excess material, sanding or polishing the surface, and applying coatings or finishes to enhance aesthetics or provide additional protection.

The specific manufacturing process for GFRP may vary depending on the intended application, the complexity of the product, and the desired properties. Advanced techniques such as automated fiber placement or filament winding may be employed for complex or specialized GFRP products.

Our tryst with GFRP

Shri Rathi Group, established in 2003 and located in Delhi, is positioned to become the leading manufacturer of Fiber Reinforced Polymer (FRP) Pultrusion Products in India. With a strong focus on engineering and technology, the company is dedicated to delivering high-quality solutions that offer superior performance in terms of strength-to-weight ratio, corrosion resistance, and durability.

The foundation of Shri Rathi Group is built on a passion for innovation and a commitment to excellence. Through leveraging the unique properties of glass fibers and polymer resins, the company creates GFRP products that surpass the capabilities of traditional materials. These products find applications in various industries, including construction, automotive, aerospace, and marine sectors.

Quality, Cost, and Delivery are the pillars that drive Shri Rathi Group's operations. By maintaining a balanced approach and prioritizing these key factors, the company aims to achieve sustained growth and gain worldwide recognition for its engineering solutions. With a track record of continuous innovation and a strong entrepreneurial spirit, Shri Rathi Group has established its presence and earned respect in the industry.

As the demand for advanced materials grows, Shri Rathi Group is committed to pushing the boundaries of engineering and technology. With a focus on diversification and a vision for the future, the company remains dedicated to delivering innovative, high-performance FRP products that meet the evolving needs of various industries.

Anil Rathi
CMD

Anil Rathi is the visionary leader of Shri Rathi Group, driving innovation and excellence. With a strong steel industry background, he has elevated Shri Rathi Group to new heights, reshaping the industry. Under his guidance, the company embraces technology and sustainability, advancing its products' quality. His strategic mindset expands market reach and establishes Shri Rathi Group as a trendsetter, cementing his role in steel manufacturing and innovation.

SHRI RATHI GROUP

80+
Years of Legacy

27.5 Lac+
Metric Ton TMT Bars sold in the 15 years

1st
company in India to export TMT bars to USA

₹11,340cr.
worth TMT bar sold in last 15 years

Dhruv Rathi
Director

Gopal Rathi
Director

1942
1st Steel Re-rolling mill commissioned at Loni Road, Shahdra, Delhi

1968
Win Exclusive right to use TOR on the steel bars in North India from Tor Istag Steel Corporation Luxumberg.

1968
1st to start production of TOR STEEL in India

1968
Birth of brand RATHI

1970
North India 1st Mini Steel Plant commissioned

1990
Introduction of branded retailing of Steel bars through the concept of Exclusive RATHI TOR steel shops.

2003
Commissioning of M/s Shri Rathi Steel Ltd., Ghaziabad

2005
Introduction of TMT bars in North India.

2007
Won rights from centre de recherches metallurgique Belgium to use tempcore on the steel bars. Commissioning of M/s. Shri Rathi Steel Dakshin Limited, Bhiwadi

2009
Launch of brand "EUROTHERM"

2011
Launch of Mera Steel; Indias 1st Made to Order RATHI steel bars.

2014
Launch of EUROTHERM Binding Wire

2015
Launch of EUROTHERM 7 STAR / Rings

2017
Launch of 7 STAR 600 Grade TMT Bar

2018
Launch of 7 STAR Made to Order TMT Bar

2020
Launch of 7 Star 550D/500D Grade TMT Bar

2021
Increase in monthly capacity by 80%

2023
Launch of 7 Star Advanced GFRP (Glass Fibre Reinforced Polymer) Bars, Mesh & Bent Elements

A new Chapter in innovation

Shri Rathi Collaborates with Armastek

&

Armastek, the global leader in GFRP

Armastek, founded in 2007, excels in composite material technology. A global leader, it innovates and produces construction materials (rebar, mesh, etc.) and equipment using unique methods. Based in Perm, Russia, it serves 30+ countries, transferring technology to 12. Complying with European quality standards, its patented products have earned awards like "100 Best Products of Russia" and "Best Exporter" in 2018 and 2021. Among market leaders, it stands with Hughes Brothers, Schöck Bauteile, and Dextra (Global Information Premium Market Research, October 2022).

Continuous leadership

Under Shri Anil Rathi's leadership, the Shri Rathi Group continues its steel sector innovation. With expertise in Steel Melting and Rolling/Re-Rolling, Shri Anil Rathi leads the Shri Rathi Group into the future, focussing on essential Rebars for the Construction Industry to meet India's growing infrastructure and real estate demands.

Sustainable growth through GFRP

Shri Rathi Group embraces sustainable growth through GFRP (Glass Fiber Reinforced Polymer) technology, offering a strong, eco-friendly alternative to conventional steel. This move reduces environmental impact and aligns with the Shri Rathi Group's values of quality, integrity, and responsible practices.

Shri Rathi Group's journey, from a small mill to a major steel industry player, reflects adaptability, innovation, and commitment to excellence. Shri Anil Rathi's leadership ensures the Shri Rathi Group's legacy of technological advancement and sustainable steel sector development.

Shri Rathi Group and Armastek

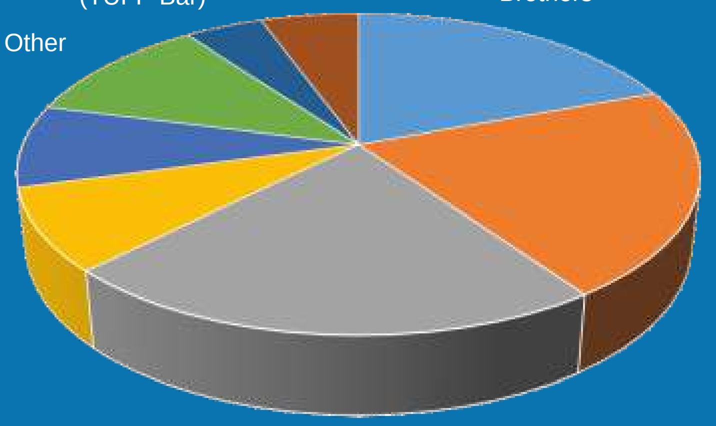
Collaborating with Armastek, a renowned Russian composite reinforcement manufacturer, Shri Rathi Group aims to revolutionize construction with sustainable solutions. Armastek's innovative fiberglass products outperform steel in strength while creating lighter, efficient structures.

The partnership promotes sustainable building, reducing carbon footprint and enhancing structure durability. Together, Shri Rathi Group and Armastek usher in an era of stronger, efficient, and sustainable construction practices.

Armastek's decade-long success in vital facility construction aligns with Shri Rathi's expertise, promising a sustainable future. Their collaboration capitalizes on GFRP technology, redefining construction practices and demonstrating commitment to excellence and the environment.

GLOBAL COMPOSITE REBAR (GFRP) MARKET RESEARCH 2022-2026

Armastek, Russia is one of the major players in the market (composite reinforcement) along with Hughes Brothers (Inc.), Schöck Bauteile (Germany), Dextra (Inc.) and others. (Global Information Premium Market Research, October 2022)



Reg. №: 3246

COMMEMORATIVE CERTIFICATE OF COLLABORATION

We hereby certify that we have entered into an exclusive and strategic collaboration with

7 STAR IMPEX LLP, India

for the supply, establishment and operations of production lines for GFRP Rebars, GFRP Mesh and GFRP Bent Elements in India.

Valid till: 18.10.2025

CEO
SPC «Armastek» Ltd

Mekhonoshin Igor

At the same, it does not grant a right to sign any agreements, trades, other legal documents on behalf of the "Armastek", unless legally granted by "Armastek"

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e-mail: info@armastek.net web-site: www.armastek.net

Application

GFRP (Glass Fiber Reinforced Polymer) finds extensive applications in various industries and environments due to its unique properties. Some of the key application areas of GFRP include:

Application	Corrosion-Free	Non-Conductive/ Non-Magnetic	Thermal Insulation	Easy to Cut	High Chemical Resistance
Roads and Highways					
Approach Slabs	✓	✓		✓	
Walkways of Foot Over Bridge	✓	✓	✓	✓	
Slab Culverts	✓	✓			
Bridge cum Bandhara, including Deck Slabs and Barriers between Piers	✓	✓	✓	✓	✓
Concrete Roads including Jointed Plain Concrete Pavement	✓	✓		✓	✓
Continuously- Reinforced Concrete Pavements (CRCP)	✓	✓		✓	✓
Short-Panel Concrete Pavements (both cast-in-situ and precast)	✓	✓		✓	✓
Retaining Walls	✓	✓		✓	✓
Noise barriers	✓	✓	✓	✓	
Box Culverts	✓	✓	✓	✓	
Crash Barriers & Bridge Parapets	✓	✓	✓	✓	✓
Pedestrian Parapets and Railings	✓	✓	✓	✓	✓
Bulkheads and Bulkhead Copings	✓	✓			
Mechanically Stabilised Earth Wall Panels and Copings	✓	✓	✓	✓	✓
Drains	✓	✓	✓	✓	✓
Bridges and Tunnels					
Tunnel Eyes	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels and Copings	✓	✓	✓	✓	✓
Retaining Walls	✓	✓		✓	
Bridge Decks and Bridge Deck overlays	✓	✓	✓	✓	
Noise barriers	✓		✓		
Concrete Roads including Jointed Plain Concrete Pavement	✓		✓		✓
Short-Panel Concrete Pavements(both cast-in-situ and precast)	✓	✓	✓	✓	✓
Bridge Decks and Bridge Deck overlays	✓	✓	✓	✓	✓
Crash Barriers and Bridge Parapets	✓	✓	✓	✓	✓

Application	Corrosion-Free	Non-Conductive/ Non-Magnetic	Thermal Insulation	Easy to Cut	High Chemical Resistance
Airports, Ports and Railways Stations					
Runways	✓	✓	✓	✓	✓
Floorings	✓	✓	✓	✓	✓
Drains	✓	✓	✓	✓	✓
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Underground Water Tanks	✓	✓	✓	✓	✓
Landscaping	✓	✓	✓	✓	
Retaining Walls	✓	✓	✓	✓	
Noise barriers	✓	✓	✓	✓	✓
Helipads	✓	✓	✓	✓	✓
Railway Beds and Tracks	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Non-Structural Walls	✓	✓	✓	✓	✓
Metro Rail and Railways					
Tunnel Eyes	✓	✓	✓	✓	✓
Railway Beds and Tracks	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Noise barriers	✓	✓	✓	✓	✓
Floorings	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels and Copings	✓	✓	✓	✓	✓
Real Estate					
Parking Garages	✓	✓	✓	✓	✓
Swimming Pools	✓	✓	✓	✓	✓
Landscaping	✓	✓	✓	✓	✓
Drains	✓	✓	✓	✓	✓
Internal Roads	✓	✓	✓	✓	✓

Application	Corrosion-Free	Non-Conductive/ Non-Magnetic	Thermal Insulation	Easy to Cut	High Chemical Resistance
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Underground Water Tanks	✓	✓	✓	✓	✓
Flooring	✓	✓	✓	✓	✓
Boundary Walls	✓	✓	✓	✓	✓
Concrete Non Load bearing walls (walls being made while using mywan shuttering)	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Industrial					
Underground Water Tanks	✓	✓	✓	✓	✓
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Flooring	✓	✓	✓	✓	✓
Research Facilities	✓	✓	✓	✓	✓
Internal Roads	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Storage facilities for chemical & wastewater-treatment plants'	✓	✓	✓	✓	✓
Drains	✓	✓	✓	✓	✓
Boundary Walls	✓	✓	✓	✓	✓
Hospitals and Research Centres					
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Testing Facilities (Critical and Advance)	✓	✓	✓	✓	✓
Research Facilities	✓	✓	✓	✓	✓
Parking Garages	✓	✓	✓	✓	✓
Underground Water Tanks	✓	✓	✓	✓	✓
Internal Roads	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels	✓	✓	✓	✓	✓

Application	Corrosion-Free	Non-Conductive/ Non-Magnetic	Thermal Insulation	Easy to Cut	High Chemical Resistance
Flooring	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Schools and Universities					
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Flooring	✓	✓	✓	✓	✓
Internal Roads	✓	✓	✓	✓	✓
Underground Water Tanks	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Laboratories	✓	✓	✓	✓	✓
Parking Garages	✓	✓	✓	✓	✓
Warehousing					
Flooring	✓	✓	✓	✓	✓
Internal Roads	✓	✓	✓	✓	✓
Underground Water Tank	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels	✓	✓	✓	✓	✓
Large Infrastructure Projects like Dams, Power Plants etc					
Internal Roads	✓	✓	✓	✓	✓
Underground Water Tanks	✓	✓	✓	✓	✓
Sewerage Treatment Plants	✓	✓	✓	✓	✓
Flooring	✓	✓	✓	✓	✓
Deck slabs	✓	✓	✓	✓	✓
Parking Garages	✓	✓	✓	✓	✓
Retaining Walls	✓	✓	✓	✓	✓
Mechanically Stabilised Earth Wall Panels	✓	✓	✓	✓	✓
Waste water treatment plants	✓	✓	✓	✓	✓

CASE STUDIES OF GFRP USED WORLDWIDE

Case Study

Delhi Metro

More than 20 tunnel boring machines were used simultaneously to expedite the tunnel work through 10 soft-eyes installed in diaphragm walls. **Thanks to the cuttable nature of GFRP (glass fiber reinforced polymer) bars, TBMs can get in or out of shafts/stations in few minutes.**

Furthermore, 450 sets of active anchors were applied to retain walls during the excavation work. The anchors are also made of GFRP, hence the tendons can be excavated by any standard equipment, and no anchor removal is required.

Moreover, around 2.3 million Bartec couplers were installed to connect rebars in various parts of the concrete structures of the stations. Bartec is a bar-break performance system, designed to withstand an ultimate tensile performance of up to 800 MPa.

Source : https://www.zeebiz.com/india/news-delhi-metro-guidelines-dmrc-notifies-timings-exit-from-rajiv-chowk-metro-station-prohibited-on-new-years-eve-215365

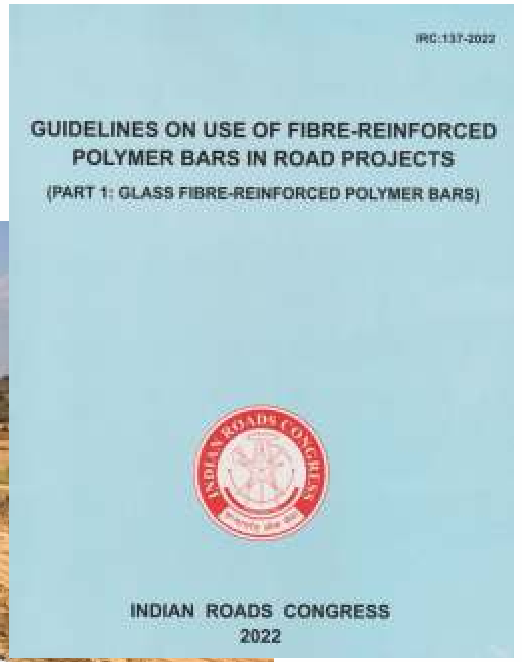
Case Study

NHAI (IRC)

Glass fiber-reinforced polymer (GFRP) materials, which are being used in military and aerospace applications for many years, have been developed into sustainable and cost-effective construction solutions for the highway community's infrastructure needs. One of the reasons why bridges and roads should be reinforced with composites is **the ability of GFRP to effectively encounter the shortcomings of traditional materials such as steel.**

Sufficient progress has been made in an attempt to start the widespread application of GFRP to highway infrastructure. It is understandable that the construction industry has to make sure whether or not GFRP technology holds to promise. Nevertheless, **the superior properties of composite materials lead to widespread use of GFRP construction products in transportation infrastructure applications.**

While it is an established fact that composites can dramatically increase the service life of highway infrastructure, it is important to determine how GFRP reinforcement and other materials can be best deployed. A significant amount of studies and research has been conducted to investigate the durability of GFRP in highway infrastructure applications.



IRC:137-2022

GUIDELINES ON USE OF FIBRE-REINFORCED POLYMER BARS IN ROAD PROJECTS

(PART 1: GLASS FIBRE-REINFORCED POLYMER BARS)

INDIAN ROADS CONGRESS

2022

Source : https://auto.economictimes.indiatimes.com/news/industry/national-highways-length-rises-by-50-in-7-years-govt-sources/92905832

Case Study

Dubai Metro Viaducts, UAE

Project Description: The Dubai Metro is a rapid transit system in the United Arab Emirates. For the construction of viaducts, GFRP bars were used as reinforcements in the concrete structures. **The GFRP bars provided excellent resistance to corrosion, a crucial factor in the humid and marine environment of Dubai.**

Source : https://www.metrorailnews.in/uae-celebrates-10-years-of-dubai-metro-operations/

Case Study

Zurich Airport

Special reinforcement to enhance flight safety

Manoeuvring aircraft on the ground is no less challenging than when they are airborne; the process is just slower. All larger airports constitute a complex system of take-off and landing runways and taxiways with built-in induction loops that help air traffic control do its job.

Like traffic lights on a road

Ground lights – known as red stop bars – that are clearly visible to pilots mark the "red line" in the truest sense of the word to warn of neuralgic points. Under no circumstances may these lines be crossed without air traffic control's permission.

Using induction to detect danger

Induction loops in the ground before and after the red lights track aircraft movement. They create an electro-magnetic field that changes as soon as a mass with its own magnetic field – in this case a plane – enters it.

GFRP reinforcement instead of steel

To ensure the functional reliability of this highly sensitive system, the relevant concrete slabs must be permanently and non-magnetically reinforced. **During the ongoing work to extend Zurich Airport, the construction manager installed GFRP in these sections. A total of around 25 kilometres of these reinforcing bars are now installed beneath the taxiways at Zurich Airport. Whereas steel would have produced interference in this case, the glass fibre bars are neither magnetic nor magnetisable, non-conductive and moreover non-corroding.** A two-part manufacturing process bundles the high-strength glass fibres as compactly as possible before proofing them with special vinyl ester. The result is a resistant and durable material that indirectly even enhances flight

Source : https://www.schoeck.com/en/case-studies/zurich-airport

Case Study

Patna Metro Rail, India

Project Description: The Patna Metro Rail project in India incorporated GFRP bars and bent elements in the construction of elevated viaducts and stations. **GFRP materials were chosen to withstand the region's monsoon climate, reducing maintenance costs and increasing the service life of the structures.**

Source : https://www.railway-technology.com/projects/patna-metro-rail-project-bihar-india/

Case Study

The Burj Khalifa, Dubai, UAE

The Burj Khalifa, the tallest skyscraper in the world, incorporates GFRP rebar in its construction.

The use of GFRP rebar offers superior corrosion resistance, higher tensile strength, and reduced weight compared to traditional steel reinforcement.

GFRP enables the structure to withstand the harsh

Source : https://www.flickr.com/photos/garethwrayphotography/16614854988

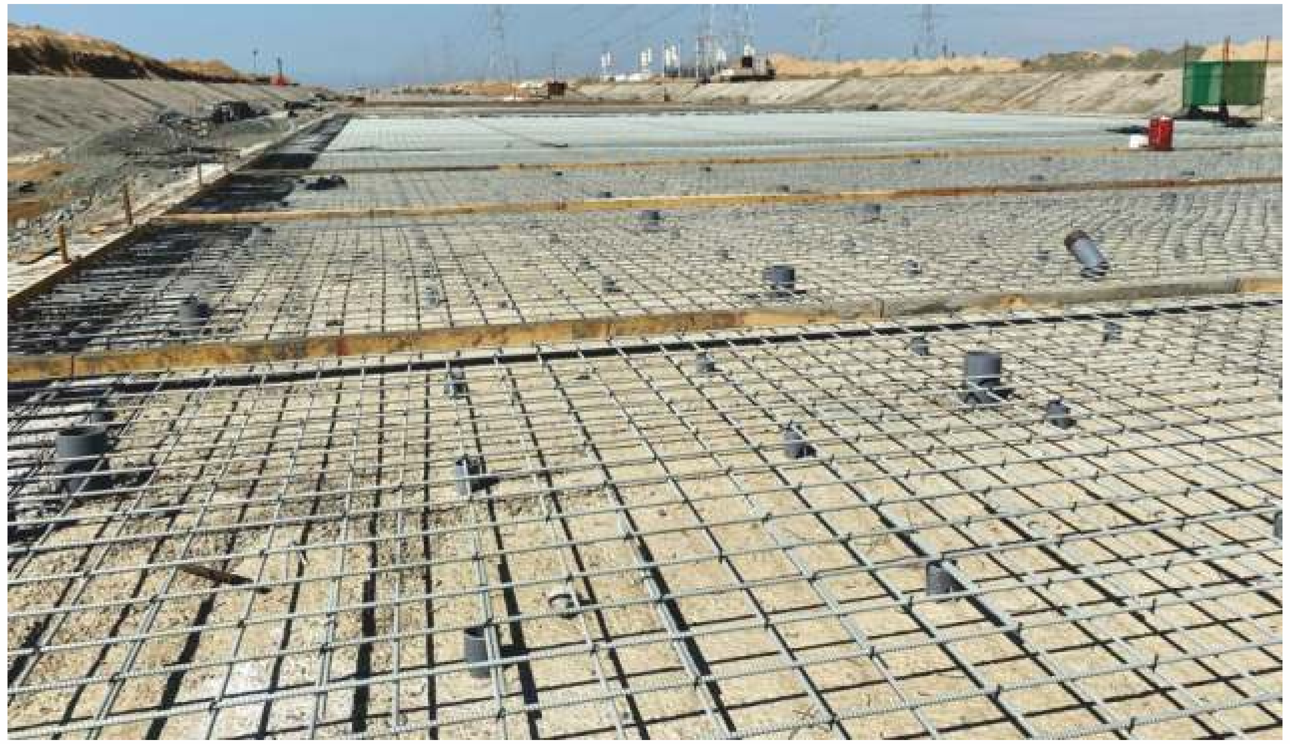
Case Study

Jizan Flood Mitigation Channel, the world's biggest GFRP project

The new Jizan Economic City is an industrial and commercial hub with a busy port on the Red Sea. The region is prone to flooding due to poor drainage and heavy seasonal rainfall.

A major Saudi Aramco project for the area is the 23km-long Flood Mitigation Channel. The channel will play a vital role in protecting infrastructure and the community who live in the city. It is also home to Saudi Aramco's Jizan oil refinery which processes 400,000 barrels of crude per day.

When completed, it will be the world's largest project to be constructed using glass fibre-reinforced polymer (GFRP) composite rebar as its concrete reinforcement. Mandating the use of **GFRP rebar is part of their non-metallic initiative, a positive step towards fighting corrosion and moving towards a more sustainable approach to infrastructure builds.** The channel marks a significant turning point in the infrastructure sector. It is one of many large scale projects choosing GFRP rebar for its concrete reinforcement worldwide.



Source : https://mateenbar.com/projects/jizan-channel/

Case Study

Herbert C. Bonner Bridge Replacement, USA

Project Description: The replacement of the Herbert C. Bonner Bridge in North Carolina, USA, utilized **GFRP bars in the concrete elements to combat the corrosive effects of the marine environment and**

Source : https://www.resortrealty.com/blog/fast-facts-about-the-old-replacement-bonner-bridge/

Case Study

Large power station (GKM), Germany

In preparation for the subsequent pipe penetrations, four drilled piles were reinforced with machinable GFRP Bars in the area of the cooling water intake structures. In the second phase in autumn 2010, the four piles were then reinforced with GFRP along the entire length, not just in the area of the subsequent penetration.

In a second part of the GKM project, GFRP bars and bent elements stirrups were used as non-ferrous reinforcement where lines were channelled through floor slabs. **Planners of LAP opted for a design that enabled installation of the GFRP bent elements stirrups without the need for structural load-bearing ability.**

Source : https://www.schoeck.com/en/case-studies/large-power-station-gkm

Case Study

Max Planck Institute Precision Laboratory, UK

When building the precision laboratory at the Max Planck Institute for Solid State Research in Stuttgart, GFRP reinforcement was chosen.

Scientists at this precision laboratory examine the electrical conductivity of – especially nanoscale – solid matter and focus on how the structure of the relevant material influences its electrical, mechanical or magnetic properties. **External influences must be minimised to ensure the precise functioning of the measuring equipment. The issue of electro-magnetic sensitivity had to be taken into account at the early stages of planning the new precision laboratory.** Since conventional steel reinforcement was not an option in the immediate vicinity of the experiments, GFRP reinforcement was chosen. It is not electro-magnetically conductive yet still has composite properties that are similar to reinforcing steel.

Source : https://www.schoeck.com/en/case-studies/max-planck-institute-precision-laboratory

Case Study

YAS Island Formula 1 Racetrack - the finishing line

A category 1 racetrack with 40 pit buildings and 5.5km of race tracks, Yas Island F1 racetrack is a popular circuit to race in the Formula 1 calendar.

Precision timing is critical with milliseconds making the difference to first past the post. Metallic materials can cause interference to sensitive equipment. **GFRP bar was used as the main reinforcement due to its non-electromagnetic and non-magnetic properties.**

Source : https://mateenbar.com/projects/yas-island-formula-1-track/

Case Study

Secant Pile application for Construction of Zayed Road Network in Mina Zayed Area Main Tunnel, Abu Dhabi UAE

The circular design needed to provide a design requiring a combination of moment and shear loads. Design safety and performance under combined loads were checked and approved. The use of GFRP rebar allowed for an economic and safe design.

GFRP bar and bent elements were used in an area of the main tunnel where the structure will be subjected to heavy loads. **The high tensile strength and high modulus of elasticity were ideal plus it allowed for good splice lengths. With the high values of GFRP bars, the weight was a lot less compared to other suppliers.**

Why is GFRP rebar ideal for secant pile applications?

Overall, GFRP rebar provides a lightweight and corrosion-free material for secant pile applications. It’s quicker to work with, easier to cut, and provides a 100-year service life.

Source : https://mateenbar.com/projects/secant-pile-uae/

Case Study

North" tunnel section (Brenner mountain pass in the Alps), 2006

In order to avoid the penetration of induction currents from the adjacent subway tunnel, reinforcement of bore piles and walls of the lower floors is steel-free.

The mesh of GFRP rebar of Ø8 mm is used. Reinforcement objectives — corrosion resistance and prevention of cracking.
Reinforced area — 6400 m2.

Source : https://bestfiberglassrebar.com/blog/experience-of-gfrp-rebar-use/

Case Study

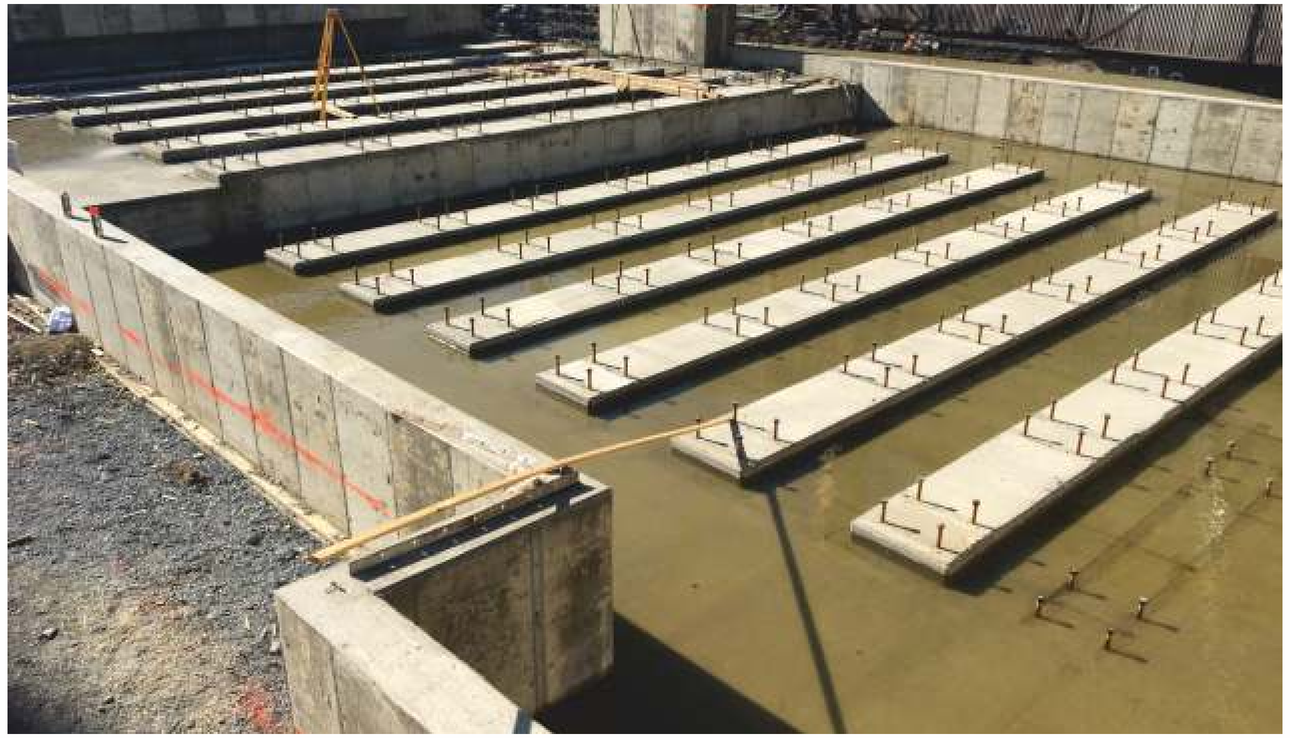
Steel Furnace Foundation

GFRP Rebar is reinforcement and it is one of the best material for roads construction. **GFRP Rebar is an alternative of Steel reinforcement bars. It has several advantages like light weight, corrosion resistant, and high strength.** GFRP Rebar is a environment friendly rebar.

GFRP rebar is resistant to corrosion and does not rust. GFRP Rebar is an alternative of steel reinforcement bars. steel bars would degrade the foundation quickly. This makes it particularly useful in foundations that are

GFRP Rebar is a durable material for foundation. It can withstand heavy loads and extreme weather conditions.

GFRP Rebar require low maintenance cost. It does not rust or degrade the construction so less cost of maintenance over life span of structure or construction.



Source : https://bestfiberglassrebar.com/blog/experience-of-gfrp-rebar-use/

Case Study

Muskrat Falls Hydroelectric Project, Canada

Project Description: The Muskrat Falls Hydroelectric Project in Canada involved the construction of a dam and powerhouse complex. **GFRP rebar and mesh were utilized to reinforce concrete elements due to their non-corrosive properties, ensuring long-term durability in the harsh, cold climate of Labrador.**

Source : https://vocm.com/2021/07/27/muskrat-falls-agreement/

Case Study

Seawall & Road Side Barrier -Maui, HI Honoapiilani Highway – built in 2001 with steel

Seawall - Honoapiilni Highway 2012

Case Study

Heavy Rail –Miami MetroRail –MIA 2.4 Miles of elevated rail

- Rail Plinths 100% reinforced with GFRP Bars

Case Study

Dry Dock

2001- Dry Dock rehabilitation- Pearl Harbor
- Multiple Dry Docks

Dry Dock rehabilitation
- Pearl Harbor

Source : https://www.fdot.gov/docs/default-source/structures/GFRPRebarWorkshop/GFRPworkshop-2016-ACMA.pdf

Case Study

McKinleyville, WV (1996)

1st Bridge with FRP Rebar

Source : https://www.fdot.gov/docs/default-source/structures/GFRPRebarWorkshop/GFRPworkshop-2016-ACMA.pdf

Case Study

Port of Rotterdam, Netherlands (Container Terminal Upgrades)

The Port of Rotterdam, Europe's oldest and busiest, serves as a crucial hub for European maritime traffic. In a monumental upgrade, engineers specified corrosion-resistant rebar and dowels, ensuring enduring structural integrity whilst minimizing the need for disruptive maintenance in the future.

Glass fiber-reinforced polymer (GFRP) rebar are ideal for heavy-load applications, particularly in areas where corrosion risk and strength are paramount concerns.

GFRP rebar were chosen to guarantee the longest life cycle and high durability, meeting the demands of the port's heavily trafficked and load-bearing

Source : https://mateenbar.com/projects/rotterdam-port-corrosion-resistant-rebars/

Case Study

FRP Rebar Use in USA 67 Bridges – 27 States

Source : https://www.fdot.gov/docs/default-source/structures/GFRPRebarWorkshop/GFRPworkshop-2016-ACMA.pdf

Bond Strength Report of GFRP

JOB

No.:	20180576
Clent:	ARMASTEK Scientific & Production Company, Ltd. 27a Fedoseeva Str. 614101 Perm, Russian Federation

OBJECT OF TESTING

Product:	fibre-reinforced polymer (FRP) reinforcement of concrete
Manufacturer:	ARMASTEK Scientific & Production Company, Ltd. 27a Fedoseeva Str. 614101 Perm, Russian Federation
Manufacturing plant:	at the manufacturer's address

PRODUCT SAMPLE

Description of sample:	ARMAST EK composite GFRP reinforcement of diameter 6, 12 and 25 mm
Designation by client:	--
Date qf production:	03/2019
Place and date of sampling:	at the manufacturer's address, 05/2019
Sampling executed by:	client
Place and date of delivery:	TSUS — laboratory branch in Bratislava, 17.05.2019
Designation of specimens by lab:	360/19

TESTS

Bond strength by pull-out testing - unaccred ited test

Test procedure:	ISO 10406-1: 2015 Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 1: FRP bars and grids
Description of test specimens:	Test pieces of shape the cube, with a single FRP bar embedded vertically along the central axis. The bonded length (5 x D, acc. to EAD DP 17-26-0023-03.01) for diamete 6 mm is 30 mm, for diameter 12 mm is 60 mm, for diameter 25 mm is 125 mm. Nominal diameter Du is used from test report no. 20-19-1071. Size of cubes is acc. the ISO 10406-1, Table 3. The cubes was made with spiral reinforcement long the central axis. Concrete quality of the cubes for testing was made in two class C20/25 and C50/60 and a 28-day cylinder compressive strength. Tested from production batch (lot): for diameter 6 mm: no. 47/1, 47/2, 61/1, 61/2, 68/1; for diameter 12 mm: no. 50/1, 64/1, 64/2 71/1, 71/2; for diameter 25 mm: no. 53/1, 53/2, 67/1, 74/1, 74/2.
Test specimens prepared by:	Peter Kir5ner
Conditioning of specimens in lab:	conditioned according to ISO 10406-1
Specimen condition before testing:	conditioned according to ISO 10406-1
Place of test execution:	TSUS - laboratory branch in Bratislava
Test conditions:	conditioned according to ISO 10406-1; loading rate: 10 N/mm 2, test temperature was 20 °C and 80°C.
Deviations from standard:	none
Date of test:	06. and 07.06.2019
Test personnel:	Peter Kirs"ner

Table 1 - Bond strength for rated diameter 6 mm, Concrete C20/25, test Temperature 20°C

Related diameter (mm)	Nominal diameter (mm)	Nominal cross-sectional area (mm^2)	No. of the test piece	Bond failure load *Pc* (kN)	Bond strength *fc* (MPa)	Failure mode
6	6,1	29,4	1	9,12	15,60	pull out failure
			2	8,42	14,41	pul! out failure
			3	8,23	4 4,08	pull out failure
			4	7,21	12,34	pull out failure
			5	9,26	15,84	pull out failure
	Maximum value			9,26	15,84	
	Minimum value			7,21	12,34	
	Total average			**8,47**	**14,45**	

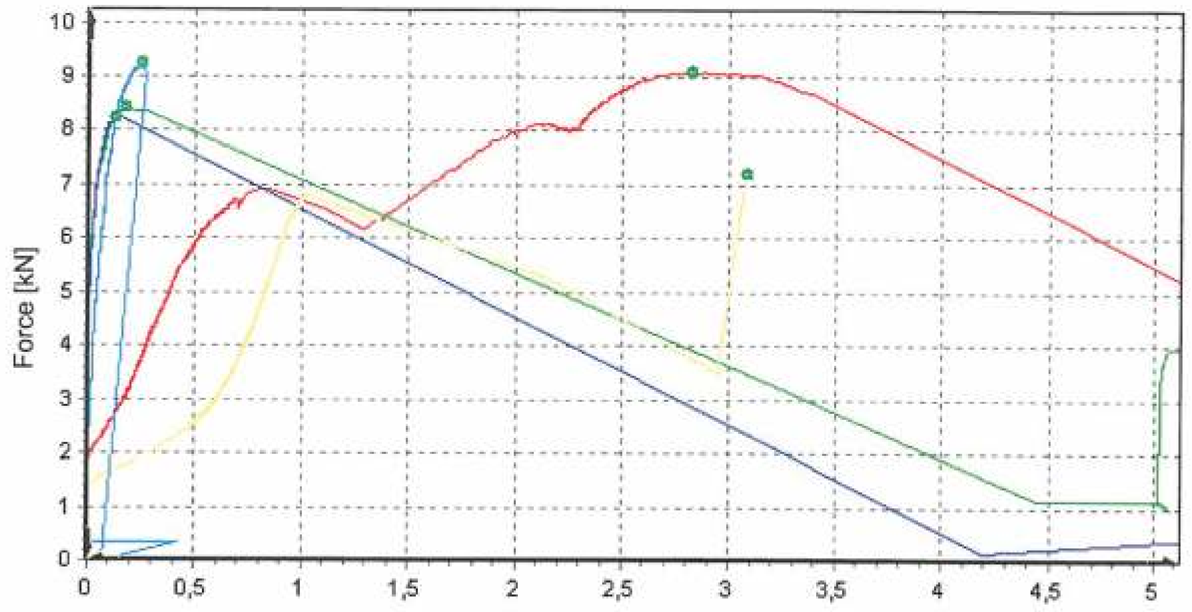


Table 2 - Bond strength for rated diameter 12 mm, Concrete C20/25, test Temperature 20°C

Related diameter (mm)	Nominal diameter (mm)	Nominal cross-sectional area (mm^2)	No. of the test piece	Bond failure load *Pc* (kN)	Bond strength *fc* (MPa)	Failure mode
12	12,2	116,9	6	30,37	13,00	pull out failure
			7	30,77	13,16	pul! out failure
			8	32,07	13,72	pull out failure
			9	33,40	14,29	pull out failure
			10	32,66	13,97	pull out failure
	Maximum value			33,40	14,29	
	Minimum value			30,37	13,00	
	Total average			**31,84**	**13,63**	

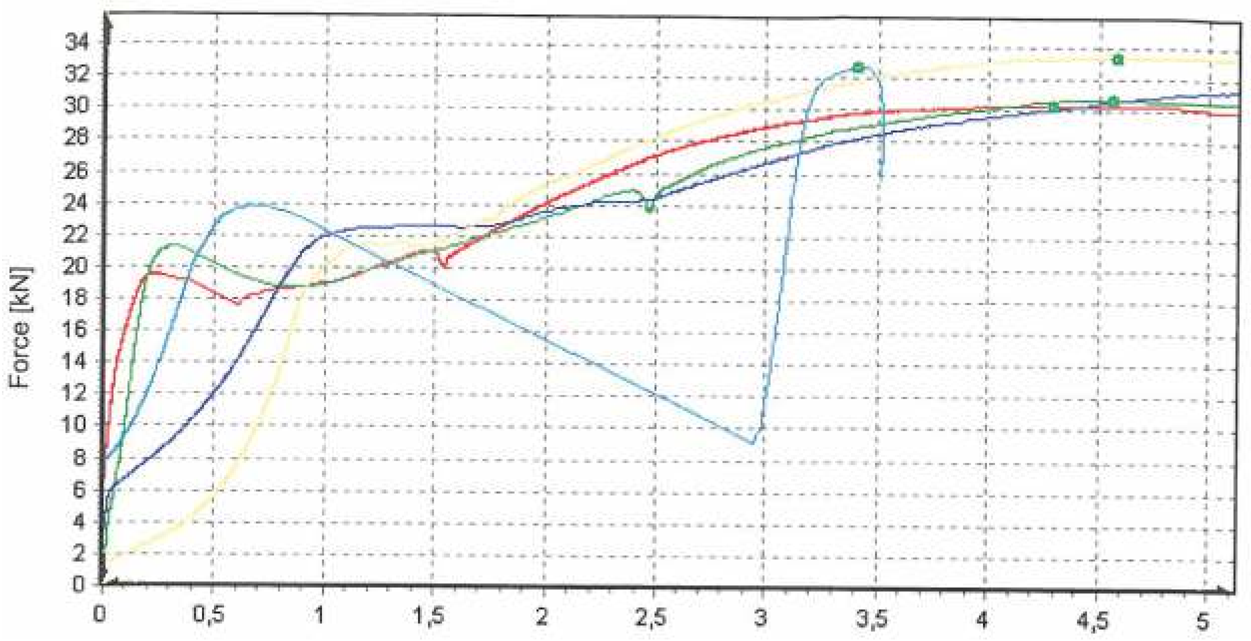
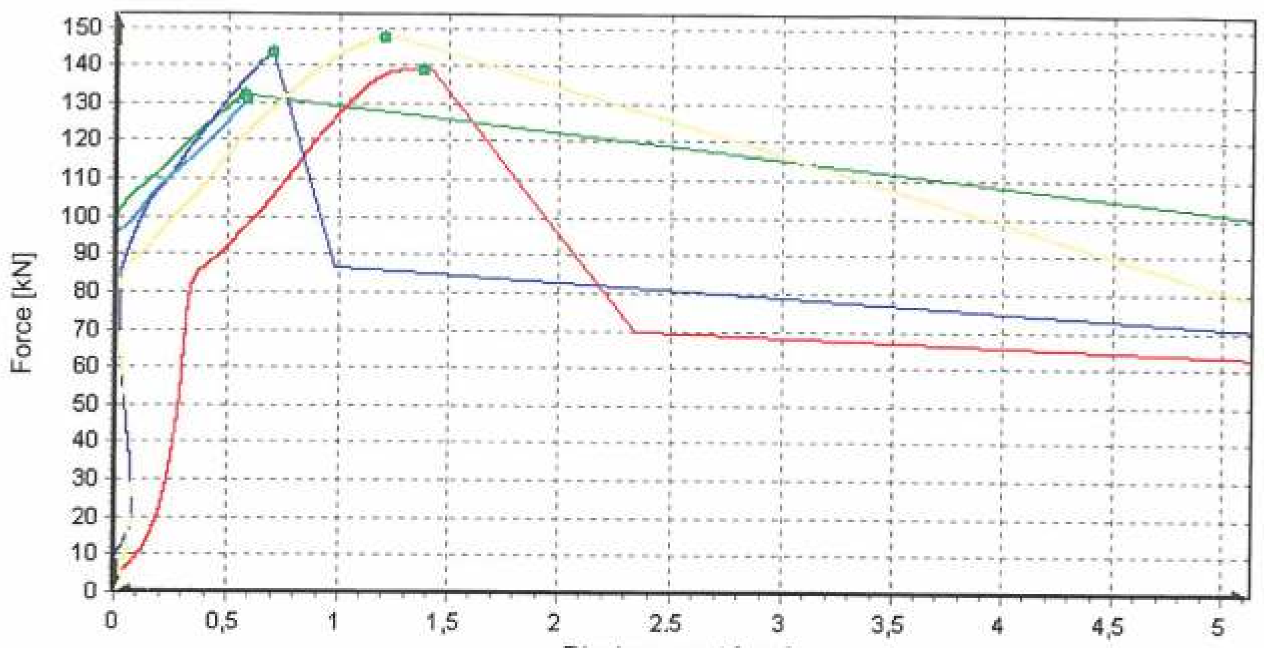


Table 3 - Bond strength for rated diameter 25 mm, Concrete C50/60, test Temperature 20°C

Related diameter (mm)	Nominal diameter (mm)	Nominal cross-sectional area (mm^2)	No. of the test piece	Bond failure load *Pc* (kN)	Bond strength *fc* (MPa)	Failure mode
25	25,0	490,4	1	139,20	14,18	pull out failure
			2	132,43	13,49	pul! out failure
			3	143,32	14,60	pull out failure
			4	147,55	15,03	pull out failure
			5	139,20	14,18	pull out failure
	Maximum value			147,55	15,03	
	Minimum value			132,43	13,49	
	Total average			**140,63**	**14,30**	



Shear Strength Report of GFRP

JOB
No.: 20180576
Clent: ARMASTEK Scientific & Production Company, Ltd.
27a Fedoseeva Str.
614101 Perm, Russian Federation

OBJECT OF TESTING
Product: fibre-reinforced polymer (FRP) reinforcement of concrete
Manufacturer: ARMASTEK Scientific & Production Company, Ltd.
27a Fedoseeva Str.
614101 Perm, Russian Federation
Manufacturing plant: at the manufacturer's address

PRODUCT SAMPLE
Description of sample: composite GFRP reinforcement of diameter 6, 12 and 25 mm
Designation by client: --
Date qf production: 03/2019
Place and date of sampling: at the manufacturer's address, 05/2019
Sampling executed by: client
Place and date of delivery: TSUS — laboratory branch in Bratislava, 17.05.2019
Designation of specimens by lab: 360/19

TESTS
Traverse shear strength - unaccredited test
Test procedure: ISO 10406-1: 2015 Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 1: FRP bars and grids
Description of test specimens: composite GFRP reinforcement of diameter 6, 12, 25 mm, Tested from production batch (lot): for diameter 6mm: no. 47/1, 47/2, 61/1, 61/2 68/1; for diameter 8 mm : no. 48/1, 48/2, 62/1 69/1; for diamete r10 mm: no. 49/1, 63/1, 63/2, 70/1, 70/2; for diameter 12 mm: no. 50/1, 64/1, 64/2 71/1, 71/2; for diamter 14 mm: no. 51/1, 51/2, 65/1, 72/1, 72/2; for diameter 20 mm: no. 52/1, 66/1, 66/2, 73/1, 73/2; for diameter 25mm: no. 53/1, 53/2, 67/1, 74/1, 74/2.

Test specimens prepared by: Andrej Petrovic
Conditioning of specimens in lab: conditioned according to ISO 10406-1
Specimen condition before testing: conditioned according to ISO 10406-1
Place of test execution: TSUS - laboratory branch in Bratislava
Test conditions: conditioned according to ISO 10406-1
Deviations from standard: none
Date of test: 06. - 18.09.2019
Test personnel: Andrej Petrovic

Table 1 - Traverse shear strength τ_s of rated diameter 6 mm

Lot No:	Nominal cross-sectional area *A* (mm²)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
47/1	29,44	1	13,37	227,07	normal sheared
		2	13,25	225,03	normal sheared
		3	14,1	239,47	normal sheared
		4	17,36	294,84	normal sheared
		5	13,81	234,54	normal sheared
47/2		6	12,95	217,94	normal sheared
		7	13,98	237,43	normal sheared
		8	17,41	295,69	normal sheared
		9	16,02	272,08	normal sheared
		10	19,06	289,74	normal sheared
61/1		11	17,07	289,91	normal sheared
		12	17,86	303,33	normal sheared
		13	12,36	209,92	normal sheared
		14	16,21	275,31	normal sheared
		15	15,96	271,06	normal sheared
61/2		16	13,06	221,81	normal sheared
		17	12,37	210,09	normal sheared
		18	11,58	196,67	normal sheared
		19	13,7	232,68	normal sheared
		20	14,46	245,58	normal sheared
68/1		21	13,36	226,90	normal sheared
		22	15,84	269,02	normal sheared
		23	14,01	237,94	normal sheared
		24	14,74	250,34	normal sheared
		25	13,76	233,70	normal sheared
Maximum value T_s (MPa)				**303,33**	
Minimum value T_s (MPa)				**196,67**	
Total average T_s (MPa)				**248,40**	

Table 2 - Traverse shear strength t s of rated diameter 8 mm

Lot No:	Nominal cross-sectional area *A* (mm^2)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
		1	22,91	225,85	normal sheared
		2	23,16	228,31	normal sheared
48/1		3	22,22	219,05	normal sheared
		4	25,3	249,41	normal sheared
		5	23,03	227,03	normal sheared
		6	20,98	206,82	normal sheared
		7	19,94	196,57	normal sheared
48/2		8	18,46	181,98	normal sheared
		9	23,95	236,10	normal sheared
		10	23,19	228,61	normal sheared
		11	23,22	228,90	normal sheared
	50,72	12	19,62	193,41	normal sheared
62/1		13	24,81	244,58	normal sheared
		14	19,09	188,19	normal sheared
		15	22,18	218,65	normal sheared
		16	20,04	197,56	normal sheared
		17	24,4	240,54	normal sheared
62/2		18	23,46	231,27	normal sheared
		19	19,42	191,44	normal sheared
		20	18,82	185,53	normal sheared
		21	22,81	224,86	normal sheared
		22	17,75	174,98	normal sheared
69/1		23	21,18	208,79	normal sheared
		24	21,85	215,40	normal sheared
		25	18,88	186,12	normal sheared
			Maximum value T_s (MPa)	**249,41**	
			Minimum value T_s (MPa)	**174,98**	
			Total average T_s (MPa)	**213,20**	

Table 3 - Traverse shear strength t s of rated diameter 10 mm

Lot No:	Nominal cross-sectional area *A* (mm^2)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
		1	31,85	218,19	normal sheared
		2	32,32	224,41	normal sheared
49/1		3	38,42	263,20	normal sheared
		4	29,38	201,27	normal sheared
		5	31,39	215,04	normal sheared
		6	26,15	179,14	normal sheared
		7	32,33	221,48	normal sheared
63/1		8	33,33	228,33	normal sheared
		9	33,28	227,99	normal sheared
		10	32,02	219,35	normal sheared
		11	31,28	214,29	normal sheared
	72,94	12	35,61	243,95	normal sheared
63/2		13	30,62	209,76	normal sheared
		14	31,4	215,11	normal sheared
		15	37,88	259,50	normal sheared
		16	28,93	198,19	normal sheared
		17	35,76	244,98	normal sheared
70/1		18	31,76	217,57	normal sheared
		19	31,75	217,51	normal sheared
		20	36	246,62	normal sheared
		21	32,74	224,29	normal sheared
		22	30,74	210,59	normal sheared
70/2		23	30,71	210,38	normal sheared
		24	29,14	199,63	normal sheared
		25	32,61	223,40	normal sheared
			Maximum value T_s (MPa)	**263,20**	
			Minimum value T_s (MPa)	**179,14**	
			Total average T_s (MPa)	**221,25**	

Table 4 - Traverse shear strength τs of rated diameter 12 mm

Lot No:	Nominal cross-sectional area A (mm^2)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
50/1	116,87	1	43,92	187,86	normal sheared
		2	48,27	206,46	normal sheared
		3	46,73	199,87	normal sheared
		4	45,61	195,08	normal sheared
		5	49,86	213,26	normal sheared
64/1		6	43,52	186,14	normal sheared
		7	45,74	195,64	normal sheared
		8	43,61	186,53	normal sheared
		9	38,9	166,38	normal sheared
		10	42,49	181,74	normal sheared
64/1		11	47,77	204,32	normal sheared
		12	46,83	200,30	normal sheared
		13	45,56	194,87	normal sheared
		14	46,69	199,70	normal sheared
		15	44,33	189,61	normal sheared
71/1		16	48,30	206,59	normal sheared
		17	47,4	202,74	normal sheared
		18	44,04	188,37	normal sheared
		19	48,64	208,04	normal sheared
		20	52,98	226,61	normal sheared
71/1		21	41,87	179,09	normal sheared
		22	48,76	208,56	normal sheared
		23	44,67	191,06	normal sheared
		24	46,11	197,22	normal sheared
		25	46,36	198,29	normal sheared
			Maximum value T_s (MPa)	**213,26**	
			Minimum value T_s (MPa)	**166,38**	
			Total average T_s (MPa)	**196,57**	

Table 5 - Traverse shear strength τs of rated diameter 14 mm

Lot No:	Nominal cross-sectional area A (mm^2)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
49/1	72,94	1	55,64	169,17	normal sheared
		2	60,77	184,77	normal sheared
		3	55,54	168,87	normal sheared
		4	55,44	168,56	normal sheared
		5	58,57	178,08	normal sheared
63/1		6	60,97	185,38	normal sheared
		7	62,99	191,52	normal sheared
		8	60,07	182,64	normal sheared
		9	58,45	177,72	normal sheared
		10	58,84	178,90	normal sheared
63/2		11	61,67	187,51	normal sheared
		12	59,22	180,06	normal sheared
		13	64,16	195,08	normal sheared
		14	66,08	200,92	normal sheared
		15	57,09	173,58	normal sheared
70/1		16	68,41	208,00	normal sheared
		17	63,12	191,92	normal sheared
		18	64,8	197,72	normal sheared
		19	59,48	180,85	normal sheared
		20	61,14	185,90	normal sheared
70/2		21	65,03	197,72	normal sheared
		22	63,79	193,95	normal sheared
		23	59,81	181,85	normal sheared
		24	68,06	206,94	normal sheared
		25	65,58	199,40	normal sheared
			Maximum value T_s (MPa)	**208,00**	
			Minimum value T_s (MPa)	**168,56**	
			Total average T_s (MPa)	**186,65**	

Table 6 - Traverse shear strength τ_s of rated diameter 20 mm

Lot No:	Nominal cross-sectional area *A* (mm²)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
52/1	337,16	1	111,82	165,81	normal sheared
		2	113,07	167,67	normal sheared
		3	112,03	166,12	normal sheared
		4	109,58	162,49	normal sheared
		5	114,05	169,12	normal sheared
66/1		6	120,4	178,54	normal sheared
		7	117,45	174,16	normal sheared
		8	121,68	170,43	normal sheared
		9	120,72	179,01	normal sheared
		10	118,5	175,72	normal sheared
66/2		11	119,55	177,28	normal sheared
		12	113,79	168,73	normal sheared
		13	123,31	182,85	normal sheared
		14	124,57	184,72	normal sheared
		15	124,1	184,02	normal sheared
73/1		16	127,09	188,46	normal sheared
		17	130,26	193,16	normal sheared
		18	126,13	187,03	normal sheared
		19	136,56	202,50	normal sheared
		20	133,03	197,27	normal sheared
73/2		21	125,59	186,23	normal sheared
		22	138,17	204,89	normal sheared
		23	132,68	196,75	normal sheared
		24	127,34	188,83	normal sheared
		25	121,77	180,57	normal sheared
Maximum value T_s (MPa)				**204,89**	
Minimum value T_s (MPa)				**182,49**	
Total average T_s (MPa)				**181,69**	

Table 7 - Traverse shear strength τ_s of rated diameter 25 mm

Lot No:	Nominal cross-sectional area *A* (mm²)	No. of the test piece	Shear failure load P_s (kN)	Traverse shear strength T_s (MPa)	Failure mode
53/1	490,41	1	168,44	171,71	normal sheared
		2	191,02	194,73	normal sheared
		3	202,38	206,31	normal sheared
		4	166,93	170,17	normal sheared
		5	157,46	160,52	normal sheared
53/2		6	182,88	186,43	normal sheared
		7	170,77	174,08	normal sheared
		8	173,32	176,68	normal sheared
		9	222,13	226,44	normal sheared
		10	191,42	195,13	normal sheared
67,1		11	202,33	206,26	normal sheared
		12	169,33	172,62	normal sheared
		13	176,77	180,20	normal sheared
		14	183,16	186,73	normal sheared
		15	189,48	193,16	normal sheared
74/1		16	168,4	171,67	normal sheared
		17	226,07	230,46	normal sheared
		18	207,74	211,77	normal sheared
		19	201,82	205,74	normal sheared
		20	181,76	185,29	normal sheared
74/2		21	183,53	187,09	normal sheared
		22	193,12	196,87	normal sheared
		23	212,71	216,84	normal sheared
		24	231,79	236,28	normal sheared
		25	192,52	196,26	normal sheared
Maximum value T_s (MPa)				**236,29**	
Minimum value T_s (MPa)				**160,52**	
Total average T_s (MPa)				**193,58**	

Tensile Strength Report of GFRP

JOB

No.:	20180576
Clent:	ARMASTEK Scientific & Production Company, Ltd. 27a Fedoseeva Str. 614101 Perm, Russian Federation

OBJECT OF TESTING

Product:	ARMASTEK composite GFRP reinforcement
Manufacturer:	ARMASTEK Scientific & Production Company, Ltd. 27a Fedoseeva Str. 614101 Perm, Russian Federation
Manufacturing plant:	ARMASTEK Scientific & Production Company, Ltd. 27a Fedoseeva Str. 614101 Perm, Russian Federation

PRODUCT SAMPLE

Description of sample:	ARMASTEK composite GFRP reinforcement of diameter 6, 8, 10 mm
Designation by client:	–
Date qf production:	03/2019
Place and date of sampling:	at the manufacturer's address, 05/2019
Sampling executed by:	client
Place and date of delivery:	TSUS — laboratory branch in Bratislava, 17.05.2019
Designation of specimens by lab:	360/19

TESTS

Traverse strength

Test procedure:	ISO 10406-1: 2015 Fibre-reinforced polymer (FRP) reinforcement of concrete — Test methods — Part 1: FRP bars and grids
Description of test specimens:	composite GFRP reinforcement of diameter 6, 8, 10 mm,
Test specimens prepared by:	client
Conditioning of specimens in lab:	conditioned according to ISO 10406-1:2015
Specimen condition before testing:	conditioned according to ISO 10406-1:2015
Place of test execution:	TSUS - laboratory branch in Bratislava
Test conditions:	conditioned according to ISO 10406-1:2015
Deviations from standard:	none
Date of test:	15-18.10.2019, 29.01.2020
Test personnel:	Jozef Filler

Table 1 - Tensile strength of rated diameter 6 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area *A* (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity *E* (MPa)	Total percentage extension at maximum force A_{gt} (%)
6	1	29.22	1144	33.42	50487	2,7
	2		1164	34,04	47580	2,3
	3		1227	35,85	49776	2,9
	4		1161	33,94	48568	2,9
	5		1143	33,40	50166	2,4
	1		1291	37,72	50549	3,4
	2		1107	32,36	51788	2,7
	3		1134	33,14	47030	2,6
	4		1153	33,70	50462	2,8
	5		1045	30,55	49511	2,7
	1		1214	35,49	51345	2,5
	2		1113	32,50	50565	2,6
	3		1110	32,45	49705	2,5
	4		1249	36,50	50876	2,7
	5		1119	31,91	55264	2,4
	1		1137	33,24	56119	2,3
	2		1166	34,04	50215	2,6
	3		1227	35,87	52123	3,2
	4		1085	31,70	51853	2,2
	5		1148	33,54	51709	2,4
	1		1177	34,40	51022	3,4
	2		1152	33,68	50685	2,4
	3		1120	32,72	47085	2,5
	4		1156	33,77	46900	1,7
	5		1152	33,66	50329	2,7
	average		1156	33,74	50469	2,6

Table 2 - Tensile strength of rated diameter 8 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area *A* (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity *E* (MPa)	Total percentage extension at maximum force A_{gt} (%)
8	1	50,27	1096	55,10	48174	2,4
	2		1168	58,73	50124	2,6
	3		1115	56,07	49857	2,7
	4		1094	55,00	50046	2,6
	5		1160	58,31	54372	2,5
	1		1261	63,37	52014	3,6
	2		1155	58,06	49526	2,8
	3		1101	55,32	51254	4,0
	4		1044	52,48	49534	2,6
	5		1182	59,42	51120	2,7
	1		1173	58,97	51965	2,8
	2		1091	54,83	52013	2,9
	3		1095	55,04	49932	2,4
	4		1066	53,60	51236	2,4
	5		1096	55,11	49627	2,6
	1		1053	52,95	49898	2,7
	2		1163	58,46	51576	2,8
	3		1075	54,02	51291	2,2
	4		1097	55,14	45461	2,8
	5		1188	59,71	51343	2,8
	1		1171	58,85	46772	2,9
	2		1094	55,00	50046	2,6
	3		1108	55,70	48905	2,4
	4		1075	54,02	45119	2,5
	5		1058	53,18	46489	2,4
	average		1119	56,26	49908	2,7

Table 3 - Tensile strength of rated diameter 10 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area *A* (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity *E* (MPa)	Total percentage extension at maximum force A_{gt} (%)
10	1	72,38	1273	92,14	53130	2,8
	2		1276	92,38	52365	2,4
	3		1279	85,31	55986	2,3
	4		1240	89,74	51897	3,6
	5		1322	95,71	53016	3,3
	1		1214	87,85	52351	2,2
	2		1150	83,26	53218	2,8
	3		1240	89,77	52738	2,7
	4		1226	88,72	51215	2,3
	5		1203	87,08	54705	2,4
	1		1230	89,02	50412	2,6
	2		1212	87,74	50888	2,6
	3		1216	88,01	53214	2,7
	4		1165	84,36	51160	2,7
	5		1222	88,42	53205	3,0
	1		1246	90,19	54620	2,6
	2		1236	89,44	53521	2,6
	3		1230	89,05	52862	2,9
	4		1261	91,26	53359	2,8
	5		1290	93,34	52695	3,5
	1		1257	90,98	50919	2,6
	2		1281	92,76	53339	2,8
	3		1234	89,33	51176	2,8
	4		1276	92,36	51208	3,3
	5		1233	89,23	52361	2,7
	average		1237	89,50	52622	2,7

Table 4 - Tensile test of rated diameter 12 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area A (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity E (MPa)	Total percentage extension at maximum force A_{gt} (%)	Type of failure
	1		999	116,76	48 611	2,4	failure of ribbers
	2		1 080	126,2	75 688	2,0	failure of ribbers
	3		1 042	121,82	51 430	2,2	failure of ribbers
	4		1 070	125,03	55 240	2,0	failure of ribbers
12	5	116,90	1 136	132,82	54 603	2,4	failure of ribbers
	6		1 022	119,44	52 554	2,0	failure of ribbers
	7		1 061	124,06	55 177	2,1	failure of ribbers
	8		1 124	131,4	52 423	2,3	failure of ribbers
	9		997	116,5	60 449	1,8	failure of ribbers
	10		1 004	117,36	53 560	2,0	failure of ribbers
	average		1 053,6	123,1	52 473	2,1	
	standart deviations		50,0	5,9	2 210,6	0,2	

Table 5 - Tensile test of rated diameter 14 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area A (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity E (MPa)	Total percentage extension at maximum force A_{gt} (%)	Type of failure
	1		1 076,2	153,59	52 166	1,9	failure of ribbers
	2		1 093,4	156,04	51 656	2,0	failure of ribbers
	3		991,3	141,48	46 412	2,0	failure of ribbers
	4		1 048,7	149,67	56 923	1,8	failure of ribbers
	5		1 006,2	143,60	46 195	2,1	failure of ribbers
	6		1 154,1	164,70	46 067	2,3	failure of ribbers
	7		1 148,1	163,85	50 916	2,1	failure of ribbers
	8		1 178,3	168,16	55 502	2,6	failure of ribbers
	9		1 078,9	153,98	47 490	2,1	failure of ribbers
	10		1 180,5	160,47	51 758	2,1	failure of ribbers
14	11	142,72	1 097,4	156,62	49 063	2,0	failure of ribbers
	12		1 035,8	147,82	54 127	1,7	failure of ribbers
	13		1 053,3	150,32	50 634	1,9	failure of ribbers
	14		1 128,3	161,02	50 120	2,2	failure of ribbers
	15		1 101,0	157,13	50 032	2,1	failure of ribbers
	16		1 229,9	175,53	52 102	2,2	failure of ribbers
	17		1 096,9	156,55	45 781	2,2	failure of ribbers
	18		1 180,6	168,49	49 335	2,2	failure of ribbers
	19		1 036,0	147,85	49 017	1,9	failure of ribbers
	20		1 111,9	158,69	46 875	2,2	failure of ribbers
	21		1 095,0	156,27	48 762	2,1	failure of ribbers
	22		1 161,1	165,71	50 541	2,2	failure of ribbers
	23		1 151,8	164,30	49 764	2,1	failure of ribbers
	24		1 089,7	155,52	51 270	2,1	failure of ribbers
	25		1 107,2	158,02	51 922	2,0	failure of ribbers
	average		**1 105,3**	**157,74**	**50 177**	**2,1**	
	standart deviations		**58,7**	**8,38**	**2 863,6**	**0,1**	

Table 6 - Tensile test of rated diameter 20 mm

Rated diameter (mm)	No. of the test area	Nominal cross-sectional area A (mm^2)	Tensile Strength R_m (MPa)	Maximum tensile force F_m (kN)	Tensile modulus of elasticity E (MPa)	Total percentage extension at maximum force A_{gt} (%)	Type of failure
20	1	315,20	1 043,2	328,80	45 647	2,6	failure of ribbers
	2		1 097,6	345,97	45 944	3,3	failure of ribbers
	3		974,0	307,00	44 416	2,7	failure of ribbers
	4		1 149,5	362,18	43 284	3,6	failure of ribbers
	5		1 088,3	343,03	43 672	3,3	failure of ribbers
	average		**1 070,5**	**337,4**	**44 593**	**3,1**	
	standart deviations		**65,9**	**20,7**	**1 175,7**	**0,4**	

GFRP BAR vs TMT BAR / CRS TMT BAR / STAINLESS STEEL TMT BAR

TECHNICAL COMPARISON

PROPERTIES	Grade 500	GFRP	COMPARISON
Tensile strength Mpa	✓ 500 min	✓ 800-1100	✓ Stronger
Weight/Meter 8mm	✓ 0.395 kg	✓ 0.080 kg	✓ Lighter
Bar Length	✓ 12 meter	✓ upto 100 meters	✓ Better improvement
Durability embedded	✓ 50 years	✓ (+) 100years	✓ More durable
Class III and IV	✓ (+/-)5years	✓ (+) 100 years	✓ More durable
Corrosion resistance	No	Yes	More durable
Electric conductivity	✓ Yes	✓ No	✓ No accidents risk
Thermal conductivity	✓ Yes	✓ No	✓ Does not dissipate heat
Concrete covering	✓ 35mm - 45mm	✓ 20mm	✓ Lower concrete volume
Shear Strength	120	170	Higher
Bond strength MPa/N/mm^2	14*	12.5	Lower
Compression MPa/N/mm^2	500	450	Lower
Modulus of Elasticity [Gpa]	160-200	65	Lower
Elongation [%]	12% (min.)	4% (max.)	Lower
Density [ton/m^3)	7.8	1.9	Lower

GFRP

TABLE OF SUBSTITUTION

TMT / CRS / STAINLESS STEEL TMT BARS (500 GRADE)		
Diameter mm	Weight of 1 meter bar kg	Tensile strength N
4	0.099	6300
5	0.154	9800
6	0.222	14150
8	0.395	25150
10	0.617	39250
12	0.888	56550
-	-	-
14	1.21	77000
16	1.58	100500
-	-	-
18	2	127000
20	2.47	157000
25	3.85	245500
32	6.31	400500
36	7.99	509000
-	-	-
-	-	-
40	9.87	628500

7 STAR ADVANCED GFRP REBARS		
Diameter mm	Weight of 1 meter bar kg	Tensile strength N
4	0.016	8000
5	0.027	13800
6	0.041	21200
7	0.059	30200
8	0.079	40700
10	0.129	66400
11	0.138	70846
12	0.169	86546
13	0.202	103816
14	0.239	122656
15	0.279	143066
16	0.322	165046
20	0.524	268666
25	0.845	433516
27	0.995	510446
28	1.075	551266
29	1.158	593656
30	1.243	637616

GFRP

PACKAGING DETAIL

Diameters of GFRP Bars	Kind of packaging	Length of bar	Quantity of GFRP bars in a packaging	Meters in a coil
Ø 4 mm	bars / coils	up to 12 meters	50	up to 100 meters
Ø 6 mm	bars / coils		50	
Ø 8 mm	bars / coils		50	
Ø 10 mm	bars / coils		25	
Ø 12 mm	bars / coils		15	up to 50 meters
Ø 14 mm	bars		10	N/A
Ø 16 mm	bars		5	N/A
Ø 18 mm	bars		5	N/A
Ø 20 mm	bars		5	N/A
Ø 22 mm	bars		5	N/A
Ø 24 mm	bars		5	N/A
Ø 26 mm	bars		5	N/A
Ø 28 mm	bars		5	N/A
Ø 30 mm	bars		5	N/A

GFRP MESH

Application:

1. Housing and civil projects
2. Structures located in coastal areas, airports, hospitals, military bases and more
3. Industrial grade projects
4. Bridge building
5. Railway construction
6. Concrete reinforcement (foundations, walls, concrete blocks and more)

Forms of Issuance:

- Cards
- Rolls

Sizes:

- Width - from 500 to 2000 mm
- Cell: 50 x 50 / 100 x 100 / 150*150 / 200*200 mm
- Bar diameter from 4 to 6 mm

Mesh Opening Size - Nominal Diameter MM	Weight KGM^2
50x50 - ∅ 4	0.78
100x100 - ∅ 4	0.41
100x100 - ∅ 5	0.64
100x100 - ∅ 6	1.11
150x150 - ∅ 4	0.28
150x150 - ∅ 5	0.44
150x150 - ∅ 6	0.70
200x200 - ∅ 4	0.20
200x200 - ∅ 5	0.37
200x200 - ∅ 6	0.54

Advantages of GFRP Mesh vs. Steel Mesh Rebar

COST SAVING

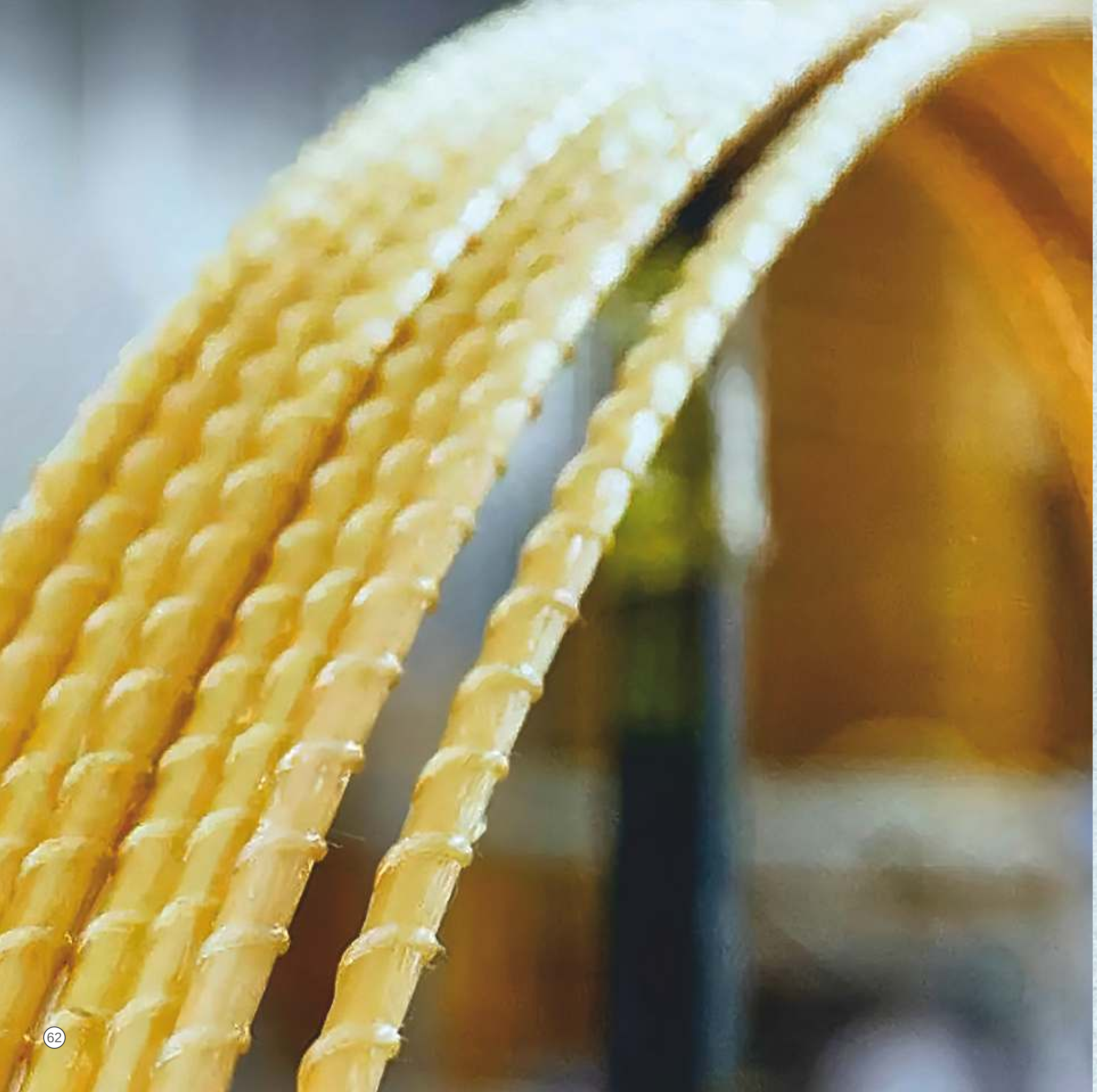
- Reduction in consumption of reinforcement by 30% to 50%
- Elimination of theft of TMT bars during transit / at Site
- No Overlapping cost
- Less Scrap Generation
- Less Expense of Binding Wire
- No requirement of expensive labour to prepare and lay the mesh
- Lower Logistics cost
- Reduced concrete cover by 25mm
- No requirement of expensive Ad mixtures for corrosion resistance
- No need to repair the flooring after 10 years due to Corrosion

TIME SAVING

- No time required for preparing the Mesh
- No Work supervision required
- Extremely fast and easy to lay

LONG-LIFE

- Corrosion Proof
- Higher crack tolerance by upto 75% in aqueous conditions
- Rust, Chemicals & Alkali resistant
- Durability of 100 years +



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