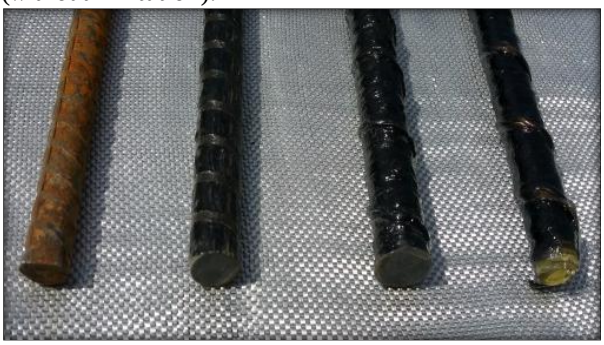
TGS Composite Reinforcing Materials for Construction Projects

TGS Composite Rebar and **TGS Geo-Fiber (Basalt) Composite Rebar** are alternatives to the Steel Rebar used for the reinforcement of concrete structures; finding particular application where corrosion and tensile strength is a concern. Depending upon the **TGS** reinforcement fiber (*Basalt, Carbon, ECR-glass or engineered hybrids*) and the resin used, the **TGS** composite rebar has a tensile strength from two to well over three times that of steel, and a service life in a corrosive environment of up to over 100-years. **TGS Composite Rebar** and **TGS Geo-Fiber (Basalt) Composite Rebar** excels over steel when:

- Lower Life Cycle Costs (LCC) are important
- Exposed to deicing salts.
- Built in or close to seawater.
- Subjected to other corrosive agents.
- Required to maintain low electric conductivity or electromagnetic neutrality.
- Required to save weight. Composite rebar (*deformed or smooth*) approximately 25% of the weight of equivalent size steel bar.
- Stronger means that in some applications, the equivalent diameter of the Composite rebar can be reduced from that required for steel rebar. Additionally, it may also provide the ability to use less quantity; thereby reducing the product cost, installation cost and use costs.

All **TGS Composite Rebar** can be provided in straight lengths and many varieties can be provided in coils when the rebar diameter is 12-mm or less. All **TGS Composite Rebar** are tested in compliance with the recommendations of the **American Concrete Institute** (**ACI 440**). According to the recommendations of **ACI 440**, field bends are not allowed. As such, **TGS Composite Rebar** prefabricated stirrups, elbows and accessories are available and built to order.

The reinforcing choices are (*without limitation*):



Shown from the Left to the Right

1. **Steel Rebar – 8+ year life (***depends on environment and could be less***)**
2. **TGS Groove Grip Composite Rebar (***Standard Grip***) – 100+ year life.**
3. **TGS Spiral Grip Composite Rebar (***Higher Strength and greater grip***) – 100+ year life.**
4. **TGS Dual Tech (*Steel Core/Spiral Grip Composite Fiber*) Rebar (***best of both worlds***) – 100+ year life.**

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Test Results Summary for some of the TGS Composite Rebar vs some alternatives

Tested per ACI 440	ASTM Test	Copper	Steel	TGS Groove Grip GFRP	TGS Spiral Grip GFRP	Typical Sanded Grip FRP	Superior Sanded Grip FRP	Standard Ribbed Grip FRP
Density g/cm^3 lbs/in^3	D 792	8.9 0.32	7.8 0.28	1.9 to 2.1 0.07 to 0.08	1.9 to 2.6 0.07 to 0.09	1.9 to 2.1 0.07 to 0.08	1.9 to 2.1 0.07 to 0.08	1.8 to 2.2 0.07 to 0.08
Tensile Strength MPa psi	D-7205 D-7205M	≥ 430 ≥ 62,000	≥ 500 ≥72,000	≥ 850 ≥123,000	≥ 1,200 to 2,500 ≥174,000 to 360,000	≥ 650 ≥ 94,000	≥ 1,200 ≥ 174,000	≥ 650 ≥ 94,000
Yield Strength MPa psi	D-7205 D-7205M	≥ 340 ≥ 49,000	≥ 300 ≥ 43,000	≥ 600 ≥ 87,000	≥ 800 ≥ 116,000	≥ 420 ≥ 60,000	≥ 800 ≥ 116,000	≥ 420 ≥ 60,000
Compressive Strength MPa psi	D-695	-	-	≥ 500 ≥72,000	≥ 600 ≥ 87,000	≥ 420 ≥ 60,000	≥ 500 ≥72,000	≥ 400 ≥ 58,000
Elongation (%)	D-7205 D-7205M	almost ∞	≥ 18	≥ 1.8	≥ 2.3 to 3.1	≥ 1.8	≥ 2.3	2.1
Elastic Modulus (GPa)	D-7205 D-7205M	110	210	≥ 40	≥ 85 *≥ 200 for Dual Tech	≥ 55	≥ 80	≥ 45
Transverse Shear Strength MPa psi	D7617 D7617M			125 to 145 18,000 to 21,000	145 to 155 21,000 to 22,000	125 to 135 18,000 to 21,000	125 to 145 18,000 to 21,000	125 to 145 18,000 to 21,000
Adhesiveness with concrete MPa psi	D-7913 D-7913M		≥ 20 ≥ 2,900	≥ 25 ≥ 3,600	≥ 35 ≥ 5,000	≥ 13 ≥ 1,800	≥ 19 ≥ 2,700	≥ 19 ≥ 2,700
Alkali Resistance	D-7705 D-7705M	Bad	Bad	100 years	100 years	100 years	100 years	100 years

Note: The above information is an evaluation aid and not meant to constrain the possibilities, as additional TGS technology exists. All usage engineering must be done through professional Engineers and/or Consulting Engineering firms.

Example of a typical Roadway project: Steel Rebar vs. Basalt Fiber Rebar

Project: Concrete Roadway (22,525 m^2 @ 28-cm thick)
Date: 2009
Location: Zhang-Shi Highway, China

1. **As Specified**: 16-mm Steel rebar
   a. Total Weight: 386 MT
      - Contains approximately 11-linear meters of steel rebar per m^2.
      - Contains approximately 17-kgs of 16-mm steel rebar per m^2.
   b. Rebar Cost per MT: ~$900 US
   c. Total Project Cost: $347,400 US
      - Based upon the estimated steel rebar costs, approximately $15.40 USD of steel rebar would be used per m^2 of concrete roadway

2. **As Built**: 10-mm & 8-mm Basalt Fiber Rebar
   a. Total Weight: 24.41 MT
      - Contains approximately 11-linear meters of Basalt Fiber Rebar per m^2.
      - On average 2-m of 10-mm and 9-m of 8-mm of **Basalt Fiber Rebar** was used per m^2 of concrete roadway.
      - Contains approximately 1-kgs of Basalt Fiber Rebar per m^2.
   b. Equivalent Rebar Cost MT: $9,000 US
   c. Total Project Cost: $237,690
      - Based upon the Basalt Composite Rebar costs, approximately $9.75 USD of **Basalt Fiber Rebar** would be used per m^2 of concrete roadway

3. **Conclusions**
   a. Cost Savings: 32%
   b. No Welding by using coils or Spools
   c. Rule of Thumb:

"***If the designer saves $1US in the elimination of the effects of corrosion, the resulting savings in Life Cycle Costs (LCC) are $5USD for start of Corrosion and $25USD for the repair of concrete cracking, and an additional $125USD for concrete replacement at the end of the Life Cycle."***

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Some Photos from the Job Site











Cage Column **Small Airport Runway**

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The use of increased fiber volume vs. pre-stressed Tendons.

To prevent flexure failures in concrete beams; the pre-stressing of the tendons along the length of a beam can be increased. However, this does not enhance the ability of the beam to resist shear forces that are often the cause of failure. To assist in the prevention of shear failures, transverse rebar reinforcement is normally just increased along the length of the beam. This provides more tensile strength perpendicular to the pre-stressed tendons. These additional rebar reinforcements are often inadequate to resist the shear failures, especially for long beams. Additionally, these reinforcement bars significantly increase the cost during casting the beams.

The use of increased fiber volume within the concrete is gaining popularity. The increased fiber volume, using **TGS basalt chopped fiber**, has been proven superior at resisting shear in concrete beams. Test data shows that increasing the fiber index of a pre-stressed fiber reinforced concrete beam noticeably increases its shear strength. The larger fiber volume indexes also increased the ductility of the concrete beams.

TGS basalt chopped fiber act as multi-directional, equally distributed micro-reinforcements throughout the concrete beam and its component elements. The **TGS basalt chopped fiber** help control and retard, if not prevent, cracking. This is accomplished by efficiently carrying the tension across the potential crack zone; spreading out and dissipating the forces that cause shear failure. The use of **TGS basalt chopped fiber** reinforcement within the concrete also aids in controlling the stresses during the curing and transportation phases of construction. The use of **TGS basalt chopped fiber** reinforcement helps to improve concrete in toughness, ductility, shear and tensile strengths, fatigue, shrinkage resistance, and durability.

The **TGS basalt chopped fiber** do slightly improve the compressive strength of the concrete. However, they more significantly improve the ductility of the concrete. It has been found that an addition of up to about 1.5% (about 4-kgs per cu-meter or about 8.5 pounds per cubic yard of concrete) of **TGS basalt chopped fiber** will result in a direct tensile strength increase of up to 40%. Ultimately, it has been found that the incorporation of **TGS basalt chopped fiber** is an effective way of replacing traditional reinforcing transverse steel rebar and even reducing the amount of rebar reinforcement needed in many applications.

When **TGS basalt chopped fiber** is used in combination with **TGS Composite Rebar** and **TGS Geogrid**, the resulting structure is markedly stronger and more durable than without.

Economic effect of TGS Basalt Chopped Fiber in Asphalt and Concrete

Research findings prove that basalt fiber enhances the resistance to asphalt and concrete fatigue cracking by 2-8 times, the resistance to cracking at low temperatures by 15% -25%. The resistance to rutting increases by 20% -40%.

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The use of TGS (Basalt) Geogrid as a foundation for road surfaces.

Increases:

- load-bearing capacity of the structure
- overall stability of the structure by up to 30-50%

Enhances:

- transportation and operational performance
- service life of the road dressing

Shortens:

- construction times

Reduces:

- volume of soil required by 25%
- extent of fill settling

Functions of TGS Geogrid in asphalt:

- to withstand the normal stresses arising from numerous short-term impacts of vehicle wheel loads, and to redistribute them horizontally, in order to prevent excessive horizontal deformation of the extension of the lower part of the road bed structure at flexure;
- to withstand the normal stresses arising in certain section from prolonged active loads of fluctuations of temperature in the ground surface and the road surface dressing, and to redistribute the horizontally, in order to prevent excessive horizontal deformation of layers of the road structure.

Functions of TGS Geogrid stabilization of soil:

- to stabilize the foundation by reinforcing the soil, used to reinforce the soil structures when building highways, railroads, hydro-technical structures, pipelines, waste disposal sites, strengthening of soil foundations, as well as for anti-erosion protection for embankment slopes and foundations, using topsoil and grass.
- used to strengthen the retaining structures and steep slopes — with the help of soil reinforcement;
- used to prevent collapse of foundation soil;
- strengthens pile foundations.

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Economic effect of TGS (Basalt) Geogrid in Asphalt

The use of **TGS Geogrid** makes it possible to significantly increase the time between repairs for asphalt pavement, reduce the consumption of traditional materials used during the life cycle.

Filaments of **TGS Geogrid,** impregnated with a special compound, adding the following special properties to the mesh: strength, frost resistance, water absorption. It is used for reinforcement of the asphalt pavement on roads, runways, airport fields, access roads, including during their installation on older cement concrete or asphalt pavement, in order to prevent cracking.

Features and benefits of TGS Geogrid (Basalt)

In their mechanical properties, **TGS Geogrid** are more resistant to chemically aggressive environments that meshes manufactured using specialized glasses;

The cost and chemical properties of **TGS Geogrid**, as compared to those of mesh made with specialized glasses, speak in favor of **TGS Geogrid**;

The temperature at which the asphalt is laid will not damage the **TGS Geogrid**, as opposed to mesh made from synthetic materials;

TGS Geogrid retains its physical and mechanical properties at low temperatures and will not lost its elasticity;

TGS Geogrid allows the thickness of the asphalt pavement to be reduced, while maintaining the same service life; Given the same thickness of the asphalt pavement, all other things being equal, the use of **TGS Geogrid** can increase the time between repairs for repair and capital repairs of the pavement by 10 — 15%, with the lifetime of the pavement increased by 3-6 years.

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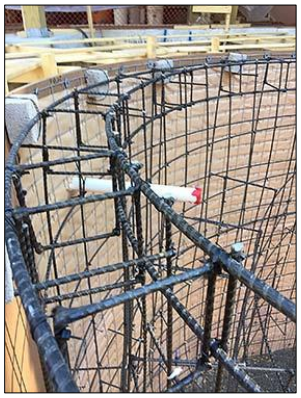
Swimming Pools using TGS concrete reinforcements

Swimming pools contain hundreds of feet of rebar reinforcements. First a grid is made vertically and horizontally, then it is encased in concrete. It sounds simple but is made easier when **TGS** Composite and **TGS** Geo-Fiber (Basalt) concrete reinforcements are used.



Bottom line: Easier to install; resulting in a huge labor and time savings **plus** it is longer lasting than similar installations that use steel rebar.

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