GALEN
Modern composites
Company products:

- Wall ties “Galen” (for connection of a bearing wall with outer layer through insulation materials in three layer constructions);
- Wall ties for warming and of the cast-in-place wall with brick;
- Facade dowel “Galen” for connection of outer insulation material in facade systems;
- Composite armature "ROCKBAR" for concrete reinforcement;
- Composite mesh “Rockmesh”;
- BFRP anchor “Galen” for reinforcing of roofs and sides in mine excavations of different applications
- Composite lightning poles “Galen-TopGlass”.
Composite armature «ROCKBAR»
Bars made of basalt- or glass fiber reinforced polymer material manufactured by pultrusion - technology of production of composite profiles by pull down of composite materials impregnated in binder through heated from die.

- Ø from 2.5 ÷ 32.0 mm
- length up to 12 m (or rolled in spools)
- different finishing coatings, including sand coating for adhesion with concrete

Figure 1. Composite BFRP bars “Galen” with adhesive coating

- 2 axial oriented
  equal mechanical properties in longitudinal and transversal directions
- low modulus of elasticity
  quick and safe dampening of vibration
- arching effect
  at structure failure the mesh retains its shape and prevents cracking

Figure 2. Mesh made of BFRP rods “Galen”.

excellent corrosion resistance  high durability

good weight & tensile strength  lighter and stronger structures

durability in concrete environment  alkali resistance

low density  reduction of transportation costs
## Composite armature Rockbar

Comparison with analogous materials

Table 1. Comparison of composite armature «Rockbar» with available analogs.

<table>
<thead>
<tr>
<th>Technical parameters</th>
<th>Composite armature Rockbar, basalt fiber</th>
<th>Composite armature Rockbar, carbon fiber</th>
<th>Armature from carbon steel of AV class</th>
<th>Glass fiber reinforced polymer armature</th>
<th>Stainless steel armature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tensile strength (MPa)</td>
<td>1200</td>
<td>2300</td>
<td>550</td>
<td>1000</td>
<td>550</td>
</tr>
<tr>
<td>2. Thermal conductivity</td>
<td>&lt; 0,46</td>
<td>&lt; 0,46</td>
<td>56</td>
<td>&lt; 1,0</td>
<td>17</td>
</tr>
<tr>
<td>3. Density (g/cm³)</td>
<td>2,10</td>
<td>1,6</td>
<td>7,85</td>
<td>2,10</td>
<td>7,85</td>
</tr>
<tr>
<td>4. Modulus of elasticity (GPa)</td>
<td>50-55</td>
<td>100-150</td>
<td>200</td>
<td>45</td>
<td>200</td>
</tr>
</tbody>
</table>

**Safety characteristics:**

1. Electrical conductivity
   - established in high scale
   - electrically conductive
   - electrically conductive
   - electrically non-conductive
   - electrically conductive

2. Magnetic parameter
   - non-magnetic
   - non-magnetic
   - magnetic
   - non-magnetic
   - non-magnetic

3. Fire resistance (°C)
   - up to 300 (600*)
   - up to 300 (600*)
   - up to 600
   - up to 150 (300*)
   - up to 600

4. Reliability parameters (corrosion and chemical resistance)
   - very high
   - very high
   - low
   - high
   - high

* at single influence and further failure
Composite armature “Rockbar”
Fields of application

- Mining industry
- Highway building
- Bridge construction
- Reinforced concrete tanks and reservoirs at treatment facilities and chemical plants
- Facilities of housing maintenance and communal utilities
- Sewage, amelioration and water disposal
- Reinforcement of coastline
- Sea and by-port constructions
- Foundations below zero bedding mark
- Poles for overhead contact system
- Reinforcement of floors in parkings made of reinforced concrete

Fig. 3. Construction of bridge, Canada

Fig. 4. Reconstruction by the river Facia, Dry dock №4, Pearl Harbour, Hawaii

Fig. 5. Barrier of a bridge, Canada

Fig. 6. Railway in tunnel under the river Thames, London
Composite armature “Rockbar”
Realized project: Thompson Bridge

New one span bridge on two side highway of A class in Co. Fermanagh, Northern Ireland

- superstructure from concrete slabs, reinforced with reinforcement mesh made of “RockBar”

- “RockBar” is chosen due to durability and excellent corrosion resistance

The UK

- > £500 millions for repair and reconstruction
- > part of – corrosion of steel armature, embedded in concrete.*
- Antifreeze salts increase corrosion

*Proceedings of Bridge Management, Fifth International Conference on Bridge Management, University of Surrey, April 2005.
Composite armature “Rockbar”. Fulfilled project: Shali-Bavli

Highway «Europe-Western China», 14 km of highway Shali (M-7) – Bavli (M-5), The Republic of Tatarstan

Laying of project concrete area with nanostructural composite materials «Galen»

Unique for world construction market! State-of-the-art type of armature «Rockbar» for concrete, durability in several time higher than that of metal analogues

✓ Road of the 1st technical category – construction corresponds to international standards
  With participation of:
  ✓ Ministry of transportation and road facilities in The Republic of Tatarstan
  ✓ Department of demand stimulation «Rusnano»
  ✓ Ministry of manufacturing and energetic
  ✓ of the Chuvash Republic

Figure 11. Laying of composite mesh at experimental ground of highway Shali-Bavli

Figure 12. Mesh made of composite bars «Galen», laying on experimental area
Composite armature “Rockbar”
Fulfilled project: Fountain park

Reconstruction of fountain park in Warsaw, Poland

application of armature bars «RockBar»
at building of fountain pool

«RockBar» is chosen for replacement of steel armature to increase life and preventing of unpleasant external look of rusty metal

Figure 13. Opening of restructured Fountain Park in Warsaw, Poland

Figure 14. Laying of composite reinforcing frame at building of fountain pool in Warsaw, Poland
Corrosion of steel armature

One of the main reasons of failure of reinforced concrete structures

✓ annual losses $57 milliards.* (Federal highway agency of USA)
✓ in Russia this problem is underestimated, no investigations that could estimate annual losses

Mechanism of corrosion

✓ Failure of concrete coating (wet air, aggressive environment)
✓ Armature defects, failure of concrete due to rope armature

Solution: construction using non-metal armature

✓ absolute corrosion resistance
✓ durability prognosis for the period of > 75 years
✓ increased interrepair time, reduction of losses for current maintenance and repair.

*www.corrosioncost.com
Life-cycle

**Creation stage** (market share 1-5%)

**Growth stage** (market share 5-15%)

**Maturity stage** (large market share)

«Old age» stage, market share reduces

Growth of volume of sales of innovative product

Composite armature in Russia

Composite armature in Western Europe, Northern America

Metal armature

Time

Cost

Figure 17. Distribution of costs by time for composite armature

Initial expenditures of objects made of composite armature are higher than of those for steel armature

Reduction of maintenance costs further confirms advantages of composite armature

Figure 18. Graphic of distribution of cost in time for steel armature
Calculation of economic effectiveness at application composite armature in bridge construction*

Two variants of bridge construction are considered here: Winnipeg town, Canada. Requirements to construction meet actual maintenance characteristics of the bridge.

<table>
<thead>
<tr>
<th>Concrete structures, reinforced with metal armature</th>
<th>Concrete structures, reinforced with metal armature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle (years): 50</td>
<td>Life cycle (years): 75</td>
</tr>
<tr>
<td><strong>Initial investments</strong></td>
<td><strong>Initial investments</strong></td>
</tr>
<tr>
<td>Design ($) 25,000</td>
<td>Design ($) 35,000</td>
</tr>
<tr>
<td>Transportation costs ($) 150,000</td>
<td>Transportation costs ($) 150,000</td>
</tr>
<tr>
<td>Coatings (m2) 6,000</td>
<td>Coatings (m2) 6,000</td>
</tr>
<tr>
<td>Other costs ($/m2) 350</td>
<td>Other costs ($/m2) 414</td>
</tr>
<tr>
<td><strong>Current cost of initial expenditures of 1 structure</strong>: $2,275,000</td>
<td><strong>Current cost of initial expenditures of 1 structure</strong>: $2,669,000</td>
</tr>
<tr>
<td>Recalculation for 1 year: $144,336</td>
<td>Recalculation for 1 year: $162,192</td>
</tr>
<tr>
<td><strong>Maintenance and repair</strong></td>
<td><strong>Maintenance and repair</strong></td>
</tr>
<tr>
<td>Transportation costs ($) 75,000</td>
<td>Transportation costs ($) 75,000</td>
</tr>
<tr>
<td>Point repair ($) 5,000,000</td>
<td>Holes patching ($) 2,500,000</td>
</tr>
<tr>
<td>Replacement of coatings ($) 150,000</td>
<td>Replacement of coatings ($) 150,000</td>
</tr>
<tr>
<td>Quantity of years 25</td>
<td>Quantity of years 25</td>
</tr>
<tr>
<td>Recalculation for 1 year: $96,602</td>
<td>Recalculation for 1 year: $12,970</td>
</tr>
<tr>
<td>Liquidation cost ($) 3,000,000</td>
<td>Liquidation cost ($) 3,000,000</td>
</tr>
<tr>
<td>Recalculation for 1 year: $10,333</td>
<td>recalculation for 1 year: $2,306</td>
</tr>
<tr>
<td>Total cost (Recalculation for 1 year): $251,270</td>
<td>Total cost (Recalculation for 1 year): $177,468</td>
</tr>
</tbody>
</table>

Effectiveness of bridge application reinforced with composite armature is 30 % Higher than that reinforced with metal armature

Composite armature Rockbar. Achievements and awards received in foreign countries

2010: The Best Product for building a house by yourself, London
The Best Product, «Bex» exhibition, Valencia, Spain

Thousands of energy efficient «passive» houses in Western Europe
Certificates

Figure 19. Sanitation-and-epidemiological conclusion

Figure 20. Certificate ISO 9001:2008

Figure 21. Certificate of conformance
Conclusion:

Clause 6. «With assumption of increased corrosion resistance, we consider that it is reasonable to apply BFRP armature of composition № 4 for manufacturing of wall ties.»

Clause 7. «Probably BFRP armature of composition № 4 can be used in various spheres of construction. For example for replacement of metal armature in bridge structures, tunnel and port constructions, where high corrosion resistance characteristic of armature is of vital importance. Here as well as in design of durability of joint operation of wall ties inside construction shall be advisable continued...”
Tests on durability. Sheffield

✓ September, 2007
✓ accelerated testing FIB – collaboration with 11 institutes (UK (2), France, Italy, Belgium, Netherlands)

Conclusion:

«At temperature 20°C, influence of pH level is considered to be low on general characteristics of bars. Apart from that at increase of temperature of impact, bars show large reduction of strength on 10 number logarithm and, consequently, retention of strength reduces. Tensile strength retention was determined using logarithm extrapolation fatigue-limit for the period 100 years. Prognosis procedure proposed by FIB for assessment of heat impact of environment on polymer bars showed good correspondence with experiments. Approximate coefficient of strength reduction due to impact of environment within 100 years in conditions of wet concrete at 20°C equals to 1.25, that corresponds to strength retention by 79.61% and standard reduction by decimal logarithm amounts 4.28%.»
International standards for application of composite armature

**USA**, American Concrete Institute  ACI, Farmington Hills, Michigan, 2003
*ACI 440.1R-03 “Guide for the Design and Construction of Concrete Reinforced with FRP bars”*

**European Union**, Investigation group 9.3, Lauzanna, Switzerland, 2005
«FRP armature for structures made of reinforced concrete»

**Japan**, Japan society of construction engineers JSCE, Tokio, 1997
«Recommendation on Design and Construction of concrete structures using reinforcement materials from continuous fibers», Series of publishing on concrete technologies № 23

**Canada**
Canadian standardization agency, Rexdale, 2002
*CAN/CSA-S6-02 «Design and Construction of components of constructions from polymers, reinforced with fiber»*

Canadian Agency on standardization, international branch CSA, Toronto, Ontario, 2000
*CAN/CSA-S6-00 «Code of structural elements for design high bridges in Canada»*

Prestandard with Rosstandard on the base of Italian and Canadian standards.

*polymer reinforced with fibers*
Gent University (Belgium)

Sheffield University (UK)

Specialization: investigation of nanoparticles, development of methods nanoparticles dispersion in polymer compound

Specialization: investigation of durability of composite armature in concrete and aggressive environment

NIFCHI named after Karpov (Russia)

Specialization: investigation of a structure and characteristics of received nanocomposites

Institute of Synthetic Polymer materials named after Enikolopov RAN

Specialization: investigation of application of composite bars in concrete and structures by prestressing technique.

Scientific-investigational planning and surveying and design technology Institute of foundations and underground structures named after M.N. Gersevanov

Specialization: investigation of application of composite bars in concrete and structures by prestressing technique.

Scientific support

Manchester University (UK)

Specialization: Developments in alternative methods of hardening

Specialization: Investigation of physical-mechanical properties of composite armature, investigation of durability of composite armature in concrete and aggressive environment.
Wall ties and dowels «Galen»
Basalt fiber reinforced polymer anchor «Гален» of 6 mm in diameter with two sand anchors are used for reinforcing of three layer brick walls with inner insulation. They provide connection between bearing and outer layers. Structures with air gap, assembled with a restrained locator.
Wall ties «Galen» with two sand anchors

$L = 90\text{mm} + T + 90 \ (150) \text{ mm}$

For example, insulation layer of 120 mm in thickness

$L \ (\text{length of a tie, mm}) = 90 + 120 + 90 = 300 \text{ mm}$, hence

Marking of a wall tie **BPA 300-6-2P** (tie length is divisible by 50 mm)
Basalt fiber reinforced polymer wall ties «Galén» of 6 mm in diameter with **one sand anchor and a dowel** are used for heat insulation and facing of monolithic or existing bearing wall with brick material. They are used for connection of bearing monolithic wall with a facing layer and insulation material placed between them.

- in monolithic wall with brick outer layer
- constructions with air gap, assembled with a restrained locator
L = 60\text{mm} + T + 90 (150) \text{mm}

For example, heat insulation of 120 \text{mm} in thickness

L (length of a wall tie, \text{mm}) = 60 + 120 + 40 + 90 = 300 \text{mm}, hence

marking of a wall tie  \textbf{PBA 310-6-1P}
Construction punchdown dowel

consists of a spacer –

a BFRP bar,

a locking pin and anchor element

– restrained locator.

Designed for strengthening of outer insulation

in facade systems of different structures, at repair or reconstruction of structures.
Dowel «Thermosave»

Dowel punchdown «Thermosave» consists of impact-resistant polymer assembled with BFRP spacer.

Designed for strengthening of heat insulation plates on base of concrete, brick at mounting of different facade systems, in particular, «wet type» with thin plaster.
Composite highway poles “Galen-TopGlass”
Highway lightning poles: description

- Utmost importance for arrangement of human activity
- Designed for fixing of:
  - Lightning elements (lamps, projectors and so on)
  - Overhead electrical lines
  - Systems of cable telecommunications
  - Telephone cables
  - Sign posts
  - Seasonal and festive

- Existing types of poles:
  - concrete
  - metal
  - timber

- Main requirements:
  - durability
  - simple usage of
  - low cost
  - aesthetic outer appearance
Composite highway poles

Advantages of composite lightning poles

✓ resistant to deterioration & corrosion, negative external factors, including ultraviolet
✓ do not require special maintenance (cleaning of corrosion, painting, crack repair, etc.)
✓ can be used in all wind zones
✓ suitable and cost-effective installation, easy transportation
✓ easy drilling of holes and cable channels, opening for detachable equipment
✓ eco-friendly

Safety!

Poles are safety at impacts with transport vehicles in comparison with reinforced concrete and metal analogues.
Harmless for road users and do not make serious damage to vehicles at crashes.
At run over it’s the pole that is damaged mechanically, but not a car, the driver and passengers.
Composite highway poles
Galen-Topglass

Composite poles are made in conical shape from glass fiber reinforced polymer material

Main characteristics:

<table>
<thead>
<tr>
<th>Length L, mm</th>
<th>Bottom diameter D, mm</th>
<th>Top diameter, mm</th>
<th>Mass, kg</th>
<th>Average wall thickness, mm</th>
<th>Load on top, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>7000 – 13600</td>
<td>194,00 – 305,00</td>
<td>76,00–120,00</td>
<td>25,00 – 92,00</td>
<td>4,00 – 6,00</td>
<td>200-500</td>
</tr>
</tbody>
</table>

Main applications:
- highway lightning
- road signs
- power supply lines and telephone lines
- Poles for flags, billboards
- Lightning of remote areas and city

Product is manufactured and certified in Russian Federation
Highway lightning poles
Galen-Topglass: advantages

- **Time, working labour and equipment safety**
  Lighter structures for transportation and mounting by group of 2-3 specialists, does not require basement from cement and ground and maintenance of surface.

- **Durability, low maintenance costs**
  No corrosion, do not require additional maintenance and painting

- **UV- protection**
  Poles are covered with special composition, which contains components, resistant to UV-radiation

- **Low risk of electricity damage**
  Glass fiber reinforced polymer is a natural isolator

- **Resistant to weathering factors**
  High wind loads and low temperatures (composite’s strength increases), resistant to high acid soil, rain and salty air

- Products is certified and has Conformance certificates to european standards (CE mark)
Foundation types for lightning poles

- **Flange foundation**: 13,247 rubles
- **Direct burial foundation**: 8,082 rubles
- **Direct burial foundation («glass» type)**: 6,530 rubles

*design is made by JSC «Chuvashavtodor»
## Composite lightning poles

**Galen-Topglass: comparison with analogues**

<table>
<thead>
<tr>
<th>Poles types</th>
<th>Cost of purchase, rubles</th>
<th>Mass, kg, easy transportation and installation</th>
<th>Ageing/Weather impact/Corrosion/ UV-resistance</th>
<th>Electrical conductivity/radio transparency</th>
<th>Cost of owning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Galen-Topglass</td>
<td>20 000 - 30 000</td>
<td>up to 90 / +++</td>
<td>+++</td>
<td>+++</td>
<td>$</td>
</tr>
<tr>
<td>Galvanized*</td>
<td>25 000 - 48 000</td>
<td>up to 500 / +</td>
<td>+ corrosion</td>
<td>+</td>
<td>$$$</td>
</tr>
<tr>
<td>Reinforced concrete</td>
<td>18 000</td>
<td>1000 / ++</td>
<td>+ corrosion of armature/concrete cracking</td>
<td>+</td>
<td>$$$</td>
</tr>
<tr>
<td>Timber</td>
<td>3 800</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>$</td>
</tr>
</tbody>
</table>

*data provided by UPRDOR «Volga»

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35
Comparison of 11 meter (over ground) nonbearing lightning poles

<table>
<thead>
<tr>
<th>Pole and foundation name</th>
<th>Cost of solution (rub)</th>
<th>% соотношение</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanized, 11 meter, flange foundation</td>
<td>45 247,00</td>
<td>Comparison base</td>
</tr>
<tr>
<td>Galen-Topglass, 13 meter, direct burial, “glass type”</td>
<td>38 530,00</td>
<td>15% lower</td>
</tr>
</tbody>
</table>

Saving from 1 pole amounts more than 6 500 rubles
Rockbolt «Galen»
BFRP rockbolt «Galen»

Composite bar from basalt or glass fiber, impregnated with epoxy compound

✓ $l = 1,8 \div 3,0$ m
✓ from $\varnothing$ 13,5 mm
✓ sand coating
✓ metal sleeve with a thread

✓ reinforcement of roofs and sides in mines
✓ strengthening of net to protect from rock falling

✓ since 2009 testings in mine «Bolshevik», Mezhdurechensk town

✓ Nominated for award of Youth award in nanoindustry «Rusnanoforum», 2009
BFRP rockbolt «Galen». Distinctive parameters.

Distinctive characteristics of the product

- easy cuttable by a tunneling machine
  increasing of drilling rate and durability of concrete
- high tensile strength not less < 9,5 tons
  Bar of lesser diameter allows to reduce the diameter of hole in rock
  and save consuming fast hardening resin
- lighter than 10 times
  Reduction transportation costs due to material properties and bars diameter
- Increased fire resistance
- Conducts electrical current – no accumulation of static electricity, i.e. rockbolt can be a reason for fire in a mine

Figure 23. Mine tunnel, reinforced with rockbolts