ROCK BOLTING AND CONTROL SYSTEMS
With over 135 years of experience, Minova is a leading global manufacturer and supplier of resin, cementitious and mechanical earth control products, adhesives and support equipment. We provide leading-edge geotechnical solutions as well as consulting, design and applications expertise for use in the mining, tunnelling, civil construction and structural remediation industries.

Minova is an industry innovator and leader both in technology and application expertise. Our product and applications specialists from around the globe provide on-site technical support for your projects no matter the location.

With a focus on safety, our success comes from customer-connected sales engineers and chemists who continually innovate and perfect solutions, raising industry standards.

Minova specialises in total solutions and vital technologies designed to meet your challenges. We are forward thinking and offer integrated solutions with sustainable results.

We offer products and solutions for rock bolting as well as the applications listed below:

- Anchoring, rock bolting and soil nailing
- Concrete repairs
- Construction adhesives
- Customer support & consulting
- Erosion control
- Filling of cavities/voids and backfilling
- Ground consolidation
- Joint sealing
- Micropiling and underpinning
- Mine gas sealing and ventilation control
- Non-potable water pipe repairs
- Pumps and ancillaries
- Slope stabilisation
- Structural repair
- Water sealing

The next generation of bolting technologies today.

This brochure represents our next generation of bolting technologies as well as our most widely used products for rock bolting applications.

Please visit, www.minovaglobal.com for more details.
ROCK BOLTING

Minova offers a comprehensive range of reinforcement and support solutions that control and stabilise rock in excavated or unstable areas.

Rock reinforcement includes methods that modify internal rock mass behaviours by installing structural elements that prevent further rock mass loosening, reduces deformation caused by excavating and stabilises the rock, extending the natural rock arch. This type of reinforcement is an active method of support and includes point anchored bolts, friction bolts, and grouted bolts.

Support methods that use structural elements such as steel arches, meshes and shotcretes, are known as passive support methods. Passive support methods rely on the movement of the rock mass to create a resistance load.

A wide range of factors are considered when determining the proper bolt type and the bolting pattern. The behaviour of the rock being supported as well as the rock material characteristics are of critical importance to this selection process.

**Rock bolt selection criterion:**
- Access area
- Corrosive rock behaviour
- Life expectancy of excavated area
- Extraction height
- Installation equipment
- Presence of water
- Rock type
- Strength and stiffness of the rock
- Structural features such as:
  - Breaks
  - Fissures or fractures
  - Presence of laminations

Geological conditions and design requirements determine the selection of the rock bolt and grouting technology to be utilised:

- Bolt service-life (temporary/permanent)
- Bolt capacity (tension-yield/shear)
- Converging/yielding areas
- Dynamic Environments
- Loaded bolt behaviour (elongation/creep)
- Optimal bolt pattern density
- Optimal length consideration (Extension of self-support rock arch)
- Sustainability
- Technology of bolt installation equipment
Minova is a leading innovator in total solutions for rock bolting. Minova leads the way in addressing critical needs for working underground safely by providing immediate rock support even in the most demanding applications. Using Minova rock bolting solutions reduces manual handling requirements and improves installation efficiency.

**Automation in bolting**

Minova is the technical leader for in-hole bolting solutions combining expertise in Steel/GFRP bolting with cementitious grouts and resins.

The Minova single pass bolting solution combines the benefits of Minova self-drilling bolts with Minova high-performance injectable resins. The immediate bonding of the resin makes it possible to load the bolts without leaving the drill-hole which makes the bolting process safer, significantly quicker and more efficient.

Minova single pass bolting combines leading-edge technology and high quality, high strength products making rock bolting safer, quicker and easier to use.
Glass Fibre Reinforced Polymer (GFRP) technology positively impacts the environment and your workforce. GFRP products reduce manufacturing and transportation CO₂ emissions.

GFRP also have lower per-unit weights compared to similar steel products leading to more units per load, thus lowering transport costs. The positive impact of lighter GFRP products extends to your workforce as lighter products translate to improved worker productivity and safety.

Minova offers a variety of GFRP products for use in various applications including continuous thread bars, self-drilling bolts, cable bolts, hollow bars, reinforcement bars and meshes.

Application areas:
- Permanent structural reinforcement (bars/mesh)
- Non-conductive or radio sensitive application
- Rock bolting (permanent and temporary)
- Soil nailing, rock face stabilisation and ground anchoring

Advantages of GFRP include:
- A wide range of diameters and shapes in solid or hollow bar
- Corrosion resistance
- Ease of cutting
- Electrically insulated
- Flexibility for installation in confined spaces
- High tensile strength
- High torsional strength
- High thermal isolation
- Lightweight (up to 75% lighter than steel)

Minova offers the broadest line of GFRP products available to the market today.

**Typical characteristics of comparable products**

<table>
<thead>
<tr>
<th></th>
<th>GFRP</th>
<th>Steel</th>
<th>Aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific weight (kg/dm³)</td>
<td>1.9</td>
<td>7.8</td>
<td>2.7</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>1000</td>
<td>600</td>
<td>350</td>
</tr>
<tr>
<td>E-Modulus (N/mm²)</td>
<td>50 000</td>
<td>207 000</td>
<td>69 000</td>
</tr>
<tr>
<td>Deformation (%)</td>
<td>&gt; 3.5</td>
<td>&gt; 10</td>
<td>&gt; 10</td>
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</table>
As mines and tunnels continue to go deeper, excavated areas are exposed to increasingly difficult ground conditions and rock pressures. Due to challenging strata and greater depths, even highly competent rock may become overstressed.

Bolting technologies for convergence and dynamic yield applications
Rock reinforcement and support elements may be exposed to converging or dynamic ground conditions.

Convergence (or yielding) can occur over short or long periods of time:
- Convergence over a short period (cm/hr) equates to squeezing ground
- Convergence over an extended period (cm/month) equates to swelling ground

Dynamic events or rock bursts occur due to the significant build-up of pressure within rock masses. These events happen when energy is released immediately in one single movement as compared to the action of convergence which occurs slowly over time.

Minova is working closely with leading mining and tunnelling companies to address the challenges of deeper excavations by offering a range of convergence and dynamic bolting technologies.

Technologies to overcome broken or weak ground
Minova SDA bolting technology is designed to improve installation times and to address hole collapses when used in fractured ground. It is a flexible system that features a load-bearing hollow bar/bolt that is encapsulated by a grout body. The bar/bolt is used as the drill rod, transferring the energy during drilling. Flushing may be achieved with air, water or simultaneously improving productivity by using the single pass drilling and grouting method.

Minova SDA bolts are manufactured from high quality seamless or welded tubes that have either left or right-handed thread types, (‘R’=Rope thread or ‘T’= Trapezoidal thread).

Minova SDA bolts are suitable for either manual handling or use onboard fully automated bolting rigs. The bolts utilise sacrificial drill bits and are easily lengthened by adding extension couplings. These extensions allow for installation of bars where space is limited or where design flexibility is needed. Uniform placement of the bolt within the borehole is achieved using optional centralisers.

Minova Rock Support Solutions control converging, dynamic and weak ground conditions.
Minova solutions are flexible and extend bolt life by delivering optimal corrosion protection.

The demand for extended bolt life requires improved rock bolting technologies. One of the main limiting factors to bolt life is corrosion acting on steel elements.

Minova offers a full range of solutions that address the requirements for increased life cycle, ranging from stainless steel bolts to speciality coatings and new technologies, like the GFRP composite bolting range.

Coating protection for rock bolts
Minova provides multiple coating solutions for a wide range of bolts that increase bolt lifespan while maintaining bolt performance. Single and Twin Coated protection systems are available, all of which can be combined with grouting solutions from Minova to optimise the lifespan and performance of our bolts.

Smart flexible designs:
The Minova Enduro System provides tough chip resistant protection to steel products. The finish offers excellent UV, alkaline and acidic corrosion protection, enhancing the useful life of steel.

Tyta Bolts are made with larger threads that extend the useful life of the bolt. These threads allow the bolt to be re-tightened as needed.

Minova Continuous Threadbar bolts allow for ease of use and flexibility when designing bolting systems. The bolts are fully threaded allowing for versatile installation and length design.

Improved resin mixing
Minova has developed cost-effective, high-performance bolting systems like the Eclipse and Secura Bolts that enhance resin mixing and minimise the adverse effects of “glove fingering.”

TWINCOAT™ PROCESS
The Minova TwinCoat process is available for our SDA anchors. The coating process is comprised of a hot dip galvanisation in accordance to EN ISO 1461 and Epoxy coating in accordance with ISO 2178. The Minova TwinCoat process is tested for suitability in accordance to corrosion category C5-M and Im3 (durability range according to ISO 12944-2). Testing performed by OFI (Austria).
Due to varying geological conditions and project applications, a single bolt is unlikely to meet all requirements. In response, Minova has developed a series of complete solutions addressing today's bolting challenges with an eye towards tomorrow's needs. Working with customers and designers, Minova can design purpose-made solutions for your bolting needs.

<table>
<thead>
<tr>
<th>Products</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td><strong>GFRP:</strong> Glass Fibre Reinforced Polymer Bolts</td>
<td>Minova GFRP bolts are manufactured using the latest technologies. The material offers high mechanical strength and favourable long-term characteristics for anchoring. Minova GFRP products offer the lowest carbon footprint of any bolting product in the market with 66% lower CO₂ emissions, due to our environmentally friendly manufacturing techniques, and 50% lighter product weights. High strength, lighter weight products improve logistics, ergonomics, safety, and productivity rates.</td>
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<tr>
<td><strong>SDA: Self-Drilling Anchor Bolts</strong></td>
<td>SDA Bolts provide an efficient and cost-effective reinforcement solution for unstable ground conditions like sand, gravel, silt, clay or fractured rock. The system features a hollow bar used as a drill string for drilling either with water flush, air flush or cement grout flush. The hollow bar is fitted with a left-hand or right-hand R- or T-thread. SDA bolts are easily extended with couplers and may be connected to conventional rock drilling equipment. For fast and efficient installations up to medium hard rock conditions.</td>
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<tr>
<td><strong>Cable Bolts</strong></td>
<td>For passive or active long tendon applications with smooth bulbed or indented strands to enhance anchorage. Primary or secondary support, long or short-term applications where high-capacity supports with high shear strength and flexibility are required. A pumped grout is used to encapsulate the cable during installation.</td>
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<tr>
<td><strong>Resin Capsule Cable Bolts</strong></td>
<td>For long tendon applications, passive or active installations with smooth bulbed or indented strands to enhance anchorage. Primary or secondary support, long or short-term applications where high-capacity supports with high shear strength and flexibility are required. The head of the cable bolt is designed to mix the two component Lokset resin cartridge already placed in the borehole. The cable is spun into position during installation thoroughly mixing the resin.</td>
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<td><strong>Friction Bolts (Expandable-Inflatable)</strong></td>
<td>Expandable Friction bolts are used for immediate support in mechanized mining and tunnelling activities. The bolt is inserted undersized to the borehole diameter. High-pressure water expands the bolt. Once fully expanded the bolt is drained of water. The bolting technology allows for improved control of the bolt loading and provides improved corrosion protection, as the bolt is not forced into the hole. Therefore, installation damage is decreased.</td>
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<td><strong>Friction Bolts (Split)</strong></td>
<td>The split bolt is made of a high strength steel and uses a spring based design with an interference fit, creating immediate load transfer between the bolt and the rock mass once the bolt is fully inserted.</td>
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<tr>
<td><strong>Resin Bolts</strong></td>
<td>Used with Minova Lokset capsules, the bolts are inserted into the borehole after the capsule is set in place. The rotation of the bolts mixes the resin. On setting of the resin (minutes) the full load bearing capacity of the bolt can be used.</td>
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<tr>
<td><strong>Tension Rebar Bolts (TRB)</strong></td>
<td>Offers precise tension and significant cost savings. The TRB System has tensile strength characteristics from 140MPa to 318MPa (20 300PSI to 46 200PSI), where needed for better beam building. This exceptional support, installed in a 25mm (1&quot;) hole, allows for dramatic savings in resin and is available with variety of tensions nuts. (Right- or Left-Hand Spin).</td>
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<tr>
<td><strong>Mix Bolts</strong></td>
<td>A combination of expansion shell bolt as temporary rock support and subsequent injection for permanent rock support through integrated injection hole and bleed air holes. The bolt remains fully secured during grouting.</td>
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<tr>
<td><strong>Post Grouted Bolts</strong></td>
<td>Using the expansion shell principle, the bolt is held in position while injection grouts fill the bolt-hole annulus, creating a fully encapsulated bolt for securing areas where higher rock pressures exist. A grout injection set, consisting of seal and piping, are used for injection of the grouts.</td>
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<tr>
<td><strong>Expansion Shell Bolts</strong></td>
<td>Simple and easy to install for immediate support to a work area, the expansion shell creates a point to anchor into the hole by turning the bolt in the hole. The shell tightens to the rock creating tension at the foot of the bore hole, transferring the load from the bolt head and plate to the rock via the shell.</td>
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<tr>
<td><strong>Wedge / Shaft Bolts</strong></td>
<td>Used primarily in mining applications to connect the reinforcement support to the shaft-lining and to fit pipeline or cable holders and other fixtures in the shaft. The wedge is inserted into the borehole and the bolts are hammered into position. The bolt can also be grouted to provide additional long-term security.</td>
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Grouting solutions for rock bolting
Minova manufactures a wide range of grout solutions for rock bolting applications – from generic grouts to highly engineered rapid setting, rapid strengthening grouts.

Our industry-leading capsule products, Lokset and Capcem, offer full encapsulation for ease of handling. Our pumpable TekGrout family is bulk packaged, scalable and for use with manual or fully automated systems. CarboThix, our latest flagship silicate resin, increases safety, significantly improves efficiency and decreases material waste.

Bulk cement grouts
Our bulk cements have grown into a diversified comprehensive group of products for all types of bolting applications. These grouts can be used for strata injection and consolidation applications in coal mining, hard rock mining, tunnelling, and civil construction projects.

Our grouts have been developed to work across a wide range of applications and placement methods including long distance pumping, thixotropic grouting and injection for water stopping. These products may be applied manually or via automated methods. In addition, these grouts can be used for rapid advance bolting.

Special application grouts have been developed in cooperation with our customers. Many of these special application grouts and are now part of our standard global product offering.

Leading edge development for productivity and savings
CarboThix is an example of our innovative approach to product development. An industry leading resin grout created by Minova engineers, CarboThix is a two-component silicate resin that instantly thickens and cures. It is used for high strength bonding of rock bolts and cables as well as for securing long-term roof supports.

Benefits of CarboThix™
- Consolidation of the borehole in fractured conditions
- Consistent grout quality
- Full encapsulation of anchors
- Immediate loading capacity
- Improved operator safety
- Long distance pumping
- Longer shelf life than resin capsules
- Resistant to water
- Thixotropic characteristic reduces product waste

THE RIGHT GROUT FOR THE APPLICATION

CAPSULES

**Lokset**
As a world-leading innovator of grouting solutions, Minova remains the market leader for resin based grout capsules. By developing and introducing the Lokset resin capsule for rock bolting Minova revolutionized an industry. Lokset is globally renowned for high performance and consistent quality when securing underground excavations and providing immediate surface bolt anchoring.

**Capcem**
Capcem is a rapid strength gaining, non-shrink, chloride free, thixotropic grout that removes waste and is easy to transport. Capcem comprises a range of cement capsules designed to meet the needs of anchoring grout applications. The Capcem solution is flexible, easy to use and makes difficult to access areas less of a challenge.

Capcem is available in pumpable versions for use with longer tendons and anchors.

All grout formulations include a non-shrink expansion compensation system and are supplied pre-blended and pre-packaged requiring only the addition of set amounts of water to produce high-quality grout.
Bolts alone are not enough. Many applications require a series of components to ensure the expected results. Minova offers a total bolting solution from Steel and GFRP products to high-performance grouts.

Minova provides a comprehensive range of accessories that work in combination with other products to allow our mining and construction customers to achieve peak results.

These include:
- Drill bits
- Couplings
- Meshes: steel, GFRP and polymer
- Plates and nuts
- Spacers
- Eyebolts
- Mechanical shells
- Mining straps
- Services hangers
- Trusses

Completing the solution
Minova offers specific lines of shotcrete materials, spray plasters, sealants and liners for the mining and tunnelling industries. Delivery systems and applications knowledge are an integral part of solutions offered by Minova.

Offering includes:
- Bolting and drilling equipment
- Consultation and application services
- Abrasion and impact resistant cements
- Fibre reinforced or fibre free grouting accessories
- Lokset installation systems
- Pumping and injection solutions
- Premixed cements and coatings
- Spray applied waterproofing membranes
- Sprayed solutions
- Thin structural liners
- Wet or dry-spray applied products

Minova is your trusted technical partner for innovative solutions.
CASE STUDIES

DAM, UNITED STATES

The Oroville Dam is the tallest dam in the US. It is an embankment dam located in California. After years of drought conditions, the area experienced significant rains causing massive flooding during the spring of 2017. The rains led to severe erosion of the dam’s primary and emergency spillways as well as many of the surrounding access roads.

Critical successes
– Celroc P was pumped to create anchoring for dowels from the new spillway to the remaining old spillway
– Provided technical field support and training for the use of TekCrete Fast materials
– Assisted in the soil nailing under service roads and the reinforcement of the slopes
– Installed reinforcing top coating

TUNNELLING, UNITED KINGDOM

Electrification for new railway upgrades required the expansion of old tunnels (dating back to the 1800s) that have unstable ground conditions. The roof to be supported consisted of sand, clay and glacial till. The solution was to insert GFRP dowels and inject polyurethane to secure the dowels, bonding loose material and filling cavities.

Advantages
– GFRP Dowels can easily be cut to length
– A single supplier total solution made matching characteristics of dowels, injection grouting for cavity filling, consolidation and securing dowels easier
– Pumps packers and small drilling equipment supplied as needed

MINING, SOUTH AFRICA

Many deep mine developments can be exposed to vibrations caused by blasting and seismic movements. Unfortunately, many of the bolts have a thinly formed thread. These bolts can easily be damaged or require re-tightening. In cooperation with mining customers, Minova has developed a new bolt, known as the Tyta bolt, featuring a bolt assembly with a robust extended length coarse thread.

Advantages
– Blast resistant thread design
– Improved meshing process due to thread design
– Improved pitch allows for easier cleaning and required re-tightening of the bolts