FREQUENTLY ASKED QUESTIONS

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What is V-ROD?

V-ROD is a highly resistant, non-corrosive glass fiber-reinforced polymer (GFRP) developed by Pultrall inc. for concrete reinforcement.

The corrosion of steel reinforcement is known to be the major cause of premature deterioration of concrete structures. At Inconmat, we are convinced that safe and durable concrete structures are achieved not by delaying corrosion with "treated" steels, such as galvanized or epoxy- coated, but by eliminating the corrosion problem at its root by removing all steel from the concrete.

V-ROD can replace all the easily corroded reinforcing steel in concrete elements! It is not only stronger than steel, but it is also a well-tested product, approved by all standards, Ministries and Transportation Departments.

V-ROD is the optimal solution against corrosion!

What does GFRP mean?

GFRP is an acronym for **G**lass **F**iber-**R**einforced **P**olymer. GFRP used for concrete reinforcement, such as V-ROD, is often refer to as *Fiberglass rebar* or *composite reinforcement*.

What are the advantages of using V-ROD

V-ROD does not rust

Being inert to corrosion and highly resistant to chemical attack, concrete reinforced using V-ROD is the way to go for:

- Bridge decks, girders and barrier walls
- Water treatment plants
- Marine application such as walls, docks and wave breakers
- Concrete pavement dowels
- Parking garages
- Road infrastructures such as concrete lightning poles and culverts

Also, because V-ROD cannot corrode, the required concrete cover is much smaller than the required one for steel. Therefore, V-ROD is best suited for applications where minimal concrete cover is needed.

V-ROD does not conduct electricity

V-ROD removes any induction problems caused by stray currents. Because of its electrical neutrality, V-ROD eliminates all need of grounding and increase of concrete coverage to eliminate the passage of electrical currents from steel reinforcement into concrete. V-ROD is unbeatable for utility poles, train tracks and electrical underground enclosures

V-ROD has a very low thermal conductivity

Keep your structures eco-friendly by using V-ROD and thus ensuring that the good thermal insulation provided by the concrete isn't reduced by steel's high thermal conductivity. V-ROD thermal conductivity is about 30 times lower than steel, which will help preventing thermal bridges.

V-ROD is non-magnetic

V-ROD will not interfere with magnetic fields and is ideal for MRI machine rooms in hospitals, research facilities, toll roads or wherever sensitive electronic devices are used.

V-ROD does not interfere with Boring Machines

By using V-ROD in wall diaphragms and bore piles, you can provide a "Soft-Eye" that will not obstruct in any way the passage of the tunnel boring machines, increasing safety on construction sites as well as being time and cost efficient.

V-ROD is very easy to manipulate

V-ROD is up to four (4) times lighter than steel. It not only makes life easier for rebar installers, but it also requires fewer transports to bring the material to site, this being ideal for remote region structures and precast elements.

V-ROD has a low carbon footprint and is environmentally friendly

A life-cycle analysis was realized on V-ROD and the following conclusions were drawn:

V-ROD impacts on Human Health is **70% lower than steel**
V-ROD impacts on Ecosystems is **85% lower than steel**
V-ROD impacts on Climate Change is **64% lower than steel**
V-ROD impacts on Resources is **63% lower than steel**

Where is V-ROD produced?

V-ROD is produced in Thetford Mines, Canada (QC). However, thanks to our ever-growing network of Authorized Distributors all around the world, V-ROD is available wherever you need it.

Is the use of V-ROD allowed by the current standards?

Yes it is! V-ROD composite reinforcing bars are covered by various Design Guides and Design Codes:

Australia

Australia Building and Construction Codes under the Alternative Solutions Provision allow international design codes to be used for specific material to meet the structural requirements as set in the BCA NCC.

Canada

CAN/CSA S806-12 – *Design and Construction of Building Structures with Fiber-Reinforced Polymers*
CAN/CSA S807-10 – *Specification for Fiber-Reinforced Polymers*
CAN/CSA S6-14 – *Canadian Highway Bridge Design Code (section 16 – Fiber-Reinforced Structures*

USA

ACI 440.1R-15 – *Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars*
ACI 440.2R-08 – *Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures* ACI 440.5-08 – *Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars*
ACI 440.6-08 – *Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement.*
AASHTO LRFD 2009 : *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*
CNR DT 203 – *Guide for the Design and Construction of Concrete Structures Reinforced with Fiber-Reinforced Polymer Bars*

GFRP reinforcement such as V-ROD is widely accepted and these standards ensure that your structure will be highly durable, without compromising security.

What is your lead time for fabrication?

Common diameters for straight bars are usually available right away for shipping. For bent bars, please allow one to three weeks for production. Please contact your local representative for more accurate lead times.

Which diameter do you fabricate?

All common diameters available for steel bars are also available for V-ROD straight from #2 (6MM) to #14 (45MM) and from #2 (6MM) to #10 (32MM) for bent bars. This is valid for every grade (LM, STD, HM)

In your specifications, you provide a *nominal cross-sectional area* and an *effective cross-sectional areal*. What is the difference?

The mechanical properties are based on the *nominal area* and therefore the latter should be used **for design purposes**. For example, the nominal diameter of a #4 (12MM) bar is ½''.

The *effective area* is the "real" area of the bar, including sand-coating. For some of our V-ROD products, the *effective area* may differ from the *nominal* one. We provide this value so engineers can ensure that the spacing between bars and the distance between top and bottom mat are acceptable.

What do you mean by V-ROD LM, V-ROD STD and V-ROD HM?

Glass-fiber reinforced polymers are divided in 3 different grades based on the modulus of elasticity of the bars. Our grades match the CAN/CSA S807-10 grade

V-ROD Grade	CAN/CSA S807-10 grade equivalency	Modulus of elasticity (GPa)
LM	Grade 1	>40
STD	Grade 2	>50
HM	Grade 3	>60

The modulus of elasticity shown in the table above are only approximations, the exact modulus of elasticity may be different. For design purposes, engineers should always use the exact values provided in the latest version of our specifications.

What shapes do you have available?

All common shapes are available:

"L-shape" with angles ranging from 0° to 180°
"U-shape" with angles ranging from 0° to 180°
Stirrups
Spirals (cylindrical or tapered)
"Z-shape"
Hooks
Etc.

There may be different limitations for some complex shapes. Please refer to the latest version of our bend guidelines.

Is it possible to use hex nuts with V-ROD?

Yes, it is! V-ROD straight bars can be threaded in order to accommodate a hex nut. We provide GFRP hex nuts at a very competitive price for a vast variety of diameters.

Do you produce rock bolts?

Yes we do! We offer highly resistant, non-corrosive GFRP Rock Bolts for mining applications.

How do you cut the bars?

V-ROD bars can easily be cut using a circular saw with carbide or diamond-coated blades. **Shear cutters must not be used.** Doing so may result in permanently damaging the bars**.**

How do you tie V-ROD bars?

Common steel ties can be used without any problem. However, plastic ties can be used if desired.

How do you manipulate V-ROD bars onsite?

One of the great aspects of V-ROD is how easy it is to manipulate it onsite. First of all, it is about four (4) times lighter than steel, making life easier for rebar installers. Also, they are easily cut which means it will not damage concrete saws or boring machines.

Although the installation of V-ROD is very similar to that of steel rebar, the two materials are different and some precautions must be taken. For more information on how bars should be manipulated onsite, please refer to our Handling and Safety Instructions.

How much does V-ROD cost comparing to steel?

Because glass fiber-reinforced polymers (GFRP) do not behave like steel, a concrete element reinforced with V-ROD cannot be compared directly with a concrete element reinforced with steel, as the two elements will be reinforced differently.

With that being said, V-ROD is probably cheaper than you think! It is competitively priced with galvanized and epoxy-coated steel and significantly less expensive than stainless steel. By using V-ROD, you can offer an even better durability than the one provided by stainless steel at the cost of galvanized steel! And it not only increases significantly the durability of your structures, but can also help you save some concrete as, in some cases, even in highly aggressive environment, the required concrete cover is only 20 mm (¾").

Also, as V-ROD is up to four (4) times lighter than steel, shipping cost are typically lower as fewer transports are required to bring V-ROD to site. This also results in faster installation and thus, more cost efficient.

What are the material properties differences between steel and V- ROD?

Below is a table that show some of the material differences between steel bars and V-ROD bars.

Material Properties	V-ROD	Steel reinforcing bars
Tensile strength (MPa)	1300 (failure)	400 (yield)
Modulus of elasticity (GPA)	40 – 60	200
Bond strength (MPa)	14	≈10
Thermal conductivity (W/(m·K))	< 1	≈50
Electrical resistance (Ω·m)	$> 10^{10}$	$\approx 1.5 \times 10^{-7}$
Longitudinal coefficient of thermal expansion (10^{-6}/°C)	6	12
Transverse coefficient of thermal expansion (10^{-6}/°C)	24	12
Required concrete cover	30 or $2d_b$	20 - 75

The material properties shown in the table above are approximate values. Please, ensure that you are using the latest version of our specification available on our website.

What is the yield strength of V-ROD?

Though the tensile strength of glass fiber-reinforced polymers such as V-ROD is much higher than steel, **they do not yield**. Their behavior is linear elastic up to failure, at which point they break.

How do I know that the bar is close to failing?

Usually, concrete structures will be over-reinforced when using V-ROD, which mean you'll need to look for failure initiated by concrete crushing, not by V-ROD rupture.

As FRP bars present a rather brittle failure, structures are designed this way in order to ensure the same level of safety than steel-reinforced concrete. This design procedure is also the one recommended by all the Design Codes.

Can V-ROD cause an alkali-aggregate reaction? Is V-ROD affected by the highly alkaline concrete environment?

Glass fiber-reinforced polymers such as V-ROD are indeed made of about 80% of silica, however in order to have an alkali-aggregate reaction, the silica must be present *in* the aggregates. Therefore, V-ROD will never trigger an alkali-silica reaction in the concrete.

It is true, though, that the fibers themselves need to be protected from the alkali hydroxides naturally present in the concrete. This is why we use a very stable vinyl-ester resin that grants V-ROD its high chemical resistance and protects the glass fibers from the concrete alkalis.

An extensive amount of research has been conducted on the subject, which demonstrate that V- ROD mechanical properties are not affected by the concrete alkalis. V-ROD also meet all the requirements of North American standards for FRP specification.

Is V-ROD's thermal expansion different from that of steel? Does it impact somehow negatively the concrete?

Glass fiber-reinforced polymers, such as V-ROD are anisotropic materials, meaning that longitudinal and transverse properties differ.

The longitudinal coefficient of thermal expansion ranges from six (6) to seven (7) (x 10^{-6}/°C) which is actually closer to concrete than steel is.

The transverse coefficient of thermal expansion is around twenty-four (24) (x 10^{-6}/°C), which is indeed higher than steel and concrete. However, because V-ROD properties are anisotropic, the transverse modulus of elasticity is also different from the longitudinal one.

As all the glass fibers are aligned longitudinally, only the resin contributes for transverse properties. Because the modulus of elasticity of the resin is lower than concrete and considerably lower than steel, the cover to reinforcement required by the Design Codes ensures that the bar is well confined in concrete and eliminates any risk of cracking due to thermal expansion.

Can I replace steel rebar with V-ROD using a 1:1 ratio?

Unfortunately, no. Steel mechanical and physical properties differ greatly from V-ROD. This is the very reason why Design Codes and Design Guides were published solely for concrete reinforced with fiber-reinforced polymers (FRP) such as V-ROD.

It is extremely important to calculate the area of reinforcement based on the Standards that were developed for FRP reinforcing applications. Designing based on steel properties can lead to unsafe structures.

Why do we have to use more bars if tensile properties are better?

It is true that V-ROD guaranteed tensile strength is up to three times the yielding strength of steel.

However, its modulus of elasticity varies approximatively between 40 and 60 GPa, which is considerably lower than steel. Therefore, to adequately control cracking, deflections and tensile stresses in the bars at serviceability limit state (SLS), the area of reinforcement sometimes needs to be increased to compensate for the lower modulus of elasticity, mostly for beams and structural slabs.

Can I use mechanical connectors with V-ROD?

There are currently no mechanical connectors available on the market specifically for glass fiber- reinforced polymers. Therefore, we do not recommend splicing the reinforcement using mechanical connectors.

Reinforcement should be lapped spliced using the provision of either the ACI, AASHTO or CAN/CSA committees. Please refer to our documentation for lap length information.

How do I reinforce negative moment regions with V-ROD?

Negative and positive moment regions are designed according to the Standard in force and the same anchorage principles as steel-reinforced structures apply.

It should be noted, though, that the tensile strength in the bent portion of a GFRP bar is considerably lower than its straight portion. Therefore, should a mechanical anchorage (such as a hook) be required, it is critical to ensure that the tensile stress in the anchorage does not exceed the tensile resistance of the bent portion of the bar. Please refer to the latest version of our specifications. Also, should you have space limitation, we offer anchor heads with our HM product line.

Can I use V-ROD for shear reinforcement?

All design codes include models for shear resistance that take into account the differences between steel and GFRP and ensure the same level of safety.

It should be noted that V-ROD bars cannot be reshaped once fabricated. Also, some stirrups configuration may be impossible to fabricate. In case of doubt about the possibility of manufacturing the desired shape, don't hesitate to verify with us by sending a sketch along with dimensions

Can I use V-ROD for pre-stressing applications?

Yes! We offer a special V-ROD product with carbon fiber instead of glass fiber, specifically developed for this application. You can also refer to the following Design Standards and Guides:

CAN/CSA S806-12 – *Design and Construction of Building Structures with Fiber-Reinforced Polymers (Section 10 – Design of Concrete Components Prestressed with FRP)*

ACI 440.1R-04 – *Prestressing Concrete Structures with FRP Tendons*

Can I use V-ROD for seismic-resistant design? How can I meet the ductility requirements?

When designed properly, concrete elements reinforced longitudinally and transversally with V-ROD will grant a high level of security.

Studies show that V-ROD ties and spirals reach an average of 10,000 micro-strains at the point where concrete is most damaged, without failing. Therefore. V-ROD provides higher confinement at higher strains because it will not yield before concrete crushing, as will steel. As the ductility of a column is directly linked to how well its core is confined, V-ROD ties and spirals not only remove all risk of deterioration due to corrosion, but also increases the ductility of the column.

The fact that V-ROD transverse reinforcement does not yield also prevents early buckling of the longitudinal reinforcement. However, some general precautions must be taken regarding the use of longitudinal GFRP bars in vertical elements in seismic areas, in particular for highly sensible areas such as ductile joint.

It should be noted that, currently, the Design Codes do not allow the design of slender columns reinforced longitudinally with V-ROD. They also do not allow to consider the compressive strength of V-ROD.

Can I use V-ROD if my structure needs to meet fire resistance requirements?

Yes! With a 40 mm concrete cover, concrete elements reinforced with V-ROD can achieve fire resistance rating of 3 hours when they are subjected to their expected service load.

Hence, the use of V-ROD for concrete reinforcement can provide high security, even the structure needs to meet fire resistance requirements.

I need to rehabilitate a concrete structure that was reinforced with V-ROD. How do I locate the bars embedded in concrete?

Bars can be located using a ground penetrating radar to see through concrete. The signal of the instrument is adjusted to detect GFRP bars instead of steel bars.

Can I chip concrete without damaging V-ROD bars?

Generally, concrete structure that were reinforced with V-ROD can be demolished using the same jackhammer technique as steel-reinforced concrete. The bars **must not be hit directly,** as this will most likely damage them. A 15 kg jackhammers can be used to demolish the concrete cover or the areas between the bars, when spacing is sufficient. A 7 kg jackhammer should be used to demolish concrete close to the bars, while carefully avoiding to directly hit them.

I'd like to investigate the use of V-ROD from my project, however I'm not exactly sure how I should proceed.

We have at Inconmat have expert engineers specializing in concrete reinforced with GFRP who can assist you.

Should you have any technical question on V-ROD, on the design process or if you'd like us to revise your design to ensure it meets the requirement of the Standard that needs to be considered for your application, do not hesitate to contact us and one of our engineers will be happy to assist you

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Composite reinforcing rod