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## 1 Reinforcement in tunnelling

There are many construction techniques when it comes to tunnels, among which the cut and cover (open pit) or the more traditional bored tunnel methods. Out of these techniques, the one that makes use of a tunnel boring machine (TBM) is widely spread and supposes the construction of reinforced concrete launch box and extraction shaft.

Although well adapted to boring through concrete, the TBMs are not well-suited to work their way through a steel reinforced concrete structure because of the resilience of the steel. The presence of this kind of reinforcement will seriously hinder the work of the rotary cutters because of its ductility, absorbing the cutter's energy and deforming instead of allowing them to fracture the concrete as they're supposed to.

## 2 Why

### Composite Rebar

To work around these obstacles **V-ROD** composite rebar are used locally in the area where the TBM will be going through the reinforced concrete wall. This section is called the diaphragm walls (Soft Eye).

The elastic to rupture behaviour of **V-ROD** allows the TBM to bore through the so reinforced concrete structure without presenting any more resistance than what would be experienced when boring through rock or unreinforced concrete.

The ultimate result, a reinforcement pattern that exhibits minor differences when compared to the steel version and a greatly improved work schedule since the demolition step needed with steel reinforcement is no longer required. In brief, using **V-ROD** will translate in important savings.

## 3 Advantages

### Time and cost saving:

The use of Pultrall's **V-ROD** GFRP reinforcement bar allows the TBM to cut through the caisson without damaging the equipment or reducing the boring speed, thus providing time and cost savings compared to steel reinforcement. The use of **V-ROD** GFRP rebars also remove the need for a pressure grout block. The anisotropic nature of **V-ROD** allows TBM to bore through station boxes prior to excavation and it allows boring through diaphragm walls.

### Good properties:

Pultrall HM grade of GFRP rebars offer tensile strength up to 199 ksi (1372MPa) and a tensile modulus up to 9,600 ksi (66 GPa). With some of the highest properties available in the world, **V-ROD** is the best GFRP option for your projects. **V-ROD** is available in straight bars, bent bars, circular ties and continuous spirals offering you complete flexibility during the design stage and speeding the installation process.

### Lightweight:

**V-ROD** is approximately one-quarter the weight of an equivalent size steel bar, thus reducing freight and placement costs.

### Approved material:

**V-ROD** is included in the CAN CSA S806-12, CAN CSA S06-06, AASHTO LRFD and ACI 440.1R-06.

## 4 Field Applications

**V-ROD** GFRP reinforcement bar is ideal for soft-eyes, shaft walls, diaphragm walls, drilled pile walls, secant pile walls, slurry walls, form-work anchors and temporary concrete buildings.



### Project: TTC North Tunnels

Engineering firm: **Tarra Engineering**  
General contractor: **OHL/FCC Joint venture.**  
Caisson Sub Contractor: **Anchor Shoring and Caissons**  
Owner: **Toronto Transit Commission**  
Qty. of caisson: **120**  
Length of caissons: **30-35 meters (98 ft. – 115 ft.)**



### Project: Eglinton LRT Cross Town Launch Shaft

Engineering firm: **Isherwood**  
General contractor: **Kenaiden Contracting**  
Caisson Sub Contractor: **Birmingham**  
Owner: **Metrolix**  
Qty. of caisson: **8**  
Length of caissons: **34 meters (111,5 ft.)**



### Project: San Francisco Central Subway

Engineering firm: **PB TELAMON/PB AMERICAS, INC**  
General contractor: **Barnard Impregilo Healy JV**  
Owner: **SFMTA**

## 5 Design and Training

Your steel reinforcement design is already done? Submit it to us and our team of civil engineers will convert it to **V-ROD** at absolutely no charge and provide an economical evaluation of your project. Also, available, custom tailored training in engineering design of tunnelling structures reinforced with composites materials to fit your needs.

Contact: [service@pultrall.com](mailto:service@pultrall.com)

### **A WORD ABOUT PULTRALL:**

*Established in 1987, Pultrall Inc. is the pioneer of non-metallic concrete reinforcement solutions in North America. Pultrall's achievements include some of the most prestigious projects in North America and around the world. The company serves clients through a network of Authorized Distributors throughout North America, Latin America, Europe, Australia and the Middle East.*

### **AT PULTRALL, WE BELIEVE IN CHALLENGING THE STATUS QUO.**

*We are convinced that safe and durable concrete structures are achieved by eliminating the corrosion problem at its roots. Our solution, a stronger, well tested, widely used and corrosion proof reinforcement that advantageously replaces the easily corroded steel rebar. Our solution, **V-ROD!***

**PULTRALL**

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