WELDGRIP GEOTECHNICAL

# Case Study

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| **Project:** | Athens Metro |
| **Client:** | Joint Venture of:<br>SOGEA<br>Attiko Metro A.E.<br>Olympic Metro<br>Public Works (Ministry of Culture) |
| **Consultant:** | Bechtel International Inc. |
| **Main Contractor:** | Olympic Metro. |
| **Products Used:** | Weldgrip Fibregrip® Rockbolts |

The Athens Metro construction project was one of the largest and most complex in Europe. The project was managed by Attiko Metro A.E., with a consortium of 25 Greek, German and French companies as the main contractors, known as Olympic Metro,

The Metro, with a construction cost of 2.2 billion ECU, consists of 2 lines and 21 stations and will serve approximately 140 million passengers annually.

Two 9.5m diameter tunnel boring machines (TBM's) were used to construct 11.7 kilometres of tunnel, a further 2.5 kilometres was excavated by cut and cover methods. The New Austrian Tunnelling Method (NATM) was used primarily for the station galleries, subways and access ways.

The geology of the tunnels was mainly heterogeneous fractured schist. There were also occurrences of limestone and peridotite. Due to the nature of the strata additional support was required in the roof, tunnel sides and floor. Weldgrip Fibregrip® 22mm and 32mm fibreglass rockbolts were used for both permanent and temporary support in these areas.

In areas of the roof where the strata was fractured, Fibregrip® 32mm by 12 metre long bolts were installed forward at the face of the drivage, before excavation by the TBM.

Lightweight Fibregrip® bolts gave better handleability

Installing rockbolts into floor

Installed floor bolt

In areas where the station cross cuts thirled into the the main drivage, the tunnel sides were reinforced by 22mm diameter Fibregrip® rockbolts.

Due to the ingress of water, particularly in the areas of the tunnel where the strata contained the porous limestone deposits, floor heave caused a problem. This was overcome by floor bolting, using Fibregrip® 22mm diameter bolts. These were able to be easily cut out when the floor was regraded.

The Weldgrip Fibregrip® rockbolts used in this project were a polyester glass fibre bar with a tensile strength of 470 kN and 820 kN for 22mm and 32mm diameters respectively. The shear strengths being 167 kN and 275 kN.

All fibreglass bolts were installed into pre-drilled holes filled with (OPC) cementitous grout.

The advantages found in using Weldgrip Fibregrip® rockbolts were:-

1. Ease of installation due to the product's light weight.
2. The bolts were easily cut out by the TBM's without damaging the machine's cutting heads.
3. Bolts which had been partially cut out during regrading and excavation continued to reinforce the roof and sides.
4. The high tensile and shear strengths of the Fibregrip® bolts provided excellent reinforcement in the Limestone and Schist strata beds.

Since completion of the construction of this project further tunnel extension work has been carried out on the Metro System.

The success of Weldgrip Fibregrip® Rockbolts as part of the tunnel reinforcement for both floor and roof in the initial project has led to it's continued use in the new extensions.

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