Case study

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Paris steps into the ring with Combar

The subsurface of the Métro is being reinforced with glass fibre

The ground has been broken: 42 metres deep, up to 1.5 metres thick and about 4 metres wide. Reinforcement cages made from steel and Schöck's Combar glass fibre reinforcement are laid into the slots, then concrete is poured. The diaphragm walls formed in this way protect a 110 x 25 metre shaft. This is where the tunnel boring machine is launched, which is now cutting a 33 kilometre long duct deep beneath the hustle and bustle of the Île-de-France for the new "Ligne 15 South" for the Grand Paris Express.

The Paris Métro network is getting a new ring line. At about 200 kilometres long, the project comprises the creation of four new lines around the capital city and the extension of two existing lines – ninety percent of which will be underground. Added to this are the construction of 68 stations and the development of new city districts around these future urban centres. The "Ligne 15 South" alone, which will be the first section to go into operation in 2022, will have sixteen stations with access to the RER, Métro, and the tram and bus network. Over one million residents in 22 communities will have even closer links to the metropolis on the River Seine as a result of the new line on the Grand Paris Express.

The Paris region has the densest population in Europe. Twelve million people - 19 percent of France's population - live in this conurbation. Then there are 8.3 million professional visitors and over 46 million tourists a year. In order to meet growing mobility needs, the city which wants to ban vehicles with combustion engines from its streets in 2030, is strongly

backing public transport. The Métro line 1 opened in 1900 for the Summer Olympic Games and the World Fair. In 2024 and 2024, both events may well mean new record numbers of passengers.

Quick and easy to machine "Soft Eye"

Europe's largest infrastructure project began in June 2016 where the Fort d'Issy – Vanves – Clamart (FIVC) station will later be located. The first challenge: the 1.2 to 1.5 metre thick diaphragm walls, which retain the over 40 metre deep shaft that admits the tunnel boring machine, must be permanently strong in order to withstand the enormous compressive forces of the earth and groundwater over many decades. However, at the same time, the walls – in contrast to reinforced concrete – must be quickly penetrable by the cutterhead. The solution: a so-called "soft eye" structure.

"Where the tunnel boring machine is meant to go through the diaphragm wall, the steel reinforcement is replaced by stable and at the same time, easily machinable glass fibre reinforcement," explains Faustin Gaufillet, who is the technical sales manager for Schöck's special reinforcement, Combar, in France. "It is crucial for the bars to be resilient enough and for their glass fibres to be protected from the corrosive effect of the alkaline concrete." This is the only way to ensure that the minimum useful life of 100 years, which is so often demanded in tunnel construction projects, can be achieved safely.

Approval as an alternative to reinforcing steel

However, there is no international standard for special applications such as the soft eye construction to date. Approvals on a case by case basis are customary, but they are often time consuming and costly. Schöck Combar is the only glass reinforced plastic bar to have general technical approval from the German Institute of Construction Technology (DIBt) since 2008. The process is similar to the European Technical Assessment (ETA). Moreover, Schöck brings a lot of international technical expertise in planning and implementation to the table, which greatly simplified the approval process in Paris which is based on Eurocodes (EC).

There are historical reasons for this: Combar (from "composite rebar") was developed in the 1990's by Schöck, specifically as an alternative to reinforcing steel. Bars of between 8 and 25 millimetres nominal diameter have a certified long-term tensile strength of 580 N/mm^2 and a design

stress of 445 N/mm^2. These values are valid for all applications and a service life of 100 years. Combar can be used where steel reaches its limits: where there are particular demands in terms of electromagnetic or thermal insulation, chemical resistance or machinability.

High load bearing capacity and efficiency

"Combar is used especially where long durability, high rigidity and formidable load bearing capacity are required," explains Faustin Gaufillet from Schöck. "The latter reduces the amount of material needed at the same time: We were able to more than halve the number of glass fibre reinforcement bars required to absorb the loads in the 40 metre deep diaphragm walls in Paris using Combar compared to the other bidder and also come well below the material quantity stated in the tender documents. This speeds up the construction time, ensures a more even flow of concrete as a result of the greater distances between bars and reduces construction costs."

Approximately 8,500 kilograms of Combar were used for the reinforcing cages per diaphragm wall in Paris. It is quick and easy to install the glass fibre bars with wire or cable ties. The cage is then taken to the construction site and placed in the excavated slots with the aid of a crane which are then filled with concrete using the tremie method. Around 150 cubic metres of concrete were needed for a single one of these diaphragm wall lamellae. It took up to half a day to pour the concrete for one lamella.

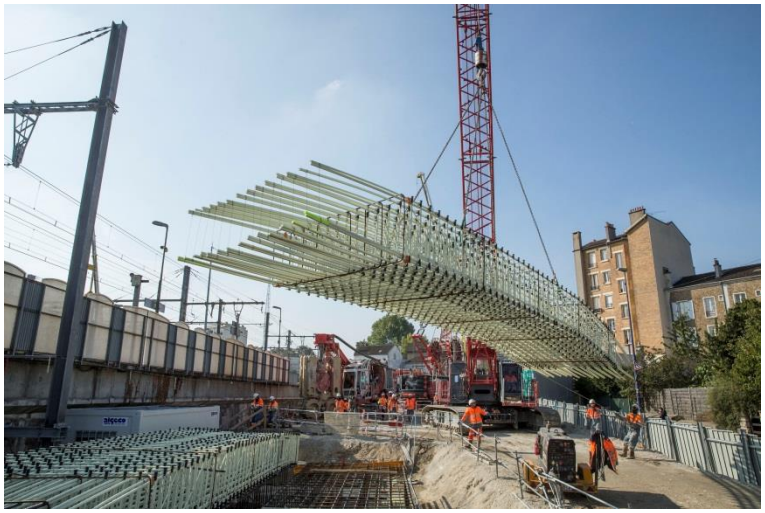
5,248 characters (incl. spaces)

Construction Information Board

Client: Société du Grand Paris
Construction company: Soletanche Bachy France, Rueil-Malmaison
Architect: Philippe Gazeau Architecte, Paris
Structural planning: Soletanche Bachy France, Rueil-Malmaison
Schöck product: 17 tonnes of Schöck Combar
(two diaphragm walls @ 8,555 kilograms)

Captions

[reinforcement cage Combar.jpg]



A pre-assembled reinforcement cage made with Schöck Combar glass fibre reinforcement is delivered by crane. Photograph: Schöck Bauteile GmbH, reprint free of charge.

[installation into the diaphragm wall.jpg]

The glass fibre segments are braced with diagonal Combar bars in both directions to form a stable framework. Consequently, the entire reinforcement cages can be brought into a vertical position over the 40 metre deep shaft for the diaphragm wall without additional steel reinforcement, which means an additional optimisation of the construction process. Photograph: Schöck Bauteile GmbH, reprint free of charge.

[glass fiber and steel reinforcement.jpg]

The reinforcement cages made from glass fibre composite material and reinforcing steel are connected easily and efficiently with wire, clips, cable ties or cable clamps. Photograph: Schöck Bauteile GmbH, reprint free of charge.

[Combar.jpg]

In particularly corrosive environments and when no steel should be used in the construction, conventional reinforcing steel does not meet the specified requirements. This is where Schöck Combar glass fibre reinforcement offers new options. Photograph: Schöck Bauteile GmbH, reprint free of charge.

Installation of the glass fibre reinforcement cages made from Schöck Combar for the tunnel at Fort d'Issy–Vanves–Clamart station in Paris (time lapse). Video: Schöck Bauteile GmbH. You can find the video on the following link: https://www.youtube.com/watch?v=iV3PPu1BU-U

For questions and feedback, please contact:

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