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Using Fiber Composite Materials for More Durable Concrete Structures

Application des fibres composites pour la solidité des constructions

Anwendung von Faserverbundwerkstoffen für dauerhafte Betonbauten

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SUMMARY

In recent years heavy-duty composite materials have proven their applicability in numerous constructions as a corrosion resistant alternative to conventional prestressing steel. This will be demonstrated in the following paper by way of three different constructions. These are the Marienfelde Bridge in Berlin, the braced arched tunnel vaulting in Paris and the prestressing of a three span road bridge in Leverkusen. All of these constructions are in turn equipped with sensors in order to minimize the maintenance costs of controlling the constructions, and in order to increase the durability of the constructions by utilizing composite fibre materials for the prestressing tendons.

RÉSUMÉ

Les fibres composites ont fait leur preuve dans de nombreuses constructions en tant qu'alternative anti-corrosion à l'acier de précontrainte. Trois réalisations illustrent cette application: le pont Marienfelde à Berlin, le haubanage horizontal d'un tunnel du Métro à Paris et la précontrainte d'un pont à Leverkusen à trois travées. Toutes ces constructions sont équipées de capteurs pour faciliter les travaux de contrôle et de fibres composites pour les câbles précontrainte afin d'améliorer la solidité des constructions

ZUSAMMENFASSUNG

Inzwischen haben sich Hochleistungsverbundwerkstoffe als korrosionsbeständige Alternative zum herkömmlichen Spannstahl an zahlreichen Bauwerken bewährt. An drei verschiedenen Bauwerken wird dies im folgenden Aufsatz dargestellt. Es sind dies die Brücke Marienfelde in Berlin, die Abspannung eines Tunnelgewölbes in Paris und die Vorspannung einer dreifeldrigen Strassenbrücke in Leverkusen. Alle Bauwerke sind wiederum mit Sensoren ausgerüstet, um den Wartungsaufwand für die Kontrolle der Bauwerke zu minimieren und durch die Anwendung von Faserverbundwerkstoffen für die Spannglieder, die Dauerhaftigkeit der Bauwerke zu steigern.

1. THE BRIDGE "BERLIN-MARIENFELDE"

A leisure park has been created during the past few years on the site of an earlier refuse depot in Marienfelde, Berlin. This park and a protected landscape area located to the south of the site were to be linked by a public footway. Industrial railway tracks, which separate the two areas from one another, necessitate the construction of a pedestrian bridge (Fig.1) which can also be used by riders and ambulances. During the design work by the Senator for Construction and Housing, it was agreed with Berlin Technical University to use the bridge as a research project for the purpose of study and for the application of new design concepts. The bridge's outline design provides for a 5 meter wide, two span, slab-and-beam bridge with spans of 27.61 mtrs. and 22.98 mtrs. The bridge superstructure has an overall height of 1.10 mtrs. and will be executed for the first time in Germany with a partial prestressing having externally arranged prestressing tendons without bond. The prestressing tendons, a new development by STRABAG BAU-AG, consist of composite fiber materials (glassfibers embedded in a resin matrix) with integrated optical fiber and copper wire sensors for the continuous monitoring of the bridge.

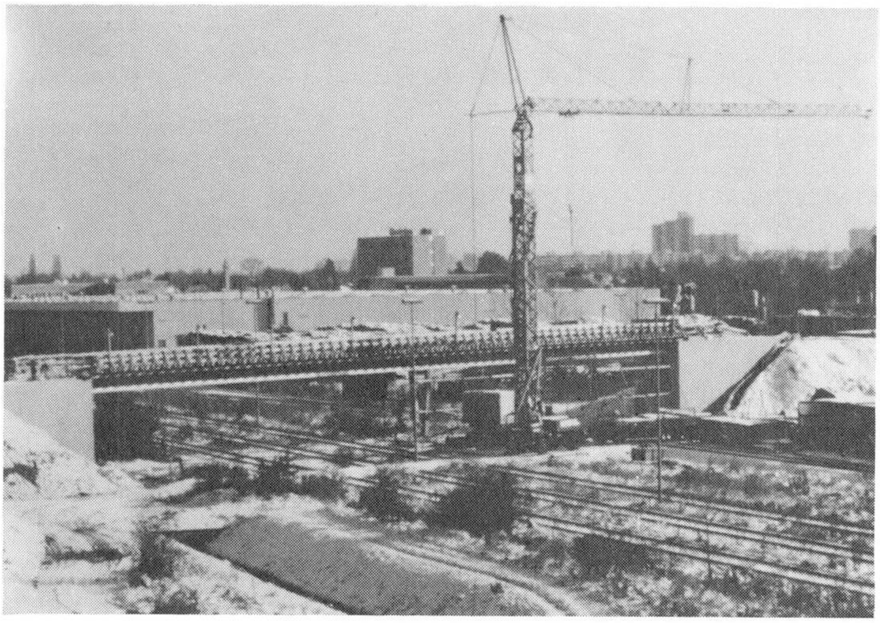


Fig. 1 Bridge Berlin-Marienfelde

1.1 THE PRESTRESSING TENDONS

The utilization of heavy duty composite materials; the future generation of prestressing tendons for concrete structures.

Following the completion of two bridge structures in Düsseldorf, prestressing tendons are again being employed which are composed of individual glassfiber bars. These glassfiber bars, manufactured by BAYER AG under the brandname (R)Polystal, have a diameter of 7,5 mm and comprise of 60.000 glass fibers which are strictly orientated in one direction.

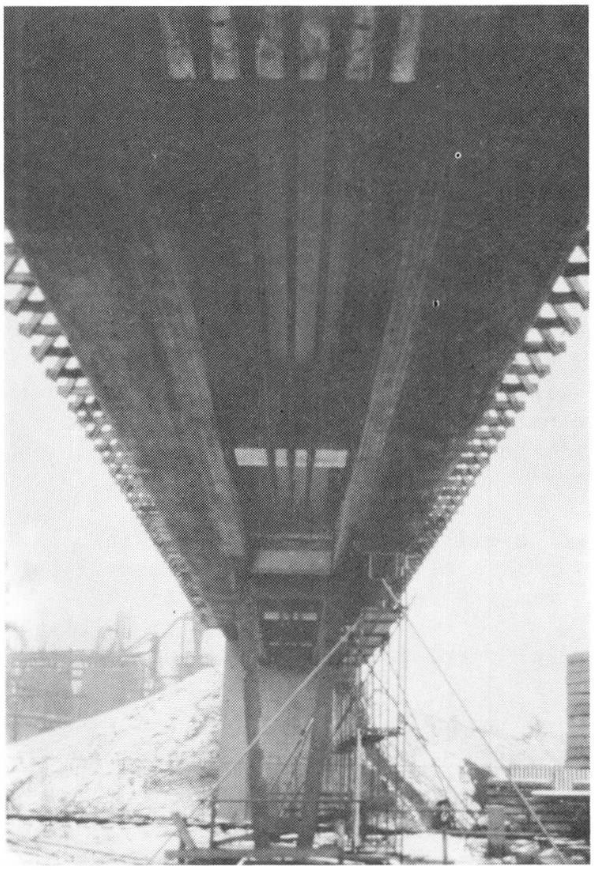


Fig. 2 External application of the prestressing tendons

A total of 19 if these glassfiber bars form one prestressing tendon which is supported against the concrete by means of in-situ-grouted anchors developed by STRABAG BAU-AG. The bar material is a further development of the prestressing tendons on the Ulenbergstraße Bridge in Düsseldorf. The innovation in this case is, however, the external application of the prestressing tendons. The tendons (Fig.2) run externally between the two main bridge beams, around each of two transverse beams in the bay sections and then upwards along the central colum over the transverse beam (Fig.3). Since the prestressing elements are accessible at all times, they can easily be checked and, if necessary, replaced. This means a bridge design which is easy to maintain.

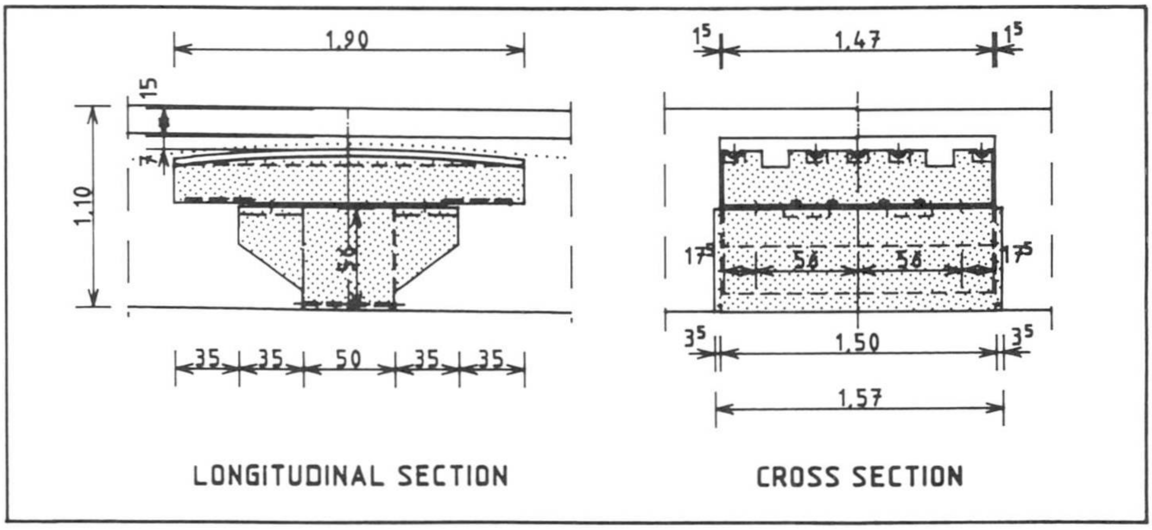


Fig. 3 Diversion support for the prestressing tendons

1.2 LOADING TEST OF THE BRIDGE

In order to be able to study precisely the loadbearing behaviour of the bridge's design, the bridge is subjected to an imposed load of 1.5 times the live load (7,5 KN per sq.mtr.). The load is simulated by means of a total of 250 pieces of reinforced concrete slabs (weight of each slab 10 KN) having a total load of 2500 KN. The deflexion of the bridge spans, the bearing forces, prestressing tendon forces and the strain on the steel concrete reinforcement were measured.

2. BRACING UP OF ARCHED TUNNEL VAULTING

The abutment strength of a station's vaulting has decreased unilaterally due to a construction pit located in the vicinity of this subway station in Paris. Thus, a prestressed tie rod has to be built in order to prop up the vaulting (Fig. 5).

The abutment for the tie rod consists of steel anchors cast in-situ into the vaulting's supports. The tie rod itself consists of 36 composite glass fiber prestressing tendons with a working load per prestressing tendon of 650 KN.

The client decided on the employment of composite fiber materials for the following reason.

- electromagnetic neutrality
- excellent resistance in agressive media
- controllability by means of integrated optical fiber sensors
- low specific weight (hence less supports required for the prestressing tendons).

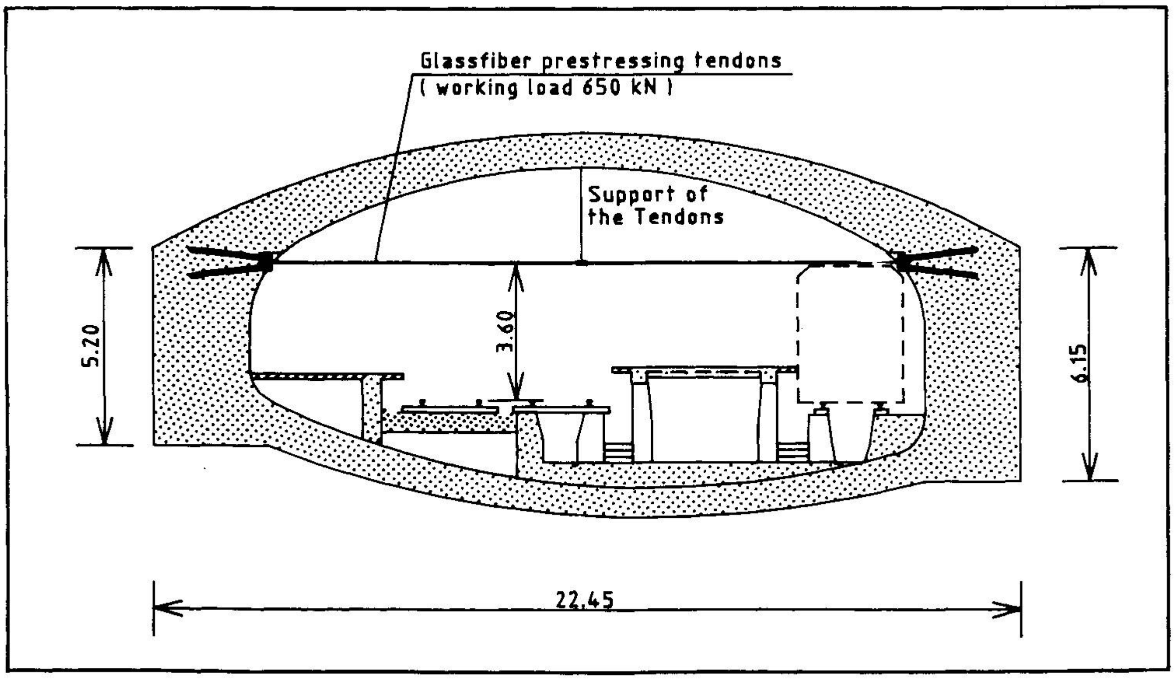
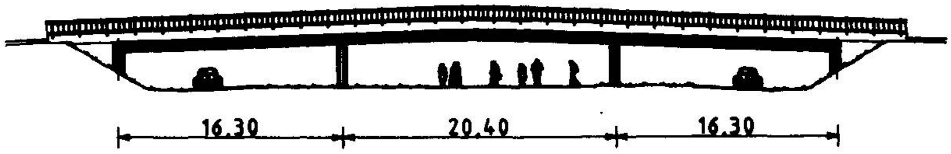


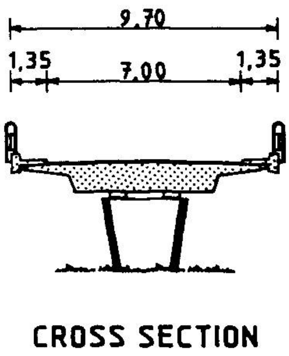
Fig. 4 Cross section of the subway station in Paris

3. TRIPLE SPAN ROADBRIDGE

This triple span road in Leverkusen crosses the entrance to a multi-storey carpark of Bayer AG (Fig. 5).

The spans amount 16,30/20,40/16,30 mtrs. The cross section of the bridge superstructure has a height of 1,10 mtrs., a width of 9,70 mtrs. and is a solid slab beam construction. Limited prestressing is applied. The bridge category is 60/30. The prestressing tendons consist of glassfiber composite bars with integrated sensors. The concrete structure is also monitored by optical fiber sensors surface installed on the concrete after construction.





Technical data

Spans	L1=L3:L2=16.30:20.40
Slab widht	9.70m
Slab thickness	1.12m
Clear height	3.00m
Load class (DIN 1072)	60/30
Degree of prestressing	Partial
Nature of the composite action	post-tensioning with subsequent bond

Fig. 5 Triple span roadbridge

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