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CFRP-Tendons - Development and Testing

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Abstract

CFRP (Carbon Fibre Reinforced Plastics), developed for the aerospace and aircraft industry, are increasingly becoming an interesting material for civil engineering. Especially the strength and stiffness in relation to weight makes them an ideal material for cable-stayed bridges.
The aim of a common research project, sponsored by the Bavarian Ministry of Economy, Traffic and Technology and conducted by the Technische Universität München (Lehrstuhl für Massivbau) and DSI (DYWIDAG Systems International), was to develop a CFRP-tendon.
Since 1983 stay cable specimens and anchoring systems have been tested at the Technische Universität München. With the testing machine (figure 1) it is possible to apply forces up to 19000 kN in dynamic and static tests.

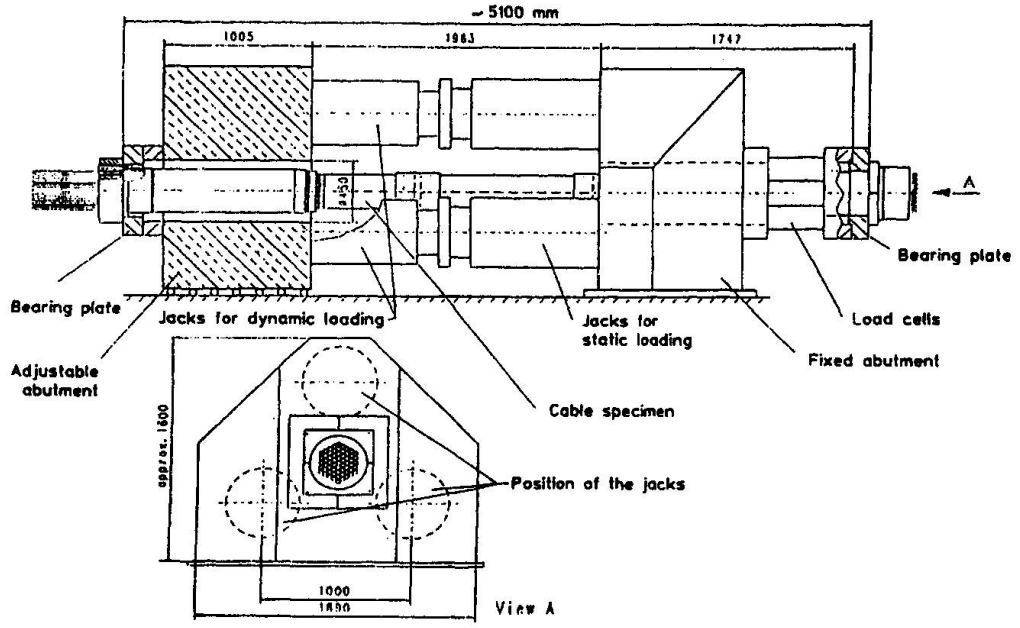

Figure 1: Stay cable testing equipment at the Technische Universität München

This paper deals with the development and the testing of this CFRP-tendon. The major problem are the anchorage systems where high forces have to be applied to the cable specimen. A FEM calculation verified by tests builds up the foundation for a practical anchorage system. The constant development led to the anchorage system for 91 CFRP wires, which was tested under dynamic (according to the PTI recommendations for stay cables) and subsequent static load in 1998.

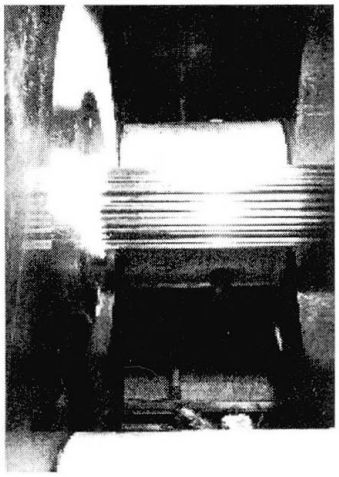

Figure 2:
Anchorage before the ultimate strength test

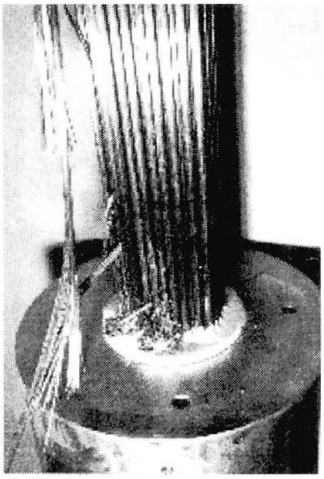

Figure 3:
Wire fracture at the anchorage

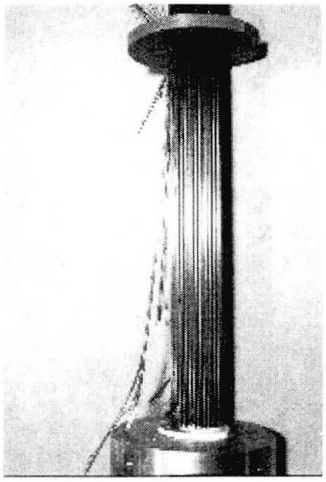

Figure 4:
part of the free length of the specimen

During the fatigue test no wire fracture occurred in the free length or in the anchorage of the cable specimen. The displacement of the adjustable abutment (anchor block) at maximum load increased due to the application of two million load cycles by 1.10 mm. This elongation was mainly caused by the pull-out of the potting material from both steel hulls. The stay cable showed very good dynamic properties as expected from CFRP. After the fatigue test was completed the static load test was performed. The cable was loaded up to a load of 3600 kN. The ultimate load of a single CFRP-wire was 50 kN. Corresponding to these value the ultimate load of the cable is equivalent to 78% of the theoretical ultimate strength. The specific elongation of the whole cable specimen corresponding to this load was about 1,9 %. The test was stopped after six wire fractures of which the first occurred at a load of 3500 kN. Due to the type of material the wires failed in the linear elastic region of the stress elongation line. The cable specimen broke wire by wire not as suspected with a sudden fracture of the whole cable specimen. Figure 2 shows the specimen at the anchorage before the ultimate strength test. The wire fractures are shown in figure 3 and 4.