Tests and Inspection for German Bridges with stay cables using prestressing strands according to *fib*-recommendations

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Summary

In the past all large stay cable bridges in Germany were built with locked wire ropes. For a new project, Ziegelgraben-Bridge crossing the “Strelasound”, the contract award also had allowed offers with stay cables using prestressing strands for tendering. Resulting from the good experience with this bridge a second bridge project with stay cables using prestressing strands, a bridge crossing the river Rhine near Wesel, was charged. Since no supplier had a general approval for these strand stay cables many tests according to the new *fib*-recommendation had been required. Before executing the bridges with stay cables using prestressing strands special requirements for the life time of the bridge were defined to ensure the durability and sustainability of the structure. The exchangeability of a stay cable as well as of a single strand has to be possible.

Keywords: Stay cables, strands, full scale testing, fatigue, exchangeability, fib-recommendations, strands, water-tightness

1. Projects

The stay cable bridge crossing the Strelasound at the Baltic Sea was constructed with a total length of 583 m and a main span of 198 m. The steel superstructure with width of 16 m is connected to the pylon by cables arranged in harp-shape in two plains.

The structure of the bridge crossing the river Rhine near Wesel with a length of 772 m shall replace the existing bridge. The maximum cable length of this bridge is 282 m. The tender also allowed offering cables using strands. Totally twelve groups of stay cables are anchored at the pylon each consisting of six stay cables.

The German approval body (Deutsches Institut für Bautechnik, DIBt, Berlin) was charged to establish an experts’ report, based on that the specific project approval could be given. On basis of the requirements of the tender and the regulations of the *fib*-recommendations [1] the DIBt together with an expert team defined requirements for the specific project approval.

2. Stay Cable System

For both bridges the stay cable system DYWIDAG DYNA Grip® was used. For the Strelasound Bridge type DG-P 37 with 34 strands, for the bridge crossing the river Rhine stay cables type DG-P 37 and type DG-P 55 are used.

The stay cables have a stressing anchor at the side of the superstructure and a dead anchor at the pylon-side. All anchors consist of tightening elements to avoid leakage in the wedge area. As tensile

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elements 7-wire cold-drawn strands Ø 15.7 mm, hot-dip galvanised and waxed, PE-mantled are used that are anchored with three part wedges.

3. Performance of tests for the specific project approvals of the stay cable system

3.1 Static tensile test and fatigue test required for the approval

After a lot of tests on single strands were completed three fatigue tests with subsequent tensile test on DYWIDAG stay cables DYNA-Grip® DG-P 37 with 37 strands had to be performed for the project Strelasound Bridge. For the bridge crossing the river Rhine two additional full-scale tests on stay cables with 55 strands according to the *fib*-recommendations [1] had to be performed.

All stay cable specimens with anchorages on both sides were installed in the testing machine of Technische Universitaet Muenchen. The abutments of the testing machine were inclined 0.6°, whereby possible imperfections as well as the influence of oscillations caused by wind and traffic should be covered. The fatigue tests were performed with an upper stress according to 45 % of the nominal breaking load. In all tests during the $2 \cdot 10^6$ load cycles less than two wire fractured occurred. The requirements on the static tensile test were fulfilled, too.

3.2 Exchangeability test

The possibility of exchanging a single strand was checked in a test. After stressing again to service load, the tightness of the anchors was demonstrated by vacuum test.

3.3 Water-tightness-test

A water-tightness-test according to the *fib*-recommendations [1] was performed on a stay cable with 37 strands in a vertical test rig filled with coloured water. After ten axial load cycles the cable was anchored. Eight temperature cycles between 20°C and 60°C followed. Within the temperature cycles four phases with transversal movements (100 mm) of the upper anchorage with each 250 cycles were applied. The applied corrosion protection system in anchorage area avoided leakage into the inner of the anchor.

4. Quality control and inspection

For all system components of the stay cable and the procedures for the usage and assembly, a comprehensive quality assurance system complying with EN DIN ISO 9001 was installed. The various steps of the QM-System were documented. Additionally to the usual inspections the suitability of inspection methods had to be tested. Thus, the inspection of the ducts by camera, cable testing using magnetic induction and lift-off tests on a single strand had been demonstrated at Strelasound Bridge.

5. Conclusions

The good experience of Strelasound Bridge initiates to execute also the bridge crossing the river Rhine near Wesel with stay cables using prestressing steel. The durability and long-term-behaviour of the cables using prestressing steel will be observed in the following years. The German approval body (DIBt) is working to create the conditions for the apportionment of general approvals for stay cables using prestressing strands.

6. References

[1] FÉDÉRATION INTERNATIONALE DU BÉTON (*fib*). “Recommendations for the acceptance of Stay Cable Systems, using Prestressing Steels”, *fib-Bulletin 30*, 2005.