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STATE OF THE ART NEW PRODUCTS AND METHODS FOR CABLE BRIDGES SMALL AND BIG

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Summary

This paper shall present new products and construction methods for cable bridges to address the issue of fatigue resistance and the need for load monitoring in tension members.

After a short description of the historical development of cable bridges, the focus changes to bridge systems using hangers of various types. Three typical examples, all bridges for tramways with high dynamic loads, are presented. Requirements and solutions for fatigue resistance and load monitoring, which are very relevant for such type of bridges, are described in detail.

Recent developments for cable and rod hangers are ensuring safe use for any bridges, even with high fatigue loads, as well as deliver monitoring data of forces during erection and the life span of the structure.

Keywords: cable bridges; fixed length cables; fatigue resistance; fatigue damage; tension meter; ultrasonic load measurement; load monitoring; dynamics

1. Introduction: History of wire rope and cable bridges

Various materials have been used as tension members carrying most if not all loads in all sorts of bridge-like structures for thousands of years. In modern times, one of the pioneers in engineering long span tension structures was Eng. John Roebling. His first wire rope suspension aqueduct was built in Pittsburgh in 1844-1845 and was, arguably the “game changing” use of new material for long span structures.

2. A Short story of up to date tramway bridges

2.1 Pont Raymond Barre, Lyon

The Lyon tramway comprises six lines. The original tramway network in Lyon was open in 1879, and the modern network was re-built in 2001. Line T1 was extended during the years 2011-2015. The Raymond Barre bridge is crossing the Rhone river to connect the Musee de Confluence. Designed by Alain Spielmann, it is a double arch bridge, whose arches are slightly tilted to the outside. Its steel deck is suspended from the arches using full locked cables. Requirements of the tender asked for fatigue resistance of the hangers. Furthermore the forces in hangers should be controlled during erection and loads monitoring was required for construction and then during operation of the bridge.

2.2 Pont du Rhin, Strasbourg

The city of Strasbourg is operating a network of six tramway lines, built from 1878 until 2000. Recent extension works of the tramway system have been done during the years 2013-2016. Amongst others Line D was elongated, which meant a new bridges to connect both sides of the Rhine river to Kehl am Rhein.

The bridge specifications required fatigue resistant tension rods.

2.3 Pont Citadelle, Strasbourg

This bridge is also serving the extension of tramway line D in Strasbourg, but on the French side. It is crossing a harbor area called Vauban.

All hangers were required to be fatigue resistant.

3. Recent developments and improvements for cable and tension rod hangers

3.1 Fatigue Resistance

On the initiative of one of the industry leaders, an efficient solution for the fatigue loads resistant cable systems has been developed. Based on the governing codes, test results and the engineering science produced to date on the subject of the fatigue loads in tension members, the engineers of Pfeifer Structures developed the theoretical models of the fatigue resistant end fittings (i.e., terminations) for any given size of cable system. Now, this model is in full operation on real structures.

3.2 Load Scan System

Precisely defined forces in a tension member is a fundamental part of the engineering responsibilities on any project with such members. If a load in already installed fixed length cable system is to be measured accurately, a 3rd party device had to be used for that exercise. It is cumbersome, expensive and may require the closure of the structure for its intended use for the time of measurements.

This is about to change due to the invention of the Ultrasonic Load Monitoring method.

It is based on the “acousto-elastic effect” of materials, and it has been used in the aerospace industry for several years. A simple example of this method is the measurement of tension in a bolt using the ultrasonic sensors. Pfeifer has developed the special pins, which are part of most cable fitting, with an ultrasonic sensor that can measure the force in the pin and convert it to the actual axial force in the cable. Once installed, the pin is calibrated against a known load cell values and the calibration is stored on the pins ID chip. The new ultrasonic load measuring technology has been tested at the university of Leeds, UK and at University of Braunschweig, Germany, as well as in the Pfeifer testing laboratories. During this testing it has achieved an accuracy of ±1.5% of the actual design loads measured on a traditional high load stretching machines.

For temporary monitoring Pfeifer has developed a handheld load-monitoring device. This device allows quick and easy “plug and play” measurements and is an excellent tool to aid in the installation of cable assemblies and stressing operations. It also offers a quick and easy method for the check of load on these structural assemblies at any time during the structures life.

4. Acknowledgements

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5. References

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