Forward Analysis and Erection Control of Gwangyang Bridge

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Summary

On the south-central coast of South Korea, in South Jeolla Province, the port of Gwangyang is situated with the famous Gwangyang Bridge. The main span of the suspension bridge is 1545 m long, both side spans amount to 358 m.

Due to the long span length and construction complexity of the Gwangyang Bridge, the sophisticated computer aided simulation of the bridge erection was needed. The numerical simulation was based on the non-linear form finding procedure of the target geometry in the first step, followed by the detailed forward analysis for all construction stages up-to the time infinity.

The simulation technique, proven with today's fourth span length of 1545m, is outlined and presented in this work. For the purpose of the simulation one global bridge model has been used. The bridge geometry, predicted with a computer simulation, showed very good agreement compared to the "as built" geometry on site. Integration of engineer's experience with sophisticated computer software was a key of success in this project. The systematic of the bridge erection simulation methodology can be applied to suspension bridges of any kind.

Keywords: suspension bridge; numerical analysis; modeling; non-linear analysis; free cable lengths; construction sequence; optimization; bridge software; form finding; cable sagging

1. Introduction

Gwangyang Bridge, with its total length of 2.260 m, is one of the largest suspension bridges in the world. The bridge connects Gwangyang City through Myodo Island with Yeosu City, Figure 1, where the 2012 Expo was held, so it played an important role in tourism during the Expo (8,2 Million visitors) and still does.

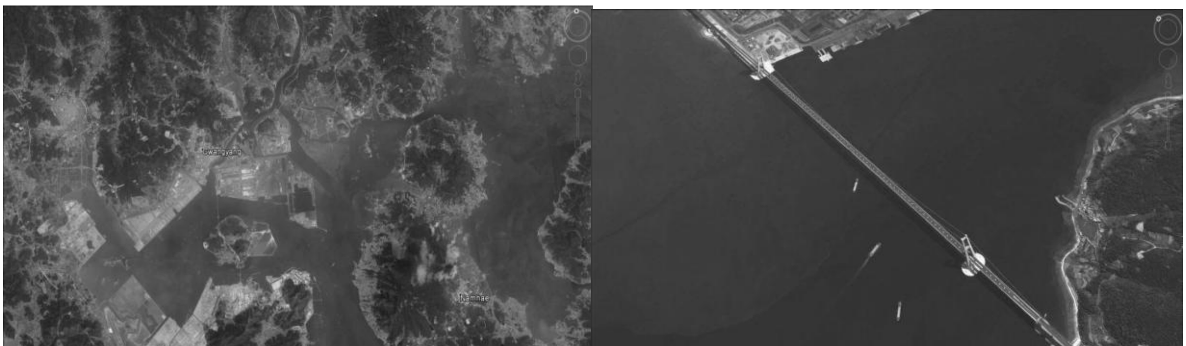

Fig. 1: Gwangyang city and Qwangyuang bridge in South Korea (source: Google Earth)

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The final shape of a suspended cable depends on the loading of the cable and on the cable tensioning force, which in turn depends on the actual elongations of the "stress-less" cable length. In suspension bridges, transverse loads on the suspension cable are caused by the self-weight and loading of the super-structure, which is transmitted to the suspension cable via hangers. The normal force in the main suspension cable of Gwangyang Bridge is anchored at the end anchor blocks.

Two step procedures are used for the forward analysis and erection control of the Guangyuang Bridge. In the first step the stress-less lengths of the suspension system (main cables and hangers), which correspond to the predicted permanent loading in the final stage and designed bridge deflection shape, are determinate. In the second step, detailed simulation of the bridge construction sequence is executed using forward analysis method.

2. Reference geometry

The process is applied iterative; the results from the previous iteration have been reused in the next iteration. The optimization workflow is shown in the Figure 6. The initial values for stress-less length are taken equal to assembled length in initial bridge model given by engineer.

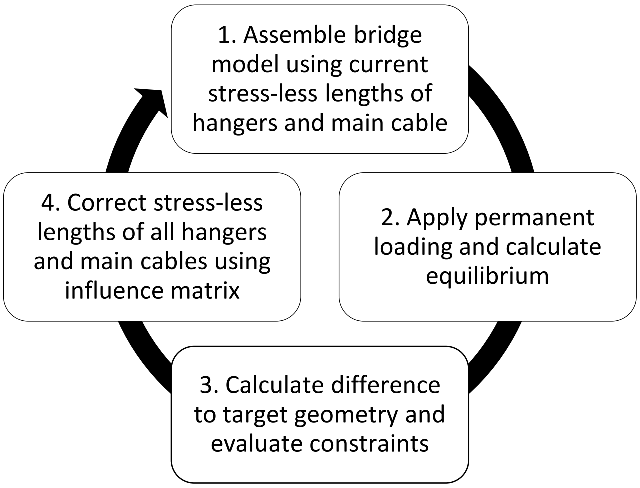

Fig.2: Iteration workflow of form finding

3. Forward analysis

In the forward analysis, all relevant construction stages has been simulated: building the pylon, installation of the main cables, "moving the saddle" at the top of the pylon, assembling of the deck segments supported only by one hanger, simulation of "welding" procedure with a frozen small rotational "kink" designed by engineer up-to the bridge closure and time infinity.

4. Conclusion

The invariance of the stress-less length on the construction stage of the bridge has been used in this process; "stress-less" length from the form finding optimisation (step 1) are reapplied as a "loading" in the forward analysis (step 2). This allowed for consistent numerical simulation of the bridge construction where large both displacement theory and cable non-linearity are combined.

The results of the simulated erection control showed excellent agreement with real state on site (source: contractor Daelim). Therefore the systematic of the forward analysis using the "stress-free" length as applied "loading" is recommended for the geometry control of suspension bridges of any kind.