CABLE-STAYED FOOTBRIDGE DECK CONSTRUCTED WITHOUT 'TENSIONING' OF CABLES – DESIGN VS. ON-SITE REALITY

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Summary

Cable-stayed footbridges provide flexibility to span greater distances in order to mitigate or to completely eliminate problems imposed by urban infrastructure located below. These bridges are often built in a segmental manner by cantilevering deck segments out and sequentially tension the cables as the works progress. The ability to tension the cables, and therefore adjust the deck geometry, during construction gives the design engineer a better control over the build-up of stresses and displacements leading to the final intended geometry representative of the cable forces. However, in some instances this is not always practicable and / or safe due to the site constraints such as a busy highway. Narellan Rd Upgrade BR2 was designed and constructed without the phase of cables tensioning. The deck geometry and cable lengths were predetermined to achieve the final design deck profile and cable forces.

Unlike the cable tensioning approach (cables are tensioned after installation), the predetermined cable length method relies on attaining the design tension through elongation of stays under the self-weight of the deck during erection. Therefore, the determination of the cable lengths and the bridge deck pre-camber are essential in this design methodology. The designer must develop a geometry control protocol, which provides the basis for any geometrical / profile adjustments during erection (at cable turnbuckles), if required. This process involves providing detailed stage-by-stage displacements of all critical points of the structure, which sufficiently approximate the geometrical changes during erection and enable their assessment and a comparison to the design.

In this paper the design methodology of the sequenced construction and the on-site geometry control protocol during the bridge erection are presented along with the impact of fabrication and construction tolerances and the temporary splice details on the footbridge design. Results of design and cable adjustment analyses are incorporated and compared to the final as-built cable forces and the deck geometry. This publication also presents the details of cables adjustment methodology with its specifics and key learnings

In this pre-determined length methodology depending on the arrangement of the structural system, its stiffness and construction sequence it may not always be possible to achieve the desired cable forces without tailoring the deck vertical profile to suit the design intent. The flexibility of steel as a material and ease of fabrication enables the designers to detail an erection pre-camber such that a certain state of stress can be introduced into the structural system. This maneuver has successfully been deployed on BR2 in order to enforce sufficient elongation of the longest cable to reach the required tension force. The detailed deck pre-camber and cable lengths allowed for a 100mm lift above Pier 2 resulting in additional vertical displacement of the deck and hence additional tension in the cable.

The adopted design and construction methodology of the cable-stayed deck erection without tensioning of the cables can successfully be implemented provided that:

- The design bridge engineer determines design criteria for any temporary works, which may affect the erection methodology and consequently the deck profile and cable forces;
- Geometry control protocol is extensive enough to provide sufficient (3D) understanding of the displacements of the structural system throughout the erection phases;
- Engineering supervision and live monitoring of displacements is present during subsequent stages;
- Aspects of fabrication and construction tolerances are understood and considered;
- Aspect of practicalibility of turnbuckle adjustments are understood and considered;
- Aspects of cables forces susceptibility to changes in geometry are understood and the potential impact on servicability performance of the deck / cables is considered;
- Acceptance criteria are defined.

Keywords: footbridge; cantilever erection; pre-camber; geometry control; turnbuckles; pulling jacks.

https://doi.org/10.24904/footbridge2022.258