DOI: 10.24904/footbridge2017.08794

MODELING CONSTRUCTION OF FOOTBRIDGES WITH CABLES

Jose A. LOZANO-GALANT

Associate Professor
University of Castilla-La Mancha
Ciudad Real, Spain

Joseantonio.lozano@uclm.es

Jose TURMO

Associate Professor
Universitat Politècnica de Catalunya-BarcelonaTech,
Barcelona, Spain

Jose.turmo@upc.edu

Summary

The usual moderate dimensions of footbridges allow design architects (and sometimes engineers) to provide such structures with capricious forms. Under such circumstances, the analysis of the service state is usually very thorough, devoting to the study of the construction stages much less attention. However, it is very well known that the construction procedure can determine the service stage. Moreover, dimensions of footbridges also allow a wide range of construction procedures. For example, when cables are used to help to support the deck, as in cable stayed bridges, those are, namely, cantilever method, temporary support method, movement of the bridge to its final position as well as bridge launching. When the cables are used in tied arch bridges most of the previously mentioned methods might be used, especially temporary support method, movement of the bridge to its final position as well as bridge launching techniques. Having this in mind, it is crucial for the designer and for the contractor to have practical tools for construction control of the tensioning process of the stays, as this will condition the service stresses of the bridges. This is challenging, as the prestressing of one stay affects the stresses of the already installed stays. This paper will present a procedure to calculate the stress to be given to the first strand of a stay when the strand by strand tensioning technique is used. Also, a procedure to modify the tensioning process of a cable supported bridges to minimize deviation between design and actual stay stresses in service will be presented.

Keywords: cable stayed bridges; strand-by-strand stressing technique; construction modelling; prestressing; service state; stressing process

1. Introduction

Most cable-stayed footbridges are built on temporary supports. In this erection method, the bridge superstructure is first erected on a set of temporary and permanent supports (Figure 1.A). Then, during the tensioning process, the load counterbalanced by the temporary supports is successively transmitted to the stay system. At the end of this tensioning process, a target geometry or stress state, known as the Objective Service Stage (*OSS*), (Figure 1.B) is achieved.

In order to achieve the *OSS* at the end of the construction process careful simulations are required. In fact, many researchers and practitioners have stated the importance of this simulation. The traditional method to simulate construction process of cable-stayed bridges is to start at the *OSS* and dismantle the structure. Several authors have proposed methods based on this “backward” approach both for the temporary supports, and the cantilever erection method. The main inconvenient of this simulation is the difficulty to model any modification in the bridge design and/or in its tensioning strategy as well as to model the effects of time-dependent phenomena. To overcome these problems, a forward simulation, which follows the erection sequence on site was proposed for the temporary supports and the cantilever method. Most of the simulation methods presented in the literature assume that any construction stage can be obtained by deactivating or activating group of elements, loads or boundary conditions from the following or the preceding construction stages. This hypothesis assumes that the construction process can be simulated by linear superposition of stages. Other works proposed a direct approach that avoided the need of this superposition of stages. This procedures increased computational efficiency.

Figure 1. Cable-stayed footbridge in Toledo (Spain) built on temporary supports. (A) Deck erected on temporary supports and (B) Finished structure or OSS. Pictures of Ramón Sánchez de León (AIA)

Cable-stayed bridges are extremely redundant structures and the effect of tensioning one cable has the effect of changing the stresses of the already installed cables. In most cases deviations between the modelling of the tensioning process and the actual results obtained on site arise. In order to adjust the final stresses in the cables, a final restress of the stays is unusually required. This re-stressing operation is usually done for the whole cable, as the strand-by-strand stressing technique used for the first stressing operations (Fig. 2), cannot be used anymore. This last operation is costly, time consuming and has less accuracy, compared with the strand-by-strand tensioning technique.

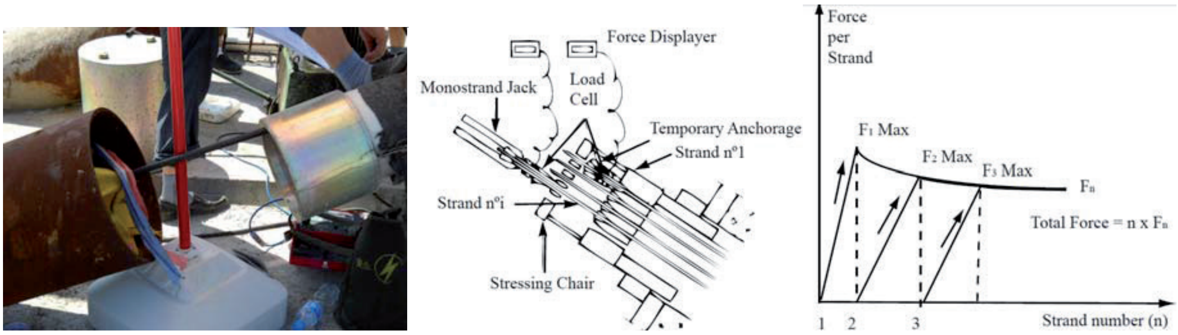

Figure 2. (A) Multi-strand stay cable, (B) Technology of the Isotension method and (C) Isotension principle diagram.

This paper presents a method, the Forward Direct Algorithm, *FDA*, to simulate the construction process of cable-stayed footbridges built on temporary supports. This procedure updates the tensioning operations if deviations with the simulation are measured on site. In this way, the chances of requiring a restressing operation are diminished. This algorithm also enables the simulation of the stresses in the strand-by-strand tensioning technique. In order to illustrate the application of this procedure a cable-stayed bridge is analyzed.

Acknowledgements

The authors thank the Spanish Ministerio de Economia y Competitividad and the FEDER funds for the funding provided through the research grant BIA2013-47290-R directed by Jose Turmo.