4D Full-Scale Finite Element Analysis of Long-Span Composite Box Girder Bridges

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Summary

In bridge engineering, besides the design in 3D space scale, the construction at the time scale is also an important aspect that will influence the performance of a bridge in use stage. Two aspects of work were contained in this paper. Firstly, based on a three-span composite bridge of continuous box girder (88m+156m+88m), a full-scale finite element model was constructed in the program Midas FEA. Specially, the box girder was consisted of corrugated steel webs and concrete flanges. Secondly, focusing on the connection style, two types of connectors including headed stud and 'perfobond strip' were applied in the composite box girder. With the simulation of 4D full-scale finite element model, the results wear reasonable and exact. And the comparison research indicated that the program with stud connectors had a smaller stiffness and a better stress condition. The 4D full-scale finite element analysis method may provide reference and experience for further study.

Keywords: 4D full-scale; composite box girder; corrugated steel webs; connectors; finite element analysis.

1. Introduction

During the past decades, corrugated steel webs were introduced to replace the stiffened steel plates of box girders for bridges. Generally, beams and girders with corrugated webs are more economical and improve the aesthetics of the structure (Sayed and Ezzeldin 2001). In 1982, the advantages of using trapezoid corrugated steel webs along with external pre-stressing for box or I-girder composite systems in bridge construction were recognized by Campenon from France (Cheyrezy et al. 1990). French research started in 1983 and led to building of four bridges between 1986 and 1994. In Japan, similar research led to construction of three bridges with corrugated webs between 1993 and 1998 (Naito and Hattorim 1994; Metwally and Loov 2003). One of the most critical issues in design of composite girders is the connection reliability between steel girder and concrete slab. Currently two types of connectors are widely used to realize compatible deformation of steel and concrete, i.e. the headed stud and the 'Perfobond strip' (PBL connector) (Kraus and Wurzer 1997; Sasri et al. 2004; Shim et al. 2004; Lee et al. 2005). Both types can transfer shear force and prevent separation between two parts of composite girders, i.e., anti-shearing and anti-uplift.

As the development of computers, finite element programs have been widely applied in analysis and design of composite bridges. In small scale, the mechanism of composite girder could be simulated exactly by fine finite element analysis. But in large scale, such as long-span bridges, the finite element usually should be simplified to save computing time (Mabsout et al. 1997; Sebastian and Mcconnel 2000). In this study, a full-scale finite element model of composite box girder bridge with corrugated webs was constructed in the program Midas FEA. As considering time scale, this 4D full-scale finite element analysis was conducted to exactly simulate the authentic construction, shrinkage and creep of concrete, effect of pre-stressed-strand, and slip effect. Furthermore, to compare the exact performance of headed stud and PBL connectors, two models with different connectors and construction were compared to approach an optimization design.

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