Multiscale Analysis of the Arch Feet Zone for CFST Arch Bridges with Steel Truss and Tie-Beams

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Summary

As the key sub-structure of this kind of bridges, the arch feet play an important role securing the safety and good serviceability of the entire bridge, and consequently the study on the mechanical behavior of the arch feet is essential for both the analysis and design of the whole bridge. However, the traditional local-elaborate modelling method for the study is enslaved to the strong dependence of the Saint-Venant Principle and significant influence of the Fuzzy Region, leading to unreliable analysis results. To solve this problem, the multiscale modelling method is introduced in this paper, employing the flexible boundary conditions (BCs) for the simulation of the complex BCs of the arch feet. A multiscale model of the arch feet is then established according to the prototype of an actual CFST arch bridge project, Dalian 1# Bridge in Dalian, China. Simultaneously, a local-elaborate model is built for comparison, and a global-elaborate model, which denotes an elaborate model of the entire bridge using shell and solid elements, is built for further validation. Intensive comparison study of the three finite element models shows that the result of the multiscale model is reliable without the influence of the Fuzzy Region. It is also demonstrated that the multiscale modeling method is accurate, efficient and well applicable for the study on the arch feet of CFST arch bridges. It is concluded that the multiscale modelling method may offer a more reasonable and reliable approach for the analysis of the arch feet zone, persisting high efficiency and well applicability

Keywords: multiscale; modelling method; arch feet; CFST arch bridge; FEA; Saint-Venant Principle; Saint-Venant Region; Fuzzy Region; flexible BCs; hard BCs.

1. Introduction

The real bridge structures differ from traditional finite element (FE) models because of their multiscale geometrical and mechanical characteristics (Nie *et al.* 2014). As shown in Fig. 1, the scale increases from decimeters to kilometers as system level developing from material to structure. Hence, the basic mechanical theories for various system levels of different scales are different: fracture mechanics and interface mechanics for concrete-filled-steel-tube (CFST) as a material scaled in decimeters; mechanics of materials for transverse beams and arches as structural members scaled in meters; Saint-Venant Principle and mechanics of materials for the arch feet zone as the

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