Refined Stress Check of SpecialConcrete Box Girder Bridges at Serviceability Limit State

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Abstract

For shallow beams, stick models are frequently used to perform the stress check at serviceability limit state with the plane section assumption. However, the behaviour of specialprestressed concrete box girder bridges, such as multi-cell box and curved box girder bridges, is more complicated than shallow beams and does not comply with the plane section assumption exactly. As a result, the load distributions and spatial effects in the structure should be analysed clearly when doing the stress check at serviceability limit state. A proper spatial model called spatial grid model is used in this paper for the behaviour analysis of specialprestressed concrete box girders. Two examples are listedin this paper.In the last part, a refined stress check method based on plate elements is proposed to ensure the safety of specialthin-walled structures.

Keywords:prestessed concrete; special box girder; stress check; serviceability limit state; spatial grid model.

1. Introduction

The stress check of bridges at serviceability limit state is very important in the whole design process,because it can provide a reasonable basis for controlling the tensile stress and preventing concrete cracking. For shallow and narrow beams that plane section assumption applies, stick models together with conventional stress check method are simple and accurate enough for designers.However, it is a big challenge to ensure the safety of special bridges with simple stick models and stress check method, especially multi-cell box and curved box girder bridges.

Special concrete box girder bridges have two main characters different from simple beams. The first one is the distribution of load (including prestressing effects), which means the curvature of each part in the cross section is dependent but different and force paths need to be analysed for specific loads. The second one is spatial effects including shear lag, warping and indeterminate shear flow distribution, which means simple beam theory with plane section assumption cannot obtain these stress results accurately.

Up to now, a significant amount of work has been conducted to better understand the behaviour of all types of box girder bridges, and several methods have been proposed for their analysis [1].Firstly, different kinds of simplifications and factors have been created to modify the resultants from current stick models, i.e., concept of effective flange width, amplified factor to account for warping effect. With these simplifications and factors, the box girder can be treated as a simple beam, and possibly make the preliminary design efficient. However, since these factors cannot generally apply to every case, designers should have a comprehensive overview of the fundamental principles and select the value with care. Secondly, in order to obtain the live load distribution and different forces in each web, plane grillage models are also generally used and the results are much more accurate compared to stick models with empirical simplified factors[2].However, the grillage model still cannot solve the horizontal indeterminate shear flow distribution and the loading effect clearly. Three-dimensional FE models can solve the most complex effects clearly [3], but the refinement and volume of data distract engineers from the

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