The research on the theory of transverse load distribution of continuous beam bridges

Zhenyu JIANG
Civil Engineer
Research institude of highway ministry of transport
Beijing CHINA
Zy.jiang@rioh.cn

Han WEI
Civil Engineer
Research Institude of Highway, the Ministry of Transport
Beijing CHINA
h.wei@rioh.cn

Haibo CHEN
Civil Engineer
Research Institude of Highway, the Ministry of Transport
Beijing CHINA
Hb.chen@rioh.cn

Jundong GAO
Civil Engineer
Research Institude of Highway, the Ministry of Transport
Beijing CHINA
Jd.gao@rioh.cn

Chunzao LI
Civil Engineer
Research Institude of Highway, the Ministry of Transport
Beijing CHINA
Cz.lee1985@hotmail.com

Kanglin ZHENG
Civil Engineer
Research Institude of Highway, the Ministry of Transport
Beijing CHINA
kl.zheng@rioh.cn

Summary

In China, the theory of transverse load distribution is widely used as a practical approximate method of calculation for space structure of girder bridges. This approximate method will lead to some error. So this article will take a five piece box girder continuous bridge as an example,A 3D solid finite element model of this bridge is used to calculate the transverse load distribution with the concentrated force applied on the main-span and side-span separately. The results are compared with bridge loading test data and show that: when calculating the transverse load distribution of the continuous bridge the corresponding equivalent deformation is more precise, while the moment is relatively unsatisfactory. And the side-span is more precise than in the main-span, meanwhile using 3D solid finite element model to analysis the load transverse distribution is practical and accurate according to the comparison of FEM and experiment results.

Keywords：continuous beam bridge；transverse distribution of load; influence line; finite element；bridge loading test

1. Introduction

According to the deformation reciprocal theorem of elastic system, vertical deflection under half-sinee load instead of concentrated unit-force is adopted as ordinate value of the transverse influence line. The calculation method of transverse load distribution for a simply supported beam bridge is extended to the one for continuous beam bridge, and the feasibility and reliability are proved by the comparison of results from an approximate method of mid-span deflection. The fundamental idea behind the method is to convert each span of a continuous beam bridge to an equivalent simply supported beam bridge and the deflections (or rotations) of both the continuous beam bridge, and the equivalent simply supported beam bridge are equal when a concentrated force(or torsion) acts at the span centre, which is called the principle of equal rigidity.

The above approximate method will introduce errors to the calculation in the following aspects:

1）Converting a continuous beam bridge to an equivalent simply supported beam bridges according to the principle of equal rigidity;

2）Adopting the half-sine load instead of concentrated unit-force for calculation;

3）Taking the vertical deflection under half-sine load as ordinate value of the transverse influence line.

Taking a 3-span box-beam continuous bridge as an example, static analyses of 3D finite element model (FEM) under mid-span load at different span/piece of the beam is carried out. The internal forces are calculated by programming according to the concept of transverse load distribution and

https://doi.org/10.2749/222137813806474480

the results are compared with the corresponding internal forces of beams under several cases by means of FEM,to find the deficiency of the transverse load distribution theory.

2. Calculation method

A 3-span PC continuous bridge consisting of 5 pieces of box beams is adopted, with the span arrangement of 19.6m+25m+19.6m (the ratio of side to main span is 0.8) and 4-lanes. The concrete component of the bridges is modeled using 8-node solid elements. The box beams are symmetrically placed, therefore the transverse influence lines of only 1 to 3 beams are calculated. In the simulation, concentrated unit-force (not half-sine load in traditional method) is adopted. The deformation and internal force of each piece of beam are obtained from the FEM program, and are taken as ordinate value of the transverse influence line based on the deformation reciprocal theorem of elastic system.

3. Calculation results

3.1 Comparison of FE analysis and traditional method

The equivalent transformation based on the deformation reciprocal theorem of elastic system works well for the side span, there is no significant difference between transverse distributions of the continuous beam bridge and the equivalent simply supported beam bridge; on the contrary, the equivalent transformation for main span is far from ideal, the difference of load transverse distribution is 5%~10%, and the equivalent transformation is possibly unsafe.

After the equivalent transformation, half-sine load is adopted to substitute for concentrated unit-force and the transverse distribution of deformation is adopted to substitute for the moment. The results of deformation are consistent and accurate; on the contrary, the results of moments lack of consistency. Therefore, using the transverse distribution of deformation instead of the moment distribution will bring errors to internal forces calculation and is unsafe.

3.2 Experimental verification

The accuracy of the FEM results are verified by a load test at the central section of the main span. During the loading process by a 300 kN three axle vehicle, the internal forces of each beam are measured, and the transverse load distribution obtained from experiment is compared with calculated results of both a current code method and the finite element method to evaluate the precision of these two methods.

The results indicate that the FEM method based on continuous beams agrees well with the experiment, and using the 3D solid model to obtain the transverse influence line of continuous beam bridge is practical. According to the calculated transverse distribution coefficient of beam 3, the internal forces obtained by the method provided in the current design code is less than the actual value about 7%, which is unsafe compared with the FEM method.

4. Conclusions

(1) Using 3D solid finite element model to analysis the load transverse distribution is practical and accurate according to the comparison of FEM and experimental results.

(2) The method provided in the current design code which equivalently transforms the continuous beam bridge into a corresponding simply supported beam bridge works well in side span but is far from ideal in the main span and possibly unsafe

(3) When adopting the method provided in the current design code to calculate the load transverse distribution of an equivalent simply supported beam bridge, the transverse distribution of deformation shows good consistency, which proves that current theory is based on the transverse distribution of deformation. However, the calculation results for moments show significant differences.

(4) No matter the beam bridge is continuous or equals as a simply supported bridge, the transverse distribution of internal forces is different from the exact computation. Although the multi-vehicle counteraction will reduce the difference, the internal force of some structure is still low and unsafe.