Curve analysis of shear lag effect of box girder bridge

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Abstract: The beam element, solid finite element models are established in this paper, which are studied the effects of different curvature radius to the shear lag effect in curved box girder. The analysis results show that the inner side and the outer side of the shear lag coefficient of curved box girder bridge is different, outside large inside small. With the decrease of the curvature radius, shear lag effect is more serious. When the curvature radius is larger than 300m, the shear lag coefficient is close to straight bridge, and the linear bridge calculation of shear lag coefficient does not produce larger error. Center curve box girder cross section of shear lag coefficient has nothing to do with the radius of curvature, and only relates to the type of load.

1 Introduction

Box section has good structural performance, so it is widely used in various modern bridges, at the same time the shear lag effect of box section has attracted more and more attention. The shear lag effect of box section is defined in a symmetrical loads, the shear deformation caused by wing plate bending normal stress is not uniform along the beam breadth. When near the web stress is greater than the midpoint wing stress, known as the positive shear lag; when the midpoint wing stress is greater than near the web stress, known as the negative shear lag[1]. Ignoring the effect of shear lag effect will underestimate the deflection and stress of box girder web and wing plate junction, the unsafe structures. For example, in November 1969 to November 1971 in Austria, Britain, Australia and the former Federal Republic of Germany have occurred four steel box girder failure or damage accidents, one of the reasons is that the design does not take seriously "shear lag effect", leading to stress too concentrated, and causing structural failure or partial failure[2]. Uneven division rate is usually measured by the shear lag coefficient λ caused by stress of shear lag effect, which is defined as:

$$\lambda = \frac{\sigma}{\bar{\sigma}} \tag{1}$$

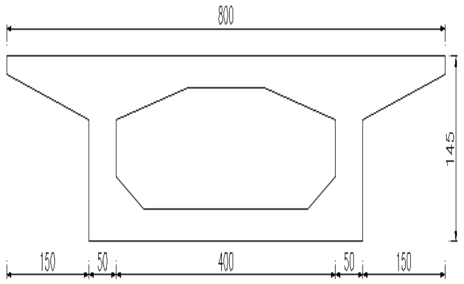
type: σ -considering the shear lag effect of the section normal stress;

$\bar{\sigma}$ -according to the cross section are obtained: the elementary beam theory of normal stress.

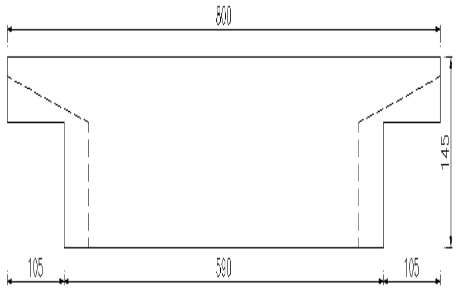
In recent years, the domestic and foreign scholars have done a lot of research work on shear lag effect. The effect of shear lag theory of straight box girder bridge has become mature, while curved box girder bridges due to the influence of curvature, and obvious lateral torsional coupling effect, the behavior of stress of curved box girder bridge is more complex[3]. There are many factors influencing the shear lag effect of box girder. There are mainly the cantilever box girder width span ratio, the flange length, web plate thickness ratio, high presence of cross beam, supporting conditions and load types, etc. The impact of these factors on the shear lag effect research more, and also have some regular conclusions[4-9]. In this paper, the bridge of bulong river in mojian line as the project background, to study the influence of curvature radius to the shear lag effect of box girder, and get some useful conclusions.

2 The Finite Element Calculation Model

The bridge of bulong river is the main bridge in mojian line, and is set to span the bulong river. The mojian line is four grade highway, and is an important highway connecting the field and area of the township road in mojiang county. Girder is a single box single room section, beam breadth 8m, beam height 1.45m, top and bottom plate thickness of 0.25 m, girder use C40 concrete, elastic modulus E = 32500MPa, concrete unit weight γ=25kN/m3, poisson's ratio of concrete μ=0.167, box girder cross section arrangement as shown in figure 1.



(a) Cross section



(b) Support section

Fig.1 Box girder cross section layout(unit:cm)

2.1 Plane Finite Element Model

Plane finite element analysis by Midas-Civil (beam element) [10], plane finite element analysis does not consider the shear lag effect, section stress distribution accords with the elementary beam theory, and using the software can calculate each box girder section on the surface of the upper and lower normal stress, plane finite element model as shown in figure 2.

2.2 Space Finite Element Model

Space finite element analysis by Midas-Fea (entity), analysis of the entire box girder structure is regarded as a homogeneous elastic body, space finite element model as shown in figure 3. To illustrate the influence of different load types of shear lag effect, the analysis of vehicle load access level II highway, which concentrated load P=180kN, uniform load q=7.875kN/m[11]. Concentrated load at midspan, uniform load and concentrated load with full span, and the concentrated load and uniform load are called for web and roof line symmetrically.

Space finite element analysis is obtained considering the shear lag effect of the section normal stress, plane truss section normal stress obtained by finite element analysis according to the elementary beam theory, and according to equation (1) can be obtained by the corresponding section of the shear lag coefficient λ.

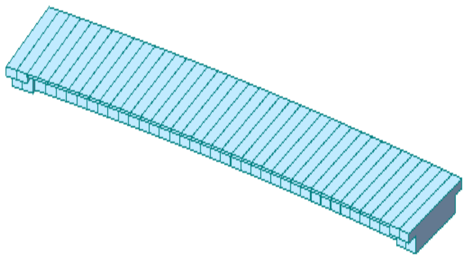


Fig.2 Plane finite element model

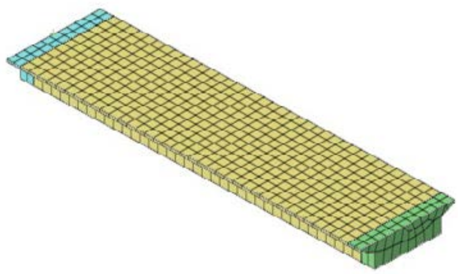
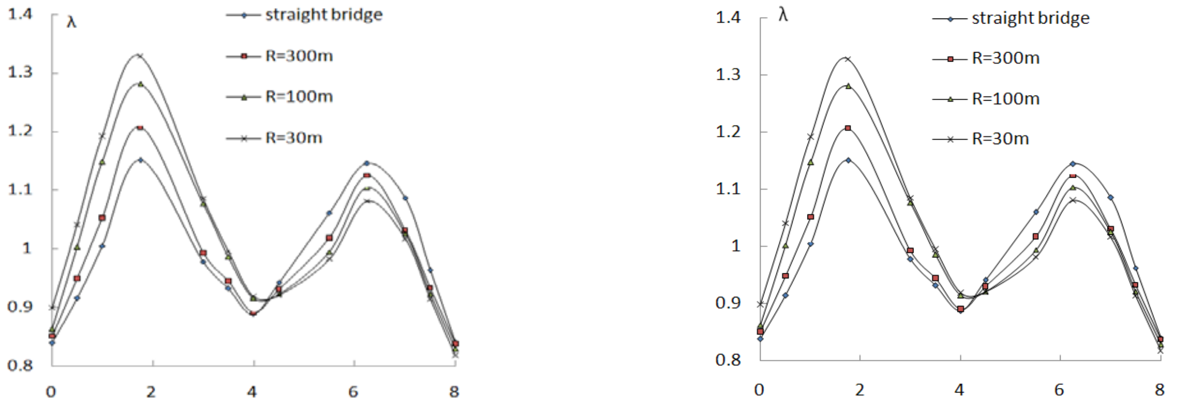


Fig.3 Space finite element model

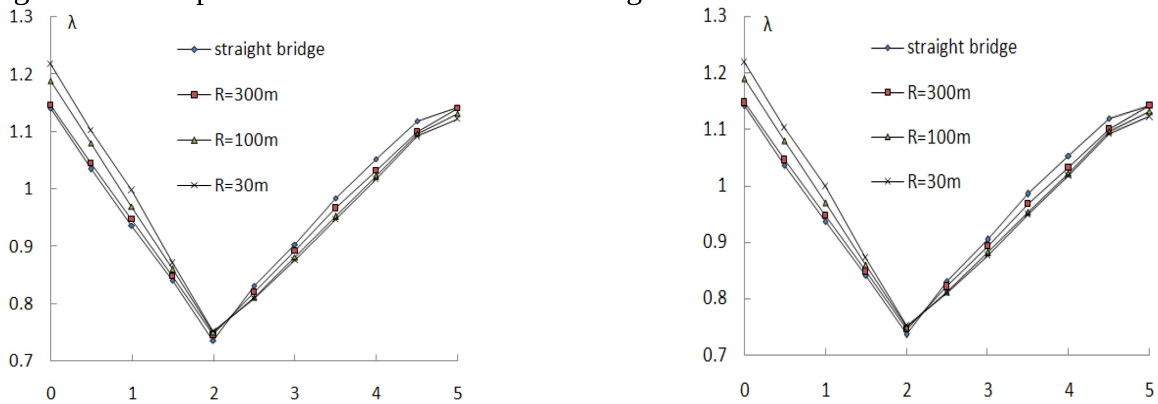
3 Analysis of The Influence of Curvature Radius to The Shear Lag Effect

By 30m, 100m and 300m respectively and a straight bridge four different curvature radius are analyzed, and the box girder under concentrated load and uniform load cross section in the top, bottom shear lag coefficient distribution as shown in figure 4, figure 5[12-15].



(a) Concentrated load (b) Uniform load

Fig.4 The map of the distribution of shear lag coefficient in the roof of cross section



(a) Concentrated load (b) Uniform load

Fig.5 The map of the distribution of shear lag coefficient in the bottom of cross section

Through the comparative analysis of figure 4, figure 5 can be concluded that the shear lag effect of box girder of roof and bottom is more obvious. Under concentrated load, the shear lag coefficients of box girder roof and bottom up to a maximum of 1.331 and 1.238, a minimum of 0.818 and 0.736. Unde uniform load, the shear lag coefficient of box girder roof and bottom up to a maximum of 1.218 and 1.123, a minimum of 0.809 and 0.729. Concentrated load and uniform load compared, changes of shear lag coefficients under concentrated load with the curvature radius is larger, and the uniform load of shear lag coefficient changes with curvature radius small. Box beam shear lag coefficients is different in internal and external side, outside large inside small. With the decrease of the radius, the lateral shear lag coefficient increases, while the inside of the shear lag coefficient decreases. When for straight bridge, the shear lag coefficient of inner and outer side is almost completely symmetrical. With the decrease of the radius of curvature, the shear lag effect of box girder is more serious. The shear lag coefficient of box girder cross section center has nothing to do with the radius of curvature, only related to the type of load. When the radius of curvature R=300m, the shear lag coefficient characteristics are close to the straight bridge. At this time, considering the shear lag effect can be treated approximately as straight bridge.

4 Conclusion

Through the analysis of the shear lag effect of the curved box girder bridge, get the following main conclusions, to provide a reference for the same type bridge design and construction:

(1) Curved box beam shear lag coefficients is different in internal and external side, outside large inside small. When for straight bridge, the shear lag coefficient of inner and outer side is almost completely symmetrical.

(2) With the decrease of the radius of curvature, the shear lag effect of box girder is more serious.

(3) When the radius of curvature is greater than 300m, the shear lag coefficient is close to straight bridge. At this time, by a straight bridge, calculation of shear lag coefficient does not

produce large error.

(4) The shear lag coefficient of curved box girder cross section center has nothing to do with the radius of curvature, only related to the type of load.

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