Error Analysis on Force Decomposition of Applied Eccentric Load for Concrete Box-girder

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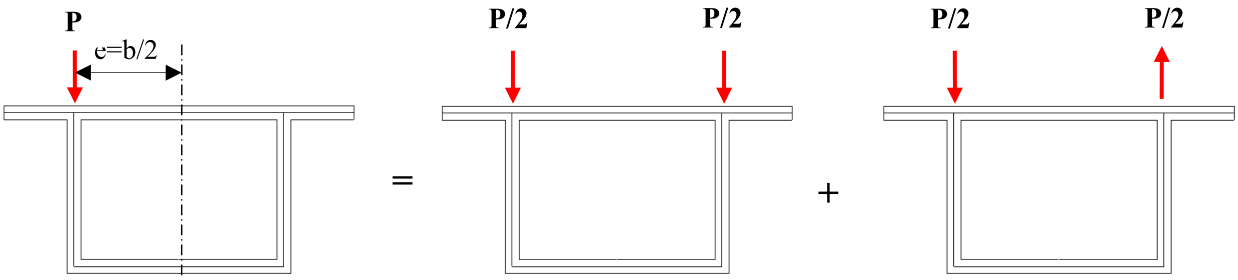
Abstract. The paper is devoted to error analysis on force decomposition of applied eccentric load for concrete box-girder, the main parameter eccentric 'e' was considered. The stress under eccentric load, symmetric load, and anti-symmetric load is extracted from ABAQUS model, the floor stress along the cross-section and longitudinal beam were analyzed. The results show that force decomposition methodology can be used when eccentric load be 0 and b/2, when eccentric distance e=b/2, the error is zero, which means the force decomposition methodology is correct under this condition; when e=0, there is no torsion exist, the error is also very small. But when 0<e<b/2, the error can be very high at some point, the majority error can get 100%, this is very high, and can't be ignored, we should pay more attention on it. As a whole, the force decomposition theory of applied eccentric load for concrete box-girder can be only used when eccentric distance e=0 and e=b/2.

Introduction

The use of thin-walled box-girder is dominant due to their large bending and torsional rigidities. Recently, it is widely used in modern bridge system. With the development of pre-stressed technology, the wide box girder was largely applied in bridge engineering. According to the actual traffic condition, the external load usually not symmetric load or centric load [1]. Based on the idea of force decomposition for thin-walled box-girder, as shown in Fig.1, which was proposed by Nakaiand Yoo [3]. When a single-cell box girder is subject to an eccentric load, the load can be resolved into flexural (symmetric load) and torsional forces (Anti-symmetric load), while torsional forces can be converted into pure torsion and distortion [2]. Sometimes, the eccentric load can not only be applied at the intersection of web and top plate. They may happen at any location on the top plate, so whether the force decomposition methodology is still applicable. Unfortunately, any study has not been reported up to date for this question.

This paper describes the investigation carried out on error analysis of force decomposition methodology under different load location. The aim of this study is to determine the effect of load location on thin-walled box-girder. A typical sized model was adopted in this paper while under different load location in middle span (as shown in Fig.2). Calibrated finite element methods were adopted for these purposes (as shown in Fig.3).



(a) Eccentric load e=b/2 (b) Symmetric load (c) Anti-symmetric load

Fig. 1 Force decomposition

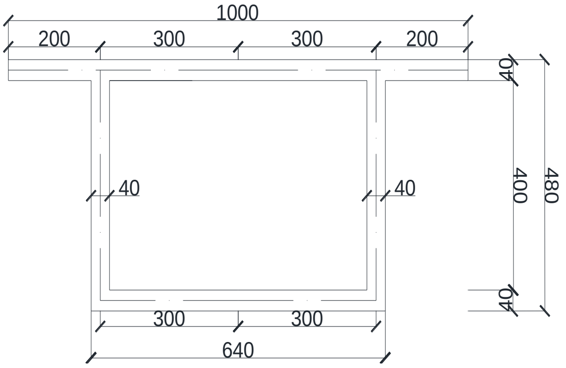


Fig. 2 Cross-Section size /mm

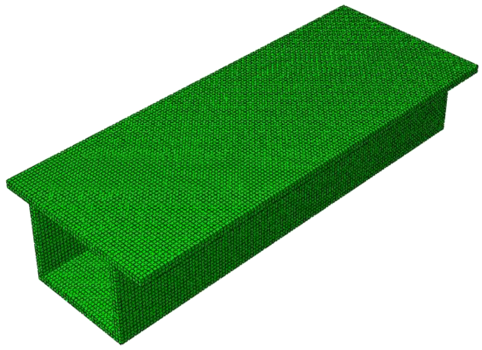
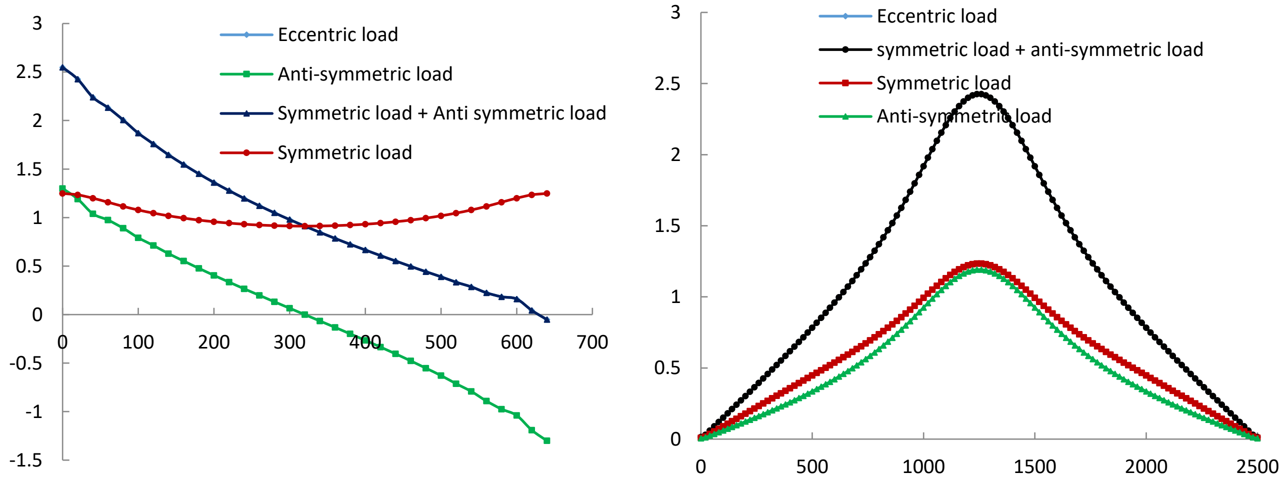


Fig. 3 FEA model

Numerical examples under different load location

To analysis the load location effect on force decomposition methodology of thin-walled box-girder, the main parameter in this paper is load location along the cross-section, take Fig.1 for example, the parameter 'e' can be list as b/2, b/4, 0. The external load will be applied at the middle span of the simply supported beam. ABAQUS software was used to model symmetric load and anti-symmetric load respectively. The stress results were extracted from the FEA model, for one is from middle span's bottom plate, the other one is the intersection point of web and bottom plate along the longitudinal beam, all these data will be plotted into Fig.4/.Fig.5/ Fig.6 respectively.

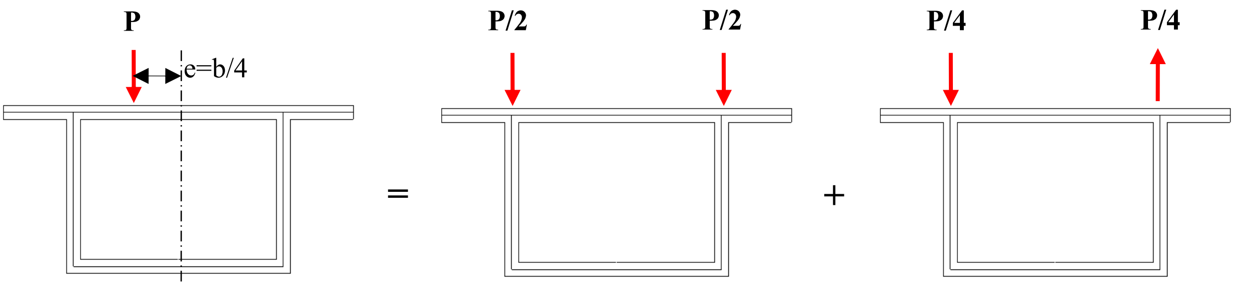


(a) Floor stress along cross-section

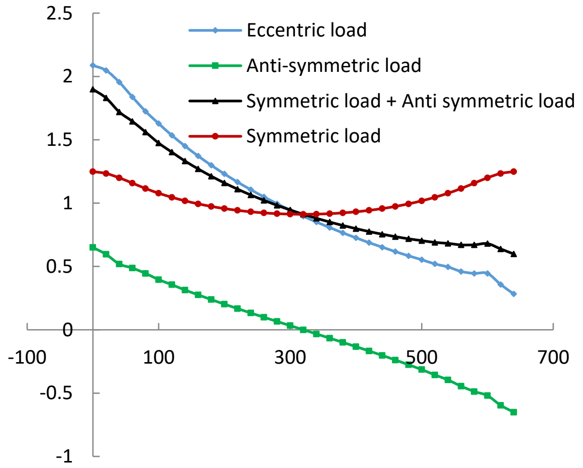
(b) Floor stress along longitudinal

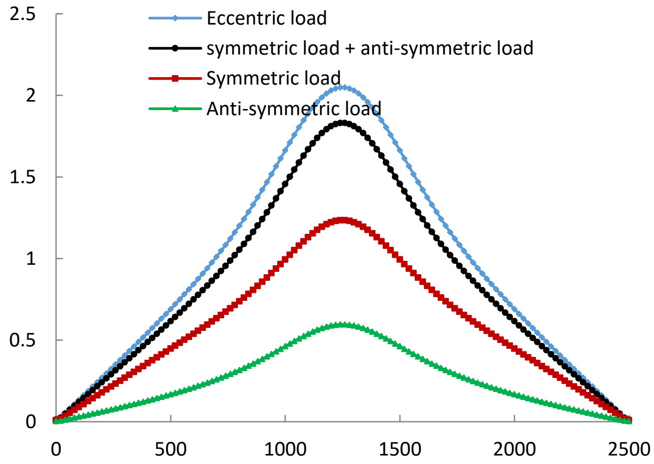
Fig. 4 Stress distribution when e=b/2

From the diagram above, we can find that, when e=b/4, the longitudinal stress under symmetric load and anti-symmetric load satisfy well with the eccentric load, which means the force decomposition methodology used can well reflect the actual stress condition while the eccentric distance e=b/2.



(a) Eccentric load e=b/4 (b) Symmetric load (c) Anti-symmetric load

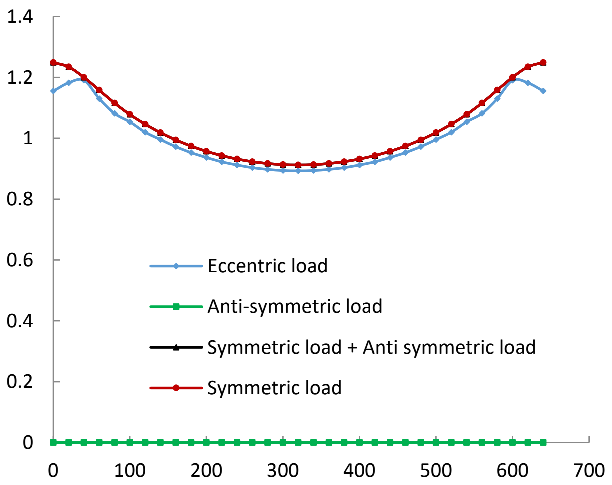


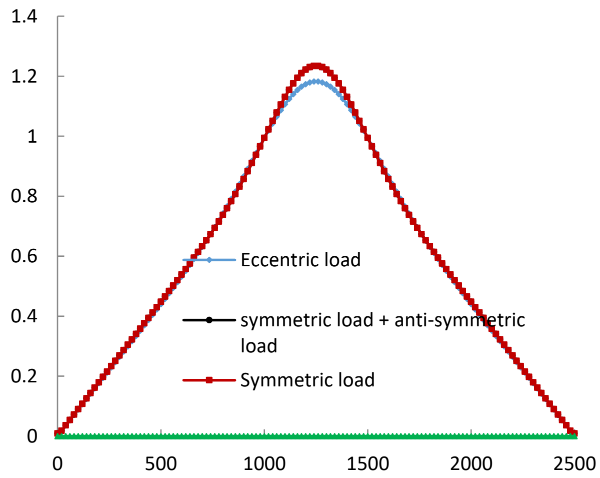


(d) Floor stress along cross-section (e) Floor stress along longitudinal

Fig.5 Stress distribution when e=b/4

From fig.5, the longitudinal stress under symmetric load and anti-symmetric load no longer satisfy the stress under eccentric load. On the left part, the stress under eccentric load is a little higher than symmetric load plus anti-symmetric load, the error is about 10%, while on the other side, it's opposite, the error can get 100%, which means that it can't reflect the actual stress situation. Along the longitudinal, the stress under eccentric load is always higher than the stress under symmetric load and anti-symmetric load. The cause of this phenomenon is due to force decomposition methodology, when load P locate at the intersection of web and top plate, we can convert them simply, because the local effect between symmetric load and anti-symmetric load are the same, however, when the load P locate between the web and mid span of top plate, the local effect is different.





(a) Floor stress along cross-section (b) Floor stress along longitudinal

Fig. 6 Stress distribution when e=0

From diagram above, when e=0, which means there is no eccentric distance, so the force decomposition can be divided into two same load works symmetrically. The data shows that even if convert the concentrate load into symmetric load, the effect is not very big, along the longitudinal direction, two curves coincide quite well; the error can be controlled fewer than 5%.

Summarize and Conclusions

In this investigation, error analysis on force decomposition of applied eccentric load for concrete box-girder was conducted by changing the eccentric distance 'e', the stress under eccentric load was extracted from ABAQUS model, as well as stress under symmetric load and anti-symmetric load. The floor stress along the cross-section and longitudinal beam were analyzed.

The results shows that force decomposition methodology can be used when eccentric load be 0 and b/2, when eccentric distance e=b/2, the error is zero, which means the force decomposition methodology is correct under this condition; when e=0, there is no torsion exist, the error is also very small. But when $0<e<b/2$, the error can be very high at some point, the majority error can get 100%, this is very high, and can't be ignored, we should pay more attention on it. As a whole, the force decomposition theory of applied eccentric load for concrete box-girder can be only used when eccentric distance e=0 or e=b/2.

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