Ultimate strength interaction of stiffening steel box girder in cable-supported bridges

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1. Introduction

When box girders are under external loads, the main load components are bending moment and axial compression. In resistant mechanism, flexural strength is affected by applied axial compression and axial compressive strength is affected by applied bending moment. So, one of the important step in general design procedure for box girder is to evaluate interaction effect. For doing that, pure bending or pure axial compressive strength have to be calculated in advance. Simply, flexural failure deemed to have occurred when the extreme fiber flange stress reaches the calculated ultimate stress of compression flange or yield stress of tension flange, so ultimate flexural resistance can be calculated on the basis of ultimate stress multiplied by elastic section modulus of box section. Where, elastic section modulus has to be calculated based on the effective section considering shear lag effect. For pure compression, the box girder can be assumed as simply supported column and the strength be calculated by column curves according to slenderness. AASHTO LRFD Bridge design specification or BS 5400 code etc. consider the interaction effect as linear relation. In other words, sum of bending performance ratio(external moment over flexural resistance) and compressive performance ratio(external compression over compressive resistance) considering proper weighting factors could not exceed one. But these interact equations were developed for simple compact box or I section, applicability to wide type box girder have to be re-evaluated. In addition, whether the methodology for ultimate flexural resistance calculated based on critical stress of the deck or bottom plate reflect the actual strength well or not have to be evaluated. For evaluation of interaction effect of bending moment and axial compression, the nonlinear finite element analysis of full section wide type steel box girder was performed using ABAQUS. After then, finite element analysis results are compared with existing codes.

2. Nonlinear FE analysis of box section

For interaction effect test of bending and axial compression, wide type steel box girder of Incheon long-span bridge (located in Korea) is modelled. 4-point bending test was conducted for box girder model and ultimate flexural resistances were calculated when constant compressive forces are imposed. For several constant compressive force, interaction curves are produced and the results were compared with AASHTO LRFD 2012 and BS 5400 codes.

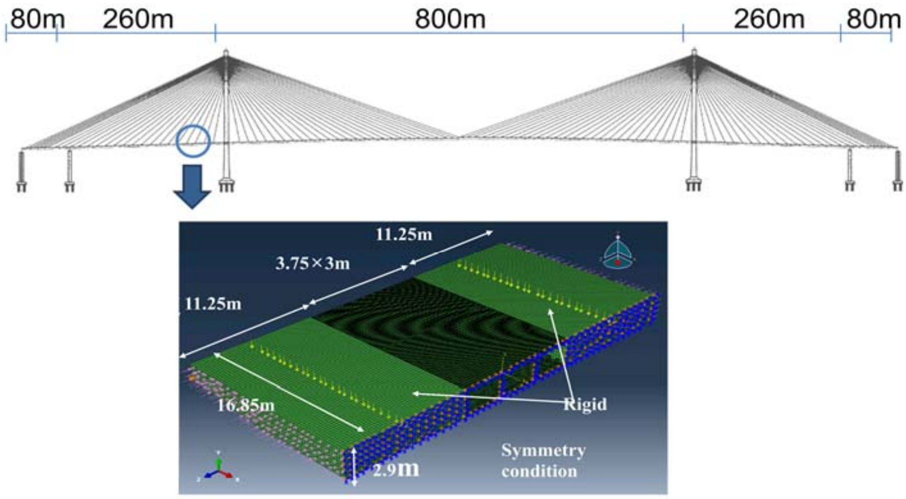

Fig. 1: FE model of Wide type steel box girder of Incheon long- span bridge

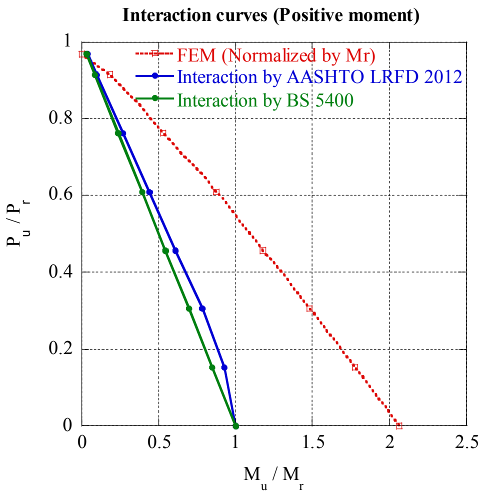

Fig. 2a: Interaction curves (positive moment)

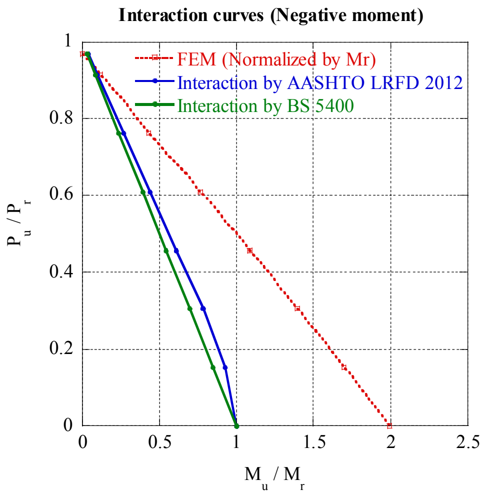

Fig. 2b: Interaction curves (negative moment)

From the results, it can be seen that interaction equation from codes are conservative for box girder model. As M_r or M_D of current code is calculated by effective section, then interaction equation have to be similar to FEM results but have notable difference.

3. Conclusion

Wide type steel box girder was modelled and analyzed using finite element software, ABAQUS. 4-point bending test was conducted for box girder model and ultimate flexural resistances were calculated when constant compressive forces are imposed. For several constant compressive force, interaction curves are produced and the results were compared with AASHTO LRFD 2012 and BS 5400 codes. As results, previous interaction formulas are still applicable to wide type box girder, but for more rational and cost effective design, establishments of the relation of effective width and interaction curves for wide type steel box girders are required.