A Study on Behavior of Continuous Steel Box Girder Bridges Constructed by Applying Up-Down Construction Method

Do Dai Thang
PhD
Inha University
Incheon, Korea
dodaithang2003@yahoo.com

Ha Bac, Viet Nam born 1975, received his civil engineering degree from the Ho Chi Minh City University of Technology.

Koo Min-Se
Professor
Inha University
Incheon, Korea
drkms@chollian.net

Incheon, Korea, born 1949, received his Doctor of Philosophy degree in civil engineering from the Aechen University, German.

Jeong Young-Do
PhD Student
Inha University
Incheon, Korea
civil22011271@hanmail.net

Incheon, Korea, born 1976, received his civil engineering degree from the Inha University.

Summary

The purpose of this paper is to investigate the behavior of steel box girder bridge during up-down construction method. The steel box girder with open-trapezoidal cross section, partial prefabricated concrete slab and double composite section by cast-in-place bottom concrete slab is considered in this study. The 3-D finite element models, considering construction sequence in modelling, have been used to carry out the analysis. A parametric analytic study is used to investigate the effects of some structural characteristic on the behavior of steel box girder. These parameters include the variation of lifting upward and lowering downward height, the length and depth of bottom concrete slab and the length of partial pre-fabricated concrete slab. An overview of the effect of lifting upward and lowering downward method to the stability design such as web buckling and top lateral bracing are also given. Results of the study with potential design recommendations are outlined.

Keywords: steel box girder; up-down construction method; prefabricated concrete slab; double composite.

1. Introduction

The existing up-down method for steel box-girder is uneconomical about material and construction time because of using closed rectangular section and full in situ casting of concrete in the deck. A steel box-girder with open-trapezoidal cross section and partial prefabricated concrete deck is proposed in this paper. The open-trapezoidal with inclined faces give a better aesthetic appearance and aerodynamic than vertical faces and save steel material due to smaller top flange area. While the partial prefabricated concrete deck give higher rigidity and stability of top flange, eliminate some top lateral bracing and save the time of pouring concrete due to in situ casting of concrete in the region near the support. In order to evaluate practicability of this method, this study estimates the elastic stresses of steel and concrete by considering full-scale model of bridge.

2. Trapezoidal steel box girder applied up-down construction method

In order to illustrate up-down construction method for continuous trapezoidal steel box-girder, a two span continuous trapezoidal steel box girder bridge is considered. First, the separate prefabricated components are launched and supported on auxiliary supports. Secondly, they are connected with each other by welding. Thirdly, the concrete is casted in the field over supports at bottom flange, and after curing the concrete, the interior supports are lifted upward. Fourthly, the concrete is casted in the field at the top flange and after curing the concrete, interior supports are lowered to initial support level. Finally, the secondary dead load and traffic load are applied.

3. Finite element analysis

In ANSYS, SHELL93 element is used to model steel cross section, transverse and longitudinal stiffeners of web and bottom flange and solid diaphragms. The solid diaphragms are used at the

https://doi.org/10.2749/222137809796205656
Distributed by structurae

supports. Both internal K-frames spaced at 5m and single diagonal type horizontal truss for top bracing are modelled BEAM4 element. The top and bottom slab concrete are modelled by four-node finite strain shell elements, SHELL181. The full composite action between a concrete deck and steel girders is typically modelled by rigid links through multi-point constraints (MPCs). All above elements are given the element birth and death capability. The majority of the loading is self-weight of material with acceleration value about 9.81m/s^2. The paper will focus on the longitudinal stress of steel flange and concrete slab in both top and bottom of cross section at each stage.

4. Data analysis and discussions

The upward lifting height should be constraint to an optimum value. The maximum upward lifting height has to be limited by the maximum permissible compression stress of top concrete. The required initial compressive stress in the top concrete slab for up-down method is -100kg/cm^2. From the result of FE analysis, the upward lifting height can be expressed as $\Delta_{up} = 0.0136\ell^2$ where Δ_{up} is the height of upward lifting in centimeter and ℓ is span length in meter.

By considering of the relationship between longitudinal stress of top and bottom steel flange and of bottom concrete slab by varying the bottom slab thickness at negative moment region, the result indicates that if bottom slab thickness is from 25 to 40cm, the bottom and top flange will have the relative minimum stress value.

If the length of prefabricated top concrete slab is about 80 percent of the span length (equal to the sagging bending moment of continuous beam) then the maximum tensile stress of prefabricated slab is smaller than tensile allowable stress.

5. Discussion of stability design during up-down construction method

In the steel box girder, the web carries out most of the shear. Since the steel box girder inherently has a thin web, stability is of primary concern. The effect of lifting-up to the web buckling and the result shows that the shear force due to lifting-up varies from 0.45 to 0.07 times the shear force due to girder self-weight with the increase in span length.

The difference in the uplifting height of the two ends at any time cause the torsional moment which is calculated as couple produced due to one tenth of shear force. The force in the diagonal due to torsion is small compared to the force due to bending, so the torsion moment component can be ignored. The ratio of stress of top flange due to lifting-up and girder self-weight is decreased from 2.5 to 0.5 times with the increase in span length. That means if span length is smaller the force in top bracing due to lifting-up is dominant.

6. Conclusion

In this paper the behavior of steel box girder bridge during up-down construction method is investigated. Through the result of 3D FE model with consideration of construction sequence, the height of lifting-up, the depth and length of bottom concrete slab and the length of prefabricated top concrete are proposed. Moreover, the consideration of stability behavior is presented. It is found that the up-down construction method for open-trapezoidal steel box-girder with partial prefabricated concrete deck has many benefits.

7. References

[1] MANCECOREA website, The Method of Improving Stiffness at the Inner Support in the Steel Box Girder, viewed: July 10, 2007 http://mansecorea.com/english/00-manse2.html.

[2] SEN R., STROH S., OLBINSKA J., HASSIOTIS S. and MULLINS G.., "Development of a New Concept for Florida's Bridges", *Report of Department of Civil and Environmental Engineering, University of South Florida*, 1999.

[3] SALMON C.G. and JOHNSON J.E., "*Design and Behaviour - Emphasizing Load and Resistance Factor Design, Fourth edition*", HarperCollins Publishers Inc, 1996, p.438.

[4] NAKAMURA S. and MORISHITA H., "Bending Strength of Concrete-filled Narrow-width Steel Box Girder", *Journal of Constructional Steel Researc*h, Vol.64, No.1, 2007, pp. 128-133.