Slab Cracking Influence in the Fatigue Assessment of Continuous Composite Decks

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Summary

The paper analyzes the influence of the slab cracking in the fatigue assessment of continuous composite decks by considering the effects of slab casting sequences and the shrinkage components (thermal, endogenous and drying). A numerical procedure for the stress calculation accounting for the tension stiffening of the slab longitudinal rebars is presented. The long term effects of casting sequences and concrete shrinkage are analysed with a simplified procedure based on the application of the modular ratio method.

Keywords: casting sequences, composite deck, cracking, damage equivalent factor, fatigue, fatigue load models, tension stiffening.

1. Introduction

Fatigue assessment of bridge decks requires the evaluation of stress range histograms due to the application of specific traffic loads. In the case of steel-concrete bridges this task has to be carried out taking into account the concrete cracking that modifies the effective resisting cross sections. A realistic evaluation of the cracked deck sections has to be carried out by taking into account the stress states produced by permanent loads and concrete shrinkage components (thermal, endogenous and drying) which are strongly affected by the concreting sequences of the slab and by the concrete creep. For the calculation of stresses in composite decks, the simplified procedure suggested by EN1994-2 [1], which disregards the tensile strength of concrete, leads to too conservative and non-competitive design solutions.

In this paper the influence of the slab cracking in the fatigue verification of continuous composite decks is analyzed by considering the effects of the slab casting modalities and of the shrinkage components (thermal, endogenous and drying).

A simplyfied procedue to calculate the stress state is presented accounting for tension stiffnening of the slab longitudinal rebars and time dependent effects. The long term analyses of casting sequences and shrinkage components are performed by means of a simplyfied method based on the application of the modular ratio method [2].

2. Case study

A three span continuous twin girder deck, with span length of 40, 50 and 40 m, is considered. The longitudinal beams are 1,90 m high and are stiffned by transveral frames.

For the slab concreting three different casting sequences are considered: unique phase casting, a continuous concreting from one to the other end, and a fractionated sequence in which the hogging segments are poured after the sagging ones.

The fatigue assessment is performed by applying the “damage equivalent factors method” [3] considering various detail categories ($\Delta\sigma_C$) [4]. With reference to a unique phase casting, Fig. 1 shows the comparisons between two methods for the stress calculation: the presented method and the simplified one suggested by the eurocode which disregards the concrete tensile strength. The

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two graphs compare the $\gamma_{Ff} \cdot \Delta\sigma_E$ diagram with the resistant $\Delta\sigma_C/\gamma_{Mf}$ values in the upper and lower flanges. The simplified procedure leads to very conservative results and the fatigue assessment is always not satisfied.

Fig. 2 and Fig. 3 show the stress range values resulting from the various slab casting methods. The obtained results show a significant influence of the slab casting methods in the evaluation of the stress range in the detail susceptible to fatigue failure.

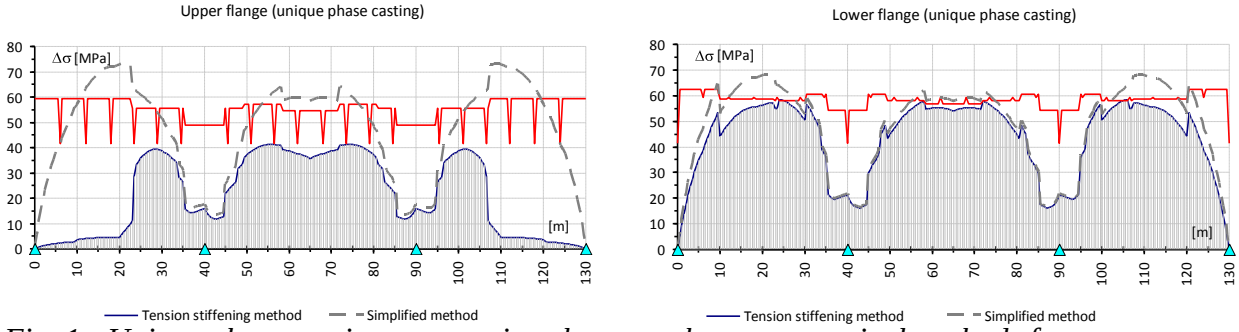

Fig. 1 - Unique phase casting: comparison between the two numerical methods for stress calculation in the two flanges

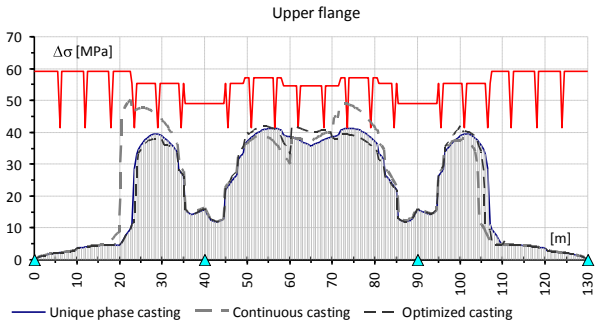

Fig. 2 - Fatigue verification of upper flange: comparison among different casting sequences

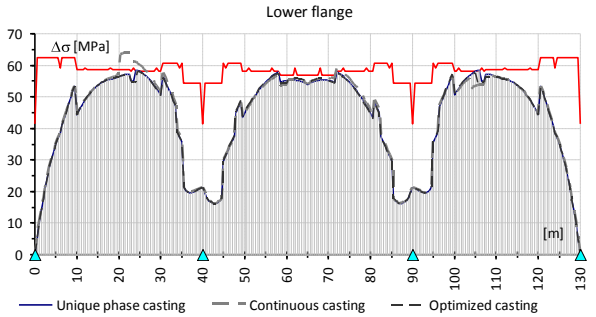

Fig. 3 - Fatigue verification of lower flange: comparison among different casting sequences

3. Conclusions

The influence of the slab cracking in the fatigue assessment by considering the effects of slab casting sequences and the shrinkage components (thermal, endogenous and drying) have been analyzed. A numerical procedure for the stress calculation accounting for the tension stiffening of the slab longitudinal rebars and for the reversal value of bending moment (hogging/sagging) have been presented.

A comparison with the EN1994-2 [1] simplified method, shows the advantages of taking into account the tension stiffening of the slab.

Obtained results prove the fundamental role of the adopted slab casting method in fatigue assessment. Using a suitable casting sequences it is possible to achieve the same stress range obtained in the unique phase casting and, consequently, no changes in plates tickness are required.

4. References

[1] EN1994-2, "Eurocode 4: Design of composite steel and concrete structures - Part 2: Rules for bridges", *European Committee for Standardization*, 2005.

[2] DEZI L., GARA F., and LEONI G., "Simplified method to analyse casting sequences of composite bridge slabs", *Proceeding 36th IABSE Smposium*, Kolkata, India, 24-27 September 2013, 2013.

[3] EN1993-2, "Eurocode 3: Design of steel structures - Part 2: Seel bridges", *European Committee for Standardization*, 2007.

[4] EN1993-1-9, "Eurocode 3: Design of steel structures - Part 1.9: Fatigue", *European Committee for Standardization*, 2005.