Economic design of composite bridges with integral abutments

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Summary

In this paper, a method for the pre-design of integral abutment bridges is presented. It is based on the use of common design tools developed for conventional bridges with bearings and joints. The soil-pile-abutment system is hereby replaced by a single rotational spring. Therefore the determination of the spring properties is described in detail. Furthermore the calculation procedure for the moment induced by uniform temperature and for the normal force in the superstructure induced by the restraint moment is presented.

As these calculations are not integrated in conventional design tools, simple hand calculation formulas have been developed. Their application is shown via a design example in this paper.

Keywords: integral abutment bridges, composite bridges, soil-structure-interaction

1. Introduction

In the design and construction of bridges, questions of durability, maintenance and sustainability become more and more important for European road administrations, in addition to safety and serviceability issues [1]. From this prospective, integral abutment bridges turn out to become highly attractive to designers, constructors and road administrations. The main reason for their gain in attention is that they tend to be less expensive to build, easier to maintain and more economical for the owner over their life time [2]. Principally this is due to the non-existence of bearings and joints, that are main sources of maintenance costs during life time. Thus, in some countries, the solution with integral abutments is already a popular alternative to conventional bridges with bearings and joints [2] [3] [4].

Within the scope of the RFCS project INTAB [5], a design guide has been developed, conducting designers and authorities through the whole design and decision making process by offering them on the one hand a comprehensive design recommendations and design aids and on the other hand by pointing out economic objectives.

In the following the pre-design of an integral abutment bridge based on the INTAB design guide [5] and the pre-design software ACOBRI [6] is presented.

2. Pre-design of an integral abutment bridge

The first aim to opt for an integral bridge is the reduction of the maintenance costs during the bridge life. However the moment restraints at the bridge abutments do also contribute to economize the cross section of the bridge in terms of reducing the steel weight. Preliminary studies showed, that a restraint of 50% is most beneficial for the choice of rolled beams, and therefore for the steel weight. Higher degrees of restraint generally evoke, that the crack width design at the supports becomes governing in design [5].

To present a design example based on this knowledge, a standard bridge application with the use of integral abutments with a span of L = 40m and a cross section in reference to RQ15,5 [7], thus with a width of B = 16,25m between the guard rails, has been chosen. The cross section is given in Fig. 1. The abutment system is based on 5 x HP 305x95 (bending about weak axis) with a geotextile behind the abutment to reduce the spring stiffness of soil behind the abutment.

https://doi.org/10.2749/222137809796067489

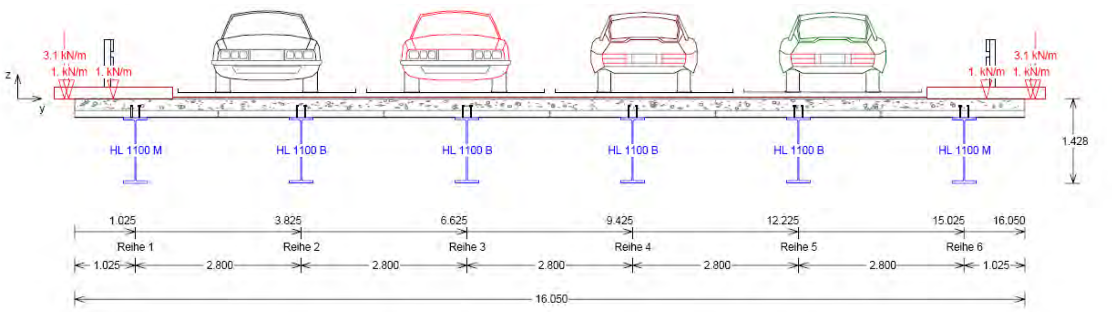

Fig. 1: Cross section RQ15,5 from [6]

The equivalent rotational spring stiffness c_φ is determined according to [5].

In general the edge beams are governing the design. For restraint systems however, also the interior beams may be significant and need to be checked. This example has additionally been optimised by choosing two different sections for inner and edge beams. Finally, positive bending at ULS respectively the stresses at the lower flange at SLS, each for the winter time, is governing the design. Due to the restraint, in comparison to a conventional solution where deflection is governing the design, 30% of the steel weight could be saved.

3. Conclusions

Within the scope of the RFCS project INTAB [5], several design tools and hand calculation methods have been developed, based on EC regulations. In combination with pre-dimensioning software already available and able to take the end rotation restraint into account, a powerful tool is offered to practitioners which allows for an easy (pre-) dimensioning of integral abutment bridges.

4. Acknowledgement

The authors are grateful for the financial support of the RFCS (Research Fund for Coal and Steel of the European Community) and for the good collaboration with the project partners LTU (Lulea, Sweden), Ramböll (Stockholm, Sweden) and ULg (Liege, Belgium).

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