Verification of three FEM programs in the analyses of a highway bridge

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Summary

The paper contains a verification of three FEM programs and different standards used in the design of a highway bridge in Hungary. The main span consists of a Langer-girder with 100 m span. The softwares used during the analysis are RM Bridge, LUSAS and Sofistik. These programs are suitable for the design of major bridges.

Keywords: bridge; arch; composite structure; finite element method; standards; Eurocode

1. Introduction

A Langer-girder highway bridge over the Körös River in Hungary will be built. The design and checking of this bridge is presented in this paper.

The basic design is based on the Hungarian Standards (UME) and the use of a finite element program called RM Bridge. For independent checking another computer program called LUSAS was used. For verifying the results, a third program called Sofistik and Eurocodes (EC) were applied. These three calculations allow the authors to compare the results reliably.

2. Description of the bridge

The bridge will consist of three separate sections; two flood sections having two and six spans, respectively, and a river section, which forms the main span of the bridge. The flood section spans vary between 43,10 and 43,40 meters. The main span is 98 m (structural span). The total length of the bridge is 449,2 m, and the overall width is 28 m. The image plan is shown in Fig. 1. The current paper deals with the river section bridge only.

Fig. 1. The image plan of the Körös river bridge

The bridge type in the main span is a Langer girder, whose main structural element is a single-box steel arch located in the middle of the bridge. The tie beam consists of two box girders, which are hanging from the arch by eight hangers and cross-girders. The upper flange of each box girder is formed by a reinforced concrete deck slab, which together with the box girder acts as a composite structure. The rise on the arch is 16,8 m above the level of the carriageway.

3. Codes and numerical models used in the analysis

The analysis was carried out using two basically different standards, the UME and the EC. The traffic loads and design philosophies are different, while the former one is based on the allowable stress method, the latter one uses partial factors.

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The basic design was carried out by the first author. For the analysis the RM Bridge computer program was used. This software uses only beam elements, which requires that the user has to determine the effective width for the deck. The advantages of this program are that it is very suitable for practical problems. In addition, creep and shrinkage phenomena can be handled.

The independent checking was carried out by the second author by using LUSAS program. This software is based on sophisticated types of elements. The advantage of this program is that it is suitable for many kinds of bridge engineering problems. Unfortunately creep and shrinkage cannot be handled as practically as in the previous case. That is why the so-called Fritz-method was used to cover that part of the study.

For verifying the results, a third program called Sofistik was applied. This part of the study was carried out in the frame of a diploma work [1]. This software is a well advanced finite element program, which besides traditional analysis problems can effectively handle also creep and shrinkage problems using shell elements

4. Comparison of the results

The comparisons of the numerical results obtained by using different softwares and standards are presented underneath. The values related to UME and RM Bridge program are referred as Calculation 1 (or Calc. 1). Accordingly, the values related to UME and LUSAS software are referred as Calculation 2 (or Calc. 2). Finally, the values related to Eurocode and Sofistik program are referred as Calculation 3 (or Calc. 3).

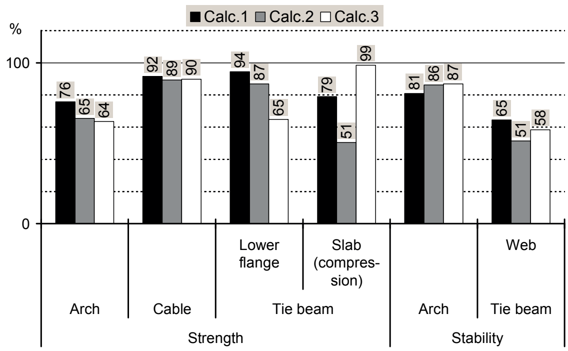

Fig. 2. Comparison of effectiveness or usability of different structural elements

Comparisons of effectiveness or usability of the different structural elements are presented in Fig. 2. On the vertical axis 100 % means that the load-bearing capacity or stability of an element are used to extreme. The strength values except the cable force are calculated at the midspan section. The other values are calculated at critical sections. It can be seen that generally speaking all elements are used effectively. It is also obvious that the differences between the three calculations are small except two cases. These are both related to the tie beam axial stresses. In these cases Calculation 3 seems to lead to values, which differ from those produced by the other calculations. This calculation probably does not quite properly take into account the long-term effects.

5. Conclusions

The comparison carried out proves that the Hungarian Standards (UME) and the Eurocode are about on the same safety level, although they are based on different design philosophies. This is due to the fact that the heavier EC loads including safety factors are compensated by higher resistance values. The three finite element programs compared in this paper, suitable and can be used in the design of big bridges. In most cases the analysis results are similar, but in some cases they can differ considerably. That is why thoroughgoing experience in the modelling is needed.

6. Reference

[1] NYÁRI, J., Design of the highway bridge over the Körös River according to Eurocode. BME Diploma Work. Supervisors: Szabó, B. & Teiter, Z. Budapest. 2011. 123 p.