Reliability Assessment of Traffic Load Models on Road Bridges

Jana MARKOVÁ
researcher
Klokner Institute, CTU in Prague, CZECH REP.
jana.markova@klok.cvut.cz

Jana Marková, received her civil engineering degree from the Czech Technical University of Prague, Czech Republic. Her main area of research is related to reliability of structures and risk assessment.

Summary

Comparative studies and probabilistic analyses revealed that the adjustment factors α of the load model LM1 given in the nationally implemented Eurocode EN 1991-2 for traffic loads on bridges in the Czech Republic should be increased. Furthermore, the special vehicles based on the load model LM3 and their combinations with other traffic are proposed.

Keywords: Road bridges; traffic load models; calibrations; adjustment factors; probabilistic methods.

1. Introduction

New road bridges are designed in most European countries on the basis of combinations of actions and traffic load models according to the Eurocodes EN 1990 and EN 1991-2 [1,2]. After two years of application of Eurocodes as exclusive standards for the design of bridges in the Czech Republic, the traffic load model LM1 including nationally determined adjustment factors α were analysed and calibrated. It was assumed that reduced adjustment factors given by the unique value 0,8 for highways and main roads recommended in the Czech National Annex to EN 1991-2 [2] might be underestimated. Moreover, the load model LM3 was not nationally defined and roads for heavy traffic were not specified.

2. Analysis of Load Model LM1

Analyses of adjustment factors of selected CEN Member States revealed that the factors $\alpha_{Q,1\text{-}3}$ are in a range from 1 to 1,15, the factor $\alpha_{q,1}$ in a range from 1 to 2,4, $\alpha_{q,2}$ from 1 to 2,4 and $\alpha_{q,i}$ from 1 to 2,2. In the first time of implementation of Eurocodes into the system of Czech standards, it was decided to selected a unique value of adjustment factors (0,8) for the load model LM1 provided in EN 1991-2 [2].

Several study cases of adjustment factors for the load model LM1were considered during the recalibration of adjustment factors. Analyses and calibrations resulted in recommendation of new, higher values of adjustment factors for the National Annex to EN 1991-2 [2] of the Czech Republic illustrated in Table 1. The roads are divided in the Czech Republic to Group 1 for highways, speedways and for 1st to 3rd class roads, and to Group 2 for 3rd class roads specified by relevant authorities, for service roads and for special purpose roads.

Table 1: New adjustment factors of LM1 for roads of Groups 1 and 2 in the Czech Republic.

Road group	α_{Q1}	α_{Q2}	α_{Q3}	α_{q1}	α_{q2}	α_{qi}
1	1	1	1	1	2,4	1,2
2	0,8	0,8	0,8	0,45	1,6	1,6

https://doi.org/10.2749/222137813806481446

Moreover, on the basis of comparative studies and analyses two types of special vehicles are proposed in the National Annex to EN 1991-2 [2]. The special vehicles 1800/200 and 3000/240 are recommended for highways and speedways considering specific requirements for simultaneous traffic in other lanes. For roads of 1st and 2nd class, the special vehicle 1800/200 is recommended and other traffic excluded. No special vehicles are proposed for roads of Group 2.

Probabilistic methods are applied for the assessment of reliability level of a bridge. The reliability indices of a bridge designed for the load model LM1 with newly proposed set of α factors in the Czech National Annex fulfils the target value of reliability index recommended in EN 1990 [1]. In case that the bridge designed for the Load model LM1 is also verified for a special vehicle (1800/200) of the load model LM3 then the reliability of a bridge satisfies requirements for target reliability level. However, for a special vehicle (3000/240) the reliability index significantly decreases below the target reliability index. Therefore, the national application of the model LM1 with newly proposed set of α factors only (see Table 1) without regarding the requirements on special vehicles of LM3 could lead to insufficient load bearing capacity of bridges under assumption of specific demands of industry. It could have adverse impact to strengthening of existing bridges which is more complicated and economically unfavourable than to take it into account in the design of a new bridge.

3. Conclusions

Comparative studies and probabilistic analyses of a bridge spanned from 10 to 80 m with 2 to 4 traffic lanes revealed that reduced adjustment factors α of the load model LM1 recommended in the National Annex to EN 1991-2 of the Czech Republic are rather low and should be increased. Furthermore, special vehicles according to the load model LM3 should be taken into account.

New set of adjustment factors is proposed in the Amendment of the National Annex to EN 1991-2 of the Czech Republic. Probabilistic analysis indicates that the reliability level of a bridge designed for the newly recommended adjustment factors of the Load Model LM1 is greater than the target reliability level recommended in EN 1990. However, the reliability level of a bridge designed for LM1 only is significantly decreasing when the special vehicle 3000/240 need to be considered.

Therefore, it was decided to nationally select two types of special vehicles (1800/200, 3000/240) based on the load model LM3. Application of the model LM3 will facilitate the transport of heavy industrial devices and could also serve for other special requirements. In case that the recalibration and new selection of NDPs for LM1 and LM3 would not be provided in the Czech Republic, the new bridges designed according to Eurocodes could not meet requirements of current traffic and might significantly deteriorate.

Acknowledgements

The study has been conducted in the framework of the research projects TA 01031314 Risk and reliability optimisation of existing bridges and VG20122015089 Safety Assessment of Transportation Structures supported by the Ministry of the Interior of the Czech Republic.

References

[1] EN 1990 Basis of structural design - Applications for bridges, CEN, 2005.

[2] EN 1991-2 Eurocode 1 Actions on structures: Part 2 - Traffic loads on bridges, CEN, 2003

[3] CSN 73 6203 Actions on bridges, UNMZ, 1987

[4] CSN 73 6222 Load bearing capacity of road bridges, UNMZ, 2012

[5] MARKOVA J., HOLICKY M., *Assessment of residual working life for bridges*, In. Sustainable Building and Refurbishment for Next Generation, CESB 2010, 2010, pp. 1718-1719.

[6] HOLICKY M., MARKOVA J., *Reliability elements for assessment of existing bridges*, In. Esrel 2010, p. 1487-1492.