Analysis for the Evaluation of a Future-Proof Load Model for Bridges

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Summary

In the last years a scientific project was edited by the chair of traffic facility structures of the Bauhaus-Universität Weimar/Germany. Simulations for the actual and the predicted heavy load traffic were made. Based on these analyses it was detected, that the current load model for bridges is not future-proof. A modified load model with higher load values has been developed by several preliminary considerations and it was possible to show, that this load is sufficiently future-proof. With some examples the realized steps of the research work and the determined results are shown in this paper. Finally some suggestions for further necessary scientific research work are shown. The scientific project was executed under the authority of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and the Federal Highway Research Institute (BAST) of Germany.

Keywords: load model for bridges, traffic measurement, heavy load traffic, traffic simulation, level crossing counting

1. Introduction

The continuous increasing of the heavy load traffic in Germany and Europe necessitate a examination of the load assumptions for the design of bridges and if necessary an adaption of these load assumptions. Based on actual traffic measurements and miscellaneous prognosis scenarios for the future heavy load traffic volume traffic simulations were executed and the effects of the crossing traffic streams to several structural systems were calculated and evaluated. With this method it is possible to identify characteristic values for different reaction and shear forces or bending moments. The identification of the characteristic values is not based on a direct probabilistic analysis. Instead of that the characteristic value is defined as a value with a returning period of 1000 years. The aim of this paper is the explanation of the realized steps of the research work and the determined results on some selected examples. Finally some open problems, which have to be solved in further research works, are shown.

2. Traffic simulation and calculation of stress resultants

2.1 Basic procedure of traffic simulation

By using evaluated data from traffic measurements it is possible to simulate the actual heavy load traffic. Furthermore the development of a future-proof load model requires the observance of the future, thus predicted heavy load traffic. In comparison to the actual traffic, the future traffic can have a considerable higher traffic density as well as new and other vehicle types. To regard those

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different possibilities of the future development of the heavy load traffic different heavy load traffic scenarios are defined.

2.2 Calculation of stress resultants

In the course of the researches the effects of the heavy load traffic for different stress resultants (reaction and shear forces, bending moments) of different structural systems are calculated with external FEM software and used in the self developed software system. The simulated traffic streams are placed on the influence surface and moved forward in small steps. By this way time-responses for the stress resultants are generated.

3. Evaluation

3.1 Evaluation methods

To get characteristic values, thus values with a returning period of 1000 years, out of the time-responses a statistic evaluation of the time-responses in necessary. In the software system a level crossing counting of the time response is carried out. The result of this counting method is a histogram of the level crossings. The “Rice-Function” is used to approach these histograms and the parameters of this function can be identified by the “least-squares-method”. Out of those parameters, values with an arbitrary returning period, including values with a returning period of 1000 years which are defined as characteristic values, can be calculated.

3.2 Results (selection)

In the course of the scientific project a variety of structural systems were analyzed. In the full paper only a small selection of the results can be shown. The results show that the level of the current load model is exceeded by nearly all prognosis scenarios for the future heavy load traffic. Exceeding of the level of a modified load model with higher values of its components is caused only by one scenario. It is possible to evaluate, that the modified load model, which is explained in the full paper in detail, emerge an upper limit of the calculated characteristic values for the different structural system and stress resultants.

4. Conclusions

Based on some selected examples this paper describes the way from actual traffic measurement in Germany and prognosis scenarios for the development of the future heavy load traffic to a load model for street bridges which can be identified as future-proof from today’s perspective.
It becomes apparent that the future heavy load traffic, which was reproduced by several scenarios in the course of the research work, exceeds the level of the current load model in a lot of the cases. Thus current load model in Germany is not future proof. Simultaneously it was possible to determine that the level of a modified load model in the most of the analyzed cases is not exceeded. Therefore this level identifies an upper limit of all calculated results of the different structural systems and stress resultants. Thus the modified load model is suitable future-proof from today’s perspective. Out of the realized research work it is possible to gather some projections and possibilities for further scientific research work like the further development of the used software tool and the verification of the assumed prognosis scenarios by frequent traffic measurement in the future to observe the real development of the heavy load traffic.
Further projection for necessary following research work is a complete probabilistic analysis. In this research work the characteristic values were defined by a returning period. The values for the design of structures in several limit states have to be calculated with a probabilistic analysis.