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R e v i e w   o f   T h e s i s
submitted in partial fulfilment of requirements for promotion to associate professorship

Specialization: Theory of Building Structures and Materials

Applicant: Dr.-Ing. Roman Lenner

Reviewer: Univ.-Prof. Dr.-Ing. Thomas Braml

Thesis title: Bridge Traffic Loads: Design and Asessment of Short-to-Medium Span Bridges

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Importance of topic of thesis

Comments:
The habilitation deals with the modeling of traffic loads on bridges with short and medium spans. This type of bridge is the most frequently built type in Europe and worldwide. When planning and building new bridges, the traffic loads are taken into account on the basis of national regulations. Due to the ageing infrastructure and the increasing volume of traffic, it is necessary to evaluate existing bridges based on their condition and on the actual traffic loads. The actual traffic load can deviate significantly from the load assumed in the planning.
In his habilitation, Mr. Lenner deals precisely with this topic, how a traffic load model for bridges with short and medium spans can be derived from measurements of the actual traffic volume. Knowledge of the actual loads is of great importance for the evaluation of a bridge. Only then is a realistic assessment of the actual condition of the bridge possible. In the future, it can be assumed that measurement data of the traffic passing over the bridge will be available as part of the implementation of digital twins. In his habilitation, Mr. Lenner demonstrates a methodology for directly deriving traffic load models and structure-related partial safety factors for traffic impacts. It takes into account all aspects of complexity in the derivation of traffic load models on bridges. This concerns, among other things, the consideration of several lanes, lane changes of the vehicels, dynamic effects or the consideration of the occurring heavy traffic. The topic of the habilitation is therefore of great importance for the evaluation of infrastructure.

Superior	☒	Good	☐	Average	☐	Poor	☐	Not applicable ☐

Method of solution

Comments:

For the objective of developing a traffic load model for bridges with short and medium spans, Mr. Lenner basically shows 2 approaches. He differentiates between whether data on the actual traffic load stress is available, so-called data from a WIM measurement, or whether only knowledge from the observation of traffic, e.g. the proportion of truck traffic in the total traffic, is available. Both cases are very interesting in practice.

For both cases, Mr. Lenner shows the procedure for evaluating the available data. In the case of WIM data, the evaluation and development of a traffic load model is based on the extreme value theory from statistics. It also takes into account different boundary conditions such as multiple lanes on the bridge. If only data from traffic observation and composition are available, a concept is developed and presented on how to proceed in this case.

In addition, Mr. Lenner shows a methodology for deriving partial safety factors for the variable actions from the traffic data. This approach is very interesting in practice. In practice, fully probabilistic calculation methods are rarely used. The semi-probabilistic safety concept based on partial safety factors is used. Even if not all boundary conditions for the derivation of partial safety factors could be dealt with within the scope of the habilitation, his approach is very promising.

Overall, the chosen approach is evalutated as good.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Quality and correctness of results achieved

Comments:

When developing the traffic load models from measurement data, an attempt is made to take into account all uncertainties that occur. The dynamic increase values during the passage of trucks have a major influence here. The interaction between the vehicle and the bridge structure must be taken into account. Mr. Lenner lists the relevant literature for this and shows his solution method very well by taking the influence into account probabilistically with a distribution density function. The other complex relationships between the collection of measurement data and the development of a model from this data are also sufficiently acknowledged and engineering solutions are shown. If only a small amount of data is available or assumptions have to be made, the work contains helpful solutions. The data for the traffic loads were obtained from bridges in South Africa. However, the approach chosen in the work is generally valid and can be applied internationally for bridges with short and medium spans.

Only in Chapter 6 in the derivation of safety factors are assumptions made that need to be validated and verified in more detail. Further research based on larger data sets is required here. However, Mr. Lenner also points this out.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Originality of results achieved

Comments:

Recently, the topic of determining the actual traffic load on bridges has become a major international field of research. Various concepts are being developed as to how traffic load models can be obtained from measurement data. An important step here is the generally valid application of the models. One approach here is object-related traffic load models. In his habilitation, Mr. Lenner shows a very practical and innovative way of doing this. He proposes a concept of how a traffic load model can be derived from the observed traffic composition, i.e. the share of heavy goods vehicles in total traffic. He also shows how partial safety factors can be obtained from the measurement data and the models developed. These are very practical approaches. This is assessed very positively.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Publication rate of results achieved

Comments:

Mr. Lenner lists a total of 9 publications that are used for the preparation of the habilitation. In these publications, Mr. Lenner develops the basics. In each of these publications, Mr. Lenner deals with a sub-area of his habilitation and gains new insights in each case. Mr. Lenner has published 3 papers in the journal Engineering Structures. In the journal Structures 2 and in the journal Structural Engineering International 1 publication. All 3 journals are internationally recognized journals with a high impact factor. The other journals are more local journals in South Africa.

The publication rate is therefore rated as good overall.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Response to results and citation rate

Comments:

The publications were cited between 10 and 30 times. The citation rate can therefore be rated as average.

Superior	☐	Good	☐	Average	☒	Poor	☐	Not applicable ☐

Applicability of results to development in the field and for further research

Comments:

As already mentioned, the development of traffic load models on bridge structures is a very topical issue. For a realistic assessment of bridges, knowledge of the actual load on the bridge is very important. The methodology developed as part of the habilitation for the evaluation of measurement data and the development of traffic models as well as the development of safety factors from measurement data can be further developed and also applied to other bridge structures. The research was limited to bridges with short to medium spans. Further development and application to bridges with large spans is possible. In addition, the methodology developed can be verified and validated with measurement data from bridges in Europe. The work also provides a good basis for the further development and validation of partial safety factors for traffic loads on bridges.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Applicability of results to technical practice

Comments:

Due to the general validity of the developed methodology, algorithms and application notes for the evaluation of measurement data from traffic load measurements can be made available to practical engineers. The fundamentals for the statistical evaluation on the basis of extreme value distributions can be taken from the habilitation and the associated publications.

Furthermore, Mr. Lenner presented a concept for the development of partial safety factors for variable actions from traffic loads. In practice, the semi-probabilistic safety concept is used almost without exception. The practical engineer can be provided with directly adapted partial safety factors thanks to the methodology he has developed. This is very valuable for practical application.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Compliance with requirements on thesis – quality of thesis

Comments:

The thesis deals with a very challenging topic. This includes the evaluation of measurement data using statistical methods, the application of forecasting models and the use of probabilistic calculation methods. The individual methods were applied very precisely. The content of the thesis is very clear and comprehensibly structured. The organization of the individual chapters is logical. The graphics developed are clearly arranged. Overall, the quality of the work is very good.

Superior	☐	Good	☒	Average	☐	Poor	☐	Not applicable ☐

Comments

Overall evaluation of thesis

The habilitation deals with a very current topic. It deals with the entire process from the generation of measurement data and the development of a model for traffic loads on bridges with small and medium spans. The various influences, such as dynamic influences, are taken into account. Furthermore, the author presents a concept and a methodology for developing partial safety factors from the data obtained or from traffic observation for use in the semi-probabilistic safety concept. This is a very important building block for the realistic evaluation of bridge structures.

The habilitation is self-contained and deals with each individual subject area in the necessary scientific depth. The international state of the art and science is taken into account in the development of the models.

Overall, I rate the quality of the work as "Good".

The only remaining comment is that the measurement technology for obtaining the measurement data from the traffic load is not dealt with. This would be an interesting point as to which measurement technique was used to obtain the data and which measurement technique is recommended by the author. However, it can be assumed that this topic was deliberately omitted

Additional comments on the thesis and the author:

Promotion to associate professorship recommended	*yes* ☒	*no* ☐

Date: 2024-03-18

Reviewer's signature: .. ..