Uncertainty of Maintenance Strategies for Bridge Sustainability Assessment

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Summary

To perform a sustainability assessment for bridges forecasts of the renewal cycles have to be made. The paper concentrates on impacts during the life cycle of highway bridges with a span of approximately 50 m. The spatial boundaries are set to the country of Germany. Considering these boundary conditions, approaches for the renewal cycles of all bridge components based on statistical analysis of the German road infrastructure information system (SIB-Bauwerke) are presented. Aspects like data quality and restrictions of the database are discussed. These input data are used to derive three possible maintenance strategies: preventive maintenance, condition-based maintenance and permitted deterioration. These strategies are suitable to include scenario uncertainties into the sustainability assessment of bridges with a life span of at least 100 years.

Keywords: Sustainability assessment, bridge, maintenance strategies, scenario planning, uncertainty.

1. Objective

For a holistic assessment especially the impacts due to maintenance and rehabilitation play a decisive role (economic and ecologic impacts enlarged by social aspects). The problem is to develop maintenance scenarios for the entire life-cycle of a bridge with a life span of 100 years that deliver the data necessary for the assessment.

All life cycle calculations must be described as probabilistic forecasts rather than accurate predictions of the future. Normally two kinds of uncertainties are used in the field of civil engineering: uncertainty because of the randomness of impacts (parameter uncertainty) and uncertainty as a result of the inaccuracy of models used for the description of the problem (model uncertainty). In addition to the two kinds of uncertainties defined above the term of scenario uncertainty is progressively used in the field of sustainability assessment [1]. When speaking of scenario uncertainties different aspects can be addressed by the usage of this term, i.e. number of years which are used to define the total service life (100, 110 or 150 years) or varying results because of different building process used during erection and maintenance (time optimized process, overnight building process). In this paper a focus is set on uncertainties as a result of different scenarios which describe different maintenance strategies within the total service life.

One big problem is to determine the strategy based renewal cycles of the different bridge components. For this reason the German road infrastructure information database is analyzed and the results are refered to bridges crossing a highway with six lanes and with a length of 40 - 60 m.

2. Developing maintenance strategies

All raw data from the database are analyzed and displayed in boxplots like in Figure 1. By sorting according to different erection periods the median and average values can be used to derive information about the renewal periods. For example, in Figure 1 a median of 34 years and an average value of 32.5 years result for the erection period between 1965 and 1974.

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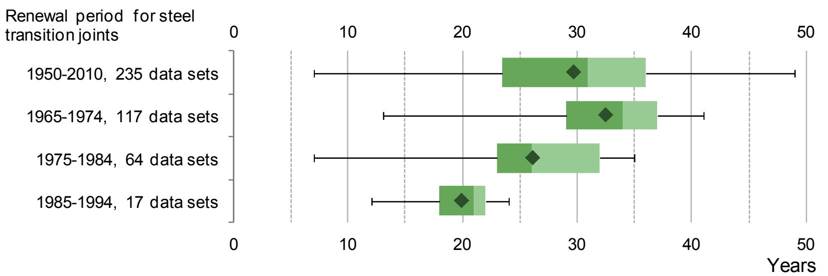

Fig. 1: Renewal period for expansion joints with steel lamella and plastic hollow sections grouped for different construction years

On Basis of these analyses of the empirical data, a literature review and discussions within the project team [1] three maintenance strategies shown in Figure 2 are derived. Generally, it can be seen that the number of interventions are reduced when changing from preventive maintenance to condition-based maintenance or permitted deterioration. The three strategies represent a range of different scenarios which describe a maximum, average and minimum strategy. They can be compared with a funnel. The renewal cycles are values which can be used for life cycle calculations (life cycle costing, life cycle assessment, external cost calculations, etc.). But still, they must be interpreted as assumption of a possible future development. Their application can help to identify sensitivities of results for the extremely long bridge life span of 100 years. Such results deliver important decision supporting information.

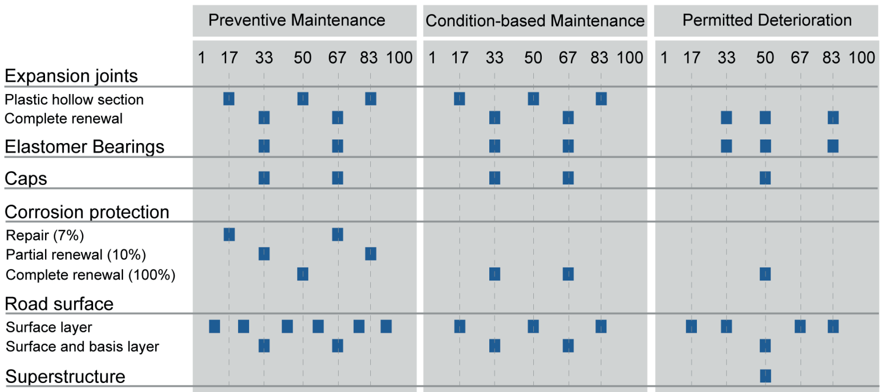

Fig. 2: Derived maintenance strategies specified for all bridge components

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3. References

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