# Upgrading Existing Railway Bridges in Europe for Higher Speeds and Loads - Assessment Procedures and Requirements

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## Summary

This paper presents procedures and requirements for the assessment of existing railway bridges in Europe. The assessment procedures and requirements are the core part of the "Guideline for Load and Resistance Assessment of Existing European Railway Bridges - advices on the use of advanced methods" [1], recently developed within the European research project "Sustainable Bridges" (www.sustainablebridges.net). The first part of the paper introduces the step-level assessment methodology recommended in the guideline. The second part is dedicated to the safety requirements for existing railway bridges and gives guidance on the safety levels required for the assessment. Furthermore, it presents several safety formats characterized by different accuracy and complexity, which might be used at different level of assessment.

**Keywords:** Railway bridges; safety assessment; load capacity evaluation; safety requirements; reliability methods; reliability index; assessment procedures.

## 1. Introduction

Many of the European railway bridges are getting close to the end of their service life. At the same time the railway operators demand higher axle loads for freight trains and higher speeds for passenger trains. This requires new and better approaches for assessing overall performance of railway bridges, including load carrying capacity, serviceability and durability.

The "Guideline for Load and Resistance Assessment of Existing European Railway Bridges - advices on the use of advanced methods" [1] has been recently developed within the European integrated research project "Sustainable Bridges - Assessment for Future Traffic Demands and Longer Lives". The main objective of the guideline was to provide bridge evaluators with the most advanced knowledge regarding methods, models and tools that can be used in the assessment of existing railway bridges in order to get a realistic evaluation of their performance.

This paper describes procedures and requirements recommended in this guideline to be used for the assessment of existing railway bridges. It presents a step-level assessment procedure, with three subsequent assessment levels that are characterized by the increasing level of accuracy and complexity. Furthermore, the paper shows the requirements regarding bridge safety, serviceability and the remaining service life adopted in the SB-LRA Guideline [1]. These requirements are defined in terms of reliability indexes. Besides that, the paper also discuss several safety formats that should be used in the assessment, starting from Partial Safety Factor format, through simplified probabilistic, up to fully probabilistic formats that allows to account for bridge redundancy and system performance.

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## 2. Procedures and requirements for assessment of existing railway bridges

### 2.1 Assessment procedures

Assessment of an existing railway bridge with the purpose of re-qualifying the bridge for increased loading and/or for prolonging the service life may be seen as an adaptive, step-level process of refining the state of knowledge regarding the present and the future state of the bridge and its behaviour. An assessment may involve a review of project documentation, inspection of the structure, testing of materials, testing of structural performance, refined numerical analysis and planning of future inspections.

The decision on whether or not to collect more information is always based on the existing information (prior information) and the expected reduction of the life cycle cost obtained on the basis of the additional information. Depending on the actually achieved knowledge (posterior information) it may or may not turn out to be feasible to refine further the state of knowledge. Also, in the same manner, the re-qualification actions (strengthening and repairs) may be evaluated, compared and selected. It should, however, be noticed that economical considerations alone, may not be sufficient for re-qualification purposes as explicit requirements to the safety of the bridge are often dictated by legislation.

### 2.2 Safety formats for assessment

As most of the current design codes, the SB-LRA Guideline [1] uses the safety concept based on the limit state (LS) approach. The application of different safety formats is proposed in parallel with the use of less or more advanced levels of assessment. In the simplest case, the assessment carried out at member level is enough to ensure the correct performance of the bridge. In this case, the “usual” safety format based on the use of Partial Safety Factor Method - PSFM (Load and Resistance Factor Design - LRFD) and a linear analysis, as in the design codes, is used. However, different safety formats become necessary when assessing a bridge for which partial safety factors provided by codes are not the most appropriate or when assessing the bridge at a system/structural level, where more advanced analysis methods are mandatory (e.g. non-linear analysis, system reliability analysis, etc.).

### 2.3 Safety levels for assessment

The target reliability levels proposed in different countries and by different international bodies (Eurocode, ISO) are presented in the SB-LRA Guideline [1], jointly with the most significant assumptions behind them. In this way, the engineer responsible for the assessment, after agreement with the bridge owner, can choose the most suitable safety level for each specific case. Because bridge assessment is highly case-specific, the SB-LRA Guideline [1] does not just propose a value to be adopted for the safety level as a general value, but gives information and guides on how to fix this level for each case.

## 3. Conclusions

The assessment of existing railway bridges should be carried out according to the proposed step-level procedure with increasing levels of accuracy and complexity in order to meet the actual needs. The safety procedures and requirements proposed in the SB-LRA Guideline [1] wish to provide to the user sufficient relevant information on the available possibilities when faced with the assessment of an existing railway bridge. In this way, various safety formats are presented starting from the partial safety factor method up to full probabilistic analysis. Depending on the results derived from the gradual application of the available methods, decisions can be taken on future investigations to be performed.

## 4. References

[1] SB-LRA, Guideline for Load and Resistance Assessment of Railway Bridges, Prepared by Sustainable Bridges- a project within EU FP6. Available from: www.sustainablebridges.net, 2007.