Monitoring of railway-bridges – an advanced component of maintenance and sustainability

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1. Introduction
A lot of the older German railway bridges are made of steel and have reached or exceeded the planned duration of use. In past decades considerable efforts were started to renew the outdated bridges continuance by suitable building measures. Thus every year about 270 bridge constructions were built in the 80-s and 90-s, so it was able to reduce the average age from 80 years of that time upon about 70 years today. By necessary alterations of the investment main focuses, above all, however, by a reduction of the federal budget means the investments in bridge new buildings had to be reduced during the last years considerably.

To guarantee reliability, road safety and stability it is therefore most important to carry out a qualified evaluation of the asset. DB AG has with respect to that an excellent set of codes in comparison with international standards.

For the evaluation of the load-bearing capacity of existing railway bridges a code system (module family 805 of German Railways) is existing. That system long ago contains the safety concept of the ultimate states and partial safety factors and thus allows the differentiated and separate consideration of influence on the load (e.g., the quality of the determination of construction- and grit loads) and on the strength (e.g., age and state of repair).

In code 805 four steps of evaluation of existing bridges are defined. At the highest step 4 a detailed static calculation is to be carried out considering investigations based on measurements. The evaluation of load bearing capacity is to complement by a fatigue proof, which is to be carried out as a standardised verification of remaining useful life on the basis of the S-N-curve concept.

Long-term measurements are used, e.g. for realistic determination of load- and stress collectives under running traffic, sometimes also under wind loads. Herewith, above all, information can be got which refers not only to a concrete investigation time, but also allow statements about time-dependent changes of effective structural system. Temperature changes or settlement processes are a cause for this as a rule. A long-term measurement can also give support for construction observation and is therefore a reasonable supplement of the building inspection. However, it can never be substitute for this.

Before thinking about an measurement investigation according to step 4 of the code 805, the possibilities of the detailed computational determination of load bearing behaviour (step 3) should be exhausted basically. On the basis of a current project the application of measurement-based investigations as part of the construction evaluation is shown in the following paragraph exemplarily.

2. Structural Monitoring of a railway bridge in Chemnitz
The Chemnitztalviadukt was built in 1901 as a multi-track railway bridge in the city of Chemnitz on the route Dresden-Werdau. At the beginning of 2000 the whole bearing structure was recalculated according to code 805, step 3 and as a result in the critical zones none or only a small remaining useful life of 5 years could be proved.

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That's why it was checked if the assumptions for remaining useful life proof could be improved by a measurement-based investigation. The elaborated measure concept is based upon the assumption that information can be got for a realistic calculation of remaining useful life, especially for the following items:

- identification of reserves at cross section- and system carrying behaviour
- verification of the real working loads by measurement of load collectives

For the implementation of the described measuring concept, the structure became part of a research project at the beginning of 2005, in which selected sub-sections were monitored for two years to gather realistic information about the short and long-term carrying behaviour of the bridge.

The acquisition of measuring values occurs continuously after a suitable time tact (every 15 min) as well as event-controlled, as a quick dynamic measurement in reaction to a suitable triggering signal. Events are defined in the present case by passing trains. Strain measurement points on the rails are used as trigger sensors. They deliver a clear signal while crossing of a train (see the following figure).

On the basis of this strain measurement on the rail the railcar type, the accompanying vehicle weight, the driving speed and, in addition, the axle loads, derived from the amplitudes, can be determined. By comparison of calculated and measured strains some load bearing reserves could be detected. For instance the maximum computed strain on the extreme loaded bottom flange plate during the passage of a specific train is circa 26 N/mm² and the belonging measured value is ca. 14 N/mm². Further comparative calculations show that these differences are to be led back on the one hand to a high involvement of the ton plates and the roadway, on the other hand, on a unloading of the examined girder as a result of a better lateral distribution of the structure.

For more information – see the full paper, published on the CD-ROM.