Changes in Traffic Demand and Influence on the Lifetime of a 45 Year old Bridge

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Summary

Risk management based on probabilistic approaches is becoming more and more the current practice. The performance of a probabilistic hazard assessment required knowledge on materials, systems and properties. Our constructed environment is, unlike the automotive or aeronautic sector, characterized by a wide scatter of the real quantities. Monitoring is able to identify the systems in a way that allows reducing the uncertainties considerably. Sorrow system identification is able to reduce the systematic errors to less than 1%. Extensive studies in the past have revealed that particular concrete structures can deviate over 30% from the values as planned by the designer. Fortunately these deviations are mainly in the save direction. This knowledge can help to adjust the assessment of our structures to justified level. In the light of the problem with bridges rated deficient in an extent that is not manageable anymore, this identification could solve part of the problem.

The monitoring campaigns carried out at more than 400 bridges in the past years have shown that over 95% of the bridge stock shows higher capacities than anticipated. The few problems remaining can easily be approached by relevant retrofit measures. It has been demonstrated that the existing budgets for bridge maintenance and retrofit are actually sufficient, in case that the money only has to be spent on those structures absolutely requiring an intervention.

Introduction

Our transportation infrastructure is aging. Bridges are an essential asset of our economy. Reference is made to the situation in the United States, where within the network of the *Federal Highway Agency* (*FHWA*) 590 000 bridges are serving, out of which 160 000 are rated deficient when the traditional methodology is applied. Replacement costs of seven billion US$ annually over 20 years are estimated to achieve a perfect upgrade. In order to avoid such costly situations, the lessons learned with relevance for design should be considered in nowadays bridge design processes. Another drastic example is a bridge built in Austria in 1978, following the minimization principle of construction costs, at 8.5 million €. Within 25 years a total of 19.5 million € had to be invested into retrofit measures. With consideration of lifecycle cost approaches such situations have to be avoided in future. The following is a collection of lessons learned from monitoring of over 400 bridge structures since 1997. The structures monitored are mainly situated in central Europe and represent the typical design for this region. Nevertheless most of these lessons can be extended to structures worldwide.

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Conservative Design

The monitoring of over 400 bridges clearly shows different behaviour of structures designed following different philosophies. Bridges designed conservatively are not affected by dynamic phenomena that generate concern or trigger damage. Bridges with design focus on economy very often do not have any reserves to cover the extraordinary loadings that appear in reality. The difference in dynamics becomes obvious in the following **Error! Reference source not found.** and **Error! Reference source not found.**. Conservative bridges show a high system damping with distinct characteristics. Economic designs very often come close to areas where resonance appears. This resonance might be a very local and limited effect, but over time it leads to damage in structures.

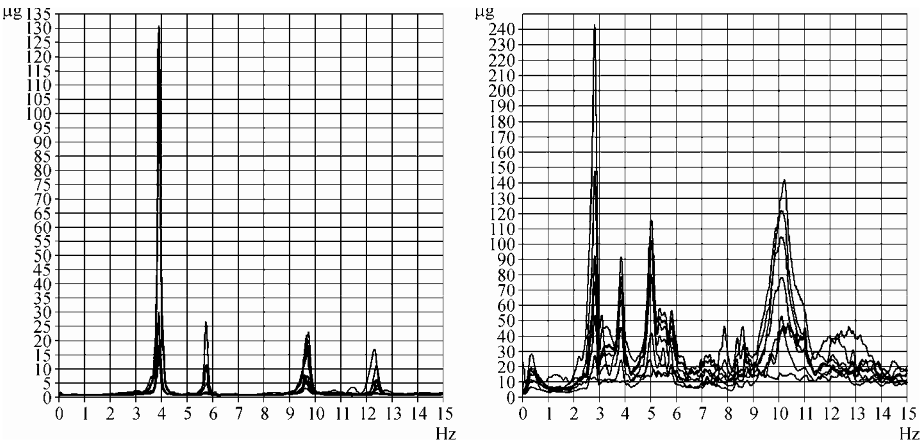

Figure 1 Spectrum of a sound bridge (left) and spectrum of a damaged bridge (right)

Value of Patterns

Certain elements of bridges exist in a repetitive form. It has to be expected that all members show the same dynamic performance under service. One of the valuable approaches of monitoring is to recognize patterns and to observe the performance of comparable components. Any deviation from the pattern indicates a malfunction or an extraordinary situation which can be identified.

As an example the case of a concrete box girder bridge with a distinct cantilever is shown. The monitored performance of the cantilever minus the action of the global system provides information on the cantilever eigenmodes. Related symmetric modes can be determined and displayed. This should provide a distinct pattern, where every deviation indicates a problem. On the basis of coloured frequency cards, so called trend cards, the relevant cantilever eigenfrequencies have been determined, which are marked in **Error! Reference source not found.**.

References

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