Title: Operational Modal Analysis in Dynamic Load Tests of Truss Railway Bridges

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Summary: Identification of dynamic properties is an important and current problem in civil engineering. In bridge engineering, this type of information is often obtained during the dynamic load tests. The role of this type of tests is still misunderstood. Their goal should be to verify design assumptions, update the numerical model, and define the initial parameters of the structure to be used in the life cycle of the bridge. Commonly used simple test methods do not give proper results in case of complex structures such as, for example, railway truss bridges. The complexity of the dynamic response of this type of bridges requires the use of adequate research tools, such as Operational Modal Analysis (OMA).

The research described in the thesis was aimed at the application of OMA in the specific and routine dynamic load tests. These tests are a unique opportunity to obtain information about a tested structure in an undamaged condition. The subjects of the described research are Warren truss railway bridges. They are one of the largest bridge structures on Polish railway lines. These structures are characterized by a specific form of dynamic response, whose identification by means of using a typical research approach, i.e. a simple signal analysis, often leads to errors. The experience gathered on truss bridges may be partially transferable to other large railway bridges.

The approach applied in the work involved the execution of several identification experiments of actual structures subjected to a dynamic load test, whereas OMA was an extension of the standard test program. The stochastic subspace identification algorithm in the variant based on the preliminary estimation of the correlation function was used to identify modal parameters. Observations made in an earlier experiment influenced the program of the subsequent one. The tests were also programmed to observe the specific behavior associated with the specific structural details. Numerous other types of bridges examined by the author enabled the generalization of the proposed approach for a wider group of bridge structures.

Common features of the dynamic response of truss railway bridges were noticed. The problem of closely spaced modes of the first vertical and torsional mode of vibration was often observed. Their unambiguous identification with simpler research methods would be impossible and could lead to errors in conclusions regarding the dynamic properties of the structure. Dynamic interaction of two independent truss spans was observed. It was also found that the identification of six to eight basic modes of vibration is usually possible. Based on the collected experience, the author developed a way of dealing with this type of objects when using OMA during dynamic load tests.

The study shows that the operational modal analysis is an identification method well suited to the load tests of large railway bridges. Its use allows for unambiguous identification of basic modal parameters in a much wider scope than previously used research methods based on the signal analysis. The greatest benefits can be derived from already used objects, because the identification of their dynamic properties can be done using ambient excitation. These natural sources of excitation forces, otherwise being an undesirable contamination of measured signals, can become a useful and free source of excitation, available without the need to close traffic on the bridge and to rent expensive trial vehicles (locomotives, trains).