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Modal Analyses of Concrete Bridges at "Stora Höga", Sweden

Analyse modale de ponts en béton, en Suède

Modalanalyse bei Betonbrücken in Schweden

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1. INTRODUCTION

Two high-way bridges were loaded to shear-failure, [1]. Simultaneously, modal parameters were measured and analysed, [2]. To accomplish the measurements, the bridges were excited vertically with impacts, and the responses were measured with accelerometers. Frequency response functions were computed and averaged as well as coherence functions to check the quality of measurements.

The purpose of the project was to gain experience of modal analysis of concrete bridges with impact excitations, establish requirements for the equipement, analyse the changes of modal parameters and relate them to changes in spatial parameters.

As a result of the project, an efficient measurement -technique was adopted, by which severe changes in stiffness and boundary conditions may be detected. Reference measurement of the undamaged structure has to be made. High accuracy in measurement results is necessary, since discrepancies in modal parameters compared to the virginal state are generally small. A refinement of the method is to establish a "Finite Element" (FE) -model to be correlated to the measured modal model. The purpose is to up-date the spatial parameters in the FE-model to obtain the same modal parameters as in the measured modal model. The FE-model may then be used in future comparisons for checking the condition of the structure.

2. DESCRIPTION OF BRIDGES AND MEASUREMENTS

2.1 Prestressed concrete bridge

The prestressed bridge was a frame with two straight girders monolithically cast together with a curved bridge-deck. The span was 32 m and the width ~ 10 m. Before the shear-failure test was performed, successive damages in form of bending cracks were introduced by overloding the center cross-section. This was made with hydraulic jacks, acting on steel bars, fixed to the ground. After each loadstep, measuarements of modal parameters and damages were made.

The impacts were accomplished by a falling weight, mass ~ 60 kg, supplied with a visco-elastic damper. The weight was dropped from ~ 0.80 m on a load-cell. The recorded forces were ~17 kN, with a contact -time ~ 20 ms. The force-spectra show that half of the applied energy excited the bridge in vibrations below 40 Hz. The "Time Reccord Length" was 8 seconds, giving a measured frequency resolution of 0.125 Hz. The responses were measured at 27 points along 3 lines on the bridge-deck. The excitations were made at the same point in all measurement-series.

2.2 Ordinarily reinforced concrete bridge

This bridge was a plate-frame structure for local traffic. The span was 21 m and the width ~5 m. To get shear-failure in this bridge, additional reinforcement in form of steel-plates were glued to the lower surface of the concrete-plate. Two measurement-series of modal parameters were made before and two after application of the steel-plates. Later the bridge was loaded to shear-failure by vertical forces applied close to one of the supports, and therafter a final modal measurement was made.

Impacts were introduced with a special equipement, consisting of a falling weight ~40 kg, an impact load-cell, and a visco-elastic damper to avoid bounces. In the first measurement a 5.5 kg sledgehammer was used. The impacts were made at 60 points along 5 lines on the bridge deck. The responses were measured at two different points, to allow for comparisons between frequency response functions.

3. RESULTS

Valuable experience is gained from different measurement-techniques. Impact excitations may be used and the results are accurate enough to detect minor defects, if the measurements are performed carefully. The most efficient way to measure is to use a stationary excitation point and several accelerometers properly fixed to the bridge surface. It is not necessary to measure in so many points in a regular sceme.

The result of the analyses shows small but significant changes in resonant frequencies for increasing damage or increasing stiffness. In case of the prestressed concrete bridge, the center cross-section was successively cracked, influencing the bending modes to a higher degree than the torsional modes. In Fig.1 a typical bending mode is shown and the relative difference in resonant frequencies compared to the reference state as a function of a damage index. The modal shapes may be used to localise damages in the structure by computer-comparisons in a systematic way. Damping ratios are more sensitive to the measurement- and analysis-technique and the obtained results are difficult to evaluate properly.

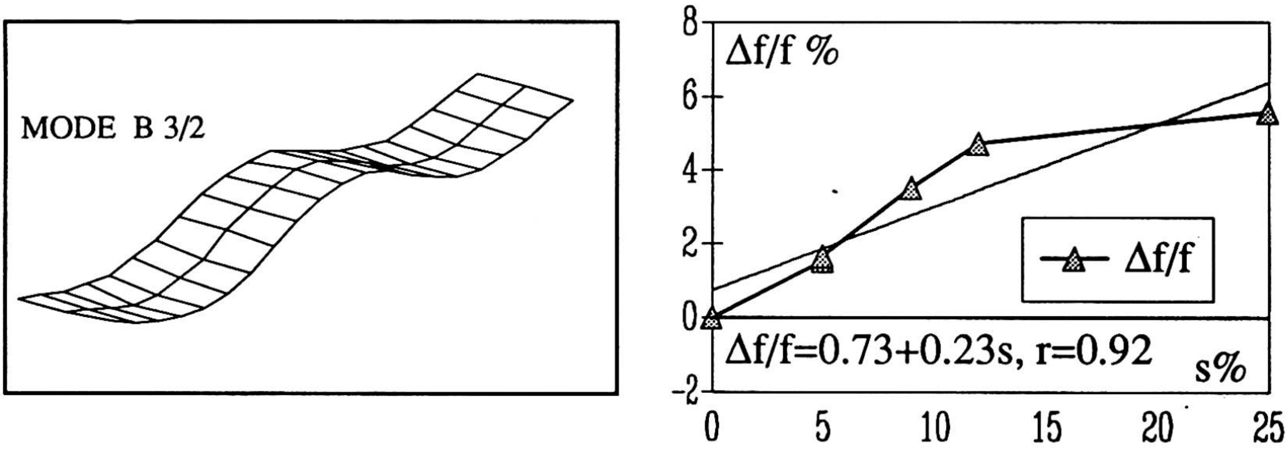

Fig. 1 A bending mode for the prestressed concrete bridge and the relative difference in resonant frequency as a function of a damage index s, with regression-line and correlation coefficient r.

4. REFERENCES

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