

Damage detection of steel-concrete composite beams using modal analysis methods

The dissertation presents efficiency analysis results of some modal analysis methods used as damage detection and localisation tools in steel-concrete composite beams. Composite beams are commonly used as main load-bearing elements in bridge structures. Constant monitoring systems are frequently used to inspect the technical condition of such structures. Based on observed changes of some modal parameters, it is possible to infer conclusions about damage and to successfully locate damaged places.

Several damage detection and localisation methods were assessed in the dissertation. The changes of natural frequency, modal damping ratio, mode shape and energy transfer ratio (ETR) were analysed. The sensitivity analysis of these parameters relative to beam damage was conducted on the basis of numerical simulation results and experimental data.

Two steel-concrete composite beams with different connections were analysed. Beam denoted as BG1 had steel stud connectors, whereas in beam denoted as BG2 perforated steel slats were used. The beams were examined in a two-step experimental study: first, undamaged beams and then beams with induced local damage were analysed. Two kinds of damage varying in terms of degree and localisation were examined. In beam BG1, damage was induced in the connection, while in beam BG2 damage was introduced in the bottom flange of an I-bar.

2D computational models for the beams were developed in the RFE (Rigid Finite Element Method). The steel and concrete parts were modelled separately. Owing to that, it was possible to calculate deflection of the connection in two directions. To define damping, loss coefficients were determined independently for steel, concrete and the connection. Loss coefficient values were estimated using experimental data.

Based on numerical simulation results and experimental data, efficiency analysis of the analysed methods of damage detection and localisation in the connection and in the lower flange of an I-section was conducted. The effectiveness of the methods was evaluated both in terms of damage detection and localisation of induced damage.