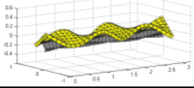

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MODELLING OF SPATIAL VIBRATION AND PARAMETER IDENTIFICATION OF DISCRETE MODELS FOR STEEL-CONCRETE COMPOSITE BEAMS

Summary

The doctoral dissertation addresses the issues of modelling spatial vibration of steel-concrete composite beams which are very often used as main elements of composite floors or in bridge engineering as main carrying girders. The main aim of the dissertation is to develop a spatial model of steel-concrete composite beams and a method of its parameter estimation, including stiffness and damping characteristics.

A discrete, spatial, computational model for a steel-concrete composite beam was developed using the Rigid Finite Element Method. RFEM enables effective determination of dynamic properties of beams. The modelling methodology was chosen following encouraging results of previous modelling studies conducted with 2D RFEM models. However, 2D finite element models can be used to analyse only some modes of vibrations: flexural vertical and longitudinal vibrations. The 3D model presented in the dissertation enables to determine, apart from those modes mentioned above, torsional, flexural horizontal and transverse vibration of the bottom flange of a steel section as well as other vibration modes with components in the horizontal direction, perpendicular to the beam’s axis. Since no commercially produced RFEM- based software is available, an original program for MATLAB environment was developed.

The study provides experimental results for three composite beams, a reinforced concrete slab and a steel section. The three beams had a different density distribution of steel connectors - headed studs which are commonly used connecting elements. Analysis was focused on determining dynamic characteristics, including frequency, vibration modes, modal damping coefficients and frequency response function using impulse excitation.

Experimental results were used to estimate model parameters. The estimation was conducted using natural frequencies as well as modes of vibration and frequency response function determined in analysis. The following parameters defining model stiffness were assumed to be estimated: substitute longitudinal modulus of elasticity of reinforced concrete E_c, *shearing stiffness* of connecting elements, i.e. translational stiffness in tangential direction to steel-concrete interface K_h, *axial stiffness* of connecting elements, i.e. translational stiffness in normal direction to steel-concrete interface K_v and rotational stiffness of connecting elements around beam axis $K_{R,X}$. Damping properties of the beam defined with loss ratio η were estimated independently for concrete η_c, steel η_s, and connection η_z.

Two algorithms of parameter identification were developed. The first one is based on the comparison of experimental and calculated frequencies and natural vibration modes. The second one is based on the comparison of experimental and calculated frequency response functions. To validate the algorithms and to demonstrate the usefulness of the 3D model, it was used to detect size of damage. Analysis was focused on damage of steel connectors that join the reinforced concrete slab with the steel section. Simulation of damage detection confirmed high effectiveness of the developed algorithms.