Elastic Wave-Based Identification of Applied Load in a Steel IPE Beam

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The progressive ageing of infrastructure and increasing safety requirements for engineering structures have driven the rapid development of structural health monitoring (SHM) and non-destructive evaluation techniques. In recent years, particular attention has been devoted to methods based on the propagation of elastic waves generated, among others, by piezoelectric transducers (PZT). These approaches enable the detection of changes in material properties, stress states, and local damage, thereby supporting real-time monitoring of structural condition [1-3]. As shown in [4], the changes in the strain field result in changes in elastic wave propagation. Acknowledging the truth of this phenomenon, inverse problem solving is trying. Namely, the load level identification. The presented study aims to investigate the possibility of actual applied load identification, based on the elastic wave propagation, generated and registered using the PZT transducers in a steel structural element with dimensions and shape identical to those of civil engineering structures. The experimental study is conducted using a laboratory test setup in which the steel element (a node combined with HEB 160 column-fixed on the top and bottom in a measuring stand, and IPE 300 cantilever beam welded to the column and loaded near the free end) is subjected to cyclic static loading, resulting in a gradual increase in displacement at the free end of the cantilever. The measurement system consists of four piezoelectric PZT transducers installed on the upper and lower flanges of the cantilevered part of the element, and two electrical resistance strain gauges used to measure local strains in the structure. The 3.5 sine signal at 38,571 Hz (resulting in an operational frequency of 135 kHz) was used to excite the wave. Measurements are performed at successive loading stages, allowing analysis of changes in wave-propagation parameters as a function of load level. Simultaneously, the magnitude of force, hydraulic piston displacement, and strain at selected points of the structure are continuously recorded. Recorded signals are filtered, carefully analysed to select the crucial parameters, and divided into learning and testing pattern sets. Due to the load level identification the artificial intelligence tools are applied. The results show the potential application of wave-based methods for structural health monitoring of steel structures with complex geometry.

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