Abstract

Studies of mechanical properties and dynamic characteristics of masonry structures in damage diagnosis

The increasing popularity of non-destructive testing in damage diagnosis of building structures, makes them commonly used, especially as part of structural health monitoring in the engineering community. In particular, vibration-based damage identification methods, and the wide availability of commercial finite element analysis software for stress analysis. The study of mechanical properties to define the numerical model and dynamic characteristics to control any change in these parameters, can be very important in the damage diagnosis process of different types of structures, including masonry structures.

The aim of the work is damage detection and localization, especially in masonry structures using non-destructive testing based on mechanical properties and dynamic characteristics determined experimentally.

Experimental studies have been presented to determine the mechanical properties of autoclaved aerated concrete (AAC) to define the numerical arch model made of AAC elements. Compressive strength, density and porosity as well as tensile strength in splitting tension test for different specimens shape were determined. Particular attention was paid to the splitting tension tests with the digital image correlation system. An original method of determining elastic constants was developed. Elastic constants are determined by fitting the theoretical solutions into the displacement field of the observed specimen surface obtained experimentally. The proposed method has been extended to investigate the elastic constants of ductile materials. Experimental splitting tests for all shapes of AAC specimens were complemented with numerical simulations using the finite element method, confirming the failure mechanism observed in the experiments.

Dynamic impulse tests were performed to determine the dynamic characteristics of the steel plate and the masonry arch made of AAC elements. Experimental dynamic tests were carried out for an undamaged and damaged structure, which allowed to determine different indicators of damage detection and location. The description of the research was preceded by short theoretical background in the dynamics field, facilitating the understanding of the experimental tests. In

addition, the static response analysis of the AAC masonry arch model was carried out in order to determine the location of subsequent cracks during failure mechanism. This simulation allowed the location of the forced damage in arch at the point of the first crack formation in the model.

Finally, an analysis of two masonry chimney was carried out. The first analysis included an approximate numerical stress analysis of the chimney model. A design response acceleration spectrum was used to identify potential damage locations in the structure. The second analysis was an experimental dynamic study of the chimney. An impulse test was carried out to obtain dynamic characteristics of the structure. The results will be used in further analyses.

Keywords:
Vibration-Based Damage Identification Method (VBA DIMs), finite element method, masonry structures, mechanical properties, Young's modulus, Poisson's ratio, Digital Image Correlation system (DIC), splitting tension test, dynamic parameters, impulse test, Autoclaved Aerated Concrete (AAC)