STRUCTURAL BEHAVIOR AND DAMAGE ASSESSMENT OF A REINFORCED CONCRETE WALL BY VARIOUS NDT METHODS AND EMBEDDED SENSORS UNDER BLAST-LOADING

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Abstract:

A safety or security related assessment of explosions, accidental and intentional scenarios alike, often necessitate performance of replication-tests. Such test results are necessary to clarify the cause for the forensic reports. To gain important insights into the behavior of structures and materials under such loading, field tests may also be performed in accordance with different testing-standards. To determine the resistance of building-structures after explosions, estimation of the residual load-bearing capacity in addition to the assessment of dynamic structural response and damage to the building components is important. In most cases an evaluation of structural integrity is based only on the visual damage, resulting in an overestimation of the residual capacity.

The Bundesanstalt für Materialforschung und -prüfung (BAM) operates the Test site for Technical Safety (Testgelände Technische Sicherheit - TTS) on an area measuring about 12 km^2 in the federal state of Brandenburg for execution of true-to-scale explosion tests. At the BAM test site, building component testing was performed to assess the suitability of different non-destructive methods to characterize the dynamic structural response and damage resulting from the detonation of high explosives.

Different blast-loading scenarios were realized by varying the net explosive quantity and the standoff distance with all scenarios representing a near-field detonation. The test object was a reinforced concrete wall 2 m high, 2.5 m wide and 20 cm thick, fixed at both vertical edges. The dynamic loading of the wall was characterized with 8 piezoelectric pressure sensors flush-mounted on the front surface, thus measuring the reflected pressures from the shock wave. The tests were conducted with the aim of characterizing the global behavior of the wall under dynamic shock loading and the resulting local damage pattern, respectively. High speed digital image correlation was implemented in combination with multiple acceleration sensors to observe the rear surface of the wall to chart the dynamic deflection during the loading and to determine the residual deformation after the loading had ceased. In addition, one test specimen was instrumented with fiber optic sensor cables, both fixed to the rebars and embedded in the concrete-matrix, respectively. Firstly, these sensors were interrogated during the blast test by a distributed acoustic sensing (DAS) device using

a particularly high sampling rate to measure the shock-induced vibrations in the structure with high temporal resolution. This delivers information on dynamics of compression and tension cycles from within the structure. Secondly, the local damage-pattern emerging during the series of blasts was determined via distributed fiber optic strain sensing (DSS) by interrogating the embedded fiber optic sensors with a high spatial resolution DSS device after each blast. This enabled the characterization of non-visual damage to the structure, in particular with regard to the formation of localized cracks in the concrete matrix. The DSS was further complimented by a structure-scanner based on ultrasonic measurements.

Our contribution will describe the test procedure in detail. Results of the three datasets, namely dynamic shock loading, global behavior of the test object and the local damage pattern will be presented. The suitability of the implemented measurement methods will be discussed in combination with the challenges in their application for technical safety evaluation of building components under explosive loading.