World Academy of Science, Engineering and Technology
International Journal of Structural and Construction Engineering
Vol:13, No:02, 2019

Residual Plastic Deformation Capacity in Reinforced Concrete Beams Subjected to Drop Weight Impact Test

Authors : Morgan Johansson, Joosef Leppanen, Mathias Flansbjer, Fabio Lozano, Josef Makdesi

Abstract : Concrete is commonly used for protective structures and how impact loading affects different types of concrete structures is an important issue. Often the knowledge gained from static loading is also used in the design of impulse loaded structures. A large plastic deformation capacity is essential to obtain a large energy absorption in an impulse loaded structure. However, the structural response of an impact loaded concrete beam may be very different compared to a statically loaded beam. Consequently, the plastic deformation capacity and failure modes of the concrete structure can be different when subjected to dynamic loads; and hence it is not sure that the observations obtained from static loading are also valid for dynamic loading. The aim of this paper is to investigate the residual plastic deformation capacity in reinforced concrete beams subjected to drop weight impact tests. A test-series consisting of 18 simply supported beams (0.1 x 0.1 x 1.18 m, ρs = 0.7%) with a span length of 1.0 m and subjected to a point load in the beam mid-point, was carried out. 2x6 beams were first subjected to drop weight impact tests, and thereafter statically tested until failure. The drop in weight had a mass of 10 kg and was dropped from 2.5 m or 5.0 m. During the impact tests, a high-speed camera was used with 5 000 fps and for the static tests, a camera was used with 0.5 fps. Digital image correlation (DIC) analyses were conducted and from these the velocities of the beam and the drop weight, as well as the deformations and crack propagation of the beam, were effectively measured. Additionally, for the static tests, the applied load and midspan deformation were measured. The load-deformation relations for the beams subjected to an impact load were compared with 6 reference beams that were subjected to static loading only. The crack pattern obtained were compared using DIC, and it was concluded that the resulting crack formation depended much on the test method used. For the static tests, only bending cracks occurred. For the impact loaded beams, though, distinctive diagonal shear cracks also formed below the zone of impact and less wide shear cracks were observed in the region half-way to the support. Furthermore, due to wave propagation effects, bending cracks developed in the upper part of the beam during initial loading. The results showed that the plastic deformation capacity increased for beams subjected to drop weight impact tests from a high drop height of 5.0 m. For beams subjected to an impact from a low drop height of 2.5 m, though, the plastic deformation capacity was in the same order of magnitude as for the statically loaded reference beams. The beams tested were designed to fail due to bending when subjected to a static load. However, for the impact tested beams, one beam exhibited a shear failure at a significantly reduced load level when it was tested statically; indicating that there might be a risk of reduced residual load capacity for impact loaded structures.

Keywords : digital image correlation (DIC), drop weight impact, experiments, plastic deformation capacity, reinforced concrete
Conference Title : ICSUSI 2019 : International Conference on Structures Under Shock and Impact
Conference Location : Amsterdam, Netherlands
Conference Dates : February 07-08, 2019