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Performance of Fibre Reinforced Concrete Specimens Subjected to Impact Loading

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Abstract: Impact resistance of concrete structures gains high importance nowadays, as the man-made disasters (such as terrorism, car crashes, etc.) occur increasingly. Development and testing of blast and impact resistant materials is highly required. This paper shows outcomes of the experiments focused on FRC performance under impact loading.

Introduction

Besides tensile strength of plain concrete itself, both reinforcement and speed of loading influence tensile resistance of concrete specimen. The dependence of concrete strength on strain rate is expressed by DIF (Dynamic increase factor). To study the effect of high strain rates on FRC specimens, drop-weight experiments were undertaken.

Experimental Set Up

For the experiment tile-shaped concrete samples were prepared. The samples with unified size of 300 x 300 mm differed in thicknesses, varying the values of 30, 60 and 120 mm. The concrete mixture was reinforced with polypropylene or steel fibres. Several samples were reinforced with basalt fabric placed in one or two layers. Also samples with no reinforcement were prepared.

Impact loading of specimens was induced using drop-weigh mechanism. The steel drop-weight consisted of central shaft and several disc attached to it. Variable amount of steel discs enabled to regulate impacting weight (reaching 20.6, 46.4 and 75.2 kg). At the bottom disc the hemispherical tip was attached, so that the impact load was concentrated. The drop-weight was lifted by the hoist to its maximal height of approx. 2.8 m above the tested concrete sample. From its top position the drop-weight was released reaching impact velocity of approx. 7.2 m/s. The specimens were supported on two of their edges by steel beams and were hit in the centre.

Fig. 1: Steel frame with hoist.

Fig. 2: Specimen supported by beams.

Fig. 3: Burden discs of different weights

Evaluation

The progress of deflection of the specimen was captured by high-speed camera. The video record was decomposed into separate frames. The frames were graphically processed to obtain instantaneous velocity of the steel burden. Velocity-time dependence of the burden was plotted. Also the time dependence of deflection of the specimen was obtained.

The deceleration of the burden after collision with the specimen represents impact resistance of the specimen. Specimens causing grater deceleration of the burden prove themselves more impact resistant. The behaviour comparison of samples of different reinforcement but equal thickness and weight of burden was the centre of interest. Knowing the deceleration of the burden, the impact force could be calculated.

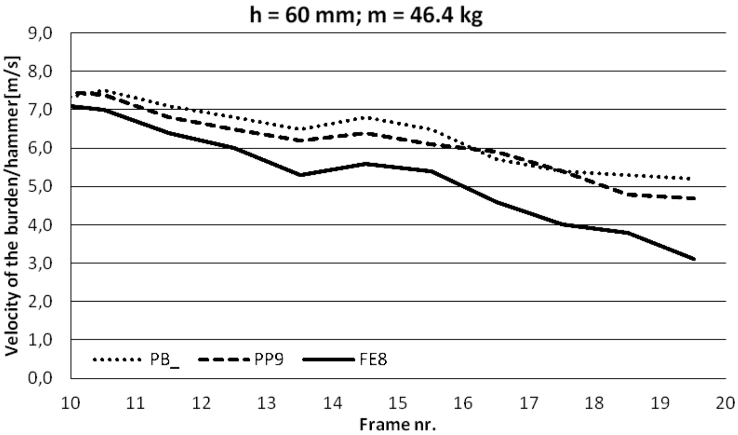

Fig. 4: Behaviour comparison of differently reinforcement specimens.

Fig. 5: Crack pattern of specimen.

One third of all samples of each thickness and reinforcement was subjected to three-point bending test. The mechanical resistance of concrete specimen depends on strain rate; in general, dynamic increase factor (DIF) increases with increasing strain rate.

Numerical simulations

According to the experimental conditions, numerical simulations were prepared. Material models were adopted from previous impact loading experiments. The aim was to validate the used material models in conditions of current experiment and in case of discrepancy between experimental data and simulation to calibrate the material model.

Summary

The aim of this paper is to compare behaviour of differently reinforced FRC samples subjected to impact loading from both experimental and numerical point of view. According to the experimental results, the main factors influencing FRC impact resistance are type, material and volume of the used dispersed reinforcement.

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