POST-IMPACT EVALUATION AT RC PLATES WITH PLANAR TOMOGRAPHY AND FEM

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1. Introduction

Due to the many possible applications, the uncomplicated production and the high application range, reinforced concrete is a widely used building material. This large range of physical material properties still poses an engineering challenge in determining all necessary requirements for predicting dynamic effects under impact load.

Many aspects of impact have already been examined and some correlations have been studied intensively. Examples are the work of Lastunen [1] and Booker [2], who studied the influence of projectile properties on the impact form. Li [3] has also investigated the local effects of an impact. The field of detailed damage analysis has not been in focus so far.

This presentation shows some studies in medium-velocity impact with the focus on post-impact damage evaluation. The impactor is modified so that the test plates show low penetration on the top and scabbing on the bottom. With the unique tomography lab test stand at BAM the plate is scanned after the impact and the damage is analyzed. Cracks and scabbing are made visible with a reconstruction. The comparison of simulation and tomography allows to create prognosis models for damage characterization.

2. Test specimen

Reinforced concrete plates of class C35/45 with the dimensions 1.5 m x 1.5 m were used. The plate thicknesses varied between 0,1 and 0,3 m and 5 plates with different impact speeds were tested for each thickness. Table 1 shows the mean value of the compressive strength (f_c) after 28 days and on the test day, depending on the concrete batch (see series designation). The age of the plate on the test day is shown in brackets.

Table 1. Small overview of the physical properties of the tested plates

plate	thickness [mm]	f_c_28d [MPa]	f_c_test [MPa]
S26/27	200	38,1	66,9 (275 d)
S28	100	33,7	63,9 (230 d)
S29/30	300	39,3	71,9 (214 d)

3. Methodology

The damage properties for the impact loads in the medium-velocity range were investigated. The impact was generated with a cylindrical projectile (diameter d=100mm, weight m=23.34kg) on a reinforced concrete plate. The shape of the impactor has a large influence on the damage [4]. The chosen flat nose shape results in small penetrations on the upper side and scabbing on the underside.

The High Energy X-Ray Lab (HEXYLab) is located at BAM. The plate is investigated with the developed scanning regime. The subsequent reconstruction allows a very detailed examination of the damage of the complete plate with a crack detection algorithm.

Fig. 1 and Fig. 2 show an example of the crack pattern of the surface and also of the interior of the plate (S26P02).

Fig. 1. Crack structure of the underside of S26P02

Fig. 2. Crack structure by planar tomographic investigation

For the development of a prognosis model, the crack structures resulting from the tomography are compared with the computed damage from the numerical simulations. The FE modeling was done using the hydrocode AUTODYN and the material models Drucker-Prager and Riedel-Hiermaier-Thoma.

4. Results

Correlations between bearing force and impact pulse could be determined and can be explained by the degree of damage. Analogous, effects can be seen in the damage volume, cumulating cracks, spalling, scabbing and punching cone (see Fig. 3).

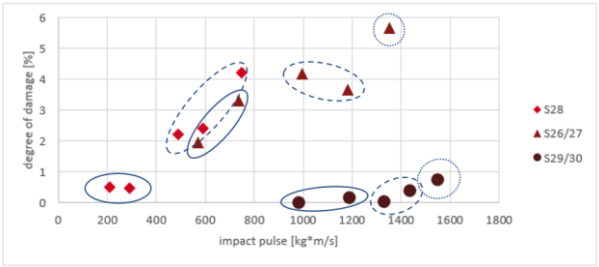

Fig. 3. Degree of damage in % w.r.t. impact pulse. Comparison of the series and their type of damage. Shear cracks (solid line), punching cone (dashed line), punching cone and increased scabbing (dotted line).

Between impact impulse and shear angle an only week correlation could be identified. Comparisons of simulation and experiment show good similarities of the experimental data as well as of the damage characteristics.

5. Conclusions

In the described impact studies with a variation of plate thickness, effects of local damage were detected. Correlations between impact pulse and damage could be determined.

With the help of tomography, the damage analysis can be extended by the examination of the internal crack structures.

Numerical simulation is a useful tool for creating prognosis model of the damage characteristics. Superpositions of FEM, optical scanning and tomographic data indicate similar damage.

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