Evaluation of internal forces distribution in RC beams subjected to impact loads

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Contemporary society is aware of the importance of ensuring structural safety when constructions are subjected to extreme loading conditions. These events – be they of natural or anthropogenic origin – attract significant media and public attention due to their sudden, catastrophic, and unpredictable nature. Among extreme loads, impulsive actions such as impacts or blast can be particularly damaging. Reinforced concrete (RC) structures show a high tendency to develop brittle failure, due to shear or punching, when subjected to impulsive loads.

Experimentally, it has been proven that RC structures that exhibit ductile bending failure in static tests may develop a brittle failure when subjected to impulsive conditions. This might be explained by the particularities of the dynamic behavior of structures. In the dynamic range, effects such as the development of inertia forces or the sensibility of failure mechanisms to the strain-rate shall be considered. In addition, in highly dynamic events, adiabatic conditions are in general prevalent. In the case of the impacts, the load imparted during the shock depends on various factors, such as the kinetic energy of the collision and the interaction between the impacting bodies. This interaction is determined by their stiffness, mass, materials mechanical properties and the non-linear behavior of the contact.

Therefore, evaluating the failure mode of a RC structure under these dynamic conditions might be challenging. One critical aspect of the structural verification under impulsive loads is that the internal forces distribution (shear and bending) is uncertain. In previous contributions, the authors have employed an experimental methodology to assess the time-varying distribution of these forces. This methodology is based on the combined use of digital image correlation (DIC) and a high-speed (HS) camera.

The present study analyzes the time-varying internal forces distribution of RC beams subjected to low-velocity impact loads. The research has an experimental basis and discusses the results with a numerical elastoplastic model. The experimental campaign consists of 6 bending-critical RC beams with a reinforcement ratio of $\rho = 1.0\%$ and various span-to-depth ratios (L/d), between 3.8 and 10.2. The aim of the study is to discuss the experimental observations with the numerical results, focusing on the influence of the span-to-depth ratios in the internal forces distribution during the impact event.