FINDINGS

The cushioning factor is a parameter that can show the structural response and have a regressive power relationship with the deformation of the structure.

PARAMETRIC STUDY ON THE MASS OF A FREE-DROPPED-HAMMER ON DYNAMIC RESPONSE OF A REINFORCED CONCRETE BEAM

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Introduction

In general damage assessment is used to determine the capacity of a structure under given loading scenarios. Impact loading is a common phenomenon in reinforced concrete (RC) structures subjected to extreme loading scenario which acts in a very short period of time. Basically, when a Moving Object (MO) hits a given structure, momentum is conserved by a reactionary force that slows down the structure until it comes to a halt. Some of the kinetic energy of the MO is converted to strain energy in the structure that is being hit.

Structural damage under impact loading is categorised into two different reaction phases: i.e. local response and overall response. A local response is originated based on the stress wave that occurs at the point of immediate loading. The overall response results from free vibration of the elastic-plastic deformation of the system and can last over a longer period of time after the impact loading. This study provides an analytical framework for determining the structural dynamic response of concrete elements based on a parametric study on the mass of a drop hammer impact.

In this study, a series of non-linear Dynamic/Explicit analysis have been conducted using the commercial finite element software ABAQUS to understand the mechanism of impact on a structure and the structural nonlinear inelastic response, for instance, maximum impact forces, the energies of the system and beam's deformation. For a selected beam section, the significance of concrete crushing with the increase in impacted mass is evaluated. Furthermore, the damage behaviour of the beam is studied.

Methods

- In this research, ten different masses of the drop hammer are used to understand the influence of the mass of the hammer on the response of the RC beam and the damage patterns. This study provides a comprehensive overview of the impact response of a simply supported RC beam and Fig1 shows the FE model the impact.
- One important observation is the distinction between free vibrational behaviour and damping behaviour of the structural system. This is demonstrated in Figure 2 by comparing the results from the nominated analysis of the RC beam under impact loading. Lighter impactors (0.2t&0.4t) cause local damage while massive impactors cause severe damage, distinguished by the convex behaviour of the impact force.
- Figure 3 provides the variation of the impact forces derived from the FEM analysis and compares the corresponding values of theoretical impact forces defined by:

$$F_{impact} = \frac{mgh}{d}$$

The capability of a structure to absorb the energy can also be defined by the cushioning factor, which is a relationship between stress and energy absorbance of a material. The cushioning factor can be described as:

$$C = (GT/H)$$

where G is the peak acceleration of the impact, T is the beam thickness, and H is the drop height. Figure 4 compares the cushioning factor in relation to the normalised maximum deformation and the ultimate deformation.

Results

1. The impact force has a non-linear relationship with the mass of the hammer
2. The mass of the hammer has a linear relationship with total energy.
3. The cushioning factor is a parameter that can show the structural response and have a regressive power relationship with the deformation of the structure

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Tables and figures

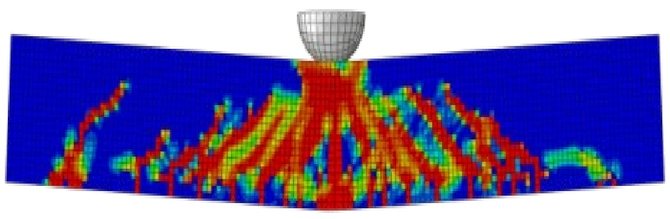

Fig. 1: FE model of explicit impact in ABAQUS

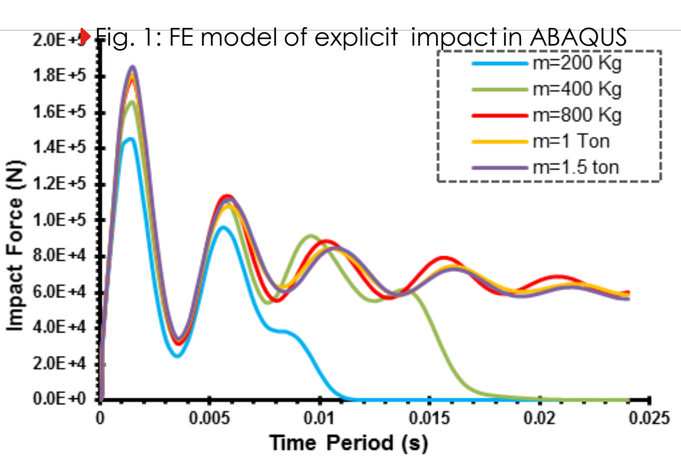

Fig. 2: Impact force for nominated masses of the hammer during the impact

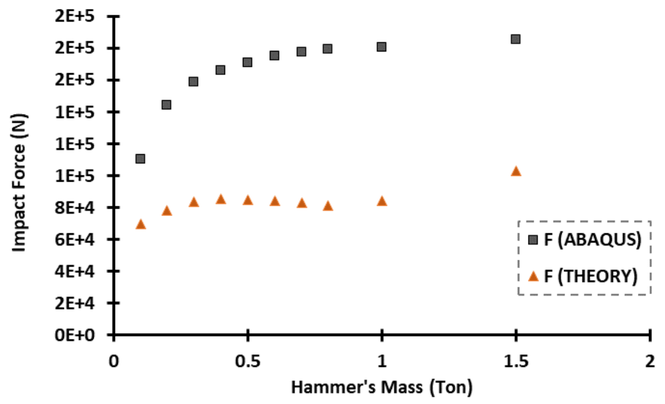

Fig. 3: Normalised maximum impact force relationship with the normalised mass of the impactor

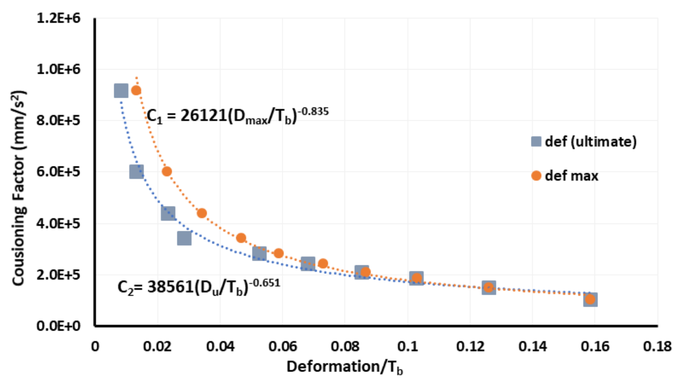

Fig. 4: Cushioning factor's relationship with the beam deformation

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