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ScienceDirect

Procedia Engineering 173 (2017) 397 – 402

Procedia Engineering

www.elsevier.com/locate/procedia

11th International Symposium on Plasticity and Impact Mechanics, Implast 2016

Behaviour of prestressed and reinforced concrete plates subjected to impact loads induced by free falling indenter

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Abstract

The behavior of reinforced and prestressed concrete plates has been studied under drop weight impact loading. The reinforced and prestressed concrete plates having the size 0.8 m x 0.8 m and thickness 100 mm. The impact was applied by dropping a mass of 242.8 kg from a fixed height. The characteristic strength of concrete cubes was 51.38 MPa. The generated impact force and deflection time response were measured and the failure modes of the plate specimens were studied. The results thus obtained for reinforced and prestressed concrete plates were compared and discussed. Prestressed concrete plates were found to have higher impact resistance and performed better in comparison to the conventional reinforced concrete plates. The deflection at bottom surface of prestressed concrete plate has also reduced.

Peer-review under responsibility of the organizing committee of Implast 2016

Keywords: Prestressed concrete, reinforced concrete, plate, drop weight impact, failure mode;

1. Introduction

Structures are subject to impact loads during their service life due to seismic oscillations, vehicle accidents with bridge columns and blast load on buildings etc. The primary motive of building an impact resistance structure is to minimize damage to these structures under severe loadings. Attempts had been made to study, influence of heavy-mass impact on behavior of reinforced concrete beams and slabs [1]. It was observed that

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Peer-review under responsibility of the organizing committee of Implast 2016
doi:10.1016/j.proeng.2016.12.037

beam support conditions had small effect on peak impact force as compared to their span length. In another study, shock resistant capacity of 'Γ' shaped and 'T shaped' prestressed concrete (PC) girder had been identified under falling weight impact test [2]. Experimental results revealed that 'T' shaped girder had higher impact resistance capacity and better load transfer to their support. Further, load transfer mechanism and impact resistance of RC cladding structure was identified under pendulum impact tests [3]. It was seen that cladding could effectively reduce the damage to underlying structures. Behavior of RC beams was investigated under varying rate of loading to understand their impact resistance and energy absorption capacities [4]. In another study, damage pattern and crack propagation in prestressed concrete sleepers had been identified for different support conditions [5]. It was observed that softer support conditions exhibit relatively lesser degradation of concrete and reduced cracks under impact loading. Further, static and dynamic experiments were performed on prestressed concrete sleeper to identify its toughness, failure pattern and load carrying capacity under varying drop height [6, 7]. To identify residual load carrying capacity, damaged sleepers were also retested under static loading. Load resistance and energy absorption capacities were found much lesser under residual static tests due to permanent deformation occurred under impact loading. The results obtained from impact testes were verified by performing numerical simulations in LS-Dyna [8]. It was observed that the magnitude of peak displacements were relatively higher at location of rail-seat than that observed at mid span; however the dynamic response and load carrying capacity of sleeper depends upon the material characteristics of ballast and rail pad.

In present study, drop weight impact experiments have performed on prestressed concrete plates to investigate their behavior and load carrying capacity. The impact force and displacement behavior of plate were investigated and results were compared with those of identical reinforced concrete plates. The crack pattern on damaged specimen has captured with help of a camera. The damage occurred in plates shows that prestressed concrete plate has higher impact resistance capacity.

2. Experimental overview

To investigate impact resistance behavior of concrete plates impact tests were carried out on reinforced and prestressed concrete plates. All the specimens were prepared simultaneously using same concrete mix compositions. The plates were prestressed and were casted at Indian Institute of Technology, Roorkee, India and experiments were performed at CSIR-Central Building Research Institute, Roorkee, India. The procedure adopted for preparation of plates and their testing is discussed below.

2.1. Material and test specimens

Impact testes have carried out on reinforced concrete (RC) and prestressed concrete (PC) plates. These plates were square in shape and having size as 0.8 m × 0.8 m and thickness 100 mm. The concrete mix was designed using maximum size of coarse aggregate as 10 mm. The designed characteristic compressive strength of concrete cubes was 40 N/mm^2 at 28 days. The compressive strength of concrete was determined by testing cubes of size 150 mm × 150 mm × 150 mm, prepared from the same concrete mix used for plates. These cubes were tested under compressive testing machine after 28 days of curing. However, the average compressive strength of concrete cubes tested after 28 days period of curing was 51.38 N/mm^2. Both RC and PC plates were prepared using same concrete mix and cured in water for same time duration to achieve uniform concrete properties.

2.2. Experimental approach

To apply impact load on reinforced and prestressed concrete plates drop weight impact setup was used. All four edges of RC and PC plates were clamped to provide symmetric support condition. All plates were impacted at the center by dropping a steel weight of 242.86 kg from 0.5 m. The generated impact force and displacement responses were recorded in a high speed data acquisition system. The damage and crack pattern occurred under impact were captured after impact event using normal 16 megapixel photography camera and results were compared.