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Evaluation of blast resistance and failure behavior of prestressed concrete under blast loading

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HIGHLIGHTS

- The blast resistant capacities of unbounded bi-directional PSC are experimentally and numerically evaluated.
- The blast test procedure and measurement system are established and used to determine blast resistance capacity.
- The simulation model of prestressed concrete panel under blast loading is calibrated using the test data.
- The PSRC members had significantly better blast resistance than RC and PSC members.

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ABSTRACT

In recent years, frequent terror and military attack by explosion and impact have occurred all over the world. Particularly, World Trade Center collapse and US Department of Defense Pentagon attack on Sept. 11 of 2001 and Fukushima nuclear power plant accident due to Northeast earthquake tsunami on the coast of Japan on Mar. 11 of 2011 resulted in devastating human casualties and structural collapses. These terrors and accidents raised public concerns and anxiety of potential structural collapse of major infrastructures and structures. In order to better combat these problems, the extreme loading resistant structural studies are initiated. Among numerous types of target structures, one of the most important structural types is prestressed concrete (PSC), which is widely used for construction of nuclear containment vessel and gas storage tank. In this study, to evaluate the blast resistance and protective capacity of bi-directional PSC member, blast tests were carried out on 1400 × 1000 × 300 mm reinforced concrete (RC), prestressed concrete without rebar (PSC), prestressed concrete with rebar (PSRC) specimens. The applied blast load was generated by detonating 25 kg ANFO explosive charge at 1.0 m standoff distance. The data acquisitions included blast waves of incident pressure, reflected pressure, and impulse as well as behavioral displacements of deflection, acceleration, and strains of concrete, rebar, and PS tendon. Then, the blast test results are used to calibrate finite element simulation model. Once the simulation model is calibrated, it is used to perform parametric study on bi-directional prestressed concrete specimens to further evaluate the blast resistance of the panels. The study results are discussed in detail in the paper.

1. Introduction

1.1. Background

In recent years, explosions, collisions, and fires have occurred frequently around the world due to terror attacks and impact accidents. Particularly, since the 9.11 terror attacks on the World Trade Center and the Pentagon of the USA in 2001, public anxiety heightened due to lack of safety in our society. According to data published by the National Intelligence Service of Korea in 2009, 55.2% of terror incidents are related to infrastructures, which led to property damages and human casualties [1]. Especially, since the Korea peninsula is the only divided area in the world with unceasing military confrontations, South Korea has suffered various provocative aggressions from North Korea by means of infiltration, terror, provocations, and bombings for the past 63 years after the Armistice Agreement. Since the sinking of Cheonan Battleship of South Korea by the torpedo and cannon attacks of North Korea near the Coast of Yeonpyeong Island in 2010, public concerns of bombing and terror attacks have continuously increased. The aforementioned incidents can be viewed as representative

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