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FACULTY OF ENGINEERING

STRUCTURAL ENGINEERING DEPARTMENT

BEHAVIOR OF STATICALLY DETERMINATE PRESTRESSED CONCRETE BEAMS SUBJECTED TO FIRE

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A Dissertation

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ABSTRACT

Prestressed concrete is widely used in the construction industry in buildings, bridges, towers, pressure vessels and offshore structures. In numerous structures, the architectural requirements prescribe the incorporation of long span and slender elements in which the prestressed concrete is rendered the most feasible design alternative. The strength and serviceability of reinforced concrete (RC) and prestressed concrete (PC) elements are generally affected after fire exposure. The basic design objective for such elements would be life safety and collapse prevention.

The main objective of this investigation is to the study behavior of statically determinate prestressed concrete beams subjected to fire. In this respect, an extensive experimental/ analytical investigation was conduced on number of medium scale post-tensioned concrete girders subjected to fire. The experimental program consisted of testing twelve beams, five of which were partially prestressed, five beams fully prestressed and the remaining two beams are non prestressed beams. The beams had an overall width, depth and length of 160, 340 and 4400 mm, respectively. The beams were simply supported with a clear span of 4000 mm. The prestressing strand had a harped profile similar to the shape of the applied bending moment. The main test variables are concrete compressive strength, concrete cover and prestressing index. All prestressing specimens were cast using bonded prestressing strands. The strands were stressed after the concrete had reached an age of 28 days, and then grouted with cementitous grout. The test program was divided into two phases. Five beams were tested as control beams and the remaining seven beams were loaded and exposed to fire at level of 600ºC for a three hours duration.

The beams were tested using two concentrated loads at mid span by two hydraulic jacks. The previously described setup was provided with a furnace located at the beam middle part. The tested beams were loaded up to its working load, then the middle 1000-mm was exposed to fire at temperature level of 600 °C for three hours. The specimens were left to cool gradually, while the load was maintained. The load was released and the beams were loaded again up to failure. The beams were tested up to failure using a stroke control system. The test parameters included fire exposure, concrete compressive strength, prestressing level and concrete cover.

Modes of failure, ultimate load carrying capacity, deflection and strain of both steel reinforcement and concrete at critical sections were monitored. The cracking behavior of prestressed and non prestressed concrete beams was presented. Analyses and comparisons of the experimental test results were also introduced. Analytical investigation based on strain compatibility approach was used to predict the deformational behavior of the tested prestressed and non prestressed concrete beams before and after fire exposure. Comparison between theoretical and experimental test results was also introduced.

The results showed that the partially and the non prestressed concrete beams with concrete cover equal to 25 mm have higher resistance to fire exposure than that of fully prestressed concrete beam in terms of ultimate capacity and ductility. Also the high strength partially and fully prestressed concrete beams had lower fire resistance than normal strength beams.

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