Experimental and Numerical Study of Full-range Behaviour of Partially Prestressed Concrete Beams with External Tendons

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Summary

One concern in the use of external prestressing in new construction and retrofitting of existing reinforced and prestressed concrete structures is the uncertaity of behaviour upon overloading up to failure. It is therefore necessary to study the full-range behaviour of such structures. This can be achieved by experimetal investigation as well as numerical simulation. This paper reports the initial findings of experimetal and numerical investigations of partially prestressed concrete beams with external tendons. A number of prestressed concrete beams with external tendons of either 7-wire steel strands or aramid fibre-reinforced polymer were tested to failure, so as to study the effect of prestressing on the ductility. The specimens tested all have T-sections having two external tendons with one on each side. The test specimens were analyzed by non-linear finite elemet method for comparison. The results from the numerical analyses agree well with the experimets. A parametric study was also conducted to evaluate the effects of initial prestressing force and tendon friction at deviators on their structural behaviour. The study provides insight ito their full-range behaviour and factors that should be considered in modelling such structures.

Keywords: beams; ductility; fibre reinforced polymer; finite elemet analysis; full-range behaviour; partial prestressing; prestressed concrete; unbonded prestressing tendons.

1. Introduction

A partially prestressed concrete member is one reinforced with a combination of prestressed and non-prestressed reinforcemet, so that tension and cracking in concrete due to flexure are allowed under service dead and live loads, while both serviceability and strength requiremets of various design codes can be fulfilled. They can be used in the form of external tendons in new structures and retrofitting of concrete bridges, as well as internal tendons in beams and slabs. External unbonded tendons have become more popular because of the potetial corrosion risks with iternal bonded tendons caused by incomplete penetration of grout. With the increasing use of unbonded tendons in prestressed concrete structures, there is a need for a closer examination of the design and analysis of such structures. Although prestressed concrete beams with bonded and unbonded tendons behave in a similar manner at the working stage, they behave differetly especially when overloaded. The behaviour of prestressed concrete beams with bonded tendons is characterised by that at individual sections, as there is bonding between the tendons and the surrounding concrete. However this is not the case for prestressed concrete beams with unbonded or external tendons because the tendons and the surrounding concrete generally move with respect to each other longitudinally (slip) and vertically (second-order effect). These, together with the non-linear stress-

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