Laterally Pre-stressed Concrete with Composites

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Abstract

A novel, economic and simple technique for the repair and strengthening of RC members by external lateral pre-stressing has been proven to perform well following experimental work undertaken at the University of Sheffield. The aim of the technique is to ensure the enhancement of the member strength and ductility by localized strengthening. The University of Sheffield has been awarded patents in Europe and USA and patent pending in Japan for this technique [1].
The above technique is equivalent to increasing the effectiveness of the composite confinement and it becomes possible to strengthen large columns with smaller amounts of composites, which are utilized earlier at much higher strengths. In addition, the level of axial strain achieved at failure is improved significantly [2]. The paper will present details of experimental work with different types of confining material (glass and carbon), amounts of reinforcement and levels of initial pre-stressing.
Keywords: Concrete confinement, FRP reinforcement, Lateral pre-stressing, Expansive agent

1. INTRODUCTION

Since the 1995 Kobe earthquake in Japan, composites have started being used for the repair and strengthening of columns against seismic actions. The composites are applied as external lateral reinforcement and are often used to prevent shear and anchorage/splicing failures, which can result in the enhancement of the ductility of RC elements.
The Japanese philosophy on earthquake resistant design aims to achieve ductility through low ratios of reinforcement and low steel strengths. This results in very large sections, which as a result require little shear reinforcement. However, during seismic violent load reversals, the shear demand can be higher than estimated, for example as a result of vertical accelerations. In addition, splicing of reinforcement causes additional bursting forces, which are difficult to contain with nominal shear reinforcement. External lateral confinement can address both of the above problems, in addition to providing other benefits.
In Europe and New Zealand, the seismic philosophy for achieving ductility is different, relying more on increasing the non-linear concrete stains through concrete confinement [3]. The advantage of this philosophy is that apart from smaller cross-sections, a significantly higher amount of lateral reinforcement is required. This lateral reinforcement, which is there to confine the concrete, is also beneficial in resisting additional shear and preventing splice and anchorage failures.
The enhancement of concrete ductility by confinement is central to the principles of Eurocode 8. However, researchers dealing with FRP confinement do not always consult the huge wealth of published work, which is derived from the earthquake engineering research. In addition, there is a fundamental difference between mild steel confinement and high strength composite materials.
Mild steel reinforcement attains its yield strength (around 80% of its ultimate strength) at a strain of around 0.002, whilst composites fracture at strains ranging from 0.014 – 0.02. Unconfined concrete crushes when the lateral strain is at best 0.001. This means, that for low levels of confinement, steel is relatively well utilized (around 50%), whilst composites are at best utilized at 7% of their capacities.
A novel, economic and simple technique for the repair and strengthening of RC members by external lateral pre-stressing has been proven to perform well following experimental work done at the laboratory.
The pre-stressing of the composites is achieved by using expanding cement. This ensures that the concrete is actively confined by the composite from the very beginning. The beneficial effect is that concrete deterioration does not take place soon after the uniaxial strength level, as is usual with composite confinement, but it is delayed. This results in not only higher confined concrete strengths, but also in higher energy dissipation.
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