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# Structural Monitoring of Externally Confined RC Columns with Inadequate Lap-Splices, Using Fibre-Bragg-Grating Sensors

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**Abstract :** A major issue of the structural assessment and rehabilitation of existing RC structures is the inadequate lap-splicing of the longitudinal reinforcement. Although prohibited by modern Design Codes, the practice of arranging lap-splices inside the critical regions of RC elements was commonly applied in the past. Today this practice is still the rule, at least for conventional new buildings. Therefore, a lot of relevant research is ongoing in many earthquake prone countries. The rehabilitation of deficient lap-splices of RC elements by means of external confinement is widely accepted as the most efficient technique. If correctly applied, this versatile technique offers a limited increase of flexural capacity and a considerable increase of local ductility and of axial and shear capacities. Moreover, this intervention does not affect the stiffness of the elements and does not affect the dynamic characteristics of the structure. This technique has been extensively discussed and researched contributing to vast accumulation of technical and scientific knowledge that has been reported in relevant books, reports and papers, and included in recent Design Codes and Guides. These references are mostly dealing with modeling and redesign, covering both the enhanced (axial and) shear capacity (due to the additional external closed hoops or jackets) and the increased ductility (due to the confining action, preventing the unzipping of lap-splices and the buckling of continuous reinforcement). An analytical and experimental program devoted to RC members with lap-splices is completed in the Lab. of RC/NTU of Athens/GR. This program aims at the proposal of a rational and safe theoretical model and the calibration of the relevant Design Codes' provisions. Tests, on forty two (42) full scale specimens, covering mostly beams and columns (not walls), strengthened or not, with adequate or inadequate lap-splices, have been already performed and evaluated. In this paper, the results of twelve (12) specimens under fully reversed cyclic actions are presented and discussed. In eight (8) specimens the lap-splices were inadequate (splicing length of 20 or 30 bar diameters) and they were retrofitted before testing by means of additional external confinement. The two (2) most commonly applied confining materials were used in this study, namely steel and FRPs. More specifically, jackets made of CFRP wraps or light cages made of mild steel were applied. The main parameters of these tests were (i) the degree of confinement (internal and external), and (ii) the length of lap-splices, equal to 20, 30 or 45 bar diameters. These tests were thoroughly instrumented and monitored, by means of conventional (LVDTs, strain gages, etc.) and innovative (optic fibre-Bragg-grating) sensors. This allowed for a thorough investigation of the most influencing design parameter, namely the hoop-stress developed in the confining material. Based on these test results and on comparisons with the provisions of modern Design Codes, it could be argued that shorter (than the normative) lap-splices, commonly found in old structures, could still be effective and safe (at least for lengths more than an absolute minimum), depending on the required ductility, if a properly arranged and adequately detailed external confinement is applied.

**Keywords :** concrete, fibre-Bragg-grating sensors, lap-splices, retrofitting / rehabilitation
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