Strengthening of preloaded RC columns by post compressed plates- A review

L. Wang[1], RKL. Su[*2]

[1] College of Civil Engineering, Nanjing Tech University, China
[2] Department of Civil Engineering, The University of Hong Kong, Hong Kong, China

Abstract: Reinforced concrete (RC) columns, as the primary load-bearing structural components in buildings, may need to be strengthened due to material deteriorations, changes in usage, new building codes or new design requirements. The use of post compressed plates to strengthen existing RC columns has been proven experimentally and practically to be effective in solving the stress-lagging effects between the original column and the new strengthening jacket due to the pre-existing loads. This paper presents a comprehensive summary and review of post compressed plates strengthening techniques to strengthen the preloaded RC columns. Studies are reviewed in terms of the failure mode, deformability, and ductility of the strengthened RC columns.

Keywords: RC columns, strengthening, preloaded, post compressed plates, ultimate load capacity

*Corresponding author, PhD, E-mail: klsu@hku.hk

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1. INTRODUCTION

Along with time passing, a large number of old buildings need to be retrofitted or repaired in the world, especially in East Asian, where has been transformed to world economic center. The aging and degradation of reinforced concrete (RC) has created serious structural problems. Simply dismantling the old buildings that are not up to current design standards or do not fit for their current usage is environmentally unfriendly, unsustainable and sometimes uneconomical. The construction waste generated would impose a huge demand on additional landfill space, which could significantly shorten the life-span of existing landfill sites. Furthermore, many old and historic buildings encapsulate the collective memory of the people. Many people, in particular the elderly, are often reluctant to move out from their old home. To conserve the social, cultural and historical value and the collective memory of the buildings as well as to rehabilitate the degraded structures, many old buildings have to be preserved and upgraded.

Many reinforced concrete structural components, especially the concrete columns, are key load-bearing structural components in buildings. Lots of them may need to be strengthened due to defective construction, having higher loads than those foreseen in the initial design of the structure, or as a result of material deterioration or accidental damage. To upgrade the existing RC columns, external jacketing is often used since it is recognized as one of the most convenient way to strengthen existing RC columns. Up to now, three principal jacketing are available for column strengthening: concrete jacketing, steel jacketing and composite jacketing using FRP (Wu *et al*. 2006; Teng *et al*. 2003; Harajli *et al*. 2006; Pellegrino and Modena 2010; Fukuyama and Sugano 2000; Cirtek 2001; Ramirez 1996; Frangou *et al*. 1995; Giménez *et al*. 2009a). With these methods, jackets are placed around the columns to increase the sectional area and/or confinement of the concrete so as to directly or indirectly increase the axial load capacity of the columns.

Although the use of jackets has become common practice worldwide, there are still some unresolved issues regarding the effects of stress lagging between the original concrete core and the jackets (Giménez *et al*. 2009b; Ersoy *et al*. 1993; Takeuti *et al*. 2008) and the difficulty of providing uniform confinement around rectangular cross sections (Wu et. al, 2006; Wu and Wei, 2010). To address these issues, a simple and innovative post-compressed plates (PCP) strengthening technique is proposed to strengthen preloaded RC columns by Su and Wang (2009). In this approach, slightly precambered steel plates are bolted to the RC member, as shown in Fig.1(a). As the plates provided are longer than the clear height of the column, progressive tightening the anchor bolts can generate a thrust on the beam supports by means of arching actions. Unlike other strengthening methods, the present approach can actively share the existing axial loads in the original column with additional steel plates. The stress relief in the original column and post-stress developed in the steel plates could alleviate the stress lagging and displacement incompatibility problems. As similar strains are induced in the RC column and steel plates, a better utilization of both components in resisting external load, and hence a higher axial load-carrying capacity, can be achieved.

The theory of this strengthening method is similar to the principle of pre-stressed concrete. The amount of post-compressed plate forces induced is controlled by the initial precamber displacement of the steel plates. By applying this strengthening method in each floor successively, the additional loads can be transferred down to the foundation, as shown in Fig.1(b).

In this paper, the experimental and analytical studies conducted on preloaded RC columns strengthened with post compressed plates are reviewed. The axial strengthening of RC columns was discussed in Section 2. This is followed by the discussions on RC columns strengthened with post compressed plates under small and large eccentric compressive loading in Section 3 and Section 4, respectively. In Section 5, the fire damaged RC columns strengthened with post compressed plates was discussed. The corresponding analytical models are presented, which allow post compressed plate strengthened RC columns to be designed with confidence.

2. AXIAL STRENGTHENING OF RC COLUMNS

2.1. General

Existing RC columns can be strengthened with externally pasted steel jacketing. When compared with other strengthening schemes, the use of steel jacketing can maintain the ductility of the column. However, the researches on the effects of pre-existing loads on stress-lagging between the concrete core and the new jacket are still very little. Some test results show a 50% reduction in the ultimate load capacity of the preloaded column.

To address the mentioned issues, the post-compressed approach was proposed to strengthen preloaded RC rectangular columns under axial compression by Su and Wang (2009). They conducted experimental and analytical studies to prove that this strengthening method could greatly