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Compressive response of substandard steel-jacketed RC columns strengthened under sustained service loads: From the local to the global behavior

M.F. Ferrotto *, L. Cavaleri, M. Papia

University of Palermo, Department of Civil, Environmental, Aerospace, Materials Engineering, Palermo, Italy

HIGHLIGHTS

- Behavior of concrete columns subjected to preload before wrapping by steel cages is presented.
- An experimental study is carried out on columns strengthened under different levels of sustained loads.
- Experimental and analytical results indicate the preload affects the compressive response.

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ABSTRACT

This paper presents an experimental investigation on substandard partially steel jacketed RC columns strengthened under sustained loads and loaded until failure.

The aim of the study is to compare the compressive response of preloaded columns with respect to the tests without preload to obtain a more realistic prediction of load-carrying capacity of structural columns after retrofitting under serviceability loads. The influence of the preload level, the delayed contribution of the confining device during the loading process and the time dependent effects are highlighted for the tested specimens. Based on the experimental observations, an analysis-oriented model is proposed for the reproduction of the compressive response of steel jacketed columns taking into account the effects of the preload.

1. Introduction

The topic of the seismic retrofitting of existing RC structures has become utmost of importance in the last decades because of the need to improve the capacity levels of buildings according to new regulatory codes. Several strengthening techniques of columns such as "Concrete Jacketing", "FRP-Jacketing" and "Steel Jacketing" are used in practical to improve the load-bearing and deformational capacity of structural elements that present capacity deficiencies due to age deterioration or change in service loads for the structure. A reliable design of the structural members after retrofitting/strengthening is needed to provide to the structures adequate performance levels, however the lack in design and installation guidelines hindered the widespread use in practical [1].

On this issue, some author investigated in the past the effect of sustained load on the compressive behavior of RC columns reinforced with Concrete Jackets [2–4], while recent papers investigated the compressive behavior of FRP-confined concrete subjected to preload before wrapping and loaded until failure [5–10]. However, based on the best knowledge of the authors, there are no available studies in the case of Steel Jacketed columns.

As demonstrated by several works [11–22], confinement of RC columns by means of steel jacketing involves elasto-plastic confinement response, with maximum lateral confining pressure achieved in correspondence to the yielding of the steel. It should be noted that the non-uniform distribution of the axial and consequently the lateral strains along the element confined translates into a complex compression response because the yielding of the external steel reinforcement is not reached at the same time by all the components. Moreover, in the case of jacketing by steel angles and battens, more attention needs for the evaluation of the axial load-bearing contribute given by the confined concrete and the steel angles. Depending on the type of end-constrains, the angles provide different axial load contribute if directly loaded or simply placed at the corners of the columns [19].

* Corresponding author.
E-mail address: marcofilippo.ferrotto@unipa.it (M.F. Ferrotto).

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This paper focuses on the evaluation of the compressive behavior of columns strengthened by means of external steel cages considering the effect of the presence of service loads at the moment of strengthening and how this effect can change the compressive capacity with respect to the commonly known compressive behavior of confined members without preload.

2. Experimental investigation

The experimental program consisted in compression tests on ten columns strengthened by means of steel cages under different load conditions. Tests on unreinforced, reinforced before any loading and reinforced after axial loading at a fixed rate of the capacity were provided.

Concrete prismatic specimens having dimension of 200 × 200 × 750 mm (aspect ratio 1:3.75) were made by means of wooden formworks. At the top and the bottom two steel grid were inserted to provide an over strength to the far ends of the specimens avoiding potential brittle failure during compression tests. During the casting process, soft vibration ensured a minimum void content in the cementitious matrix. Leveling of the end cross-sections of the specimens was performed to guarantee a uniform contact during the compression tests between machine loading plate and specimen.

The steel cage was composed by angles and strips, of type S275 steel (steel with yielding stress of 275 MPa according to *EN 10025-2* standards), having dimension of 50/50/5 and 40/4 respectively connected with each other by welding (see details in Figs. 1 and 2). For both angles and battens, no mortar was uses at the contact surfaces with the concrete columns.

The effect of a load preexisting at the time of the reinforcement was investigated experimentally by applying the steel jacketing on loaded specimens and subsequently performing collapse tests. The

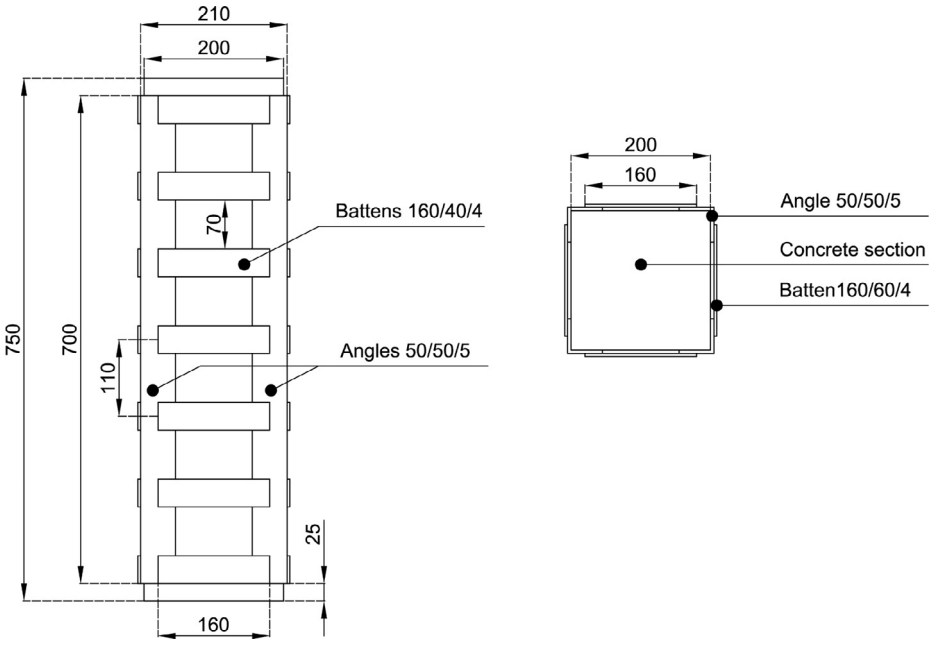

Fig. 1. Details of the specimens.

Fig. 2. Preparation of the specimens and the steel cage.