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Effect of confinement on behavior of short concrete column

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Abstract

In this experimental program a series of nine one-third scale square reinforced concrete columns specimens having cross sectional dimension as 150mm x 150mm with height of 960 mm were tested. The experiment is performed for control column, columns with ferromesh jacket as confinement reinforcement in addition to stirrups and column with ferromesh jacket only as confinement reinforcement. The overall response of the specimens was investigated in terms of load carrying capacity, axial displacement, stress, strain, lateral displacement and ductility. The test results indicated that column wrapped with additional ferromesh as confinement gives 20% increase in axial strength compared to regular control column. It is observed that columns with ferromesh jacket as confinement reinforcement in addition to stirrups gives better ductility and the column wrapped only with ferromesh as additional confinement fails in ductile manner.

Keywords: Concrete; Ferrocement; Column; Axial compressive strength; Axial displacement; Lateral displacemet; Ductility

1. Introduction

Columns are very important structural element of a building, as the column has to with stand the entire load and transfer it to foundation. The strength as well as ductility is of same important in a column. Various techniques are applied till date to provide sufficient ductility to column and still the process is in continuation. Use of ferrocement also increases the ductility of columns. Ferrocement is a form of reinforced concrete using closely spaced multiple layers of mesh and/or small diameter rods completely infiltrated with, or encapsulated, in mortar. The most common type of reinforcement is steel mesh. Other materials such as selected organic, natural, or synthetic fibers may be combined with metallic mesh [1]. It is well known fact that the RC Jacketing technique is one of the efficient techniques for repair and rehabilitation of the damaged RC columns [2]. Confinement with the ferrocement encase-

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ment improves the ultimate load carrying capacity and increases the axial and lateral deflection of RC column. It is investigated that in column confined with jacketed specimens shows increase in load carrying capacity and ductility performance. The external confinement using ferrocement resulted in enhanced stiffness, ductility, and strength and energy dissipation capacity. The mode of failure could be changed from brittle shear failure to ductile flexural failure [3]. Increase in the concrete strength results in reduced displacement ductility and drift capacities for a given curvature ductility. To achieve the same level of displacement ductility or drift capacity in a high strength concrete column, the use of a larger amount of confining reinforcement is required. The relationships between various ductility parameters (curvature ductility, displacement ductility and drift capacity) are affected by the level of axial load. As the axial load increases, the loss of lateral load carrying capacity becomes higher due to the P-Δ effect [4]. A Ferro cement shell, with high particle strength mortar between Ferro cement layers is an effective way of providing additional confinement of concrete in axial compression and has the advantage over lateral tie confinement of improving material performance under large deformations. The additional confinement with the Ferro cement shell improved the ultimate strength, the strain at ultimate strength and the ductility of concrete increases with the increase of confinement [5]. The ductility of a structural member is obtained from the idealization of the experimental or theoretical diagram response. The ductility factor is obtained as the ratio between the ultimate value and the yielding value. The ductility factor in curvatures does not always decrease with the axial load. It decreases with the strength of concrete, the reinforcement ratio and the relative cover of the longitudinal reinforcement and it increases with confinement level [6]. Experimental investigations have shown that under severe conditions columns can fail with different modes of failure. These failure modes range from: large shear cracks, spalling of cover concrete due to debonding of longitudinal reinforcement in lap-splice regions at potential plastic hinge areas, confinement failure leading to buckling of longitudinal bars between widely spaced transverse reinforcement [7]. The decrease in the design ductility factor can be prevented by controlling the variability of the actual yield stress versus the nominal yield stress of steels used in seismic design [8]. The load carrying capacity, ductility and serviceability of unreinforced masonry columns can substantially be improved if encased by ferrocement. The parameters such as cement mortar thickness, gage-wire spacing and bond at the interface of ferrocement and brick columns have effects on overall behavior [9]. The structural design of the vast majority of reinforced concrete civil engineering structures relies on the inherent ductility of the members to accommodate changes in load patterns, to absorb energy and to give prior warning of failure [10]. Most of the rehabilitation works consist of repairing old deteriorating structures, and structures damaged by earthquakes and natural disasters. Hence the development of cost-effective and long-lasting construction methods can greatly reduce maintenance requirements, increase life safety and increase the service life of concrete structures. Ferrocement jacket can be used as strengthening techniques as well as after ferrocement jacket columns fails in ductile manner [11]. Many of the existing short columns have poor seismic detailing. Due to short dowels and little transverse reinforcement, risk of brittle shear failure in such members is very high. Premature shear failure prevents formation of flexural plastic hinges and decreases ductility capacity. It is very important to develop efficient techniques to retrofit shear critical columns and increase their ductility capacity. Wrapping concrete columns with a proper strengthening material can be an effective solution. Reinforced concrete, steel plates, steel straps and fiber-reinforced polymer, FRP, composites are common retrofit techniques [12]. The main objectives of this experimental work are to investigate the effectiveness of providing ferromesh as confinement reinforcement in addition to stirrups & without using stirrups. The results of all on one third-scale reinforced concrete square columns are compared with each other to study the behavior of columns, in terms of axial strength, axial and lateral displacement, stress-strain ductility, cracking pattern and failure modes.

2. Experimental program

In this experimental program nine one third scale square (150 x 150mm) column specimens with a height of 960mm were tested. The longitudinal reinforcement used in the entire column is four bars of 10mm diameter. 6mm dia. bar is used for stirrups. A square welded wire mesh of 2mm dia. is used as confinement r/f with 75 x75mm spacing between the bars. All the nine columns are categorized in three types as follows.

Type I: Control specimen:

This type of column is of size 150 x 150 mm with four longitudinal bars of 10mm diameter & rings of 6mm