AN EXPERIMENTAL STUDY OF DOUBLE CONFINED CONCRETE COLUMNS ON PROXIMITY DISTANCE

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ABSTRACT

In the recent past double layered confined reinforced concrete columns have already been put under investigation and of late the authors have elsewhere published detailed findings of a consistent experimental study carried out on a novel and newly proposed reinforced concrete column consisting of two layers of confining transverse reinforcement. A number of double confined concrete square column specimens of normal strength concrete, of size 150x150x450 (mm), were casted to study the stress-strain behavior, peak stress and peak strain, on the varied proximity distances between the inner and outer transverse confining layers, under axial compression. 6 mm and 10 mm diameter reinforcing bars, of 500 MPa grade were used as transverse and longitudinal reinforcements respectively. Important findings based on the results were analyzed and thenceforth compared with IS: 456 (2000). The analysis has shown a positive impact of the proximity distance over the stress-strain behavior, in terms of strength and ductility. It could be reckoned that smaller the proximity distance, the greater is the impact registered on strength and ductility.

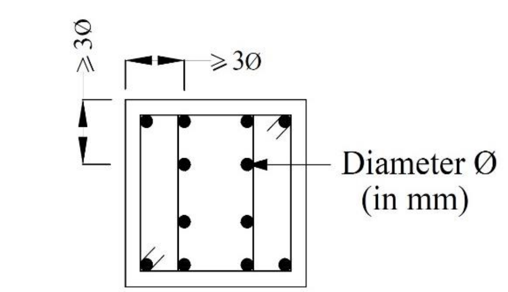
Key Words: Axial compression, peak stress, peak strain, confined concrete, proximity distance

INTRODUCTION

Columns are reckoned to be the critical members of a moment resisting structural frame. In seismically active regions it is indispensable to ameliorate the ductility contortion capacity of columns. The desired capability in columns is normally attained through proper confinement of core concrete. The outcomes of a number of key parameters with regard to confinement over the strength and ductility of single layered confined concrete are well referenced [Sheikh, S. A., et. al. (1980), Mander, J. B., et. al. (1988), Saatcioglu, M., et. al. (1992), Razvi, et. al. (1994), Sharma, U. K., et. al. (2005), Zaidi, K. A., et. al. (2011), D. H. Jing, et. al. (2016)]. It is widely known that confinement in concrete is attained by appropriate emplacement of transverse reinforcement to enhance the strength and ductility of reinforced concrete columns under seismic activity.

Some recent researchers, such as, Sun, L., et. al. (2016), Wu, D., et al. (2016), D. H. Jing, et. al. (2016), Yang, F., et. al. (2015), Hui-Ding, Jie Chen and Li, Song (2015) and Lin Zhu Sun, et. al. (2011) carried out experimental studies on double layered confined concrete columns and explored the mechanical behavior of confined concrete by characterizing the increase in strength and ductility of columns. Still, there has been an inescapable need to reckon at length, the amount of confinement offered by double layer stirrup in the critical hinge region of columns.

The orderly arrangement of transverse reinforcement, as per clause 26.5.3.2 (b) – 3 (ii) of BIS – IS: 456-2000 ["No bar of inner row is closer to the nearest compression face than three times the diameter of the largest bar in the inner row"] has been shown in Figure 1. It is important to mention that, till date, there has been no suggestive study



Arrangement of transverse reinforcement [Vide Clause 26.5.3.2 - 3(ii)] BIS - IS:456 - 2000

Figure 1

available in the literature, which may serve as a reference. Keeping above in view, the present work has been carried through, where in the proximity distance has been taken, as a variable, to study the impingement of the distance between the outer and inner layer in the act of confinement etc. particularly with respect to strength and ductility which are notified in the paper as peak stress, peak strain and ductility respectively.

EXPERIMENTAL PROGRAM

The concrete mixes were designed as per specifications contained in IS-12620-2009, using Pozzolanic Portland Cement, natural river sand, crushed lime stone aggregate of 12.5 mm nominal size and tap water. 6 mm and 10 mm diameter reinforcing bars of Grade Fe500 were used as transverse and longitudinal reinforcement respectively.

A few double layered confined concrete column prism specimens of size 150x150x450 (mm) were casted and tested in triplicate in order to get the average of three results. A set of specimens comprising of DCCCN1, DCCCN2 and DCCCN3, as shown in Figure 2, with proximity distances as 2ø (20 mm), 3ø (30 mm) and 4ø (40 mm) respectively, were taken to study the stress-strain behavior, while keeping the other attributes such as strength of concrete, shape, spacing, amount of reinforcement as constants.

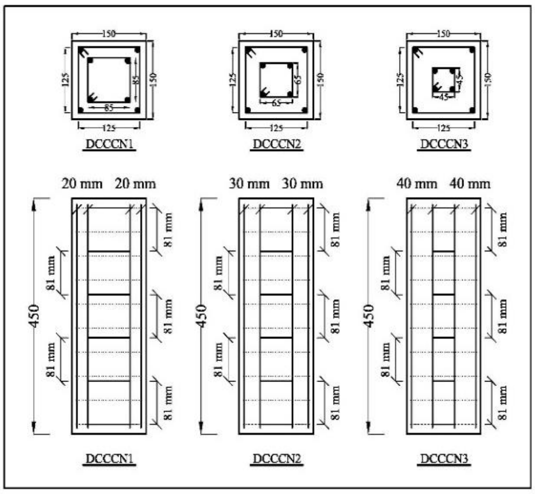


Figure 2

The first four letters in the abbreviations DCCC denote that it is doubly confined concrete column, and the last letter speaks of the type of concrete mix, i.e., normal grade concrete mix (N).

Test setup and instrumentation

Before processing the specimens for mechanical testing, a failure test region was forced into the middle 300 mm length of the specimens by providing external confinement in the 75 mm end-regions. The external confinement obtained by fastening the end-regions of the test specimens using 18 mm thick steel collars prevented an undesirable and premature end failure of test specimens to happen. The test specimens were loaded onto a 3000 kN capacity Universal Testing Machine (UTM) blessed with displacement-controlled capabilities, stiff enough to obtain a stable descending branch of the load-deformation curves. The monotonic concentric compression was applied at a very slow rate to capture clear and complete post peak behavior of the load-deformation curve. The axial shortening of the prism specimens was monitored by a linear variable displacement transducer (LVDT) attached with the test specimen laterally. The mean axial deformation of the 200 mm gage length in the central zone was measured and converted into an average strain. An in-built load cell in the UTM was used to record the loads. A data acquisition system was employed to feed and store the recorded data of the LVDT and the load cell into the computer. Pictorial representation is shown in Figure 3 - (a - b).

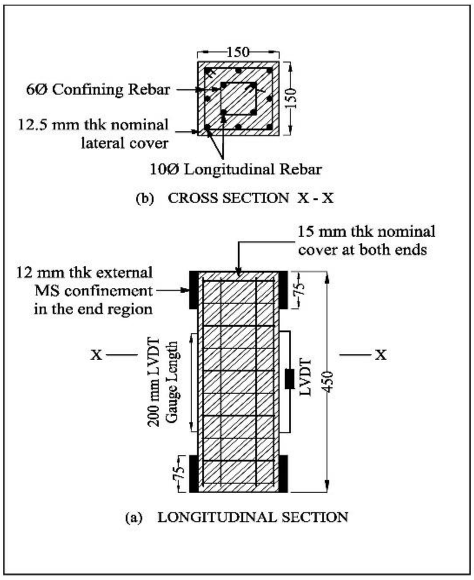


Figure 3 (a - b) Column specimen detail

Table 1: Properties of Square Test Specimens

ɔecimen No.			**CCCN1**	**CCCN2**	**CCCN3**
, (kN) = Concrete strength obtained from andard cube test			.00	.00	.00
o (kN) = Modified concrete strength ken as = 0.85 f_{co}			).09	).09	).09
oximity Distance			) (20 mm)	) (30 mm)	) (40 mm)
ter nforcement	ɔngitudinal ar	umber			
		(mm)			
	ansverse ar	umber of Bars	)	)	)
		(mm)			
		(mm)			
		hape	uare	uare	uare
er nforcement	ɔngitudinal ar				
		(mm)	)	)	)
	ansverse ar				
		(mm)			
		(mm)			
		hape	uare	uare	uare

RESULTS AND DISCUSSION Figure 4 contains response curves of all specimens.

Experimental results in terms of numeric values have been summarized in Table-2.

Table 2 Specimens Experimental Results

cimen No.	ximity Distance	erimental Peak Stress (MPa)	eoretical Peak Stress (MPa)	erimental Peak Strain (εo)	confined Peak Strain (ε′o)	ain [Load drops to 85% of k Confined Load (εc85c)]	ain [Load drops to 50% of k Confined Load (εc50c)]	a under the curve up to [Load ps to 85% of Peak Confined d (Ac85c)]	a under the curve up to [Load ps to 50% of Peak Confined d (Ac50c)]	a under the curve of Confined ncrete (Accc)
CCCN1	) mm (2ø)	.47	.68	00492	00215	0115	0228	0155	0684	0357
CCCN2	) mm (3ø)	.31	.68	00328	00215	0082	0170	0118	0201	0256
CCCN3	) mm (4ø)	.42	.68	00464	00215	0089	0168	0122	0215	0251

In Figure 4, the abscissa represents axial strain of the specimens recorded from the average reading of the two LVDTs. The ordinate symbolizes the axial stress directly recorded by the load cell and converted into stress value i.e. in MPa. The stress-strain curves of these specimens generally feature two stages. The first ascending stage is followed by a descending second stage. The outcomes as well as the stress-strain curves of specimens DCCCN1, DCCCN2 and DCCCN3 were compared. It's worth mentioning that all parameters for the specimens are same except the proximity distance. Non-uniform results were obtained. However, the present study revealed that the strength and ductility are influenced by the proximity distance and higher values in terms of stress-strain were achieved at the proximity distance of 2Ø and 4Ø.

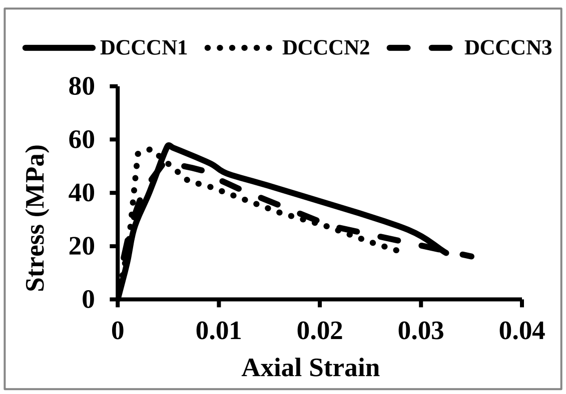


Figure 4

Further the value decreased at the proximity distance of 3Ø. Failure pattern of unconfined concrete cover cracking, spalling and buckling of outer longitudinal bar were observed to be more or less identical for the entire double layered stirrup specimens, during the second descending stage.

CONCLUSIONS

Based on the experimental results following conclusions could be drawn:

1. This study calls forth a review of the provision of BIS – IS: 456-2000 apropos the arrangement of lateral ties.
2. Smaller the distance between the inner and outer layers of the transverse confining layers, higher is the measure of strength and ductility attained.
3. Both the inner and outer layers have considerable wallop on the demeanour of the specimens.
4. More studies are required to be accomplished so as to further verify the existing outcomes of the present cogitation.

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