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EXPERIMENTAL STUDY ON BEHAVIOUR OF STRENGTHENED R.C.C COLUMN USING EXTERNAL STEEL CONFINEMENT

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Abstract - *This paper investigates the behavior and efficiency of load carrying capacity reinforced concrete column strengthened by battens with steel angle. Totally four numbers of specimens were involved for this investigation. Among four specimens, one of the column specimen is treated as conventional, two column specimens were confined with batten arrangement and the last one column specimen were strengthened with batten type with rod arrangement. M20 grade of concrete was used for this study. Size of the column is 200 mm x 200 mm. four numbers of 12mm diameter bars were used as main reinforcement and 8mm diameter bars used as lateral ties. 1200 mm length of column was involved for this investigation. Steel angle size, batten spacing and the connection between the steel cages to the specimen were treated as the main parameters in this research. Columns were tested under loading frame. Experimental program was conducted on axially loaded column specimens up to failure. From the test results Load carrying capacity, energy absorption capacity and ductility of the column were determined. The mode of failure was investigated.*

Key words: confinement, steel angles, energy absorption capacity, ductility.

1. INTRODUCTION

Concrete is strong in compression and weak in tension. So, to make strong in tension reinforcement is inserted into it. Reinforced concrete (RC) column is compression member that resist axial load. It is used to transfer the slab or beam load to foundation and finally to soil. So, column can be considered as main structural element of building. But sometimes these RC structures also require strengthening to increase their load carrying capacity. This strengthening may be necessary due to change in use that resulted in additional live loads, deterioration of the load carrying elements, design errors, construction problems during erection, ageing of structure itself or upgrading to confirm to current code requirements [1]. There are various methods of strengthening the columns some of them include concrete jacketing, steel jacketing, fiber reinforced polymer(FRP) jacketing etc. retrofitting square reinforced concrete columns with full steel jackets enhanced the compressive strength more than double the strength of the original column without retrofitting. Also, confinement of reinforced concrete columns with steel jackets enhanced the ductility of the column [2]. Using vertical angles welded to horizontal spaced strips in order to strengthen concrete column is very efficient and gain in the axial load capacity of the strengthened columns was very promising. Failure mode was initiated by the buckling of the vertical angles after their yielding point [3]. The complete wrapping like glass fiber can enhance the structural performance of concrete columns under axial loading [4].

In this experiment, four numbers of RC columns of size 200mm x 200mm x 1200mm with main reinforcement of 12mm diameter and shear reinforcement of 8mm was used. The clear cover in the column was 25mm and grade of concrete was M_{20}. These columns were tested separately in loading frame provided with different steel batten strengthening techniques. Finally, from the test results, load carrying capacity, energy absorption capacity and ductility of column and mode of failure was also investigated.

2.EXPERIMENTAL PROGRAM

Four square columns 200mm x 200mm were prepared and total height of the specimens was 1200mm. All the tested columns were reinforced with the same longitudinal 4 bars of diameter 12mm and tied with 8mm mild steel square stirrups spaced at 190mm along the column height and 20mm at both ends (fig-1). The first one is conventional column, other two columns were provided with battens in different position and the last column specimens were strengthened with batten type with rod arrangement. The entire column is provided with top and bottom clamp of thickness 5mm and depth 50mm.

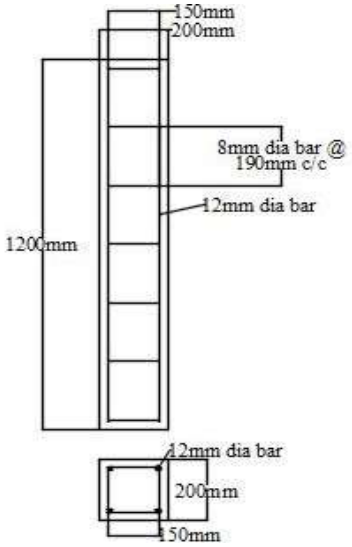


Fig -1: Reinforcement detailing

3.INSTRUMENTATION AND TEST SETUP

The tests were carried out and the specimens were placed vertically (Fig-2). All the specimens were tested using 2000kN hydraulic machine. The specimens were placed on the loading frame using hydraulic jack. Four LVDT instrument were used. Two LVDT (97, 98) instrument were placed at l/3 length in opposite direction to one another to measure buckling. The third LVDT (96) was placed at bottom to measure the compression and the fourth LVDT (99) was placed at centre of the column to measure lateral deformation. The compressive strength as well as lateral deformation of the column was measured using LVDT and data acquisition system (DAS). The age of concrete is 28 days. The load was applied gradually as 10kN, 20kN, 30kN and so on. Fig-2(a), (b), (c), (d) represent the batten type with rod, top and bottom batten, top, middle and bottom batten, conventional column respectively.

(a) (b) (c) (d)

Fig -2: Experimental setup of column

4. FAILURE MODE OF COLUMN

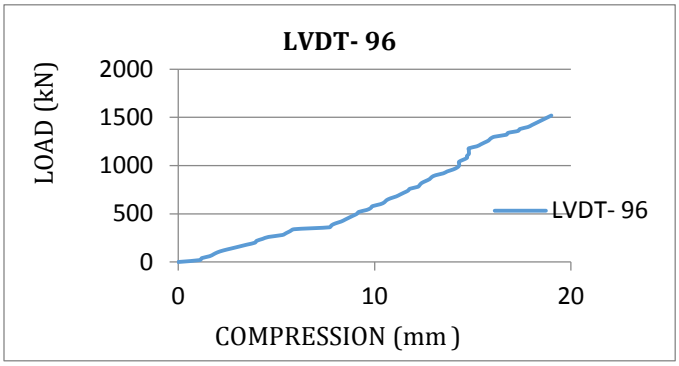
The conventional column test was done by using clamp on both top and bottom sections. After application of the load it was observed that the failure was found just below the top clamp of the column which eventually spread up to the center of the column as shown in Fig-3(a). The remaining columns with external confinement were found to broken at bottom of the column which spread up to center of the column. The welded part of the confinement was broken first and the main angles were buckled later on due to load as shown in Fig-3(b,c,d).

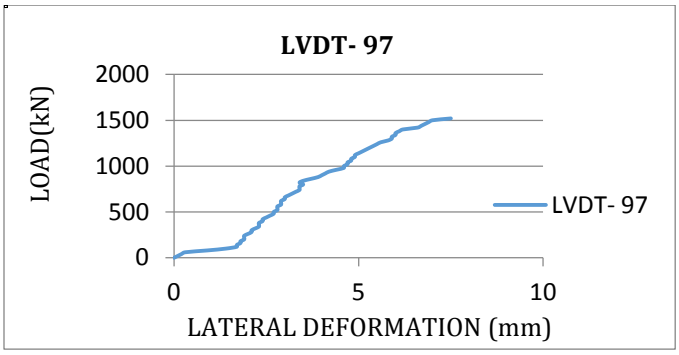
(a) (b) (c) (d)

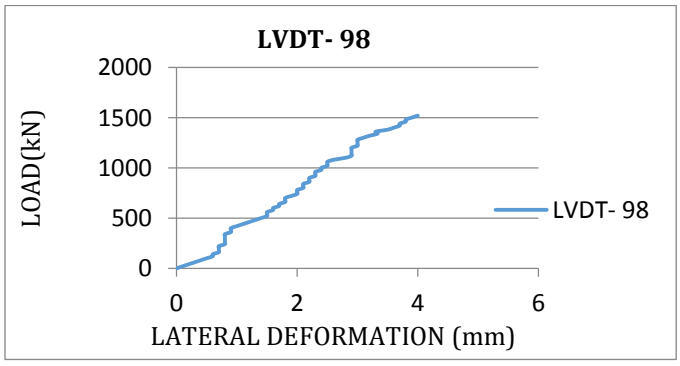
Fig -3: Failure Modes

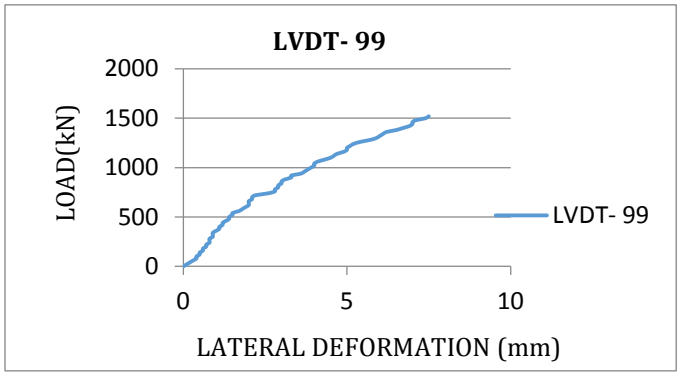
5.LOAD DEFORMATION CURVE

The Chart-1, 2, 3 shows the compression strength of the column with different external confinement whereas Chart-4 represents the compressive strength of conventional column. Similarly Chart-1, 2, 3 gives the lateral deformation of the column with different external confinement and the Chart-4 shows the lateral deformation of conventional column. The size of angle used in this study is 35mm x 1200mm x 5mm and batten size is 175mm x 200mm x 5mm. After using confinement it is observed that load carrying capacity of the column increases when compared to conventional one.









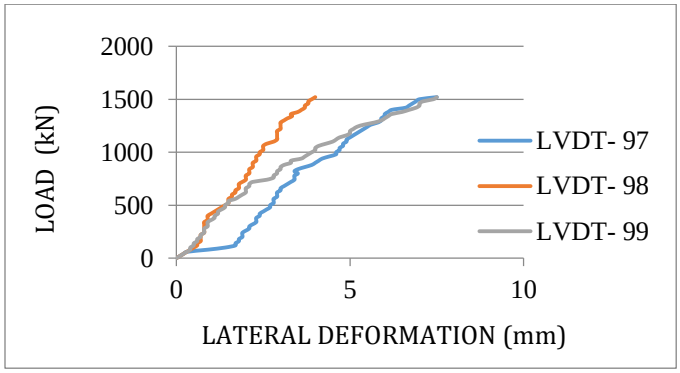
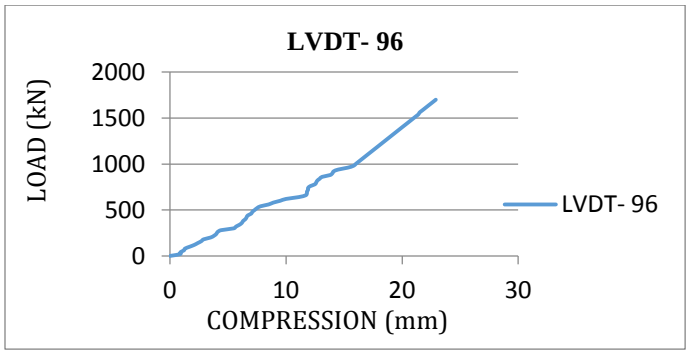
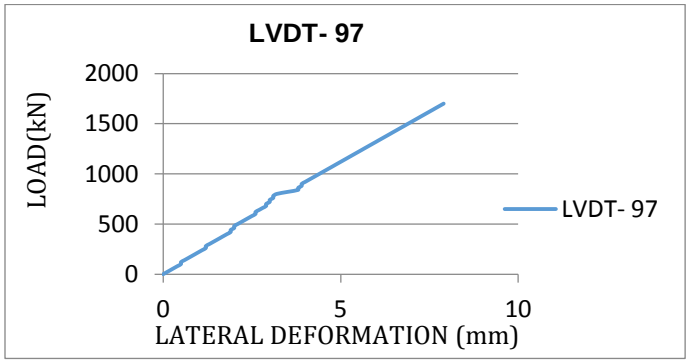
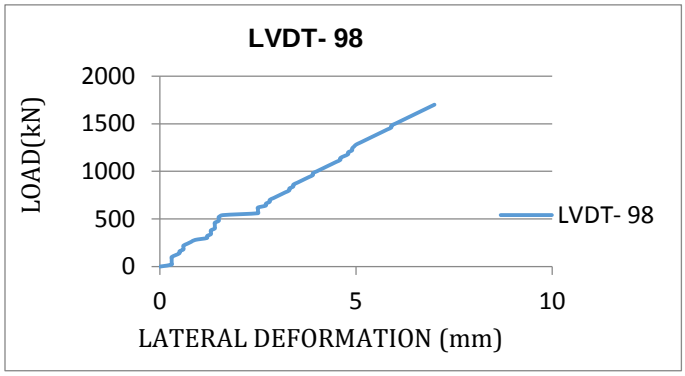
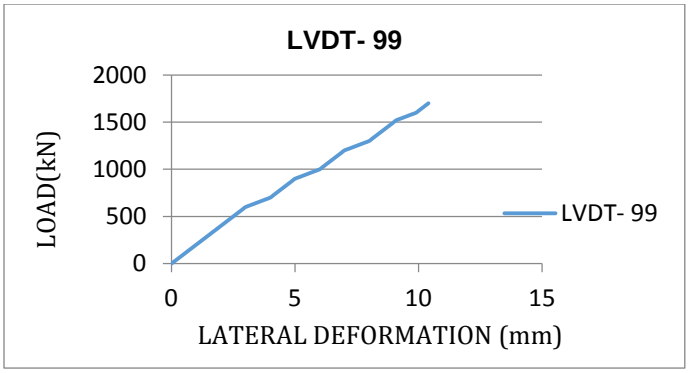


Chart -1: Batten type with rod arrangement of the column









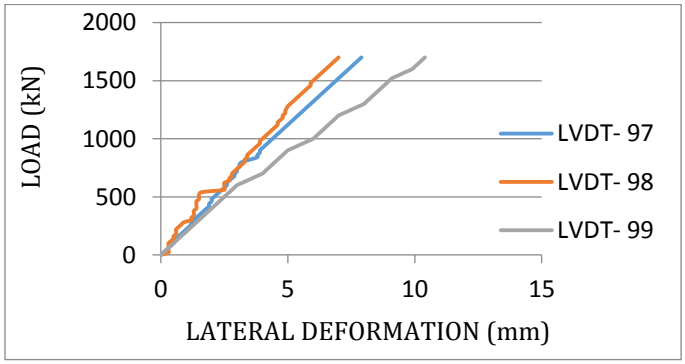
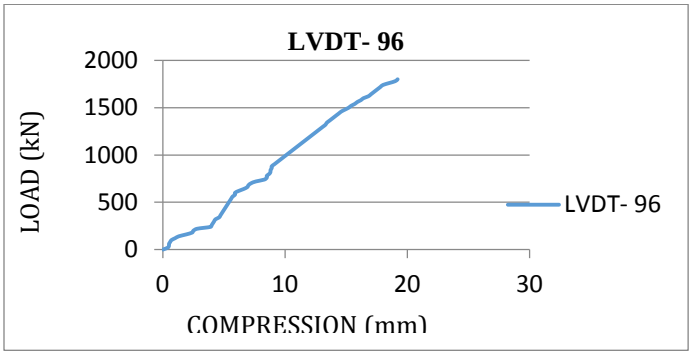
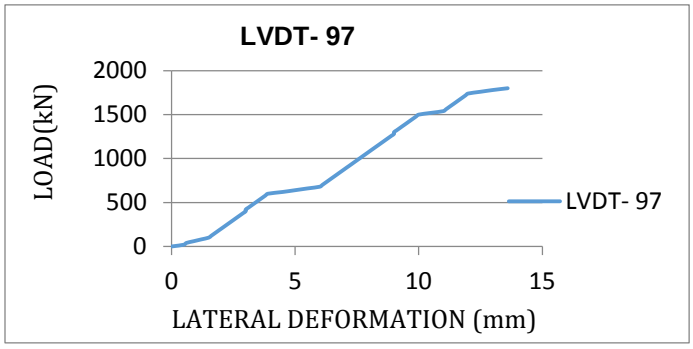
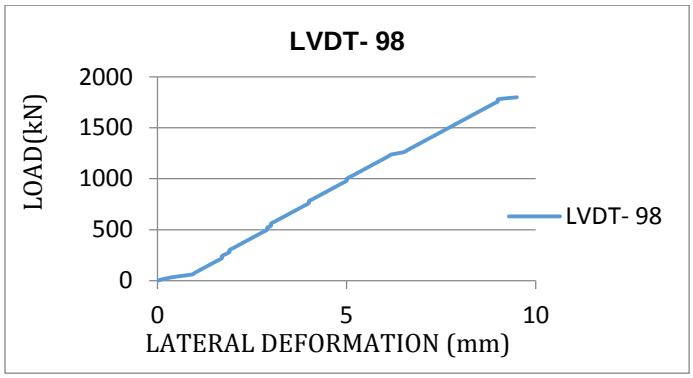
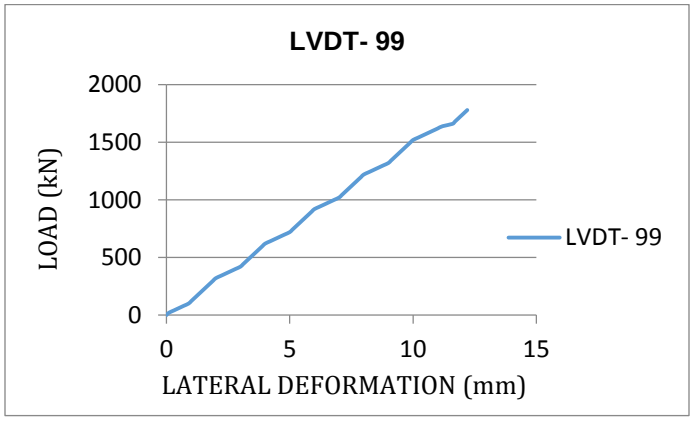


Chart -2: Top and Bottom batten column









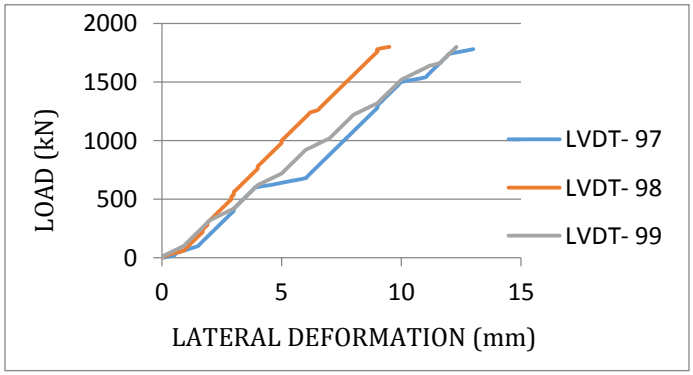
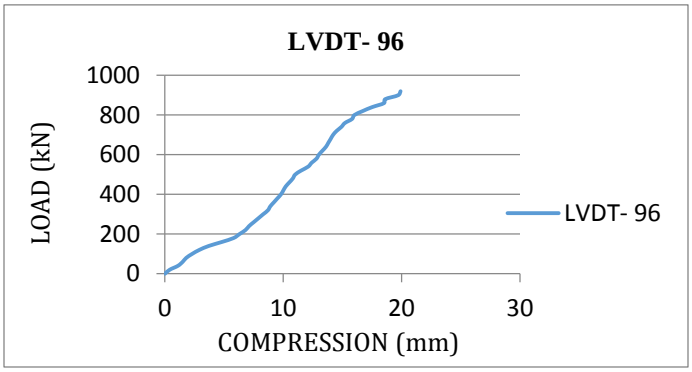
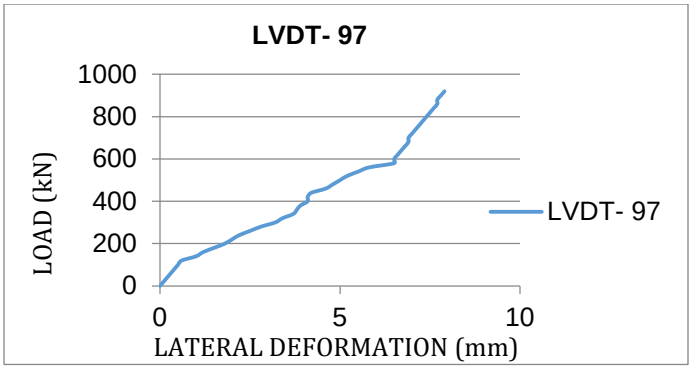
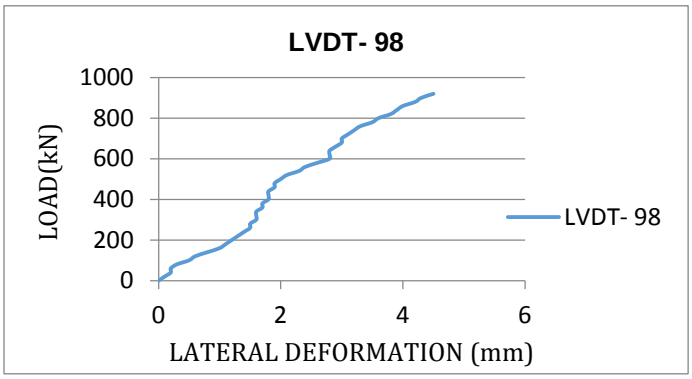
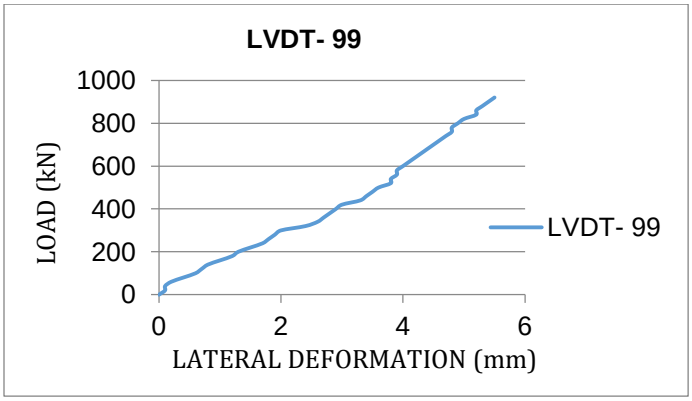


Chart -3: Top, Middle and Bottom batten column









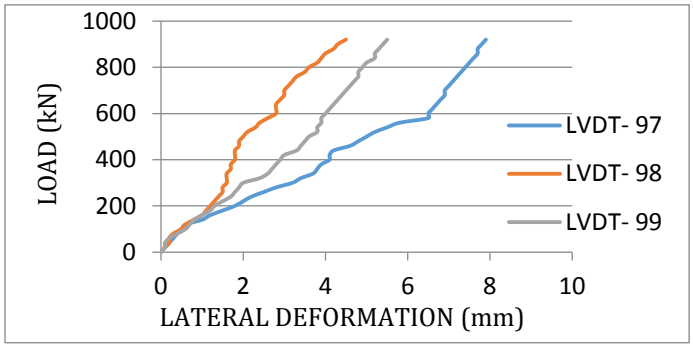


Chart -4: Conventional Column

6.COMPARISION OF TEST RESULTS

In these experiment four columns tested, three columns were provided with different strengthening technique and remaining one column was conventional column without any confinement. After testing it is found that the confinement provided at the top, middle and bottom batten type shows the high resistance to load than others. The first crack load and ultimate load of different column is shown in Table-1.

Table -1: Load Carrying Capacity

Specimen details	First crack (kN)	Ultimate load (kN)
Conventional column	180	920
Batten type with rod	200	1520
Top and Bottom batten	230	1700
Top, Middle and Bottom batten	250	1800

7. CONCLUSIONS

In this experimental program, four axially loaded column specimens were tested till failure. The main objective of this study is to increase the strength of column by applying external steel confinement in different position. The behavior of tested column, axial deformation and lateral deformation were studied. From the test results it was concluded the following:

1. When axial load is applied in the column, deformation is formed at center.
2. If confinement is provided in the conventional column then the load carrying capacity increase twice.
3. There are different strengthening techniques. As per my experiment, the use of batten at top middle and bottom gives the high strength and also the load capacity is higher than the remaining types.

4. In all tested strengthened column, failure was initiated at the bottom and was spread to the center of the column. It was found that the welded plates were broken and the cracks were propagated.

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