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A Laboratory Testing Study of Strength and Axial Displacement by Welded Wire Mesh (WWM) for Improving the Properties of Circular Columns

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Abstract. *For columns made of reinforced cement concrete (RCC), conventional steel-tied reinforcement could not offer the best containment. based on many experimental findings and theoretical works evaluation a variety of materials, including WWF and FRP, were used as reinforcements to boost the ductility and load-bearing capability of the components of the structure. So, welded wire mesh is one such material. (WWM) that we employed for this project in an effort to enhance the restriction and malleability. The entire effort seeks to specify how compression will be aided by confinement and improved confinement. members to make them more ductile (Circular column). Thus, we employed an added to the prior reinforcement using welded wire mesh. An example used were divided into two groups, with samples contained using both traditional techniques and more advanced confinement.*

Keywords: Conventional, steel tied, ductility, wire mesh, confinement, reinforcement.

Introduction

A compression member is an important component of reinforced concrete structures. Compression member such as column, in general, it can be defined as an element that carries direct axial stresses which result in compressive stress of such amount that these stresses largely have effect on its design. Both column & strut are compressive elements, the effective length of which is more than 3 times the least horizontal dimensions. When an element carries mainly axial stresses is vertical, it's called as a Column, while if it is inclined or horizontal, it's called as a 'Strut'. Depending upon structural or architectural requirements, Columns are mainly seen in shapes, i.e. (circular, rectangular, square, hexagonal, etc.). Concrete as we came to know through various experiments is stronger in compression. Therefore, mains bars or vertical steel rods are always provided in order to assist in carrying the direct loads. And there is set limit to provide that longitudinal steel in different shapes of column, whether it is taken into consideration of the type of load acting or not. And this is done to avoid tensile stresses formed due to some eccentricity of the loads acting longitudinal direction. Different sets of benchmarks that are listed in codes to provide the amount of maximum reinforcement, because reinforcement more than the upper limit may generate difficulties in pouring of concrete and compaction of the concrete. Vertical reinforcing bars are tied horizontally by ties or stirrups or welded joints at certain intervals so that the bars do not shatter or cause bulging.

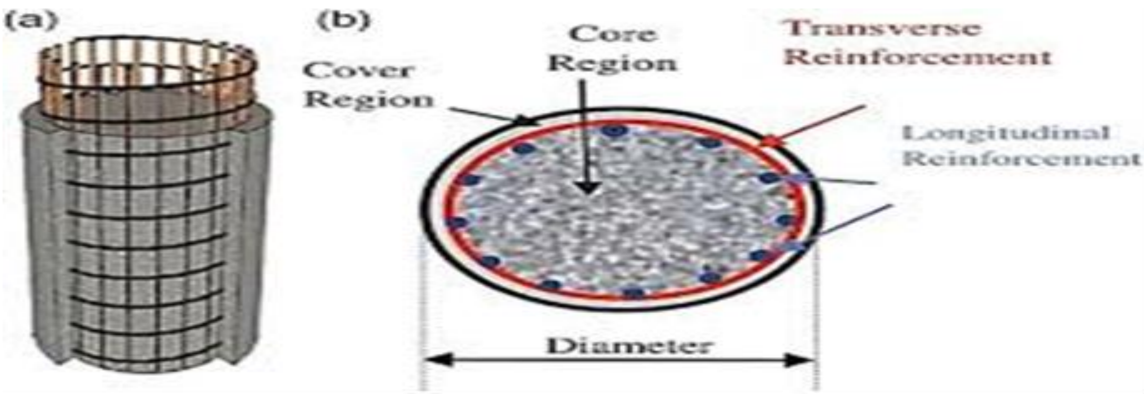


Figure 1: Confinements.

Objective of The Work

1. To find the strength of a circular column using traditional design for steel reinforcement.
2. To improve design for steel reinforcement of the traditional design used by: -
    a) Decreasing the number of steel ties.
    b) Using a welded wire mesh on the periphery of the steel reinforcement.
3. To find out whether strength of the two samples improved.
4. To compare the strength and axial displacement in all the samples on the 28th day.

Literature Review

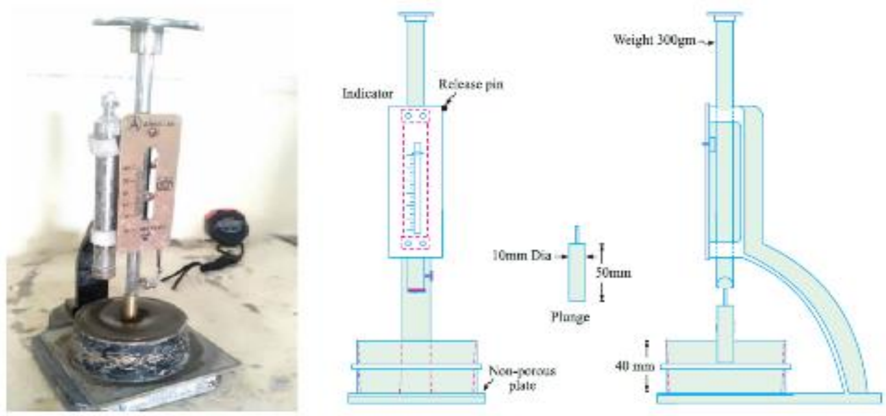
Huang Yuan (2018) the steel tube-fortified cement (ST-RC) segment is comprised of solid filled steel hollow bars implanted in strengthened cement. As an inventive sort of composite structures, there is as yet an absence of data on the conduct and flexibility of ST-RC segments, especially on arranged development steel tube-fortified solid (ST-SC-RC) segments. This paper contemplated the component of two sorts of ST-RC sections in a 15 story building. A limited component (FE) model with legitimate material constitutive relationship was proposed for ST-SC-RC sections exposed to consolidated hub compressive power and parallel stacking. The material nonlinearity and the cooperation between steel cylinder and cement were thought of. The proposed FE model had the option to anticipate the horizontal solidness, quality and distortion limits of ST-SC-RC segments with a sensible degree of exactness. At that point, the impacts of various parameters on removal pliability were talked about in detail. At long last, a rearranged recipe for ascertaining the removal pliability of ST-SC-RC sections was created dependent on the parametric investigation, the forecasts of the proposed equation fitted well with countless test outcomes. Using the proposed equation, the interest of removal flexibility under various seismic plan grade in current ST-RC detail was introduced, which may give a valuable reference to the seismic structure of the ST-SC-RC structures.

Chengxiang Xu et al. (2019) Firmness of the examples and the CFRP sheets improved the malleability & vitality scattering of the examples, Carbon Fibre Reinforced Polymer sheets or ESJ didn't crumple in a reenacted solid quake and was like or even surpassed the Seismic exhibition of the first example; this outcome is significant and pertinent to building practice. Along these lines, the ESJ ingredient is ideal when just one kind of ingredient is utilized for reinforcing The seismic exhibition of the RCC shaft SRC segment outline joints fortified with the CFRP sheets. Youssef (2021)… in Innovative Infrastructure Solutions (2021) Concrete is one of the most widely used construction material. Its usage is twice that of steel, wood, plastics and aluminium combined. It provides superior fire resistance compared with wooden construction an Reji and Anu in Proceedings of SECON 2020 (2021) The present study is an attempt for strengthening the reinforced concrete beam damaged due to overloading using polymer ferrocement laminates which were directly glued into the cracked tension face of the beam... N. R. Harish Kumar, Sachin R. Biradar, R. Prabhakara… in Recent Trends in Civil Engineering (2021) This chapter presents the seismic simulation systems (shaking tables) as essential resources for experimental research on adobe masonry structures. An overview of selected relevant shaking tables existing in l... Marcial Blondet, Nicola Tarque… in Structural Characterization and Seismic Re… (2021) Usable time under site conditions and a cure rate which does not hinder the construction programed. Workmanship under conditions prevalent on site is less conducive to quality control than in other industries, and thus ability to tolerate minor variations in proportioning and mixing, as well as imperfect surface treatment, is important. In addition, the products involved are more expensive than traditional construction materials. Non-destructive test methods for assessing the integrity of bonded joints are now available for civil engineering

Materials

A) Cement: - For experimental work we used OPC 43 Grade. Before using it for experimental work we did some basic tests as mentioned below : -

i) IST & FST: - consistency test in a cement paste is defined as the minimum amount of water that is required to form the cement paste. And practically if we talk about this test then if it vicat's apparatus needle reaches a depth of 33-35mm from the upper end, then it defines the consistency of the cement at that amount of water. This is also known as Ordinary consistency. Apparatus is shown below in Figure 3.4. Through all this experiment we found out the IST and FST of cement. The IST is the time elapsed between adding water to the cement to the time cement paste starts loosing plasticity. It came out be 40 min as per the experiment conducted in lab (As per IS-4031 it should not. And the FST of the cement. Final setting period is the period from adding water to the cement to the time when cement paste completely loses its plasticity. It came out to be 310min (As per Indian standards it should not exceed 600min.



Vicat Apparatus

Figure 2: Apparatus for IST and FST.

i) Soundness Test: - According to IS-4031, soundness value should not exceed 10mm else the cement is termed as unsound. Sound cement is one retains its volume expansion up to some extent. For this experiment we used Le-Chateiler apparatus. The new Expansion value was 5mm.

ii) Specific Gravity: - For specific gravity of cement we used Le-Chateiler's flask (As shown in Figure 3.4). By using the formula given below we found the specific gravity with respect to known kerosene oil.

$$\text{Specific gravity of cement} = \frac{W2-W1}{(W2-W1)-(W3-W2)*0.79}$$

Where, W1= weight of empty bottleW2= weight of

bottle +cement

W3= weight of bottle + cement + kerosene

0.79 is the S.G. of kerosene oil

Figure 3: Density bottle.

iii) Fineness Test: - Fineness test of cement was carried out by sieving in through 90 micron sieve. Lumps due to moisture were crushed using trowel (As shown in Figure 3.5). Percentage retained on the sieve was approximately 4%.

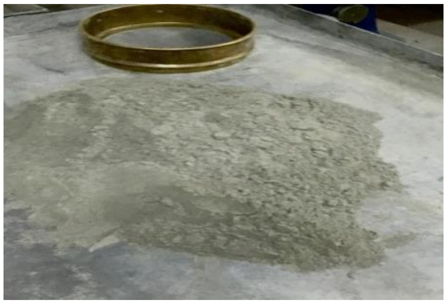


Figure 4: Fineness test of cement.

iv) Cement's compressive strength: - This is one of the most important properties of Cement. So here we took sand and cement mixture. For compressive quality we don't utilize straightforward concrete glue in light of the fact that exorbitant shrinkage and breaking quality tests are not done on concrete paste. Mix proportion and strength of the cube is shown in table 3.1 and below that Figure 5 of a tested cube specimen tested under compression testing machine.

Table 1: Compressive strength of cement.

Mix proportion	Days	Compressive strength (MPa)
1:3	7	38
1:3	28	45

Figure 5: Crushed cement specimen.

b) Coarse Aggregate: - For the experimental study we used coarse aggregate of size 12.5mm and 20mm (As shown in figure 6). Having following specifications as listed intable 2.

Table 2: Coarse Aggregate specifications.

Properties	Specifications
Water absorption	1.4%
Specific gravity	2.78
Bulk density	1437 kg/m^3

Figure 6: Coarse Aggregate.

c) Fine Aggregate: - For all the experimental work Zone II Sand was used (As shown in figure 6). Basic specifications of the fine aggregate have been listed below in the table 3.

Table 3: fine aggregate specifications.

Properties	Specifications
Water absorption	6%
Fineness modulus	2.47
Specific gravity	2.65

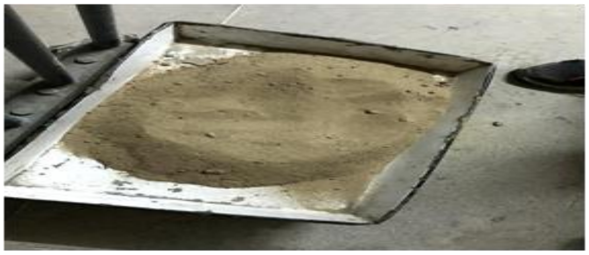


Figure 7: Fine aggregate.

a) Reinforcement: -For the experiment were used two types of steel reinforcements of diameter 6mm and 8mm both of Fe 500 grade as circular ties(Figure 8) and main reinforcement (Figure 9) As shown respectively. Design of Reinforcement used in the experiment is explained in design part 3.2.

Figure 8: Circular ties.

Figure 9: Main reinforcement.

Design for Reinforcement

As per ACI guidelines for design of structure and also as per IS: 456 we designed the reinforcement part of the column. For whole reinforcement part we use main bars of diameter 8mm and circular steel ties of 6mm diameter both of Fe500 grade, also we used a welded wire mesh of diameter 2mm and size 2*2 inches as shown above in the material section.

Design for longitudinal reinforcement

As per IS456 (table 16) if the longitudinal reinforcement used is other 12mm then nominal cover can be less than or equal to 25mm (As per Exposure conditions).

Here the total area of concrete without reinforcement is 17678 mm^2. Area of steel reinforcement is compression is 201 mm^2.

According to Seems to be: 456 conditions 26.5.3.1 says longitudinal fortification ought to be between (0.8% to 6%) of the gross zone of cross-segment of the section. Hence, we can use 4 bars of 8mm as longitudinal reinforcement (As shown in figure 10).

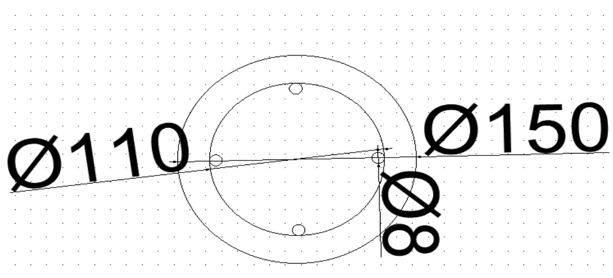


Figure 10: Top view of mould and reinforcement.

Design for Transverse Reinforcement

According to IS: 456 Clause 26.5.3.2 says that the dispersing between the horizontal reinforcement will be not more than and least of the accompanying: -

1) Least lateral dimension of the column.
2) 16 times the dimension of the longitudinal bar 3) 300mm.

So after calculating all the spacing we were to apply those spacing in three cases (two of the cases are shown in figure 11 and 12 respectively): -

Case I: - 4 vertical bars of diameter 8 mm and 5 ties of diameter 6mm tied at a spacing 217mm. Case II: - 4 vertical bars of diameter 8 mm and 4 ties of diameter 6mm tied at a spacing of290mm.

Case III: - in addition to Case II we'll be adding welded wire mesh around the periphery of main reinforcement.

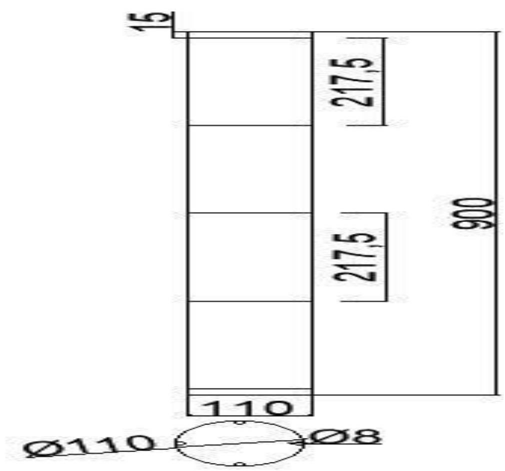


Figure 11: 5RS-design.

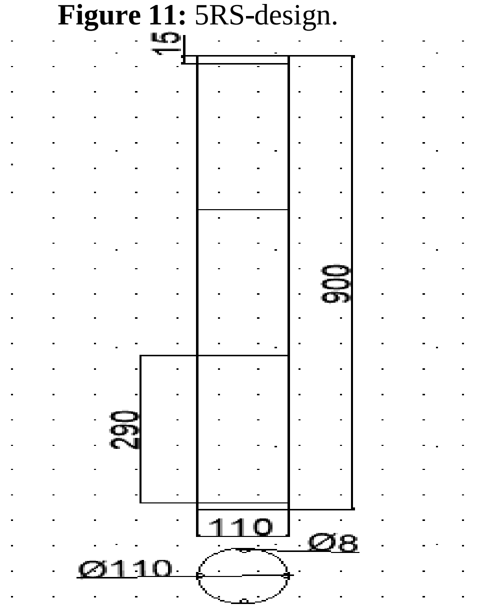


Figure 12: 4RS-design.

Results

Compressive Strength test

The compressive strength value in kN of each sample (Case I, Case II and Case III) has been tabulated in table 4 with respect to time period. And graphical representation of data is shown in Figure 12 in the form of bar graph.

Table 4: Compressive strength Results.

Specimen name	Compressive strength (kN)		
	7 DAYS	14 DAYS	28 DAYS
Case I – 5RS	430	597	663
Case II- 4RS	418	579	643
Case III-4RWS	465	644	716

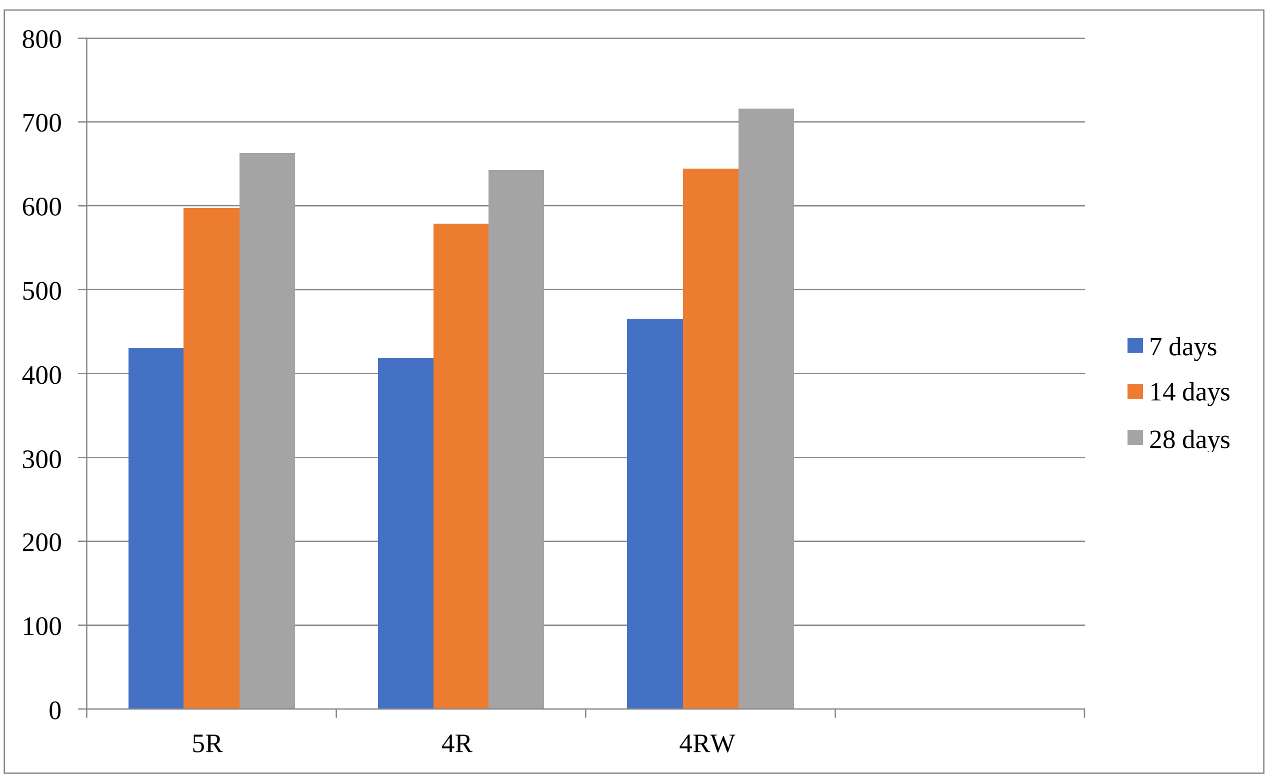


Figure 12: Compressive strength (kN).

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Axial Displacement

Axially loading was applied by using universal testing machine on each sample on the 28th day and using data logger we measured load Vs axial displacement values of each sample and this data was created from the data logger (As shown in Table 5).

Table 5: load vs. displacement.

Axial displacement (mm)	Load(kN)		
	5RS	4RS	4RWS
0	0	0	0
0.1	23	20	27
0.2	39	37	52
0.3	55	50	82
0.4	71	65	88
0.5	87	77	110
0.6	103	85	138
0.7	119	99	147
0.8	135	110	179
0.9	151	121	190
1	167	135	210
1.1	183	150	235
1.2	199	175	255
1.3	215	181	263
1.4	231	193	287
1.5	247	202	298
1.6	263	206	309
1.7	264	222	330
1.8	276	249	353
1.9	290	261	369
2	310	277	380
2.1	319	291	395

2.2	359	301	409
2.3	375	318	430
2.4	391	330	446
2.5	407	350	461
2.6	423	372	479
2.7	439	391	491
2.8	455	407	505
2.9	471	430	515
3	487	466	531
3.1	503	491	555
3.2	519	532	568
3.3	535	560	580
3.4	551	591	593
3.5	567	608	594
3.6	583	625	595
3.7	589	643	597
3.8	598	635	599
3.9	607	631	608
4	636	626	610
4.1	663	619	616
4.2	660		620
4.3	651		625
4.4	644		629
4.5	637		633
4.6			638
4.7			641
4.8			647
4.9			651

5			664
5.1			677
5.2			690
5.3			703
5.4			716
5.5			701
5.6			695
5.7			680

Discussion of results

a) Load bearing capacity: - As from the above table 4 of compressive strength results we clearly concluded that the compressive strength in case of 4RWS sample (4 circular ties and wrapped with welded wire mesh) is more as compared to other cases (say 5RS and 4RS). As 4RSW had 716kN load bearing capacity than that of 5RS and 4RS i.e. 663kN and 643kN respectively. So it is seen that on including welded wire work it expanded the heap conveying limit of example by 7% when contrasted with 4RS example.

b) Axial Displacement: - with the help of data logger we observed the displacement with respect to change in load. In all specimen's different designs were used so it was observed that the 4RWS (sample with wrapped welded wire mesh) had more ductility than the other two 5RS and 4RS as shown in the figure 13.

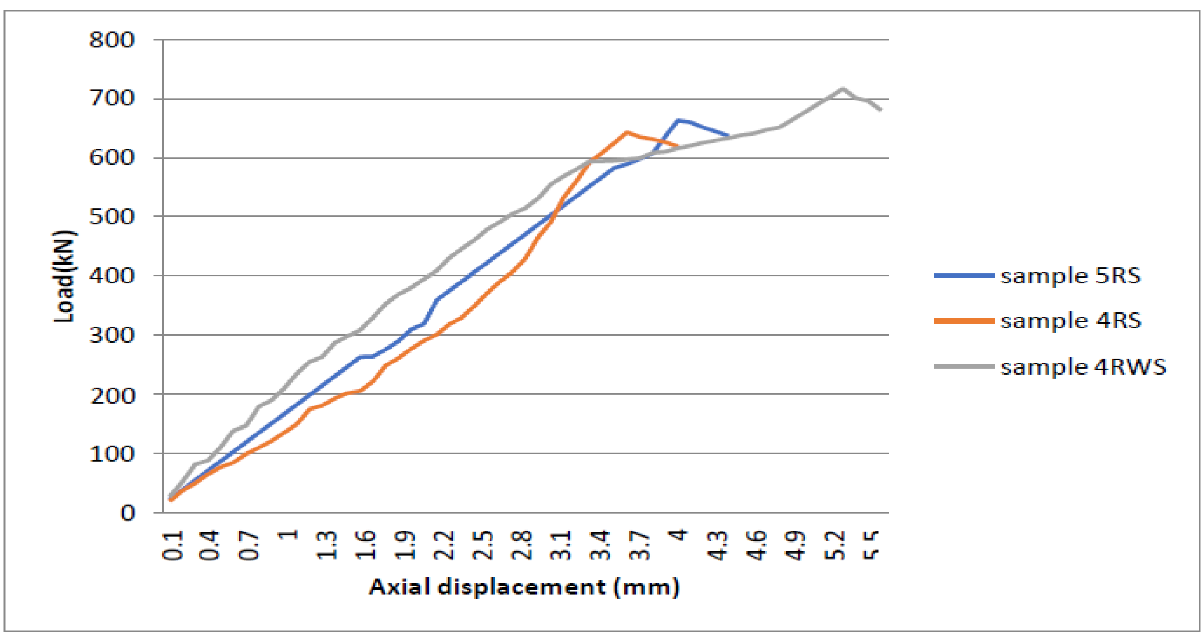

Figure 13: Load and axial displacement curve.

Conclusion

Based on the test results some conclusion listed are as follows: -

1) The load carrying capacity or we can say compressive strength of the sample that was wrapped with the welded wire mesh on the outer periphery of the major reinforcement of the column has 7% more compressive strength than that of the other two samples named as 4RS and 5RS.
2) The ductility of the column confined with welded wire mesh is more than conventionally or traditionally reinforced samples.
3) The axial load carrying capacity load carrying capacity was not having much difference.
4) Cracking pattern was more observed in case of in case of samples confined the welded wire mesh than in case of the other two was less as compared to the welded wire mesh sample.
5) Basically after all these results it can be concluded that the confined sample with welded wire mesh has more ductility and load bearing capacity so somehow such reinforced structures can play a better role in earthquake resistance structure.

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