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EVALUATION OF BEHAVIOUR OF RC SQUARE COLUMN CONFINED WITH WELDED WIRE MESH

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Abstract: This study aims to investigate the behaviour of reinforced concrete (RC) square columns that are confined with welded wire mesh through a series of experimental tests. The primary objective of this research is to assess the effect of welded wire mesh on the load-carrying capacity, deformation characteristics, and failure modes of these columns. A total twenty-four RC columns were constructed with welded wire mesh confined externally, internally or partially and subjected to axial loading conditions. The experimental setup included the use of universal testing machine (UTM) of 1200 Kn capacity deflection meter compression testing machine (CTM) to monitor deformation patterns, and applied loads. The results indicate that welded wire mesh significantly improves the load-carrying capacity and ductility of RC columns compared to unconfined column. Moreover, the mesh contributes to improved crack control and altered failure modes, demonstrating its effectiveness in providing additional confinement. The study compares the findings with the conventionally reinforced column to validate their accuracy and provides insights into the practical application of welded wire mesh in column design. The study concludes that the load carrying capacity or we can say that axial compressive strength of the column specimen that was confined with welded wire mesh wrapped around the external periphery of the conventional reinforcement (ECC) shows that compressive strength increased by 8.42% than that of other groups CRC, ICC and PCC respectively

***Index Terms* – Confinement, Deformation, Deflection, Wrapping, Buckling, Ductility.**

I.INTRODUCTION

In terms of strength and stability, the reinforced concrete (RC) columns constructed in the past are unable to meet the present seismic design standards. Severe weather conditions can also cause severe corrosion of embedded reinforcing steel rebars, which is one of the main causes of structural damage to RC columns. These factors can have a substantial detrimental impact on the longevity and structural integrity of RC columns. Large dynamic loads cannot be supported by RC columns, and when they fail, the structural system may sustain severe damage or even collapse. A structure made of reinforced concrete is meant to withstand a variety of forces safely over the course of its lifetime while also taking economy into account.

Both lateral and longitudinal reinforcements are present in columns. A column is a structural element designed to securely carry and move heavy loads from slabs and beams to the foundation. The column has longitudinal reinforcement to lessen the impact of creep and shrinkage stresses as well as to resist bending caused by a variety of pressures, such as eccentric loads and lateral loads brought on by earthquakes. On the other hand, the column's lateral reinforcement is there to keep the longitudinal reinforcement from buckling and to withstand any induced shear force. However, it has been found in a number of studies that the typical reinforcement offered is insufficient to sustain the necessary levels of ductility and lateral loads. Maintaining the concrete within the column's core will preserve its ductility. Although the column's lateral ties help to partially confine the concrete, further steel need be added for the concrete to last a long time. For this reason, further research is needed on confinement reinforcement. It has been noted that an earthquake can cause a building to collapse, hence it is crucial that the building frame be strong enough to withstand these forces. An earthquake causes vibrations, which means that additional forces are applied to the structure and must be distributed among its structural components to prevent failure, more often than other structural elements, columns are abused in India; minimum sizes required by codes are not met, rebars are bent for better alignment, the difficulty of concreting and vibrating in tall or narrow formwork causes them to become porous, and the difficulty of curing vertical elements causes them to not cure properly. There is just minimal transverse reinforcement and a limited number of 90-degree hooks. However, because working loads only account for roughly 67% of failure loads and because materials have partial safety factors, we do not observe many failures. Plastic hinges will form in columns and beams in the event of an earthquake or inadvertent lateral loading. Columns that are poorly designed, detailed, or constructed are certain to fail, as multiple earthquakes have shown (e.g., like the ones in Bhuj, and Haiti). Traditionally, codes have advised designers to use strong columns and weak beams, where columns are sized so that their flexural capacities are at least 20% (or only 10% more, according to clause 7.2.1 of the draft IS 13920) greater than the flexural capacities of the beams that meet them. This prevents plastic hinges from forming in the columns, it is essential to understand that even if the strong column–weak beam theory is adhered to, some columns will still hinge and some will yield during big earthquakes. For this reason, it's critical to plan the transverse reinforcement of columns and detail them to offer the necessary degree of ductility. One crucial component that determines a column's ability to withstand large axial, eccentric, and lateral stresses is its ductility. Therefore, the column's ductility requirement is the primary concern. If the loads are within tolerance, additional lateral reinforcing shouldn't be necessary. However, further investigation into lateral strengthening is necessary when taking into account the unpredictable vibrations caused by earthquakes. Because standard lateral ties are inefficient at handling this kind of loading, column confinement reinforcement needs to increase its lateral load carrying capability in order to improve its ductility. IS 13920 includes provisions for reinforcing imprisonment.

The equations for confinement reinforcement in IS 13920-1993 do not offer a standard level of protection against deformation and damage in terms of flexural yielding during earthquakes. An equation is commonly used to determine the secondary reinforcement in line with IS 13920-1993. Ash ¼ 0:18Sh Fck Fy ½Ag=Ak, where S is the separation between the centres of the ties and h is the bigger side of the rectangular confining column measured to its outer face. It should not exceed 300 mm. Ag is the gross area of the column cross section. Calculated in respect to the external dimensions of the rectangular hoop, Ak is the contained concrete core area.

1.1 Confinement of concrete

To keep the necessary level of ductility, the column is constrained to bind the concrete into its core. Although reinforced steel and concrete are supposed to withstand both stresses and strains together, we are aware that concrete is strong in compression and weak in tension. Previous studies and tests have demonstrated that the unconfined concrete cap begins to spall first when a load is applied to a concrete column. Because of the lateral ties that hold the concrete in place, the inner core's concrete is kept in place to some extent. Numerous studies have also recommended increasing the number of lateral links, but in practice, it is not a good solution because casting and concrete continuity are equally crucial. The primary goal is to maximize the restricted core's capacity to absorb energy, guide axial, eccentric, and lateral stresses properly, and transmit those loads to the foundation without experiencing any failures. There are two forms of confinement available: internal and external. While materials are added during the concrete column's casting process in internal confinement, such as welded wire mesh, chicken mesh, galvanized steel mesh, welding of conventional reinforcement, welded steel plates, etc., in external confinement, the materials are available to the outer surface on the structural element (e.g., FRP jacketing, Steel jacketing, ferrocement and retrofitting's, etc.).

1.2 Reinforcement in Column:

A column has transverse and longitudinal reinforcements. Functions of reinforcement are discussed below: -

vertical reinforcement:

a) To distribute the column's axial compressive stresses.
b) To prevent the formation of tensile stresses in compression members as a result of:
1. Irrational stress.
2. force operating away from the center.
3. Horizontal load
c) To prevent the column from breaking suddenly.
d) To impart certain ductility to the column
e) To provide the sufficient amount of degree of malleability.

Horizontal Reinforcement: -

a) Prevent inclined strains created by horizontal shear caused by moment
b) Prevent longitudinal shattering of vertical reinforcement.
b) Limiting the vertical reinforcement in place at the moment the concrete is poured.
d) To hold the main vertical reinforcement at its original position during the concreting.
e) To confine the concrete, thereby preventing its longitudinal splitting.

2. NEED OF THE STUDY.

It is clear from reading the previous research studies it state that confining the column improves performance in terms of how well it responds to earthquakes and large axial stresses. As it helps the column after the elastic limit and the necessary level of ductility. Previous literature has examined a wide range of confinement reinforcement techniques, but considering their practical application, economy and convenience of building should be taken into account. Thus, a relatively cheap and locally available material is required. Taking into account all of these factors, using welded wire mesh turns out to be a better choice. So in this proposed work evaluation of RC square column is done experimentally with and without using welded wire mesh to the reinforcement cage. And after experimental work Ansys modelling is done and comparing both results to validate work

3. METHODOLOGY AND MATERIAL

Methodology:

This proposed work aims to evaluate the load carrying capacity, deformation, and performance of the confinement reinforcement used in the square column. Stresses and strains generated by the columns are also important for this reason as well. considering this, the Methodology is adopted and the following Configuration are done to perform the study. Size of the column specimen is decided as 200 mm x 200 mm x 600 mm

Configurations –

NC: Normal Column

CRC: Conventionally Reinforced Column

ECC: Externally Confined Column with welded wire mesh

ICC: Internally Confined Column with welded wire mesh

PCC: Partially Confined Column with welded wire mesh without stirrups.

(Stirrups used only at top and bottom to hold the longitudinal reinforcement at its position)

To maintain the accuracy of work three specimens for each group are casted and tested experimentally for 7 days, and 28 days and results are validating with Ansys software results. Testing of samples is conducted on (UTM) Universal Testing Machine available at our university laboratory.

Description of Tested Column Specimen

For this work twenty-seven square columns having size 200x200x600 mm were cast in five groups, from which three columns are casted with conventional reinforcement to validate theoretical calculations. Specimens were provided with four bars of 12 mm dia as longitudinal reinforcement and 6 mm stirrups are used as lateral reinforcement in three groups.

3.1 Material Description:

A. Longitudinal and Lateral Reinforcement

Longitudinal reinforcement of 4 bars #12 mm dia. (Fe 500) is used and it fulfil the criteria as per IS 1786 (2008).

Lateral reinforcement of 6 mm (Fe 500) is used at 170 mm c/c spacing.

B. MS Welded Wire Mesh

Mesh opening was 30x 30 mm and having wire diameter of 2 mm was used to confine the column. The material properties provided by the manufacturer are shown below:

Table 3.1: Properties of WWM

Properties-	WWM
Mesh Opening	30 X 30 mm
Wire Diameter	2 mm
Weight (Kg/m^2)	2.9 kg/m^2
Proof Stress	670 Mpa
Ultimate Stress	891 Mpa
Specific Gravity	6.5
Poisson's Ratio	0.3

C. Cement

For this experimental work we use OPC 43 Grade Cement and casting of specimen is done,

Table 3.2: Properties of Cement

Properties	Specifications
Specific Gravity	3.15
Fineness Modulus	2250 kg/m^2
Soundness (by Lee Chatelier)	10 mm

D. Fine Aggregate (Sand)

Crushed stone sand is used for all experimental work

Table 3.3 Properties of Fine Aggregate

Properties	Specifications
Specific Gravity	2.81
Bulk Density	1437 kg/m^3

E. Coarse Aggregate

We use coarse aggregate having size 12.5 mm and 20 mm for this proposed work.

Table 3.4 Properties of Aggregate

Properties	Specifications
Specific Gravity	2.78
Bulk Density	1520 kg/m^3
Aggregate size	12.5 mm and 20 mm

3.2 Experimental Work

For preparing column specimens mould of plywood having dimension 200x200x600 are made and casting should be done in two set. Also the six cubes of 150x150x150 mm are filled during concreting work and tested after 7 day and 28 days curing to check the compressive strength of concrete.

a) Preparation of Mould
- Moulds are prepare from plywood, cutting the plywood as per required dimension and all planks are arranged and nailing was done.

b) Preparation of Reinforcement case

All steel bars and welded wire mesh are cut to their desired dimension with the help of grinder. After that all reinforcement case are tied up as per the given configurations.

c) Casting of Column

Casting should be done in two stages, arrangement of all reinforcement case is done into the moulds, proper covers are placed and concreting is carried out. Before that weight batching of material is done using weighing machine then hand mixing is done and concrete is filled using travel, compaction is done by using vibrating table and tamping rod.
- To evaluate the workability of the concrete Slump cone test is carried out, the value of slump is 130 mm.

d) Demoulding and Curing
- Demoulding of columns is done after 24 hrs and all the specimens are keeping in curing tank for curing to 7 days and 28 days.

e) Testing

Universal Testing Machine (UTM) is used to check the axial compression of the column specimen having its capacity 1200 KN. For checking deflection of column deflection testing instrument is used.

Compaction testing machine (CTM) is also used for testing of 150x150x150 mm cubes to know the compression strength of concrete. Cubes are tested after 7 days and 28 days curing.

Table 3.5 Results of Compressive Strength

	7 Days	**28 Days**
Compressive Strength (N/mm^2)	13.5	22

4. RESULTS AND DISSCUSION

All column specimens are tested for axial compression loading and all the test results are used to check effectiveness of MS welded wire mesh in accordance to the column axial capacity, core concrete strength. For every specimen, stress-strain graphs were also drawn.

Table 3.6 Results after 7 days curing

specimen	load at peak			average peak load
for 7 days	no. 4	no. 5	no. 6	
crc (conventionally reinforced column)	247.93	331.42	537.6	372.32
ecc (externally confined column)	490.16	481.82	274.12	415.37
icc (internally confined column)	386.54	411.22	383.48	393.75
pcc (partially confined column)	314.86	384.78	445.31	381.65

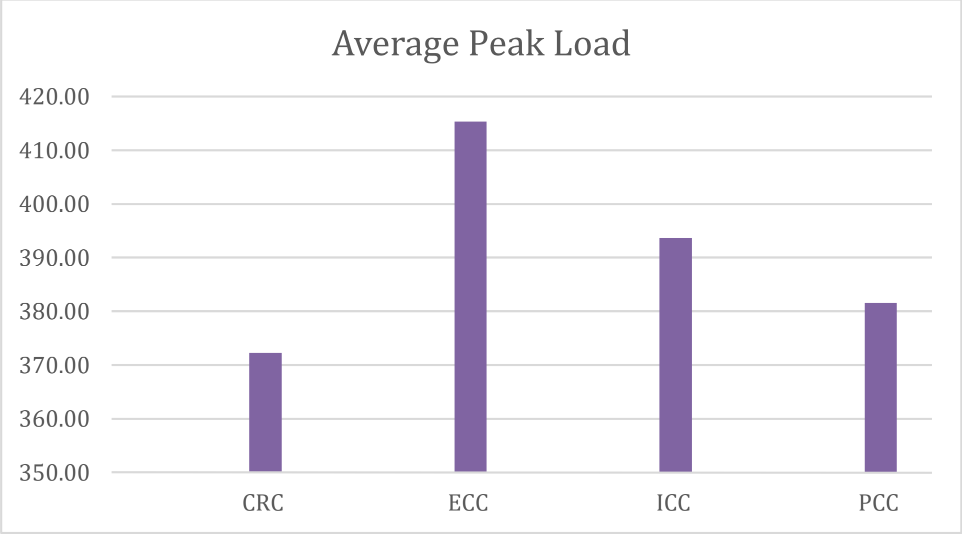

Fig 3.1: Avg. Peak Load at 7 days

Table 3.7 Results after 28 days curing

Specimen	Load at Peak			Average Peak Load
For 28 Days	No. 1	No. 2	No. 3	
CRC (Conventionally Reinforced Column)	435.64	487.204	508.34	477.06
ECC (Externally confined Column	404.5	550.98	596.212	517.23
ICC (Internally confined Column)	446.93	460.58	541.734	483.08
PCC (Partially confined Column)	451.24	405.28	390.77	415.76

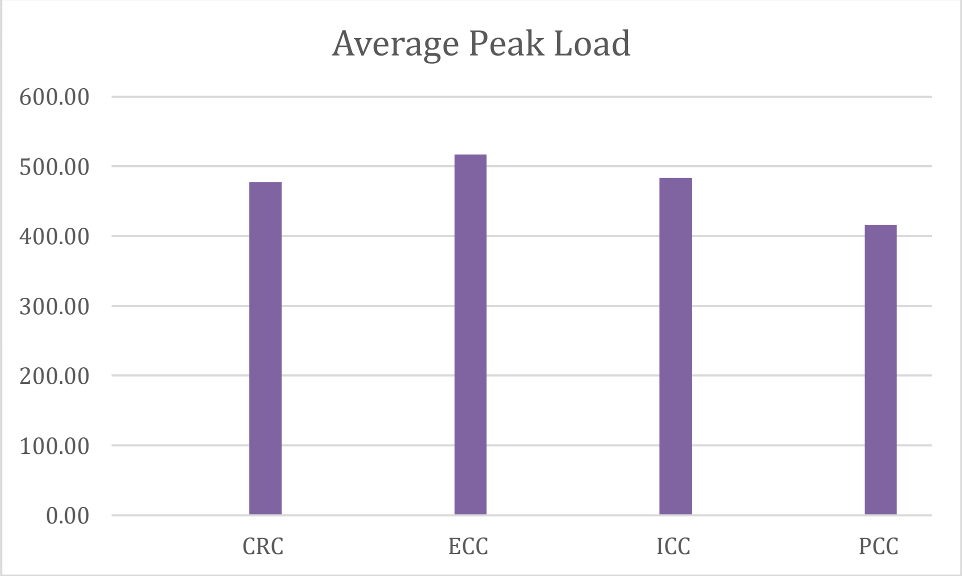

Fig 3.2: Avg. Peak Load at 28 days

Fig3.3: CRC Member Failure

Fig 3.4: ECC Member Failure

Fig 3.5: ICC Member Failure

Fig 3.6: PCC Member Failure

Table 3.8: Result for Conventionally Reinforced Column Specimen (CRC)

For 28 Days	Axial Load (KN)	Avg. Vertical Deformation (mm)	Stress (N/mm^2)	Strain
At Ultimate Point	477.06	6.32	11.92	0.000533

Table 5.4: Result for Externally Confined Column Specimen (ECC)

For 28 Days	Axial Load (KN)	Avg. Vertical Deformation (mm)	Stress (N/mm^2)	Strain
At Ultimate Point	517.23	5.69	12.99	0.000580

Table 5.5: Result for Internally Confined Column Specimen (ICC)

For 28 Days	Axial Load (KN)	Avg. Vertical Deformation (mm)	Stress (N/mm^2)	Strain
At Ultimate Point	483.08	5.67	12.07	0.000540

Table 5.6: Result for Partially Confined Column Specimen (PCC)

For 28 Days	Axial Load (KN)	Avg. Vertical Deformation (mm)	Stress (N/mm^2)	Strain
At Ultimate Point	417.76	5.89	10.44	0.000466

4. CONCLUSION

Based on the test results following are the conclusions are made

a. The load carrying capacity or we can say that axial compressive strength of the column specimen that was confined with welded wire mesh wrapped around the external periphery of the conventional reinforcement (ECC) shows that compressive strength increased by 8.42% than that of other groups CRC, ICC and PCC respectively.
b. The column confined with welded wire mesh shows more ductility than the conventionally reinforced columns
c. Cracks are more observed in column confined partially and in conventionally reinforced column as compare to ECC and ICC.
d. Ansys modelling is done for all the column specimens which concludes that welded wire mesh is more efficient in terms of stress-strain and ultimate load carrying capacity.
e. After analysing all the results, it is essentially possible to conclude that the confined specimen with the welded wire mesh has greater ductility and load bearing capability, which suggests that these reinforced structures may be more effective in creating structures that withstand earthquakes.

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