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EFFECTOF DIFFERENT WRAPPINGTECHNIQUES ON RETROFITTING OF RCC BEAM COLUMN JOINTS USING FERROCEMENT

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ABSTRACT

In various parts of the world, Reinforced Concrete (RC) structures, even in seismic zones are still being designed only for gravity loads. Such structures, though performing well under conventional gravity load case, could lead to a questionable structural performance under seismic or wind loads. In most cases, those structures are highly vulnerable to any moderate or a major earthquake. Along with the seismic prone zones like Himalayan region in India, Iran, Turkey, New Zealand and fault regions in US etc., devastations from earthquake have also been seen at the places believed to be seismically not-so-active Therefore, in the design of the reinforced concrete beam-column joints against seismic load, it is desirable to limit joint strength degradation until the ductility capacity of the beam reaches the designed capacity.The repair and retrofit materials can be classified into three categories: 1.Grouts.2 Bonding Agents. 3.Replacement and Jacketing Material. Present work includes experimental investigation to study the structural behavior of Beam Column Joint by wrapping technique. There are two types of Wrapping Techniques Type I Retrofitting & Type II Retrofitting. The study is carried out to analyze the Effect of Different Wrapping Techniques on Retrofitting of RCC Beam Column Joints Using Ferrocement. After experimental investigation, observation are Type I and Type II are better mechanical properties than control specimen. Type II has better properties than Type I.

Keywords: Ferrocement, Retrofitting, RCC Beams, RCC Columns, RCC Joints.

I INTRODUCTION

Structures deteriorate due to problems associated with reinforced concrete. Natural disasters like earthquakes have repeatedly demonstrated the susceptibility of existing structures to seismic effect and hence implements like retrofitting and rehabilitation of deteriorated structures are important in high seismic regions. Thus retrofitting and strengthening of existing reinforced concrete structures has become one of the most important challenges in Civil engineering. Engineers often face problems associated with retrofitting and strength enhancement of existing structures. Commonly encountered engineering challenges such as increase in service loads, changes in use of the structure, design and/or construction errors, degradation problems, changes in design code regulations, and seismic retrofits are some of the causes that lead to the need for rehabilitation & retrofitting of existing structures. Complete replacement of an existingstructure may not be a cost-effective solution and it is likely to become an increased financial burden if upgrading is a viable alternative. In such occasions, repair and rehabilitation are most commonly used solutions.

1.1 Historical Background

The credit of using ferrocement in the present day goes to Joseph Louis Lambot who in 1848 constructed several rowing boats, plant pots, seats & other items from a material he called ferrocement. Lambot's construction consisted of a mesh or grid reinforcement made of two layers of small diameter on bars at right angle & plastered with cement mortar with a thin cover to reinforcement. Lambot's rowboats were 3.66 m long, 1.22 m wide & 25 mm to 38 mm thick .These were reinforced with grid & wire netting. One of the boat build by him, still in remarkably good condition, is on display in the museum at Brignoles, France.In 1945, Nervi built the 165 ton Motor Yatch "Prune" on a supporting frame of 6.35 mm dia rods spaced 106 mm apart with 4 layers of wire mesh on each side of rods with total thickness of 35 mm. It weighed 5% less than a comparable wooden hull & cost 40% less at that time.

1.2 Applications of Ferrocement

Ferrocement has found wide spread applications in housing particularly in roofs, floors, slabs, & walls. Some researchers were also made on the use of Ferrocement in beams &columns. Ferrocement roofs investigated included shell roofs, folded plates & the channel shaped roofs, box girders & secondary roofing.Ferrocement roofing channels are manufactured using designed mix of cement, sand and water to give high strength mortar that is reinforced with a layer of galvanized iron chicken wire mesh of 22 gauge and tor steel bars of 8-12 mm diameter provided in the bottom ribs of the channel.Ferrocement roofing channels can be safely transported for the application after a curing period of 14 days.

Advantages of ferrocement channels

Fast construction – prefabricated channels enable to construct a roof in just 3 days

No shuttering required, unlike in-slab casting

30% cost saving over RCC roofing

Less dead load on the walls

High strength to weight ratio

Appealing aesthetics - elegant profile and uniform size.

II. LITERATURE REVIEW

Lee et al (2009); reported a method to predict the ductile capacity of reinforced concretebeam-column joints failing in shear after the development of plastic hinges at both ends of the adjacent beams. After the plastic hinges occur at both ends of the beams, the longitudinal axial strain at the centre of the beam section in the plastic hinge region is expected to increase abruptly because the neutral axis continues to move toward the extreme compressive fibre and the residual strains of the longitudinal bars continue to increase with each cycle of additional inelastic loading cycles.

Bing et al (2002); This paper, through a comprehensive experimental work, investigates the behaviour of reinforced concrete frame specimens designed to represent the column–beam connections in plane frames.

Al-Salloum et al (2002); studied that the efficiency and effectiveness of using CarbonFibre Reinforced Polymers (CFRP) sheets in repairing and upgrading the shear strength and ductility of seismically deficient exterior beam-column joint. For this purpose, a reinforced concrete exterior beam-column sub-assemblage was constructed with non-optimal design parameters (inadequate joint shear strength with no transverse reinforcement) representing pre-seismic code design construction practice of joints and encompassing the vast majority of existing beam-column connections.

2.1 Gap Study

According to literature survey it is concluded that:

1. Work done in wrapping the Beam Column Joint using wire is not very common.
2. Method used in wrapping the Beam Column Joint diagonally is not done.

2.2 Scope & Objectives

Present work includes experimental investigation to study the structural behaviour of Beam Column Joint by wrapping technique. There are two types of Wrapping Techniques Type I Retrofitting & Type II Retrofitting.

SECTION A:

1. To consider a joint which has low strength.
2. To analyse the existing strength of the Joint.
3. To compare the existing strength of Control Specimen with the design strength.

SECTION B:

4. To retrofit the C.S using type I & type II Wrapping Technique.
5. To find out mechanical properties by experimental study changing the position of loads.
6. To compare the retrofit C.S of type I & type II with existing C.S.
7. To analyse the outcomes.
8. Recommend the retrofitting measures using different wrapping techniques.

III.METHODOLOGY

3.1 LVDT(Linear Variable Differential Transducer)

LVDT is the most preferred choice for the measurement of displacement, pressure, force, level, flow, & other physical quantities in engineering application & in industries. Measuring displacement, settlements, deformations of slopes is a critical need in many structural processes, so some sensors are used for this purpose like potentiometer, capacitance picks, LVDT etc. The main aim of studying LVDT'S is to find various other uses in structural processes advantageously which consumes less time and are more efficient. LVDT's when used with ETPFS's in a concrete Beam cannot only measure deflection of the Beam but also cracks in it. LVDT has a wide range use in railways to measure dynamic displacement of rail bridges with advanced video based system. Because of it high sensitivity and high resolution LVDT's can detect vibrations in structure. Apart from dial gauges, using a LVDT is a primitive technique for obtaining deformation in conventional structure tests. Although there are certain advantages to using LVDT's such as high resolution and accuracy ,simple installation, and real time logging ability.

3.2 Retrofitting Schemes

The two types of retrofitting schemes used for wrapping of wire mesh are categorized as:-

- Type one retrofitting, and
- Type two retrofitting.

1) Type one retrofitting: - In this retrofitting we make two L-shapes of appropriate size from the wire mesh and wrap these on the lower and upper faces of the beam at the joint.Then we use cement mortar of thickness 20mm on the wire mesh bonded on the beam-column joint

2) Type two retrofitting: - In this retrofitting we make again two L-shapes of appropriate size from the wire mesh and wrap these on the lower and upper faces of the beam at the joint but in this type we use some extra mesh of appropriate size diagonal to the joint. Then we use cement mortar of thickness 20mm on the wire mesh bonded on the beam-column joint.

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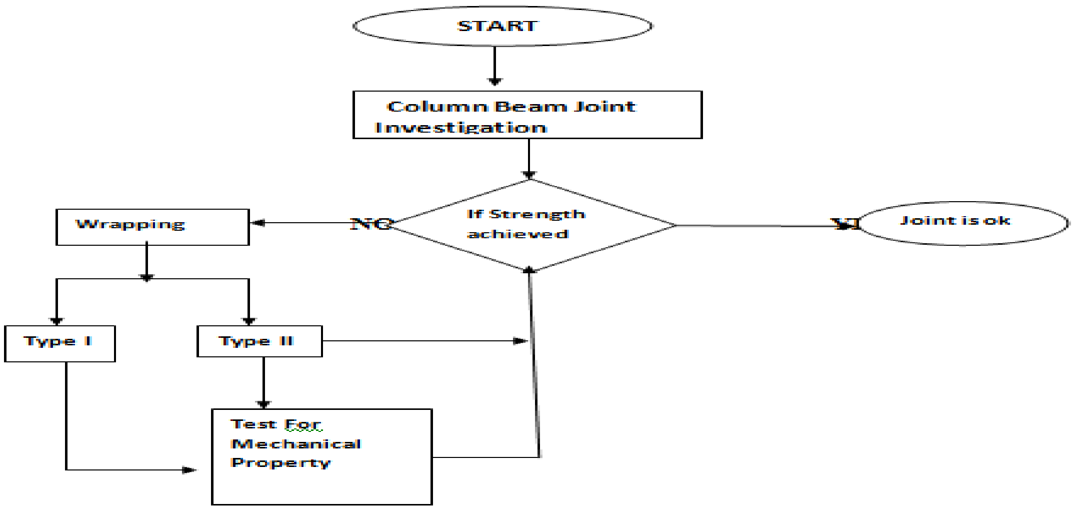

3.8:Flow chart (Methodology)

IV.EXPERIMENTAL PROGRAM

The test program is so devised so as to study the behavior of retrofitted beam-column joints subjected to different ways of wrapping the retrofit material. The test program consists of:

First is the determination of basic properties of constituent materials namely cement, fine and coarse aggregates and steel bars as per relevant Indian standard specifications and designing the relevant concrete mix proportions. Casting of five beam-column joints, with column rectangular shape of dimensions 225 mm x 150 mm and length of 1000 mm and the beam with dimensions 225mm x150 mm in all test specimens and length of 500 mm, using M 20 grade concrete.One beam-column joint is considered as control beam. The remaining are stressed and retrofitted with ferrocement, in-order to find out the load carrying capacity. The stress levels maintained are 80% of the maximum load carrying found out by testing the control beam.

4.1 Materials Used

Cement, fine aggregates, coarse aggregates, reinforcing bars and water are used in casting of beams and ferrocement is used as the retrofitting material. The specifications and properties of these materials are as under: 1.Cement,2.Fine Aggregates,3.Coarse Aggregates,4.Water,5.Reinforcing Steel,6.Wire mesh,7.Concrete Mix 8.Mortar Mix.

4.2 Design of Beam-Coulmn Joint

To study the proposed behaviour, five external beam column joint specimens are cast using M-20 grade concrete and Fe-500 grade steel. The column is rectangular in shape with dimensions 225 mm x 150 mm and a length of 1000 mm. The beam has dimensions 225 mm x 150 mm in all test specimens and length of 500 mm. In all five joints the column main reinforcement consisted of 4 no’s of 8 mm diameter whereas in the beam portion, the reinforcement consisted of 2 no’s of 10 mm diameter bars in tension zone and 2 no’s of 8 mm diameter in the compression zone and, from the face of beam, an anchorage length of 600 mm to both sides of column is provided.

4.3 Casting of Composite Beam-Column Joints

The casting of the joints is done in the single stage. A steel mould is made of dimensions 225mm x 150 mm for the beam portion and of length 500mm and 225 x 150 mm for the column portion with length 1000mm. The steel mould is shown in the Figure 3.5. Cover blocks of 20 mm are placed under the reinforcement to provide uniform cover. Coarse aggregates, fine aggregates, cement and water are mixed manually as per the proportions of design mix.

4.4 Process of Retrofitting

The four beam column joints which are loaded upto 80% of the ultimate load are retrofitted using two different schemes. The retrofitting schemes are discussed below. The retrofitting scheme consists of wrapping the beam portion and column portion with the help of the rectangular wire mesh. Firstly, the surfaces of specimens are cleaned. After the wrapping of specimen with wire mesh is done, the cement slurry is applied as bonding agent to the surfaces of beam-column joints. The cement mortar of 20mm thick made of ratio 1:3 and having water cement ratio (w/c) equal to 0.45 is applied on the specimen. The beams are cured with jute bags for 7 days before testing. They are then tested with the same procedure as adopted during the testing of control beam to calculate ultimate load and corresponding deflections.

Table 4.1 Physical Properties of Portland Pozzolana Cement

Sr. No.	Characteristics	Test Values	Value specified by IS :1489-1991 (Part 1)
1.	Standard Consistency	32	---
2.	Fineness of cement as retained on 90 micron sieve (%)	0.7%	Maximum 10%
	Setting time (mints)		
3.	1.Initial	105	Minimum 30
	2.Final	255	Maximum 600
4.	Specific gravity (Specific gravity bottle)	3.10	-
	Compressive Strength(N/mm^2)		
5.	7 days	23.50	Minimum 22.0
	28 days	35.60	Minimum 33.0

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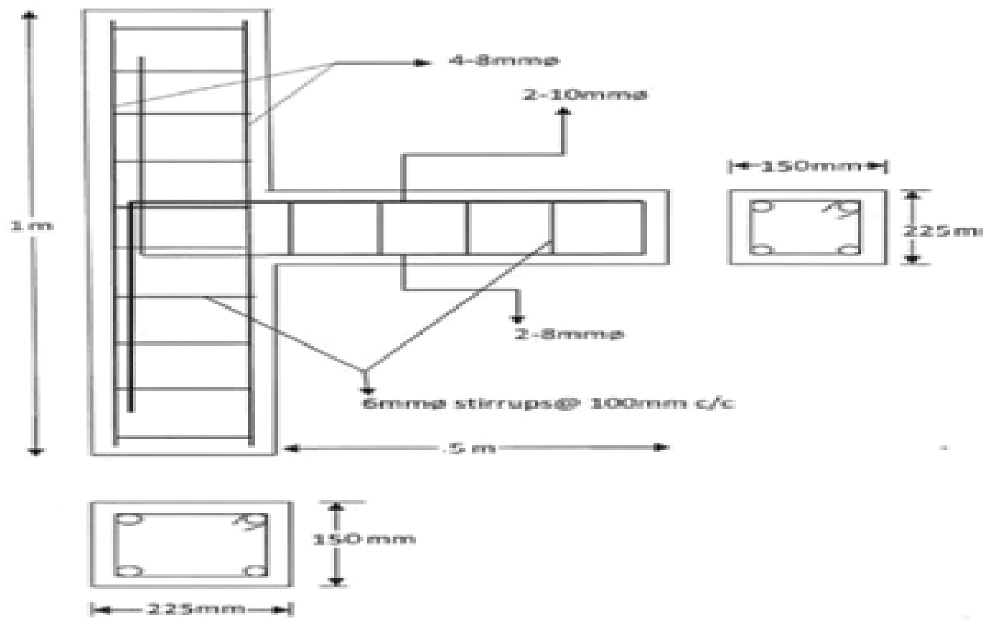

Figure 4.1 Reinforcement Detailing Of Beam Column Joint

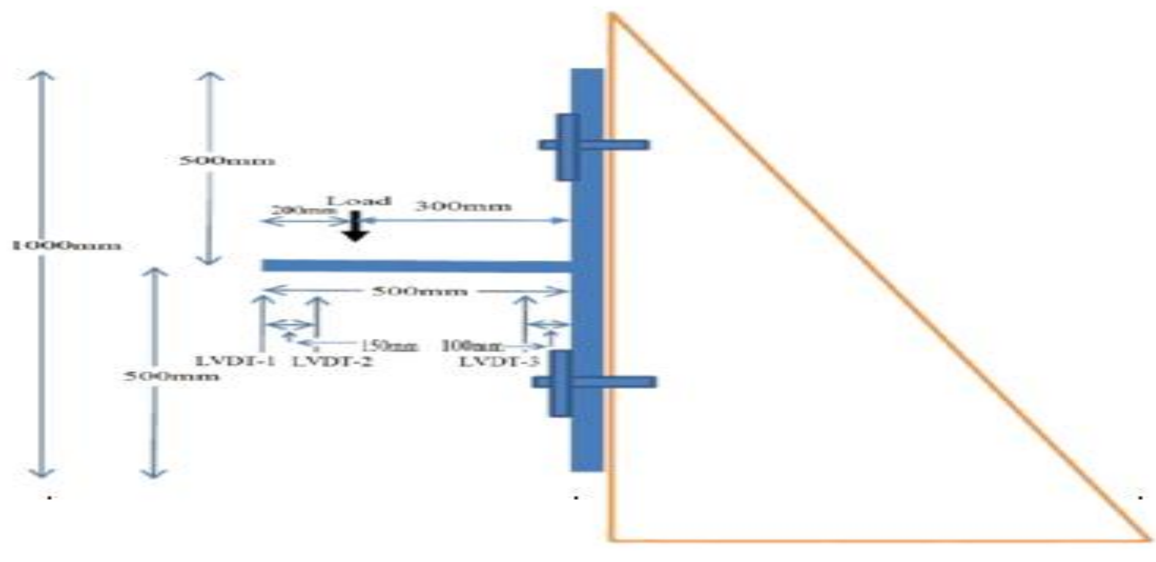

Figure 4.2: Beam Column Specimen Attached with Frame

V.RESULTS AND DISCUSSIONS

5.1 Effect of Method of Wrapping Technique

1.Effect on Ultimate Load

The effect on strength of retrofitted RCC beam-column joint R1loaded to 80 % level is shown in Fig. 5.1. The Table 5.1 show the load deflection data for control specimen& 80 % loaded retrofitted specimen. Plates 5.2 &

5.3 shows the crack pattern for the retrofitted beam-column joint.It is observed from the experimental data and the corresponding graph that retrofitting leads to increase in the ultimate load carrying capacity from 64.1 KN (control specimen) to 102.21 KN whereas the deflection corresponding to ultimate load of 102.21 KN is 20.31 mm as compared to 24.1 mm for the control specimen at 64.1 KN. Also there is a considerable increase in the yield load from55 KN (control specimen) to 95 KN for the retrofitted specimen.From a comparative point of view it is observed from Fig 5.7 and Table 5.8 that percentage increase in the ultimate loads of the retrofitted beams has been able to justify the thesis work till date because the results are in lieu to the economy considerations, all the beams have been able to perform very efficiently increasing the ultimate loads to a percentage as high as 27.12%, 59.56% for type one retrofitted-beam column joints and type two retrofitted beam-column joints for 80% stress level respectively as compared with controlled beam-column joint.

2.Effect on Ductility: The values of ductility ratio are shown in Table 5.7. The ductility ratio of the controlled specimen is 3.35 and the ductility ratio of type one retrofitted specimen R1 is 1.24. So the ductility ratio of type one retrofitted specimen is less than controlled specimen CS. On comparing the average values of ductility ratio of type one retrofitting with type two retrofitting, the ductility ratio of type one retrofitting is less than type two retrofitting

Table 5.1 Load and Deflection Values at Free End of Beam of Controlled and Retrofitted Specimens R1 and R2.

S. No.	Control beam column joint (CS)		Retrofitted beam-column joint (R1)-type one Retrofitting		Retrofitted beam-column joint (R2)-type one retrofitting		Avg=(R1+R2)/2	
	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
1	0	0	0	0	0	0	0	0
2	5	0.01	5	0.43	5	0.55	5	0.49
3	10	0.09	10	1.34	10	1.33	10	1.335
4	15	0.41	15	2.2	15	2.19	15	2.195
5	20	1.12	20	2.92	20	2.92	20	2.92
6	25	1.7	25	3.55	25	3.52	25	3.535
7	30	2.44	30	4.29	30	4.31	30	4.3
8	35	3.49	35	5.04	35	5.05	35	5.045
9	40	4.32	40	5.81	40	5.8	40	5.805
10	45	5.36	45	6.59	45	6.6	45	6.595
11	50	6.28	50	7.38	50	7.37	50	7.375
12	55	7.2	55	8.21	55	8.2	55	8.205
13	60	9.6	60	9.2	60	9.19	60	9.195
14	64.1	24.1	65	10.36	65	10.39	65	10.375
15	60	33.59	70	11.72	70	11.72	70	11.72
16	59.5	35.23	75	13.08	75	13.1	75	13.09
17			80	15.07	80	15.11	80	15.09
18			81.45	16.23	81.52	16.61	81.485	16.42
19			80	17.29	80	17.33	80	17.31
20			75	22.5	75	23.1	75	22.8
21			70	29.59	70	30.32	70	29.955

Table 5.2 Load and Deflection Values at Free End of Beam of Controlled and Retrofitted Specimens R3 and R4.

S. No.	Control beam column joint (CS)		Retrofitted beam-column joint (R3)-type two retrofitting		Retrofitted beam-column joint (R4)-type two retrofitting		Avg=(R3+R4)/2	
	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
1	0	0	0	0	0	0	0	0
2	5	0.01	5	0.23	5	0.25	5	0.24
3	10	0.09	10	0.5	10	0.51	10	0.505
4	15	0.41	15	0.85	15	0.87	15	0.86
5	20	1.12	20	1.21	20	1.22	20	1.215
6	25	1.7	25	1.67	25	1.67	25	1.67
7	30	2.44	30	2.12	30	2.13	30	2.125
8	35	3.49	35	2.55	35	2.57	35	2.56
9	40	4.32	40	3.15	40	3.14	40	3.145
10	45	5.36	45	3.71	45	3.72	45	3.715
11	50	6.28	50	4.5	50	4.48	50	4.49
12	55	7.2	55	5.22	55	5.22	55	5.22
13	60	9.6	60	6.01	60	5.99	60	6
14	64.1	24.1	65	6.81	65	6.8	65	6.805
15	60	33.59	70	7.67	70	7.66	70	7.665
16	59.5	35.23	75	8.55	75	8.56	75	8.555
17			80	9.46	80	9.45	80	9.455
18			85	10.6	85	10.61	85	10.605
19			90	11.91	90	11.9	90	11.905
20			95	13.4	95	13.42	95	13.41
21			100	18.05	100	18.04	100	18.045
22			102.21	20.31	102.35	20.35	102.28	20.33
23			100	30	100	29.94	100	29.97
24			95	35.08	96.5	35.13	95.75	35.105

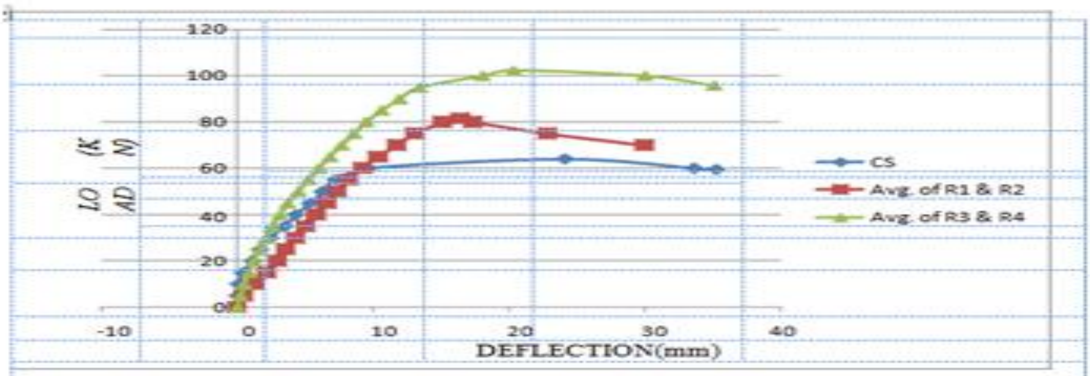

Figure 5.1Average Values of Load and Deflection at Free End of Beam of Controlled and Retrofitted specimens.

VI CONCLUSIONS

The study is carried out to analyse the Effect of Different Wrapping Techniques on Retrofitting of RCC Beam Column Joints Using Ferrocement. The important conclusions drawn from the study are as

1. The load carrying capacity of retrofitted beam-column joints for both types of retrofitting techniques increases significantly as compared to control beam-column joint.
2. Specimens with mesh wire wrapped diagonally show maximum improvement in their ultimate load.
3. There is increase in the yield load also in both types of retrofitting; in case of specimens with mesh wire wrapped diagonally there is significant increase in the yield load.
4. There is decrease in the deflection in case of retrofitted specimens as compared to control specimen

5. The ductility ratio of retrofitted specimen is less than the ductility ratio of control specimen.
6. The ductility ratio of those specimens in which mesh wire is wrapped diagonally is more than those specimens in which mesh wire is wrapped in the shape of L.
7. The value of ultimate moment of retrofitted specimen is more than the ultimate moment of controlled specimen, and the ultimate moment of those specimens in which wire mesh is wrapped diagonally is more than the specimens in which wire mesh is wrapped in the shape of L. There is decrease in rotation in case of retrofitted specimen as compared to controlled specimen.

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