EFFECT OF DIFFERENT WRAPPING TECHNIQUES ON RETROFITTING OF CONSTRUCTIONAL JOINTS USING FERROCEMENT AND CONPLAST SP432

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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:(i) Injection grout(i) Injection grout.2 Bonding Agents. 3.Replacement and Jacketing Material(i) Steel plate bonding ii) Ferrocement*

Keywords: *Retrofitting,Ferrocement, RCC Beams, RCC columns, RCC joints.*

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.

Historical Background

The credit of using ferrocement and conplast sp432in 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 fercement. 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.

APPLICATIONS OF FERROCEMENT

Ferrocement and conplast sp432has found wide spread applications in housing particularly in roofs, floors, slabs, & walls. Some researchers were also made on the use of Ferrocement and conplast sp432in beams &columns. Ferrocement and conplast sp432roofs investigated included shell roofs, folded plates & the channel shaped roofs, box girders & secondary roofing. Ferrocement and conplast sp432roofing 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 and conplast sp432roofing channels can be safely transported for the application after a curing period of 14 days.

Advantages of ferrocement and conplast sp432channels

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.

FUTURE OF FERROCEMENT AND CONPLASTSP432IN CONSTRUCTION:

Somequestions are launched for argumentation on the future of ferrocement&conplastsp432in construction which are factors that have inhibited the full development and dissemination of ferrocement and conplast sp432technology e.g. is ferrocement and conplast sp432cost- competitive? Is high structural performance always needed in ferrocement and conplast sp432applications/is ferrocement and conplast sp432durability reliable.a)Durability b) Cost

OBJECTIVE:

The hysteretic behaviour of Reinforced Concrete columns and joints depends on the amount of reinforcement. The scope of the work includes a study on the effect on ductile behaviour of Reinforced Concrete columns under lateral cyclic loading with varying percentage of longitudinal reinforcement. The reinforced concrete frames without seismic provision are often characterized by an unsatisfactory structural behaviour due to low available ductility and lack of strength which in turn induces global failure mechanism. Hence it is very much essential to retrofit the vulnerable building to cope up for the next damaging earthquake. The scope of the work involves experimental investigation to study the structural behaviour of columns strengthened by Glass Fiber Reinforced Polymer (GFRP), Carbon Fiber Reinforced Polymer (CFRP), Reinforced Concrete jacketing (RC), Steel plate, Steel strip, corrugated steel jacketing and Ferro cement jacketing of column footing.

But during my research work i have gone through type 1 retrofitting and type 2 retrofitting using ferrocement and conplast sp432as their efficiency and workability was much more than previous ones used.

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

Effect on Ultimate Load

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.

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

Effect on Energy absorption

On comparing the average values of energy absorption of type one retrofitting specimen with type two retrofitting specimen, the energy absorption of type one retrofitting decreases by 56.584% than the type two retrofitting specimen.

Effect on moment & rotation:

The average value of ultimate moment of the retrofitted specimen is more than the ultimate moment of controlled specimen. The average ultimate moment of type two retrofitting is significantly more than the ultimate moment of control specimen.

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 center 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.

METHODOLOGY:

Ferrocement and conplast sp432is a composite material consisting of rich cement mortar matrix uniformly reinforced with one or more layers of very thin wire mesh with or without supporting skeletal steel. American Concrete Institute Committee 549 has defined ferrocement and conplast sp432in broader sense as "a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous & relatively small diameter mesh". The mesh may be metallic or may be made of other suitable materials. Ferrocement and conplast sp432possesses a degree of toughness, ductility, durability, strength & crack resistance which is considerably greater than that found in other forms of concrete construction

The construction of ferrocement and conplast sp432can be divided into four phases:

Fabricating the skeletal framing system.

Applying meshes.

Plastering.

Curing phase

Phase 1 & 3 require special skill while phase 2 is very labour intensive. The development of ferrocement and conplast sp432evolved from the fundamental concept behind reinforced concrete.

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 mix of ferrocement and conplast, 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.

MATERIALS USED

Cement, fine aggregates, coarse aggregates, reinforcing bars and water are used in casting of beams and ferrocement and conplast sp432is used as the retrofitting material. The specifications and properties of these materials are as under:
1.Cement2. Fine Aggregates3. Coarse Aggregates4. Water5. Reinforcing Steel 6. Wire mesh 7. Concrete Mix 8. Mortar Mix.

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.

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.

PROCESS OF RETROFITTING

The four beam column joints which are loaded up to 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.

Sr. No.	Characteristics	Test Values	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

Table 4.1 Physical Properties of Portland Pozzolana Cement

Cement	395.62 kg/m^3
F.A.	571.63 kg/m^3
C.A. (CA-I : CA-II)	1163.70 kg/m^3, (50:50)
Water	189.90 kg/m^3
Ratio	1:1.46:2.94
W/C Ratio	0.48

Table 4.8 Concrete Mix Design for M-20 Grade Concrete (As per I.S.)

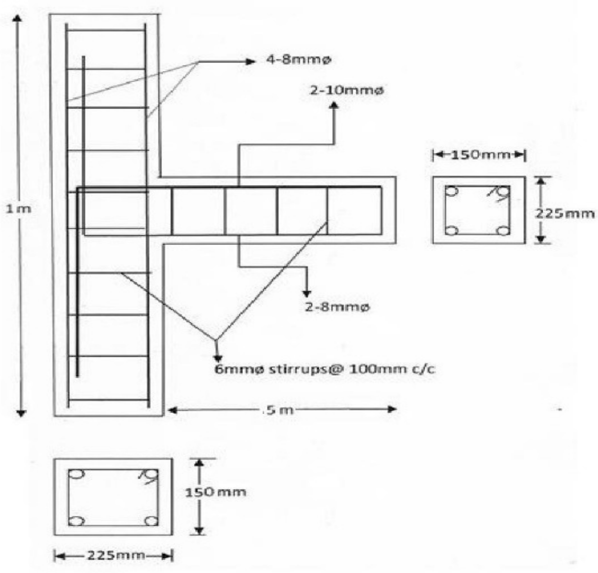

Figure 4.1 Reinforcement Detailing of Beam Column Joint

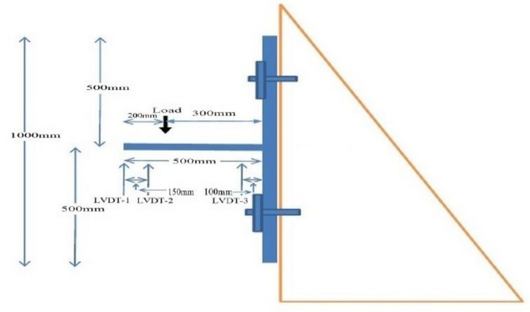

Figure 4.2: Beam Column Specimen Attached with Frame

RESULTS AND DISCUSSIONS

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.

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type one retrofitting with type two retrofitting, the ductility ratio of type one retrofitting is less than type two retrofitting

CONCLUSIONS:

The study is carried out to analyze the Effect of Different Wrapping Techniques on Retrofitting of RCC Beam Column Joints Using Ferrocement and conplast. The important conclusions drawn from the study are as listed below:

The load carrying capacity of retrofitted beam-column joints for both types of retrofitting techniques increases significantly as compared to control beam-column joint.

Specimens with mesh wire wrapped diagonally show maximum improvement in their ultimate load.

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.

There is decrease in the deflection in case of retrofitted specimens as compared to control specimen

The ductility ratio of retrofitted specimen is less than the ductility ratio of control specimen.

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.

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