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EVALUATION OF EFFICIENCY OF REHABILITATION SCHEME OF VIERENDEEL GIRDER

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ABSTRACT

The significant advantage of vierendeel beam system in building construction is that they can be used in portal frames, taken suitable advantage of the member flexural and compression resistances eliminating the need for extra diagonal members. For this reason, they allow greater interaction with building services, enabling a free space for pipes, ducts, etc. Due to tremor, this-structures are damaged partly or totally. In general, such structures are repaired and used again. In this study, two bay single storey R.C. bare frame is carried out in experimental manner. The R.C bare frame is retrofitted by using infilled, strut, GFRP and CFRP. All these frames were tested under static cyclic loading. This paper summarises the tests experimentally carried out to develop an efficient strengthening method for seismically affected vie rend eel structures. The experimental results were compared by using a finite element software. In this study shows that the retrofitted vierendeel girder shows more stiffness than the R.C. frames.

INDEX TERMS: Vierendeel frame; Static cyclic loading; Rehabilitation; Finite element software.

1.INTRODUCTION

Several higher seismic zone places have necessitated in evolving new strategies for rehabilitation of structures. Recent tremors have shown that most of the reinforced concrete structures are damaged severely during tremors and retrofitting of those damaged structures are must. A major technique for strengthening the reinforced concrete structural members is through external confinement [Antonopoulos and Triantafillou, 2002]. Infilling, strut, GFRP and CFRP are one of the major techniques of retrofitting which significantly enhances the ductility, strength and increasing the energy absorption capacity of the structural member. Since beam-column joints are mostly vulnerable to failure due to earth quake, being the horizontal and vertical load resisting R.C. members, retrofitting of those joints is key to improving the efficiency of those joints [Arulselvan and Suyamburaja, 2008]. CFRP and GFRP could be a suitable strategy for successful retrofitting since they are less weight, thinner and easier to implement over reinforced joints making them more ductile [Shri and Thenmozhi, 2014]. Where as in the case of infilled since there is a load transfer occurring through the infill's energy dispersion tends to be high, increasing the load carrying capacity of the joints. As in the case of strut, these steel plates tend to have greater tensile and compressive strength and failure occurs due to buckling at the diagonal rods. The behaviour of beam-column joints are complicated and still understudy. Various researches on existing structures has revealed that rehabilitation is necessary for a structure under three conditions. The structure is designed inadequately for the current load conditions. Structures which are detailed inadequately for current loading conditions [Auguto, et at., 2015]. And structures which are found to be more susce-ptible to seismic conditions. And the structures which are damaged.

2.EXPERIMENTAL WORK

2.1 SPECIMEN DETAILS:

The design and analysis of vierendeel girder have been done by an elastin plastic theory which assumes that material is isotropic, homogeneous and has linear stress–strain relationship. The experimental programme consists of testing two R.C. Frame of same sizes [David, 1972]. The frame is one storey four bay system of cross section 1275 x 700 mm^2 with two openings at the centre which are spaced equally from cross section 525x500 mm^2. The horizontal members are of cross section 100x100 mm^2 with an overall length of 1275 mm, and the vertical members are of cross section 100x75 mm^2 with an overall length of 500 mm. The horizontal and vertical members are rein-forced with four numbers of 6mm diameter steel bars, and the lateral ties 6mm diameter steel bars are provided with the spacing of 40mm.

All two R.C.frames(virgin) were cast and cured for 28 days[Del Savio, 2004]. After testing of these virgin frames, these virgin frames are retrofitted.The experimental program involves retrofitting by infilling and CFRP.

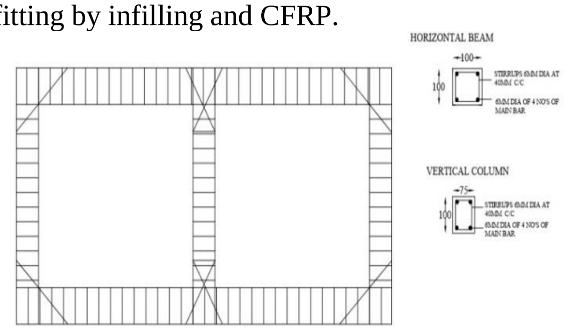

Fig 2.1:Reinforcement detail for test frame

2.2 APPLICATIONPROCEDURE FOR REHABILITATION SCHEME

The virgin frame is tested for ultimate load failure, after failure, this frames are chosen for retrofitting [Dhineshraja and Lakshmipathy, 2016]. Retrofitting by infilling is done by hacking the interior surface of the opening inside the frame and the concrete is made to infill the two opening of cross section 525x500 mm^2.

Apply epoxy resin and hardener mix to the surface which needs to be prepared for retrofitting. The CFRP/GFRP must be cut to required shape before application over the mix applied region.

The strut used are provided at the beam-column joints and with diagonal bars which connections are made through welds, the plates used for beam-column joints are 6 mm thick and the diagonal rods used are 3 mm thick.

Fig 2.2: Strut welded along tested frame beam column joint

Fig 2.3 tested frame with concrete infill

2.3 TEST SETUP:

The specimen was fixed on self-straining loading frame, such that roller supports were provided at the distance 100mm from the vertical member outer surface. The frame is loaded by static, dynamic loading at the middle beam column joint by using hydraulic jack and readings are taken from deflection meter. The deflection meter was placed at the bottom of the frame below the beam-column joint where the load is being applied. The whole arrangement setup is shown in the figure. The whole arrangement is as shown in a figure.

Fig 2.4: Test arrangement of virgin specimen

3.TEST RESULTS AND GRAPHS:

The graph is plotted for corresponding loading and deflection on the virgin frame and rehabilitated frame specimen.

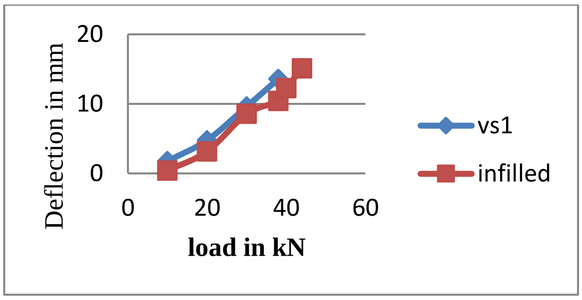

Fig 3.1 load deflection curve virgin frame Vs infilled frame

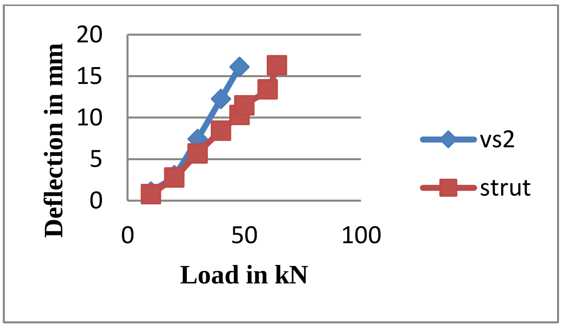

Fig 3.2 load deflection curve virgin frame Vs strut

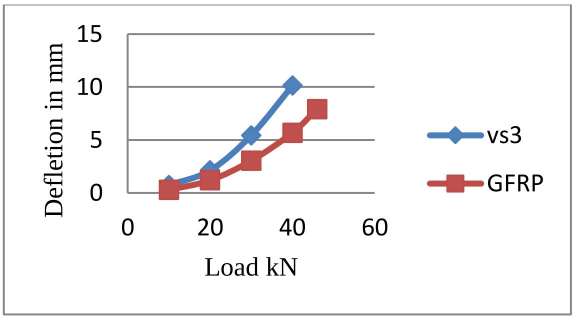

Fig 3.3 load deflection curve virgin frame Vs GFRP

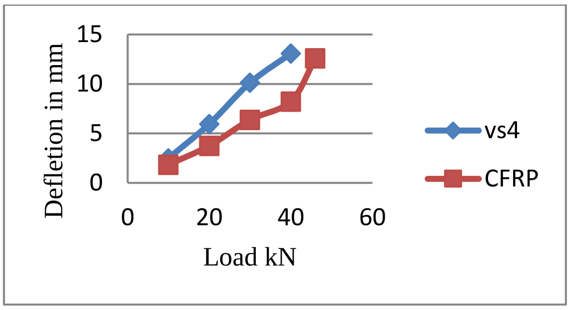

Fig 3.4 load deflection curve virgin frame Vs CFRP

OBSERVATION

1. From the graph, it has been understood that strut tends to exhibit more ultimate load carrying capacity than virgin specimen and remaining rehabilitated specimens.

2.From graph increase in deflection for the corresponddding increase in load were less in CFRP comparing to another rehabilitated specimen.

4.DISCUSSION ON TEST RESULTS

4.1 LOAD STUDY: From the test results examined, the load on the virgin frame at the initial crack is compared with a load on rehabilitated at an initial crack. It has been observed that the load bearing capacity of CFRP is increased at initial crack stage compared [El Demirdash, 2015] to other rehabilitated samples. From these values percentage of initial increase in load bearing capacity of rehabilitated specimen over virgin frame is in table 4.1

Table 4.1 Load at initial crack for virgin and rehabilitated frames

Sample no	Load at first crack(kN)		% increase in strength
	Virgin ample	rehabilitated	
VS1	11.40	15.16(infill)	33.51
VS2	13.80	17.11(strut)	24.62
VS3	12.67	13.63(GFRP)	07.60
VS4	14.30	20.02(CFRP)	40.32

4.2 DEFLECTION:

From the test results examined, the deflection in a virgin frame at the initial crack is compared with deflection occurring in rehabilitated at first crack. It has been observed that the deflection was decreesed compared to virgin samples. From these percentage of reduction in deflection of rehabilitated specimen[El Demirdash, 2011] over the virgin sample is tabulated in the table, and infilled frame has been found to have decreased deflection when compared to virgin frames.

Table 4.2 Deflection at initial crack for virgin and rehabilitated frames

Sample no	Deflection at first crack (mm)		% increase in strength
	Virgin sample	rehabilitated	
VS1	8.70	3.22(infill)	63.41
VS2	3.45	2.45(strut)	29.93
VS3	6.18	3.40(GFRP)	45.86
VS4	7.42	4.75(CFRP)	36.23

4.3 STIFFNESS

From the test results, the stiffness values are compared for both virgin frames and the rehabilitated frames, by the values from load and deflection at the initial cracks [Balsamo et al., 2015]. From the resulting study, it has been found that strut has more stiffness than other rehabilitated frame. All rehabilitated frames had increased stiffness than the virgin frames.

Table 4. Stiffness at initial crack for virgin and rehabilitated frames

Sample no	STIFFNESS (kN/mm)		% increase in strength
	Virgin sample	Rehabilitated	
VS1	1.31	1.77(infill)	35.10
VS2	4.13	6.98(strut)	74.52
VS3	2.05	3.04(GFRP)	47.30
VS4	1.92	2.86(CFRP)	48.24

5. CONCLUSION

Depending on the experimental investigation on virgin frames and rehabilitated frame, the following conclusion is obtained. All the rehabilitation method has been proven to be effective. The strength and rigidity of the frame are found to be improved by rehabilitation. All these rehabilitation methods can be used in vierendeel girder rehabilitation in multi-storey buildings. Whereas from the results, an increase in initial crack load can be achieved by CFRP and decrease in deflection at first crack can be achieved by infill and increase in stiffness at first crack can be achieved by the strut. Wrapping of beam-column joint for a damaged frame by strut is proven to be most effective. Test on rehabilitated frames suggests that strut not only restores its original strength but also enhances yield load and initial stiffness and exhibited maximum deflection. Rehabilitated specimen is found to have less crack with and more stiffness compared to virgin frames.

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