

# Performance of CFRP Retrofitted RC frames subjected to Broad band excitation

S.Gobinath, DR.S.V.Itti, DR.S.Suresh Babu

**Abstract**— Moderate and severe earthquakes have struck different places in the world, causing severe damage to reinforced concrete structures. Retrofitting the existing structures is one of the major challenges to face. One of the retrofit techniques of RC structural members is confinement with a composite enclosure. This external confinement of concrete by high strength Carbon Fibre Reinforced Polymer composites can significantly enhance the strength and ductility and will result in large energy absorption capacity of structural members. Beam-column joints, being the lateral and vertical load resisting members in framed RC structures are more vulnerable to failures during earthquakes and hence strengthening of the joints is often, the key to achieve successful seismic retrofit strategy<sup>[2]</sup>. This paper depicts experimental investigations carried on RC frames subjected to broad band excitation, which are conducted to study the performance of wrapping on retrofit effects on it & the influence of Carbon Fibre Reinforced Polymer wrapping on aseismic performance of RC Frame. Wrapping is done externally at beam-column joints. For this purpose, a single bay three storied scaled down RC frame is subjected to dynamic loads under broadband excitation using servo-controlled hydraulic actuator, till model frame fails & this failed frame is strengthened by using Carbon Fibre Reinforced Polymer. The retrofit frame is subjected to the same intensity of dynamic excitation, till it fails. The uni-axial accelerometers is used at various storeys to quantify the absolute accelerations and the extent of its decay<sup>[1]</sup>. The above investigations conducted on the RC frame revealed the performance of the retrofit measure adopted as diagnostic alternates.

**Index Terms**— Seismic Energy, Retrofitting, Carbon Fibre Reinforced Polymer Wrapping, Ductility, Energy Absorption Capacity

## 1 INTRODUCTION

In this present era of construction, it is not important how fast/architecturally we construct the new structure but how you upgrade the safety of the decade old existing structure plays a vital role. The codes are always upgrading from time to time, every time an earthquake occurs, a new concept is arising and vanishing the old one. So, the structure(s) which are constructed with past seismic requirements are not considered safe today by comparing to present day requirements. The responsibility of today's engineer is to strengthen these structures. Number of research works was conducted earlier for strengthening the seismic deficient structures. Studies carried out mainly on strengthening of weak part of the structure emphasise beam-column joint. The beam-column joint transfer the load coming on it to the sub-structure, so it is important that beam-column joint of the structure should be stiff and ductile to transfer the load without undergoing any deformation by itself<sup>[14]</sup>. Past study reveals the strengthening of beam-column joint, various fibres and polymers are used<sup>[8]</sup>.

The objective of the study is to evaluate the effectiveness of Carbon Fibre-Reinforced Polymer wraps in strengthen-

ing deficient and damaged beam column joint<sup>[12]</sup>.

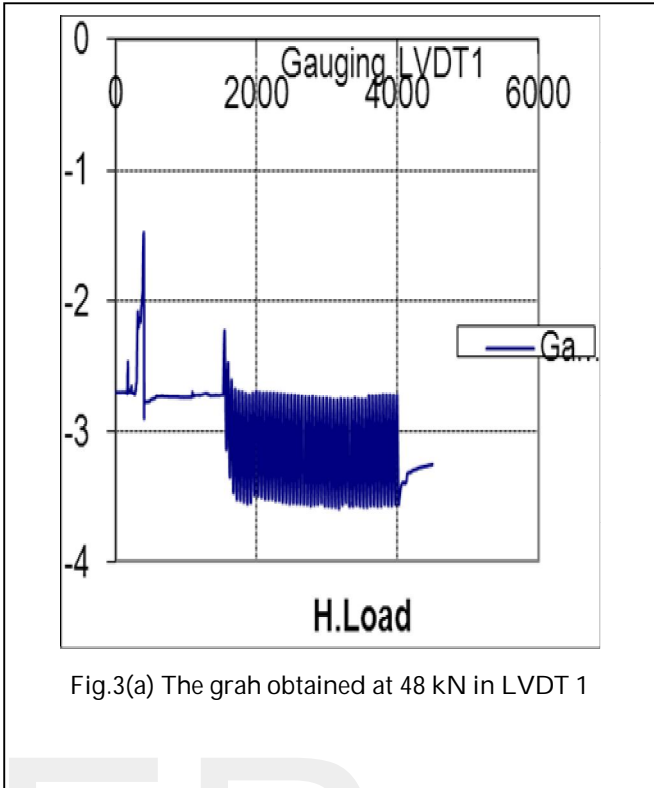
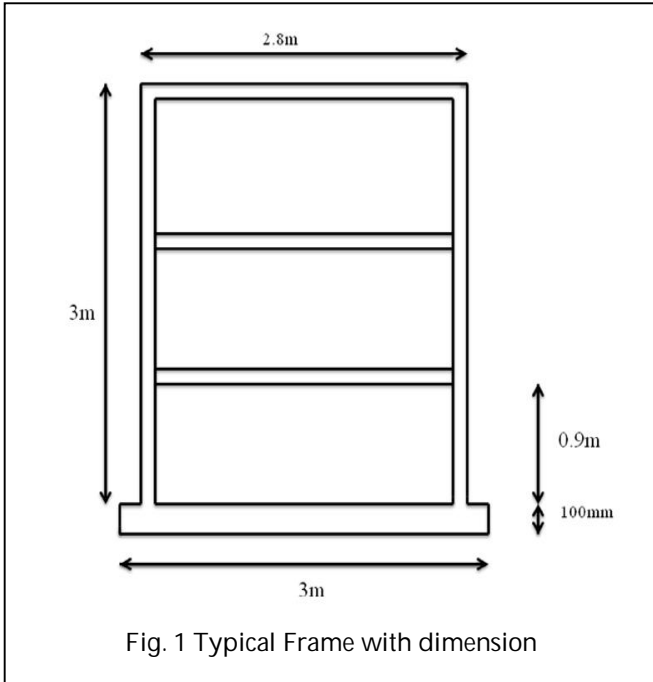
## 2 EXPERIMENTAL INVESTIGATIONS

The experimental program consists of loading RC frame with beam length of 2.8m and column length of 3m. The specimens had 4nos. of 8mm diameter bars as longitudinal reinforcement in column designed as per IS 456:2000, and stirrups of 6mm dia, and with the spacing of 100mm. The development length of the beam rods were provided as 4 cm. The grade of the concrete is M20<sup>[7]</sup>. Controlled specimens are subjected to broad band excitation (0 to 10 Hz) uni-axial accelerometers are used to quantify the absolute acceleration and LVDT'S are used to measure the sway. Loading is continued till specimen fails then, the failed specimens are strengthened by using CFRP and retrofitted frames are again subjected to broad band excitation<sup>[11]</sup>.

### 2.1 Structural Frame

The test structure employed in this study is a scaled model 1:3. The IS codes IS- 875:1987, Part 1, 2 and 3 are used in designing the RC frame<sup>[9]</sup>. The study is carried out on modelled three storey RC frame, consists of beams and columns and footings<sup>[3]</sup>. Beams are of size 100mm×100mm and Columns of size 100mm×100mm and the footing size is 300mm×300mm×100mm<sup>[10][6]</sup>.

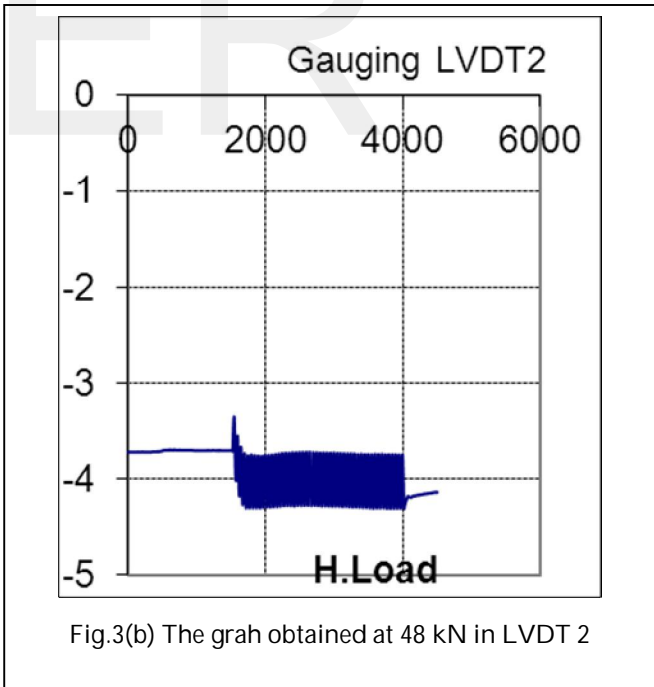
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## 2.2 Material used



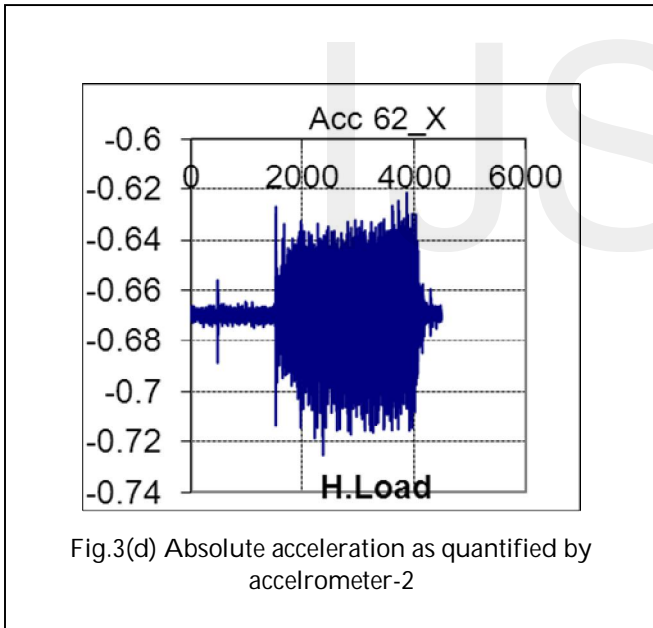
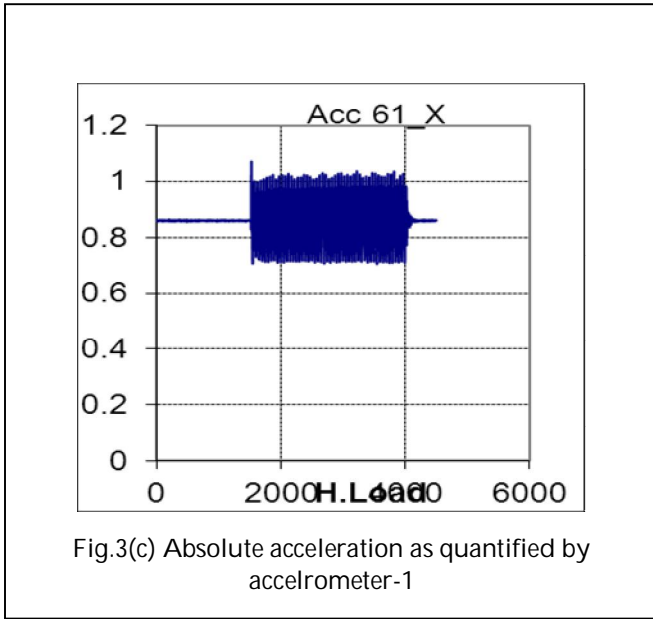
The Carbon Fibre-Reinforced Polymer is a polymer, which is used to enhance shear strength of reinforced concrete by wrapping fabrics or fibres around the section to be strengthened. The properties of the Carbon Fibre-Reinforced Polymer is having its Tensile strength is 2768 N/mm<sup>2</sup> Elastic modulus is 189900N/mm<sup>2</sup> , Tensile modulus is 420 GPa. Ultimate tensile strength is more than 10 times of mild steel.



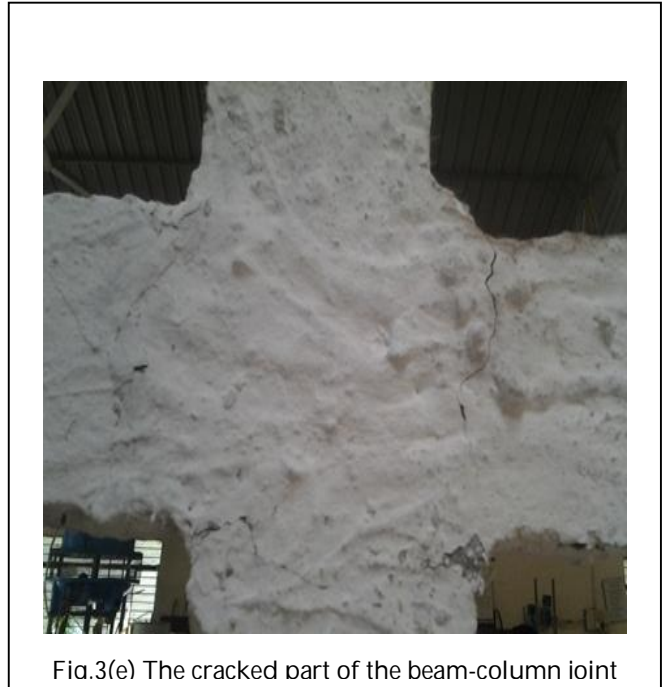
## 3. EXPERIMENT

The lateral load was applied at one end of the beam column joint using servo-hydraulic actuator. The test has been carried out at the load of 3, 6,9 KN. At the 48 KN cracks are majorly formed and developed at the weaker joints.

The absolute accelerations as quantified by accelerometers are as shown in the figure



The cracked part of the beam-column joint is as shown in Fig. 3(e)



The cracked portion of the RC frame is prepared for wrapping, with carbon fibre [4]. The specimen is prepared for wrapping as per the code, IS 13935:1993. The wrapped specimen is cured properly for 10 days. CFRP is wrapped at four positions of beam column joint with the development length of 0.3m each. The portion of the CFRP retrofit frame is as shown in Fig. 3(f) and (g)





Fig.3(g) Schematic view of retrofitted RC frame

The retrofit frames cured for 10 days are again tested as done for the frame without retrofit. The retrofitted RC frame now withstands the load of 33kN [5].

The graph obtained at 33kN as shown in Fig 3(h) to (k)

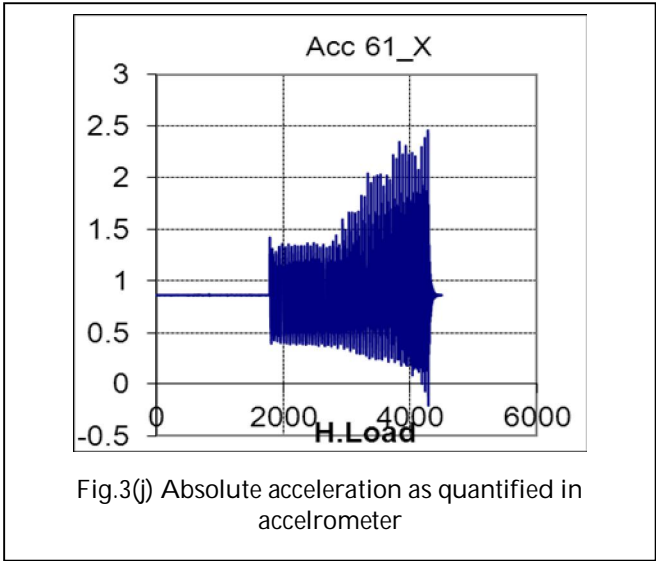


Fig.3(j) Absolute acceleration as quantified in accelrometer

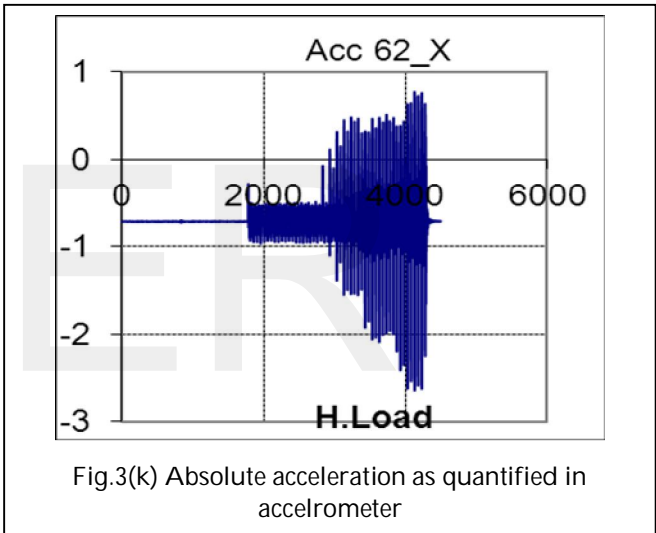


Fig.3(k) Absolute acceleration as quantified in accelrometer

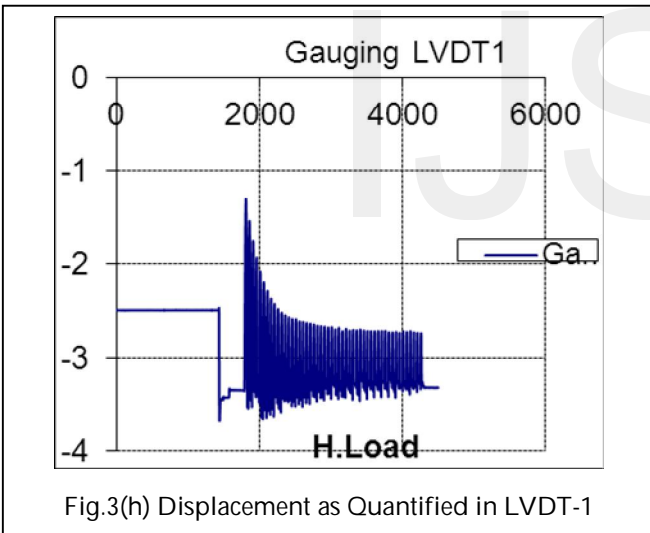


Fig.3(h) Displacement as Quantified in LVDT-1

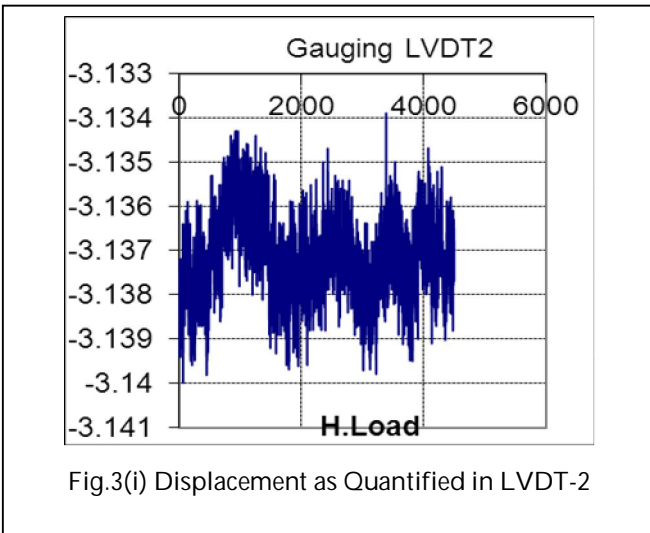


Fig.3(i) Displacement as Quantified in LVDT-2

#### 4.0 CONCLUSIONS

CFRP for retrofitting has proven itself to be a better feasible option than other methods. So the future prospects for the utilization of CFRP in civil engineering infrastructure are good. Researchers around the world are now looking at the new and innovative ways of utilization of the same. Based on the test results of the experimental investigation carried out , the following conclusions are :-

- Load carrying capacity of CFRP retrofitted specimens was 89 % that of maximum load carrying capacity of conventional concrete specimen which shows that load carrying capacity of retrofitted specimens is 19% more than load carrying capacity of conventional frame.
- The use of FRP laminates in strengthening concrete frame reduces deflections and increases load carrying capacity.

Cracks that occur are smaller and more evenly distributed. Furthermore, the use of FRP vertical layers can help to further reduce deflections and to further increase ultimate load carrying capacity.

- The specimen with CFRP wrapping have been measured 49 % less deflection than that of conventional specimen.
- The ductility factor of CFRP retrofitted specimens are is 2.39 times more than that of conventional frame.
- The energy absorption capacities of CFRP retrofitted specimens is 78% more than that of conventional frame .
- The Stiffness of CFRP retrofitted specimens is 50% and 80% more than that of conventional frame.

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