Seismic Retrofitting Of RCC Structure By FRP Jacketing

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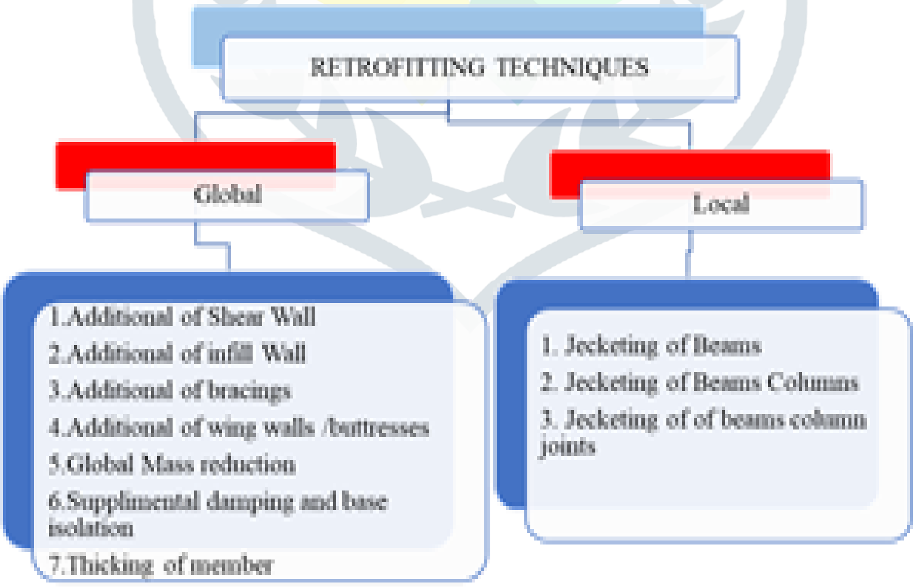
Abstract *:* Seismic Retrofitting for reduction of vulnerability of a structure is a relatively new concept in India. India was not considered to be a seismically active country unless recently some earthquakes like one in Latur (93) and Bhuj Earthquake (2001) among the major ones has happened. In the recent past, India has seen mass destruction due to failure of structures hit by earthquakes and consequently, lost a lot of lives. Hence, it is of utmost importance that attention be given to the evaluation of the adequacy of strength in framed RC structures to resist strong ground motions. In this project, four storey reinforced concrete structure without seismic loading has been considered, which lies in zone III according to IS 1893:2000 classification of seismic zones in India. FRP jacketing is the most appropriate method of retrofitting the failing members in the given 4-storey RC structure. The norms stated in ACI 440-2R.02 have been followed to calculate and suggest the method and scheme of application of FRPs to the member and covering by frp to be used.

Keywords- Equivalent Static Method, Demand Capacity Ratio, Flexural Capacity, Shear Capacity, Reinforced Concrete Structure, FRP Strengthening.

INTRODUCTION

A Fiber Reinforced Polymer (FRP) composite is defined as a polymer (plastic) matrix,either thermo set or thermoplastic, that is reinforced (combined) with a fibre or other reinforcing material with a sufficient aspect ratio(length to thickness) to provide a discernable reinforcingfunction in one or more directions. FRP composites are different from traditional constructionmaterials such as steel or aluminium. FRP composites are anisotropic (properties apparent in the direction of the applied load) whereas steel or aluminium is isotropic (uniform properties in all directions, independent of applied load). Therefore, FRP composite properties are directional, meaning that the best mechanical properties are in the direction of the fiber placement. According to the Seismic Zoning Map of IS 1893:2002, India is divided into five seismic zones, in ascending order of a certain zone factor which is assigned to them on the basis of their seismic intensity. The 4-storey RC Structure being analysed in this particular project is considered without seismic loading which is located in zone 3 (Mumbai). hence, some of the RC members may fail due to the earthquake because they not able to resist against seismic activity. studying the performance of the structure without earthquake loading and compares the same with the application of the earthquake load suggesting suitable retrofit measures for failing members in the structure.

SOME POPULAR SEISMIC RETROFIT TECHNIQUES ARE-



FRP'S ARE INCREASINGLY USE FOR JACKETING BECAUSE OF :-

High Strength to weight ratio,Immunity to corrosion,Easy handling & applications, No effect on external aesthetics of structre,High tensile strength,Flexible,Less lebour & equipment cost.

DRAWBACKS OF FRP-

Sensetive to fire & temperature,Expensive ,Difficult in near MEP Survices & openings.

TYPES OF FIBERS :-The fiber reinforced polymers used for strengthening civil engineering structures are made of

CARBON:-Stable under high temperature. Resistant to acidic/alkali/organic environments. High stiffness and tensile strength. More expensive.

GLASS:- E-glass (less expensive), AR-glass (alkali-resistant), S-glass (stronger and stiffer)

ARAMID:- Polymeric fibbers appropriately processed to achieve high tensile strength-to-density ratio. Aramid fibers share some general characteristics that distinguish them from other synthetic fibers: High strength,Good resistance to abrasion,Good resistance to organic solvents,Non-conductive,No melting point,Low flammability,Good fabric integrity at elevated temperatures

FRP'S CAN BE USED IN THE CONCRETE STRUCTURES IN FOLLOWING FORMS.

1.PLATES- at the face to improve the tension capacity.
2.LAMINATES-below beams & slabs to improve load taking capacity.
3.BARS- as reinforcements in beams & slabs replacing the steel bars.
4.CABLES- can be used as tendons and post- tension members in suspension and bridge girders**.**
5.WRAPS- around concrete members i.e. columns, beams, slabs etc for confinement.

THEORY & FORMULATION

DEMAND CAPACITY RATIO:-The calculation of Demand Capacity Ratio to identify the failing members, is the part of Equivalent Static Analysis.

DEMAND: -It is amount of force or deformation imposed on an element or component (in this case, with respect to earthquake loading).

CAPACITY: - It is the strength or deformation of a structural member or system (Without Earthquake Loading).

DCR= DEMAND/CAPACITY

If **DCR** is lesser than 1, the member passes, else it passes. It is an important tool used to determine whether a certain member of the structure is passing or failing due to moment and/or shear. The check for **DCR** exceeding 1 was performed for both flexural and shear capacities of the beams of the structure.

TO AVOID FAILURE, THE FOLLOWING METHODS CAN BE ADOPTED-
Reducing the loads acting on the member, Increasing the area of the section ,Replacing with a material of higher strength
If **DCR <1,** the member is labelled PASS i.e. it can take the moment induced by the seismic loading.
If **DCR >1,** the member is labelled FAIL i.e. it cannot take the moment induced by the seismic loading.

STEPS OF FRP JACKETING

DESIGN OF BEAM FRP JACKETING AS PER ACI 440-2R

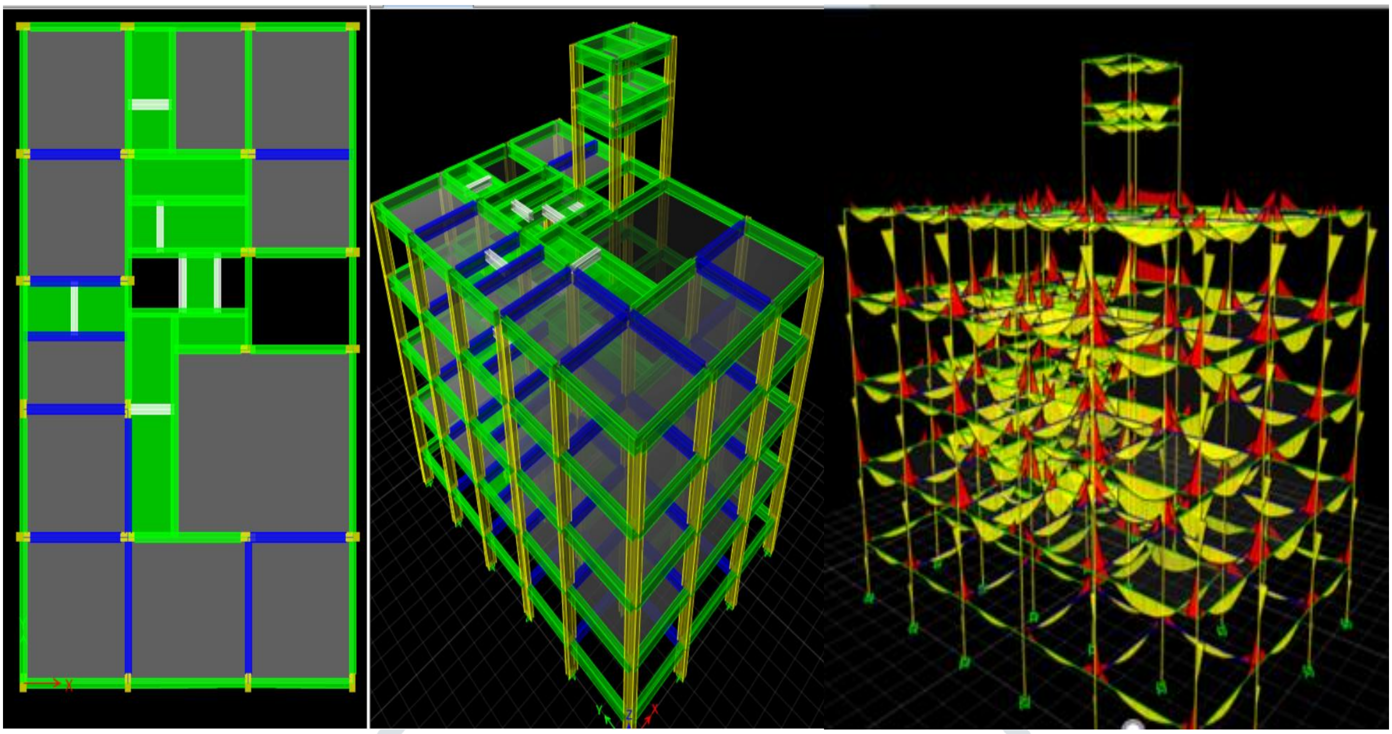
STEP 1:- Calculate the FRP system design material properties
STEP 2:-Preliminary calculation
STEP 3:-Determine the existing state of strain on the soffit
STEP 4:-Determine the design strain of the FRP system
STEP 5:-Estimate the depth to the neutral axis
STEP 6:- Determine the effective level of strain in the FRP reinforcement
STEP 7:-Calculate the strain in the existing reinforcing steel**.**
STEP 8:-Calculate the stress level in the reinforcing steel and FRP
STEP 9:- Calculate internal forces resultant and check equilibrium
STEP 10:- Calculate flexural strength components
STEP 11:- Calculate design flexural strength of the section

DESIGN OF SHEAR REINFORCEMENT AS PER ACI 440-2R

STEP 1:- Calculate the FRP system design material properties.
STEP 2:- Calculate the effective strain level in the FRP shear reinforcement
STEP 3:- Calculate Contribution of the FRP r/f to the shear strength.
STEP 4:-Total Shear Strength of Section.

STRUCTURAL DATA

The structural system for the proposed residential building.It consists of R.C.C. framed structure with columns, beams, slabs and staircases etc. The floor slabs are mainlyR.C.C. slab system. The report outlines the key structural design criteria/assumptions. The design has been done in accordance with theprovision given in the architectural/services drawings as well as IS standards.The Number of floors which has to be Design is given below
Ground +4 Floors +Terrace + OHT/LMR



PLAN SHOWING FRAMING PLAN,3D VIEW AND BEANDING MOMENTS DIAGRAMS

DCR CACLCULATIONS FOR COLUMNS

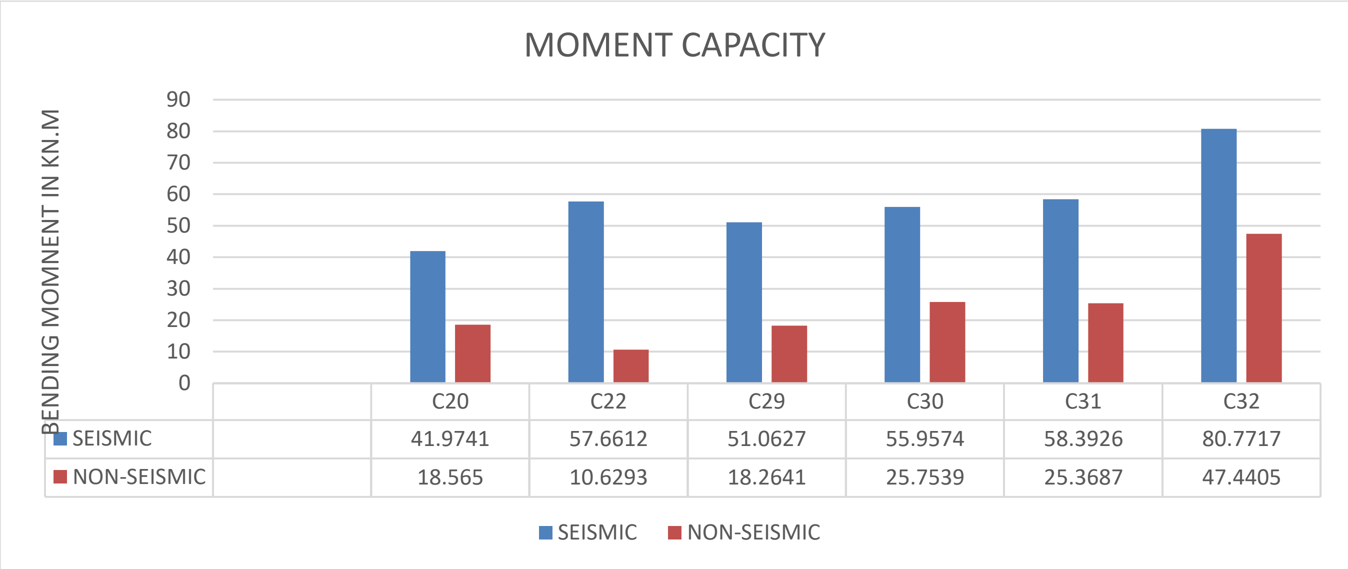
MOMENT CAPACITY

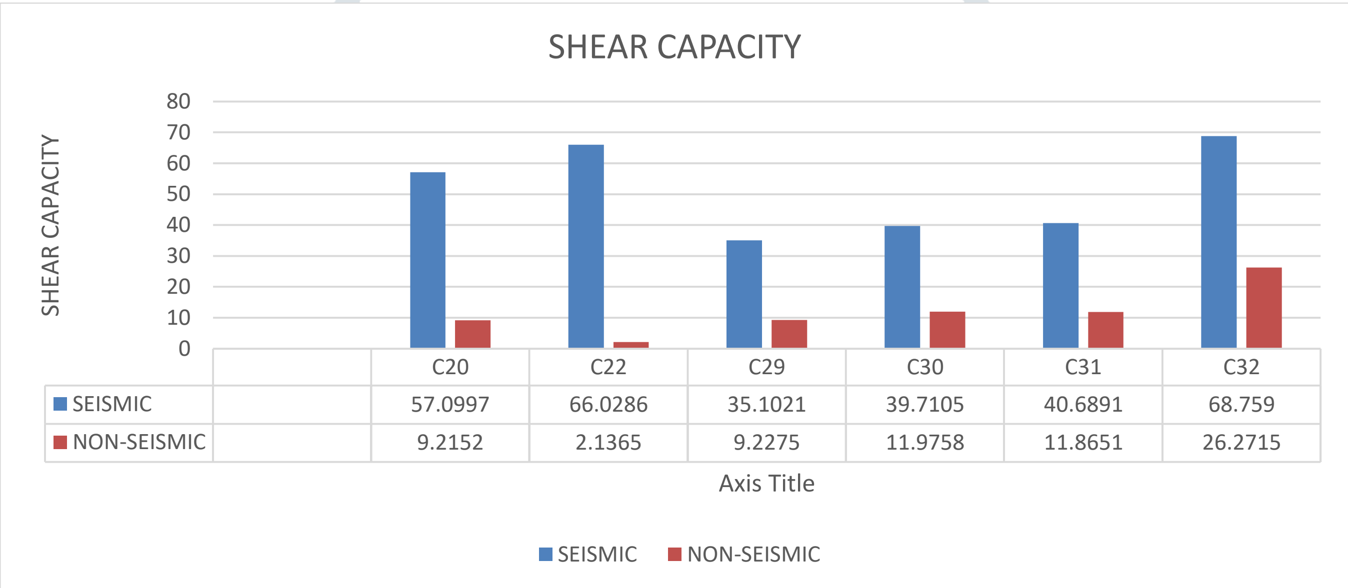
MOMENT CAPACITY						
COLUMN NO	FLOOR	BEAM SIZE	DEMAND MOMENT KN.M	CAPACITY MOMENT KN.M	DCR	RESULT
C20	SECOND FLOOR	C230X500	41.9741	18.565	2.261	FAIL
C22	SECOND FLOOR	C230X500	57.6612	10.6293	5.425	FAIL
C29	SECOND FLOOR	C230X500	51.0627	18.2641	2.796	FAIL
C30	SECOND FLOOR	C230X500	55.9574	25.7539	2.173	FAIL
C31	SECOND FLOOR	C230X500	58.3926	25.3687	2.302	FAIL
C32	SECOND FLOOR	C230X500	80.7717	47.4405	1.703	FAIL

SHEAR CAPACITY

SHEAR CAPACITY						
COLUMN NO	FLOOR	BEAM SIZE	DEMAND MOMENT KN.M	CAPACITY MOMENT KN.M	DCR	RESULT
C20	SECOND FLOOR	C230X500	57.0997	9.2152	6.196252	FAIL
C22	SECOND FLOOR	C230X500	66.0286	2.1365	30.90503	FAIL
C29	SECOND FLOOR	C230X500	35.1021	9.2275	3.804075	FAIL
C30	SECOND FLOOR	C230X500	39.7105	11.9758	3.315895	FAIL
C31	SECOND FLOOR	C230X500	40.6891	11.8651	3.429309	FAIL
C32	SECOND FLOOR	C230X500	68.759	26.2715	2.617247	FAIL

BAR CHART





DESIGN OF COLUMN FRP JACKETING

Data:-b =230 mm, d = 500mm, fck provided = 20mpa,fck required = 25mpa, Pt % provided = assume 0% due tocorrosion of bar, Area of concrete = 1,15,000mm2, Pu = 705 kN, Mx =38kN.m

Manufacture Data –

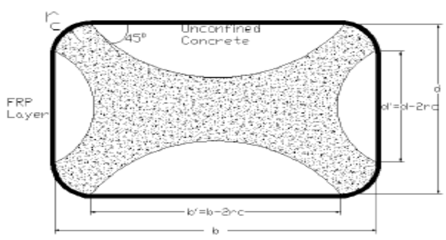
Ultimate strain in carbon fiber (ε f) = 1.5%

Elastic modulus of carbon fiber (E f) = 137000 N/mm2

Effective fiber thickness (t f) =0.33 mm

No of Wrap (n) =2 No.

Solution:-



Effectively Confined Core for Non Circular Section

Total Plan Area of Unconfined concrete is obtained as per Fib 14 eqn 6.28 is given as,

b’ = b - 2 x rc = 230- 2x 25 = 180 mm

d’ = d- 2 x rc = 500- 2x25 = 450 mm

$$A_u = \frac{b'^2 + d'^2}{3}$$

= 78300mm2

The confinement effectiveness coefficient ke considering ratio (Ac-Au)/Ac as per Fib 14 eqn 6.29 is given as,

$$Ke = 1 - \frac{b'^2 + d'^2}{3Ag(1-\rho sg)} = 1 - \frac{Au}{Ag(1-\rho sg)} = 0.367$$

The Lateral confining pressures induced by the FRP wrapping as per Fib eqn 6.30 is given as Along direction b,

Kconfb = b ke Ef Along direction d,

Kconfd = d ke Ef

Where, $\rho_b = \frac{2 \times nt \times f}{b}$ and $\rho_d = \frac{2 \times nt \times f}{d}$

= 0.0057 and b = 0.0029

Kconfb = 288.09 Kconfd = 147.31

Effective confining pressure, along direction b

$$flb = \frac{Kconfb \ \varepsilon f}{2Ke} = 5.89 \text{ N/mm2}$$

Along direction d

$$fld = \frac{Kconfb \ \varepsilon f}{2Ke} = 3.01 \text{ N/mm2}$$

Taking min value,

fl = 3.014 N/mm2

Maximum confining pressure as per Fib eqn 6.5 is given as,

$$fcc = f'_c \left(2.254\sqrt{1 + 7.94\frac{fl}{f'c}} - 2\frac{fl}{f'c} - 1.254\right)$$

fcc = 25.73 N/mm2

"Hence provide 2 layer of CFRP jacket."

RESULTS

FRC can be used to upgrade the beam or column elements and the joints of RC frames. While FRC wraps improve the deformability of the sections FRC longitudinal improve their stiffness. Depending on the required capacities in bending moments and rotations the required FRC can be found out using the method presented here.

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