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A STUDY ON RETROFITTING STRATEGIES FOR REMOVAL OF SOFT STORY EFFECT IN A REINFORCED CONCRETE FRAMED STRUCTURE

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ABSTRACT
Strengthening and increasing stiffness of existing reinforced concrete (RC) members is of great importance. Many techniques such as concrete jacketing, steel jacketing, steel skeleton and composite (FRP) are used. There are many experimental studies to strengthen the column by jacketing, but there is still a need to improve the performance or rehabilitation of the retrofitted method. In the RC structure, the column is subjected to uniform and continuous vertical loading, which may lead to partial or total damage of the column. The cost of re-strengthening and re-stiffening is much higher than that of retrofitting. Immediate attention is needed to overcome the total failure. Retrofitting is the process of addition of new features or modification to the old structures and bridges, i.e. it reduces the damage vulnerability of an existing structure due to seismic activities. The present study focuses on strengthening column subjected to axial load.
Presented for the first time are the results of an experimental investigation comparing the behaviour of reinforced concrete (RC) columns strengthened with transverse fibre reinforced polymer (FRP) wrapping under impact loads with equivalent unwrapped columns. Eleven tests were conducted with the impact velocity and point of load application varied. It was shown that the peak displacements of columns strengthened with FRP were up to 39% lower than those of specimens not wrapped with FRP for comparable impacts. Through a plasticity theory based model it was shown that the improved behaviour could be predicted by allowing concrete to reach a much higher failure strain, as a result of the confinement provided by the FRP wraps.
Keywords: Frp, Retrofitting, soft storey, framed structure

I. Introduction

Till to date, earthquakes are one of the most unpredictable and devastating natural disaster which cause extensive damage to the buildings/structures. This damage results in loss of lives and property. Thus, it is very important on the part of the civil engineers to build structures with high seismic performance. But here the question arises. “What to do with the present old/weak or earthquake structures?” It has been observed that majority of such structures/buildings may be safely reused if they are made seismically strong by using some methods/techniques (retrofitting techniques).
Reinforced concrete framed structures with a soft first story and infill walls in top stories are very common, even in areas of substantial seismic hazard. Despite their merit from a functional and an architectural perspective, they constitute a poor solution from a mechanical point of view. When subjected to earthquake loads, the discontinuity in lateral strength and stiffness at the first (ground) story causes a concentration of the energy dissipation demand (i.e., damage) in this story. This amount of energy—very large in the case of a severe earthquake—must be dissipated by the columns of the first story in the form of cumulative plastic deformations. If the columns have an insufficient energy dissipation capacity (true of many existing reinforced concrete (RC) frames), the building eventually collapses. The plastic mechanism developed by the frame, called in the literature soft first story, is one of the most undesirable forms of collapse.

SOFT STORY: -

a) Stiffness Irregularity — Soft Storey

A soft storey is a storey who’s the lateral stiffness is less than that of storey above.
The structural plan density shall be estimated when unreinforced masonry infills

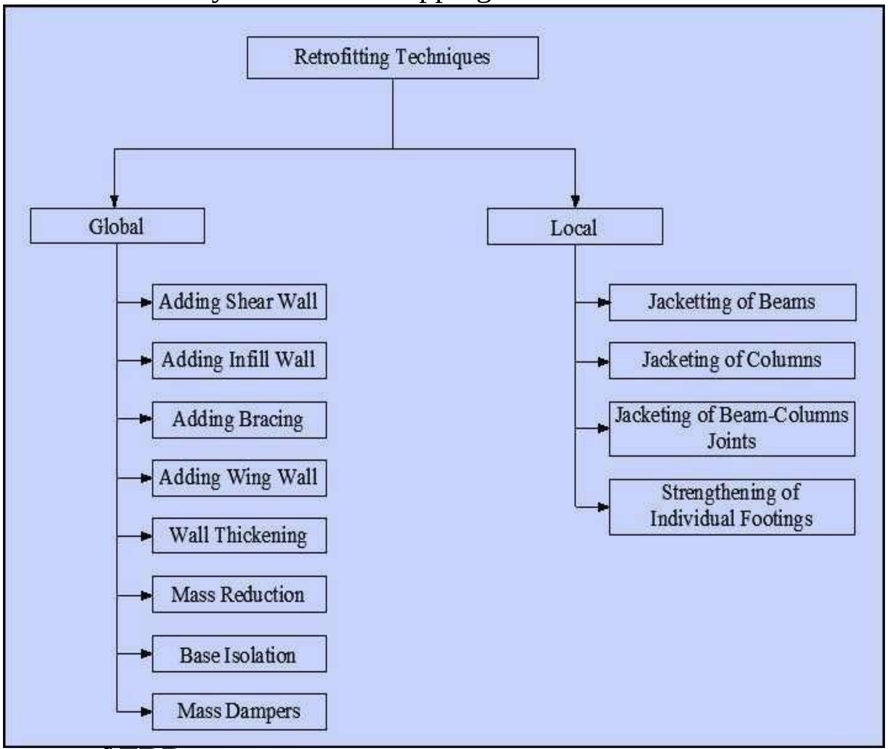
Exceed 20%,
the effect of URM infills shell be considered by explicitly modeling the same in structural analysis.

b) **Stiffness Irregularity — Extreme Soft Storey**

A soft storey is a storey who's the lateral strength is less than that of storey above.
Earthquake creates great devastation in terms of life, money and failures of structures.

- Earthquake Mitigation is an important field of study from a long time now.
- Seismic Retrofitting is a collection mitigation technique for Earthquake Engineering.

I. Reinforced Concrete Jacketing (RC Jacketing)
II. Wire Mortar Jacketing
III. Fibre Reinforced Polymer Sheet Wrapping



1.1. Advantages of FRP

- Provide strength to building.
- Greater building durability.
- FRP doesn't show any yielding or plastic behavior
- FRP composites have tensile stiffness lower than that of steel
- Resistance to corrosion so it can be utilized on interior and exterior structural member in all almost all types of environments.

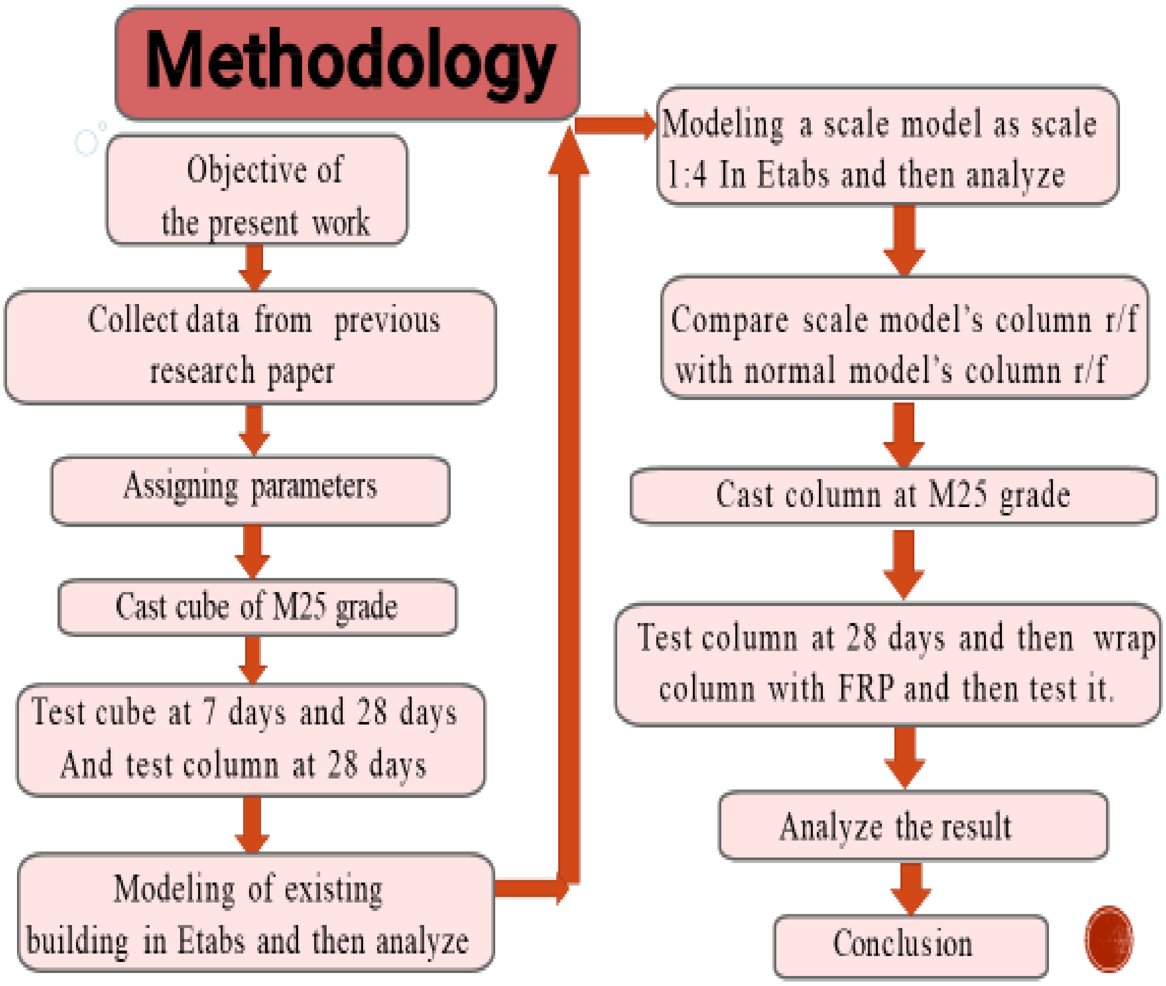
II. Literature

S.No.	**Author**	**Year**	**Topic**	**Findings**
1.	Baris Binici	21 Dec 2006	Analysis and design of FRP composites for seismic retrofit of infill walls in reinforced concrete frames.	• The performance of the FRP retrofit scheme was demonstrated by analyzing an actual deficient RC building with hollow clay tile infill. It was observed that prior to the FRP retrofit about 75% of the columns were in a total collapse limit state meaning that their deformation capacities were significantly exceeded. • FRP retrofit it was observed that drift control was provided and deformation demands on the structure were significantly reduced. In this way it was possible to satisfy the collapse prevention performance state.
2.	X.K. Zou	23 Dec 2006	Optimal performance - based design of FRP jackets for seismic retrofit of reinforced concrete frames	• It is seen that the optimal design process with the multiple drift constraints converges after five design cycles, with an increase in the FRP volume from 0.00 to the final 2.046x102 m3. The main reason for such rapid convergence is the low sensitivity of the internal forces and moments in all members to the thicknesses of the FRP jackets applied to columns. The FRP jacket thicknesses were checked and found to be large enough to ensure that $k_{s1}f_l/f'_{co} \geq 0:07$. • FRP confinement enhances the strength of columns but has little effect on

				their stiffness, which is an important advantage in seismic retrofit as larger stiffnesses lead to higher seismic forces.
3.	Yousef A. Al-Salloum	2007	Influence of edge sharpness on the strength of square concrete columns confined with FRP composite laminates	• The FRP jacket increased both the axial load capacity as well as the ultimate concrete compressive strain. • The failure of the carbon/epoxy jacketed specimens was explosive in nature releasing tremendous amount of energy. • The failure of the square columns always starts at one of the corners proving that the stress concentration occurs at the corners.
4.	Lei-Ming Wang, Yu-Fei Wu	2008	Effect of corner radius on the performance of CFRP-confined square concrete columns	• For unconfined concrete specimens, their strength is nearly identical and does not change with the corner radius. • For C50 columns, confinement is effective in increasing the ductility of all of the columns. However, a higher confinement may not provide a higher ductility for columns with a large corner radius ratio. • For C30 columns, apart from those with sharp or small corners, confinement may not lead to an increase in ductility; in contrast, it may reduce the ductility of the columns.
5.	M. Yaqub, C.G. Bailey	2011	Cross sectional shape effects on the performance of post-heated reinforced concrete columns wrapped with FRP composites	• The circular cross sections wrapped with GFRP or CFRP jackets displayed higher ultimate strains compared to the square cross sections. • The use of a single layer of GFRP or CFRP jackets had negligible effect on the stiffness of both the square and circular post-heated columns
6.	Misam Abidi	2012	Review on Shear Wall for Soft Story High-Rise Buildings	• Use of shear wall is a good way to provide more level of ductility and getting more stable behavior and appear to be a novel approach to reduce effect of soft story in seismic response. • it will help to resist the major portion of lateral load induced by an earthquake.
7.	C.Z. Chrysostomou & N.	2012	Seismic Retrofitting of RC Frames with	• The structure managed to sustain an earthquake of 0.25g without significant damage,

	Kyriakides		RC Infilling	• Some column lap-splices failed with concrete spalling, but the structure continued to carry load, • The 3-sided CFRPs protected the wall bounding columns at the 1st floor and prevented lap-splice failure, • The "weak" south frame behaved equally well as the "strong" north frame, • There has not been visible movement at the interface between the wall and the bounding frame, • The behavior of the wall was mainly flexural, although on the south-frame wall some diagonal cracks appeared, • Higher mode effects appeared in the response of the structure • Some vertical cracks appeared at the connection of the beams to both the exterior column and the wall columns, and • A horizontal crack appeared at the ground-beam of the walls, and it was the main reason for loss of strength of the south frame.
8.	Teresa Guevara-Perez	2012	"Soft Story" and "Weak Story" in Earthquake Resistant Design: A Multidisciplinary Approach	• When the "soft first story" irregularity is present can be dealt with: • Using strong and stiff complete elevator and staircase cores, which can take all but the total base shear, leaving the first story columns almost only with axial loads; • By using diagonals to stiffen the first story; • By specifically designing the first story for much larger loads and smaller induced displacements than the rest of the structure, keeping the overall framed character of the building;.

3.3. Methodology



(Fig-3) Methodology flow chart

III. Conclusion

- From all the experimental work, I have found in my research work, if we are taking FRP wrapped column and normal RCC column then the strength of FRP wrapped column is increased by 33 % in comparison of normal RCC column.
- From all the analytical work, I have found in my research work, if we are taking combined modulus of elasticity of FRP and concrete in E.TAB for one floor where soft story is created and then analysis that building, I found the drift of that particular story is reduced and it is approximate reduces 22% of that particular story.
- If we know the existing building strength and we want to increase, it's strength up to 33% and stiffness up to 22% of that building so we can go through a retrofitting by FRP wrapping

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