Integrated Approach to Retrofitting of Walls

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***Abstract*— Now-a-days retrofitting has become common, as many of the historical, public and private buildings get old and become weak over a period of time. Retrofitting is one of the best option to make an existing building safe against earthquake or other natural forces. Retrofitting is the process of adding new features to older buildings, heritage structures, bridges, monumental building etc. It reduces the chance of damage of an existing structure during a future seismic activity. Its main objective is to strengthen a structure to satisfy the requirements of the current codes for seismic design. In this respect, retrofit is way beyond conventional repair or even rehabilitation. It is the process of modification of existing structures to make them more resistant to seismic action, motion of subsurface, and failure of soil due to earthquakes or other natural calamities such as tornadoes, cyclones and hurricanes. Structures lose their strength in due course of time. Few structures require aesthetic importance, social or past importance. Retrofitting helps to increase the strength, resistivity and lifespan of the existing structure.**

Index Terms*—Local Strengthening, Seismic Technologies, Elasto-Plastic Dampers, Visco-Elastic Dampers, Shotcrete Overlays.

I. INTRODUCTION

Upgrading certain building systems to make them more resistant to seismic activity is called retrofitting. It proves to be a better economic consideration and provide shelter to problems rather than replacement of the building. Retrofitting specifically for earthquake hazards is often referred to as rehabilitation. To meet up the advancement in infra-structure, new innovative technologies in civil engineering industry has started to make its way. Retrofitting of structures like building includes rehabilitation, maintenance and strengthening of the structure. Structures with the passing of time lose their strength because of various reasons like seismic activity, soil failure due to ground motion etc. If the question of safety arises, there comes the solution- Retrofitting. If private and public buildings get damaged, in extreme cases they can be dismantled. But structures of historical importance can't be dismantled. And the only way to save these structures is Retrofitting.

II. METHODOLOGY

Retrofit in structures is done to increase the durability. The applications include different types of bridges, buildings, industrial buildings, transport structures in urban areas, earth retaining structures and marine structures.

A. Basic Principles of Retrofitting Design

The principles of retrofitting design for buildings are:

1. Strengthening of members versus strengthening of structural system. The members that do not meet safety requirements needs to be strengthened. The mistake that the strengthening of whole structural system is neglected. Strengthening of association of network between members is quite powerful to structural integrity.
2. Local strengthening versus global strengthening. Local strengthening of a member can be carried out only if the strengthening does not affect the structural performance of the whole system.
3. Temporary strengthening versus permanent strengthening. However requirements for temporary strengthening may be lower than those for permanent strengthening.
4. Special considerations for strengthening of earthquake resistant buildings.
5. The aim of using modern seismic technologies.

B. Various Techniques of Retrofitting

There are many technologies developed for seismic Retrofitting. These techniques provide extra damping using dampers like friction dampers, Elasto-plastic dampers, tuned liquid and tuned mass dampers, lead extrusion dampers, visco-elastic dampers, etc. A certain techniques called base isolation is introduced to take care of seismic control.

1. *Elasto-Plastic Dampers*

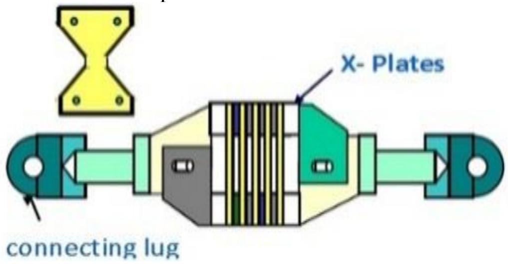

Fig.1. Elasto-Plastic Dampers

It is the process of deformation of plastic plates of steel which consist of X-shaped steel plates. These steel plates sustain cycles of stable yielding deformation. They result in high levels of damping and energy dissipation.

2. *Tuned Liquid Dampers (TLDs):* TLDs are rigid walled containers containing liquid up to certain height, to match the splashing frequency and are commonly placed at the rooftop of the structure. The device absorbs vibration energy through liquid sloshing principle.
3. *Base isolators:* Isolation of superstructure from foundation is called base isolation. It is the most powerful tool for passive structural vibration control technique.

III. PROCEDURE AND DETAILS

Fig. 2. Shotcrete overlays are sprayed onto the surface of a masonry wall over a mesh of reinforcing bar: 6-13mm diameter at 25-120.

The process is completed basically in various steps considering the safety of the structure and the work.

1. The condition assessment of the structure to find out the exact strength, evaluation for seismic forces which the building can resist.
2. Application of layer of plaster of paris on the existing wall to protect it during retrofitting work. During the work various compressive loads placed on the wall will lead to damage. Thus to solve this problem layer of plaster of paris is provided over the wall, which can be removed easily after retrofitting.
3. The existing plaster is removed in order to expose the vulnerable parts and suitable treatment will be given to remove the formation of alkali salts by rinsing it with hot water or by chemical washing without eroding the brick surface and without deforming the joints. Cutting off the deteriorated concrete is done up to 20 mm with pneumatic chisel andzinc primer is applied on the steel in order to increase the strength of the steel and thereby provide reinforcement to the structure.
4. Application of pre-packed polymer modified protective mortar, placing of micro concrete and applying low viscous hydrophobic silane-siloxane solvent to avoid entry of water and salts to minimize efflorescence and to fill the holes and cracks in the walls and ceiling.
5. Grouting chemical injection(epoxy base) is done by fixing minimum 10 mm diameter nozzle of suitable length, over the surface of RCC member and also along the cracks, wherever required. At first holes are made using drill machine then mall pipes of diameter 10 mm are inserted into those holes. By using manual or electrical pumping machine the epoxy base chemical is injected into the walls to increase and regenerate the strength of the damaged part of the structure. Epoxy resin is used to inject for relatively small cracks(less than 2 mm wide), while cement-based grout is considered more appropriate for filling of larger cracks, voids.

Fig.3.

Fig. 4.

6. The injection of cement slurry grouting (M 50 grade) and application of two coats of zinc chromate is done after the surface is removed of corrosion rust, pit patches, etc.
7. Fixing shear connectors, anchors, erecting self-supporting scaffolding for vertical, horizontal and diagonal bracing, fixing SS bracket to the required portion including cutting, bending, fabricating, welding and anchoring with hole, are all done to support the structure before and after retrofitting work.
8. Fixing seismic strap, made of G.I wire mesh on walls with the help of anchor bolts, including cutting, bending and binding, providing and fixing of RCC jolly. It provides support to the walls by holding them. The seismic strap is first cut to a definite size, then fixed to the walls with anchor bolts which are previously fixed with M50 grade concrete mixture.

Fig 5

9. Provide new electric wiring with the help of new technologies, new equipment, lift or escalators wherever needed.

Fig 6

10. Provide plastering preferably M50 grade over the structure increases the strength of the structure. This process is known as concrete jacketing.

11. Removal of the plaster of paris which was previously applied to protect the wall from retrofitting work.

12. Apply new paint, provide upgraded electronic suite, and other accessories to make the structure same as before.

IV. RETROFITTING MATERIALS

1. Fibre Reinforced Polymer (FRP).
2. Carbon Fibre Reinforced Polymer (CFRP).
3. Glass Fibre Reinforced Polymer (GFRP).
4. Steel Strips.
5. Polypropylene Fibre.

IV. EXPERIMENT

The size of the panel is kept as 2'6" X 2'6" feet square. Six masonry wall panels are constructed. Steel strips and polypropylene fibre mesh are used as retrofitting materials. The firstclass bricks procured from local market having 7 N/mm^2 average compressive strength is used. Bricks are laid in 1: 6 cement sand mortar.

The second masonry wall panel is constructed and strengthened with steel strips in diagonal manner on both sides of the wall. The diagonal strips are anchored with bolts at the spacing of 9" centre to centre and bolts in the strips spacing are 4" centre to centre.

The third masonry wall is strengthened with polypropylene fibre in vertical and horizontal direction as a mesh manner .The spacing of the strips are 2" in both direction. The 1" nails are used to anchor the fibre at the distance of 4" inches centre to centre in diagonal manner.

A combination of vertical load and in-plane shear lateral load was applied to all the three specimens. The vertical pre-set load of 5 ton was applied through hydraulic jack. A flat poly tetra fluoro ethylene (PTFE) bearing was placed between the stiff horizontal reaction beam and rigid steel beam. The shear load was applied to the wall by a horizontal jack and the proving ring was attached along the jack to measure the applied load. The horizontal deflection was measured using a deflection gauge.

Fig 7

Minor cracks appeared at vertical load of 7 tons corresponding to a compressive stress of 40.18 KN/m2.In diagonal steel strips retrofitted wall minor cracks appeared at vertical load of 13 tons corresponding to the compressive stress of 74.37 KN/m2. The failure is not sudden and good composite behaviour is observed due to presence of steel strips.

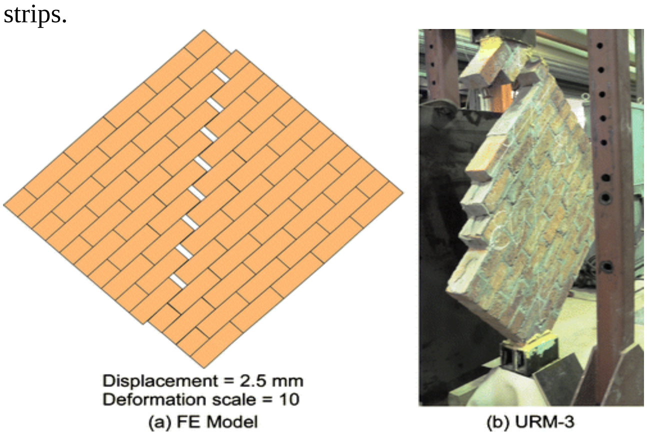

Fig 8

In polypropylene fibre retrofitted wall, minor cracks appeared at vertical load of 9 Tons corresponding to a compressive stress of 51.48 KN/m^2. The failure is not sudden and good composite behaviour is observed due to presence of polypropylene fibre.

An experimental work was carried out to study the enhancement of compressive and shear strength of masonry wall panels using steel strips and Polypropylene Fibre.

1. The compressive strength was increased up to 26.32 % to 37.50 %percent due to strengthening of masonry wall panel with strips and polypropylene fibre.
2. The increase due to confinement of masonry by steel strips and polypropylene fibre wall showed reasonable composite behavior.
3. Shear testing the diagonal steel strips contributed equally in confining the masonry wall against the lateral displacement.

4. The easy external application, effectiveness against lateral / gravity load sand less skill are the added advantages of the technique.

IV. REASONS THAT MAY LEAD TO RETROFITTING

There are some reasons that may lead to retrofitting:

1. Buildings which are designed considering gravity loads only.
2. Developmental activities in the field of Earthquake Resistant Design (EQRD) result in change in the design concepts.
3. Lack of timely revisions of appropriate codes of practice and standards.
4. Lack of revisions in the seismic zone map of country.
5. In cases of alterations in buildings of high seismic activity i.e. increase in loading class, increase in number of story, etc.
6. The quality of construction may be lower than what was originally planned.
7. Improper planning and huge distribution on floors.

V. CONCLUSION

In this paper we have presented a brief study, the procedure and the use of retrofitting in various fields. In these contemporary days, retrofitting has a very profitable level in the market. It gives numerous ways to improve the damaged structure and helps to increase the lifespan of the building thereby increasing its functioning, safety and durability. Retrofitting mainly depends upon the modern technology and the unique ideas of the engineers and varies from place to place. When a new element is introduced to an existing structure, the load transfer and the compatibility of deformation between the new and the existing elements are mandatory. Retrofitting strategy will only be successful when the new element is able to share the load and can deform along with the existing components of the building. The quality for constructing a successful retrofit building cannot be overemphasized. Any patchwork will be of wasted effort. The effective participation of the owners, real estate promoters, architects, engineers and contractors are necessary to mitigate the fear of the residents of multistoried buildings.

VI. ACKNOWLEDGMENT

We pay our sincere thanks to the almighty and our beloved parents for their valuable blessings, which paved way for the successful completion of our project. We would like to express our most sincere thanks to Dr. M. Mageshwari, M.E., Ph.D., Professor and Head of the Department of the Civil Engineering for her constant encouragement and guidance in every step of our project with valuable suggestions. We express our utmost gratitude and thanks to all faculty members of Civil Engineering Department and our family and friends who have directly helped in the completion of this project.

VII. REFERENCES

[1] Retrofitting: Urban Design Solutions for Redesigning Suburbs‖ by Richard Florida.
[2] 2. ―Seismic Retrofitting Project: Assessment of Prototype Buildings‖ published by TGCI.
[3] ―CPWD Research Paper on Retrofitting(2003)
[4] ―Bosiljkov V, Uranjek M, Žarnić R, Bokan-Bosiljkov V. An integrated diagnostic approach for the assessment of historic masonry structures. Journal of Cultural Heritage. 2010 Sep 30;11(3):239-49.
[5] ―Konstantinou T, Knaack U. Refurbishment of residential buildings: a design approach to energy-efficiency upgrades. Procedia engineering. 2011 Jan 1;21:666-75.
[6] Orehounig K, Evins R, Dorer V. Integration of decentralized energy systems in neighbourhoods using the energy hub approach. Applied Energy. 2015 Sep 15;154:277-89.
[7] Ashraf M, Khan AN, Naseer A, Ali Q, Alam B. Seismic behavior of unreinforced and confined brick masonry walls before and after ferrocement overlay retrofitting. International Journal of Architectural Heritage. 2012 Nov 1;6(6):665-88.
[8] Ehsani MR, Saadatmanesh H, Velazquez-Dimas JI. Behavior of retrofitted URM walls under simulated earthquake loading. Journal of Composites for Construction. 1999 Aug;3(3):134-42.
[9] Elnashai AS, Pinho R. Repair and retrofitting of RC walls using selective techniques. Journal of Earthquake Engineering. 1998 Oct;2(04):525-68.
[10] ElGawady MA, Lestuzzi P, Badoux M. Retrofitting of masonry walls using shotcrete. In2006 NZSEE Conference, Paper 2006 Mar (Vol. 45).