A Review on Retrofitting

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Abstract— Now-a-days retrofitting is expanding its legs in the world like a wild fire, as many of the historical, public and private important structures get real old and become weak due to flow of time.Retrofitting is one of the best options to make an existing inadequate building safe against future probable earthquake or other environmental forces. Retrofitting is the process of addition of new features to older buildings, heritage structures, bridges etc. Retrofitting reduces the vulnerability of damage of an existing structure during a near future seismic activity. It aims to strengthen a structure to satisfy the requirements of the current codes for seismic design. In this respect, retrofit is beyond conventional repair or even rehabilitation. It is the modification of existing structures to make them more resistant to seismic action, motion of ground, and failure of soil due to earthquakes or other natural calamities such as tornadoes, cyclones, and winds with high velocitycaused by thunderstorm, snowfall, hailstorms etc. Structures lose their strength in due course of time, some structures are important in view of public, social or past importance. Retrofitting helps to increase the strength, resistivity and overall lifespan of the structure.

I. INTRODUCTION (*HEADING 1*)

To meet up the requirements of advance infra-structure new innovative materials/ technologies in civil engineering industry has started to make its way. With structures becoming old and the increasing bar for the constructed buildings the old buildings have started to show a serious need of additional repairs. Retrofitting of structures like building, which includes rehabilitation, maintenance and strengthening of the structure, is not only a need in construction and management in urban areas, but also a problem which arises to structural engineers in property management disciplines. Retrofitting is defined as the process of modification of existing structures like buildings, bridges, heritage structures to make them more resistant to the seismic activity and other natural calamities.

Out of many natural and environmental disasters, seismic action-"earthquake" affect the structures most. It has been seen that structures with the passing of time they lose their strength because of many reasons like seismic activity, soil failure due to ground motion etc. Then there arises problems like damaging of roof, foundation, walls, pillars, columns and beams. For these, structures becomes statically unsafe. And there arises the question of safety and there comes the solution- Retrofitting.

There are various building structures of public, private and historical importance. If private and public building structures get damaged, in extreme cases they can be dismantled. But in case of structures of historical importance, they can't be dismantled. And here comes the only way to save these structures- Retrofitting.

II. METHODOLOGY

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

A. 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 must be strengthened, however there is often an underlying mistake that the strengthening of whole structural system is neglected. Strengthening of connection between members is quite influential to structural integrity.

2. Local strengthening versus global strengthening.

Local strengthening of an individual member can be carried out only if the strengthening does not affect the structuralperformance of the whole system.

3. Temporary strengthening versus permanent strengthening.

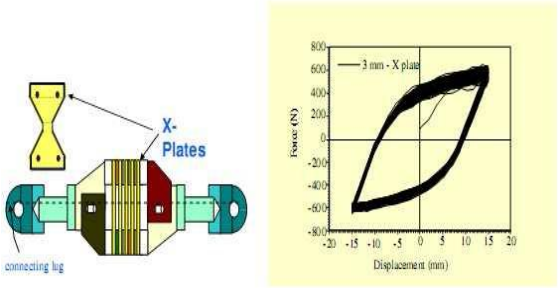
The standards and requirements for temporary strengthening may be lower than those for permanent strengthening.

4. Special considerations for earthquake resistant strengthening.
5. To use new seismic technologies.

B. TECHNIQUES OF RETROFITTING:

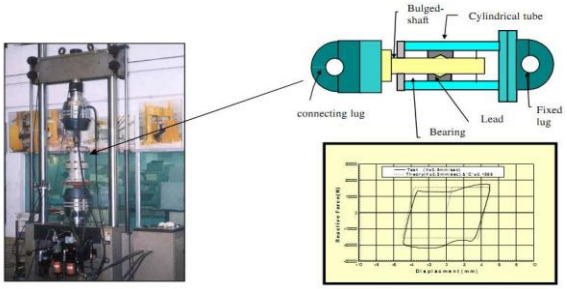
There are many technologies developed for seismic Retrofitting which are based on-response control. These techniques are used to provide extra damping using dampers like friction dampers, elasto-plastic dampers, tuned liquid and tuned mass dampers, lead extrusion dampers visco-elastic dampers, etc. Also there are certain techniques like base isolation which are introduced to take care of seismic control.

1. Elasto-Plastic Dampers:
These are based on plastic deforming plates of steel which consist X-shaped steel plates. These steel plates sustain many cycles of stable yielding deformation, which result in high levels of damping



or energy dissipation. (Shown in Fig.1)
Fig. 1. Elasto- Plastic damper and the hysteretic Characteristic of the x-plate

2. Tuned Liquid Dampers (TLDs):
TLDs are rigid walled containers filled with liquid up to certain height, to match the sloshing frequency and are placed at the rooftop of the structure. The Device



absorbs vibration energy through liquid sloshing principle. (Shown in Fig 2.1 and 2.2)
Fig.2.1.LED on a Test machine Fig.2.2. The Structure and the Hysteric characteristic

3. Base isolators:
The base isolation is aimed to attenuate the horizontal accelerations transmitted to the superstructure. The isolators try to decouple the building or structure from the horizontal components of the ground motion. Since the isolators have low horizontal stiffness and they are placed between the structure and foundation. (Shown in Fig.3)

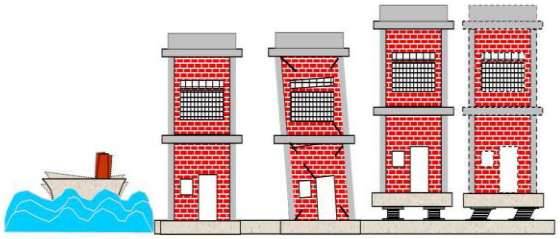


Fig.3. Principles of Base Isolation Technology

III.PROCEDURE AND DETAILS

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

1. Encompass condition assessment of the structure to find out the exact strength of the structure, evaluation for seismic forces to find out the threshold limit of seismic activity up to which it can resist, and finally selection of retrofit strategies and construction process.

2. To provide the layer of Plaster of Paris on the existing floor to protect the floor during retrofitting work. During the work various loads and support structures are placed upon the floor. Due to this the floor may get damaged. To solve this problem layer of plaster of Paris is provided over the floor, which can be removed easily after the retrofitting work. (Shown in Fig.4)
Fig.4. Layer of plaster of Paris over the floor

3. The removal of existing plaster wherever found required to expose the vulnerable parts and suitable treatment to remove the formation of alkali salts rinsing with hot water or by chemical wash without eroding the brick surface and without further deforming of the joints. Chiseling of the deteriorated concrete is done up to 20 mm thick with power driven or pneumatic chisel of standard including cleaning loose friable materials, also removal of rust around the steel using rust removing papers or manually (shown in Fig.5), then apply of zinc primer on the steel to increase the strength of the steel and to provide reinforcement to the structure.

Fig.5. Removal of existing plaster

4. To provide and apply of pre-packed polymer modified protective mortar, providing and placing in position micro concrete and providing & applying low viscous hydrophobic silane-siloxane solvent to

avoid ingress of water and water borne salts to minimize efflorescence and to fill the holes and cracks in the walls and ceiling due to ageing.(Shown in Fig.6)

Fig.6. Apply of pre packed polymer modified protective mortar

5. The providing and grouting Chemical injection(epoxy base) by fixing minimum 10 mm diameter nozzle of suitable length, over the surface of RCC member also along the cracks, wherever required . First holes are made using drill machine. Small pipes of diameter 10 mm inserted in those holes.(Shown in Fig.7) By using manual or electrical pumping machine the epoxy base chemical is inserted in the walls to increase and regenerate the strength of the damaged part of the structure specifically.

Fig.7. Injection of chemical (epoxy base)

6. The injecting of cement slurry grouting (M 50 grade), applying two coats of zinc chromate paint after due surface preparation by removing corrosion rust, mill scales pit patches. This process is done to repair the damaged ceiling, walls, beams and columns of the structure, to remove the defects in the steel part, to remove the rusting of steel, so that it become more resistant to seismic activity. (Shown in Fig.8)

Fig.8. Injecting of cement slurry grouting (M-50 grade) & applying of two coats of zinc.

7. The process of fixing shear connectors, fixing anchors, erecting self-supported scaffolding double row type using steel pipes for vertical, horizontal and diagonal bracing, fixing SS Bracket fixed to the required portion including cutting, bending, fabricating, drilling holes, welding and anchoring with hole, all these to support the structure during and after retrofitting work. (Shown in Fig.9)

Fig.9. self-supported scaffolding double row type using steel pipes for vertical, horizontal and diagonal bracing.

8. To fix 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 RCCjolly. This seismic strap 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.(Shown in Fig.10)

Fig.10.seismic strap, made of G.I wire

9. To provide new electric wiring with the help of modern technology, new equipment, lift or escalators where needed.

10. Providing new plaster preferably M50 grade over the structure which increase the strength of the structure, process known as concrete jacketing.

11. Remove the Plaster of Paris layer which was previously applied to protect the floor from retrofitting work.

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

IV. REASONS MAY LEAD TO RETROFITTING

There are some reasons that may lead to retrofitting:

1. Building which are designed considering gravity loads only.

2. Development activities in the field of Earthquake Resistant Design (EQRD) of buildings and other structures result into change in design concepts.

3. Lack of timely revisions of codes of practice and standards.

4. Lack of revisions in seismic zone map of country.

5. In cases of alterations in buildings in high seismic activity zone i.e. increase in loading class, increase in number of story etc.

6. In cases of deterioration of Earthquake (EQ) forces resistant level of building e.g. decrease in strength of construction material due to decay in structure, damage caused by fire, and settlement of foundations.

7. The quality of construction actually achieved may be lower than what was originally planned.

8. Lack of understanding by the designer.

9. Improper planning and mass distribution on floors.

CONCLUSION

In this paper we presented a comprehensive study, its steps, procedure and the use of retrofitting in various fields. The combination of engineering, machines and years of experiencemake this possible to develop the technology of retrofitting. At present day, retrofitting has a very lucrative market in the developed and as well as developing countries. It provides a number of ways to improve the damaged structure and allows to expand the lifespan of a structure, increasing its functioning and safety. Retrofitting mainly depends upon the modern technology and the unique ideas of the engineers and may vary from place to place.

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