International Journal of Scientific Research & Engineering Trends
Volume 10, Issue 2, Mar-Apr-2024, ISSN (Online): 2395-566X

A Review of Strenthening the Structural Elements for Stability Using Jacketing Techniques

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Abstract- It is important to analyze the old structures for structural integration to understand the type and extent of damage the structure has sustained and what type of retrofitting is further required. Non-Destructive Testing (NDT) is a wide group of analysis techniques used in Science and Industries to evaluate the properties of a material component on the system without any damage. Structural audit is an overall health and performance check-up of building .It is important to the building to check their safety and they have no risk. It is process of analyses of building and this process suggest to perform better in its service life, structural audit is an important tool for knowing the real status of the old building. Currently, safety of old buildings which is present in heavy rainfall area is one of the critical issues in India though, there are many practices to conduct structural audit of such buildings. The need of structural audit is for maintenance and repairs of existing structure whose life has exceeded the age of 30 years to avoid mishaps and save valuable human life. The concrete is widely used as construction material being inexpensive, easy for construction, application and because of it high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability. NDT measurement technique has been used for more than two decades for concrete quality evaluation and assessing concrete compressive strength. During this period, the advantages of its use and the factors influencing the test results have been widely reported. The major issues in executing the Structural Audit are Peoples are not aware about the importance of the Audit. They do not come forward. There are many misconceptions about the audit such that the buildings will be demolished. Secondly there is no Standard or Legal Procedure to Carry out Structural Audit. It completely depends on knowledge and Experience of Structural Engineer.

Index Terms- Damage Structures, Jacketing, Rehabilitation

I. INTRODUCTION

Optimization techniques play an important role in structural design, the very purpose of which is to find the best ways so that a designer or a decision maker can derive a maximum benefit from the available resources [1]. In the design of structural elements, it is possible to obtain more than one feasible and safe solutions. But not all these designs may be cost-effective. But out of the possible design solutions of a structural element under a given loading conditions, only one of them will be cost effective. How to obtain this one design, called optimal design, that optimally satisfies cost effectiveness and performance is the goal of structural optimization. Structural optimization can be defined or explained in a number of ways. However, its principal objective is to find the best design out of many designs that satisfies a prescribed criterion. It can be explained as a process of maximizing or minimizing a desired objective function while satisfying the prevailing constraints. Another approach looks at it as a process of determining the optimal values of design variables that maximizes or minimizes an objective function, within the limits of imposed constraints. Structural optimization involves making decision that will result in maximum benefits from available resources. Many types of optimization methods are described by [2, 3, 4]. However, according to [5], structural optimization process and methodology adopted for a given problem is influenced by many factors like: (i) type of structure, (ii) model of structure, (iii), dimensionality of structure, and (iv) choice of design variables. The type of structure being optimized affects the way the process is carried out. According to [6], four types of structure are identifiable. These are: Truss, Shell, Solids, and Composite materials. The Truss structures occur in all areas of engineering that involve structural mechanics. Shell structures: its properties of in-plane and out-of-plane deformation are frequently used in aerospace structural analysis and optimization. Solids structures play an important role in mechanical and geo-technical engineering [7]. And

lastly, the composite structures are mostly encountered in aerospace and civil engineering. All these affect the way optimization is carried out. Also the models of a structure defined in terms of how the structure is idealized for the process of optimization affects optimization process. Engineers conceive a structure in the form in which it will be built, however, the analysis must be based on mathematical and skeletal model which approximates to the behavior of the structure in under service loads. In structural optimization process, the structural engineer will model the structure accurately in this mathematical sense. The optimization models should be such that it is close to Real-World problems. Dimensionality deals with whether it is 1-D, 2-D, 3-D structural configurations [2]. In practice, 3-D models are usually used, since it is considered to be true to the real-world material realities and problems. While the choice of design variables plays an important role in structural optimization. In this regard, variables can be discreet (that is, material choices) or continuous (that is, physical dimensions). Variables should not be too little or too many [1]. Using too few variables can limit the diversity of possible solutions, and thus sacrifice the optimality of the results. Also too many variable can lead to an overly complex models. Structural optimization problems can be classified into three:

(i) sizing optimization, (ii) shape optimization, and (iii) topology optimization [3, 8, 9]. Sizing optimization problems uses trusses or grillage member cross- sectional areas, plate or shell component thickness as design variables. In sizing optimization problems, the shape and topology of the analysis domain is fixed. This will help the designer to see the effect of the design variables on the member sizing. Shape optimization involves finding the right shape which will optimally perform a given function, subject to certain constraints. The very important aspect of optimization problems is that the topology of the analysis domain is fixed.

Objective

Heritage sites, ancient buildings, bridges, etc., may all benefit from retrofitting, which is the process of updating them with modern equipment and technologies. When concrete elements have weakened due to age or wear and tear, they may be retrofitted with newer, stronger components using the RCC method. Preventing additional concrete suffering is another benefit. Retrofitting may lessen the likelihood that an existing building will be damaged in the event of a natural catastrophe or seismic activity.

Changes might also be due to other factors, such as the aggressiveness of potentially dangerous chemicals. It's possible that design flaws or sloppy construction are to blame for the concrete element's lack of durability. It all relies on the extent of the damage sustained by the structure as to whether or not the necessary capacity can be rest. There are a number of issues that arise in structural members that must be addressed. Some of them include seismic damage, honeycomb corrosion, structural fractures, and fissures in structural elements, modifications to the structural system, and improper design or construction. These issues can be dealt with through retrofitting. Topology optimization problem is also called generalized shape or layout optimization [2]. In this type of problems, the optimal boundary and connectivity, as well as the optimal size, shape, location, and number of other factors in an analysis domain are sought. Three fundamental modules are involved in most structural optimization process. These are: (i) design parameters, (ii) constraints (equality or /and inequality), and (iii) objective functions (criteria).

The design parameters specify the geometry and topology of the structure, as well as the physical properties of the members. These may include: cross-sectional variables (like areas, sectional modulus, etc), parameters that defines the structural configurations, or the material properties. The restraints that must be satisfied for the design to be acceptable are termed as constraints. Examples of constrains on the performance of the structural systems, are usually on stress, or deflections, or buckling, or natural frequencies, or thickness. The objective function (also called merit function) is formed by the proper choice of design parameters. This function is either minimized or maximized or balance combination of these. For example: (i) If this function is cost or weight of structure, it is minimized, (ii) if this function is performance, or reliability, or other performance-based parameters (like energy requirement, thermal capacity, sound, insulation, etc.), it is maximized, and (iii) or their combinations. According [1], the structural optimization problems are usually mathematically posed in this format.

II. LITERATURE REVIEW

Varinder . K. Singh(2012): has detailed investigation of the buildings with rebound hammer test, ultrasound pulse velocity test and core tests, carbonation test and chloride tests have indicated that there is lot of variation in the compressive strengths of concrete in beams as well as columns. At certain locations, the strengths were found around 10 N/mm2 only indicated poor quality of concrete practices adopted in the original construction. Lower value of compressive strengths also indicates higher permeability of the concrete leading to ingress of harmful agents like carbon dioxide gas , chlorides etc from the environment resulting in corrosion of steel bars and disintegration of concrete covers. From this case study, following recommendations / conclusions are drawn for durable concrete constructions requiring minimum structural rehabilitation at later stages of life.There is no substitute for good quality concrete construction practices for durability of reinforced concrete structures. The quality control of materials and workmanship viz. watercement ratio, concrete cover, compaction and curing etc. which are prerequisites for good quality construction are very important parameters and must

be strictly observed at site. Poor quality concrete construction done cannot be rectified at a later date except repeated costly repairs to keep the structure functional. To achieve the quality at site, the role of manpower is very significant. The engineers and workers responsible for construction should be well experienced, quality conscious and must be fully aware of the repercussions of poor quality work. Also sufficient technical staff should be deputed for achievement of quality construction with full support and encouragement from top management.

The early deterioration of concrete structure is also due to poor maintenance practices. The water supply and drainage system should be kept intact so that there is no leakage/ seepage on the walls and no stagnated water on roofs due to overflow of water tanks or rains which acts as an enemy to the structural integrity of the buildings. The repair/ rehabilitation of damaged structure should be carried out urgently to avoid further deterioration with time so that the life of the structure and the occupants is not jeopardized. The design for structural rehabilitation should be carried out after laboratory testing of the repair materials because the claimed strengths in the brochures from the manufacturers may not always be achievable. Structural rehabilitation is more challenging then new concrete construction. It requires special considerations for evaluation of damage, selection of suitable material, technical specifications, and techniques for repair and quality control of material and workmanship. Therefore sufficient time and cost allocations should be made for durable rehabilitation work.

P.V.Bhosale & Sumant Kulkarni (2019): has discussed about the Rehabilitation of structures embroils contribution of high end technology, advanced skills and calculations. This is a very responsible job to be done to save hazardous failure of structures due to deterioration. The success of this subject totally depends on gaining expertise in the field and day to day advancements. Rehabilitation is highly recommended for age-old buildings showing signs of decent and save human lives from failure. This paper provides compressive study of repair and rehabilitation of heritage buildings. The existed problems and its reported solutions are finely reviewed. An effective solution for the reported problem is formulated based on trade-off between cost, lifetime and adaptability of the solution. This papers delivers its usefulness to those who as an objective of doing Repair and Rehabilitation of civil structures.

M. J. Monteiro, & N. J. Pathak (2011):The authors are describing two NDT's and two Partially destructive tests, viz. RH, UPV, Carbonation and core sampling tests. They express need of evaluation of structure periodically for: Assessing the load carrying capacity of building and of earthquake resistance (As per revised codal provisions) in old structures, and structural soundness periodically, as well as checking feasibility of change in occupancy, for construction of additional floors, for structural modifications, or placing higher capacity equipments on building. The authors opine and state therule, "According to the model bye-law no. 77 for co-operative housing societies, it is mandatory that if the age of a building is 15 to 30 years, a structural audit must be carried out once in five years and for buildings older than 30 years it should be carried out once in three years."

Sivasubramanian K, Jaya K.P, Neelemegam M. (2013): has discussed Cover-meter for identifying cover depth and rebar diameter in high strength concrete, "The present work focuses on identifying the capabilities and the limitations of using cover meter in high strength concrete". Ascertaining the cover depth is important to implement durability standards to the structure under construction. In cases where concrete core extracts are to be taken the identification of the rebar locations becomes essential to avoid cutting of the reinforcement bars. To determine these aspects it becomes necessary to apply non-destructive testing methods. Hence, rebar locators or the cover meter used in the site. It shall be noted that these results are obtained under laboratory conditions. Hence, the results will be unreliable in field conditions.Bhattacharya Shubhamoy, NayakSanket, DattaSekhar Chandra (2014):described A critical review of retrofitting methods for unreinforced masonry structures. The authors state that URM buildings are common in Himalayan region and Indian subcontinent. They observed that these buildings cannot withstand the lateral load imposed by the earthquake and often fail in brittle manner. They have collected information on various types retrofitting methods. On analyzing they concluded that this study will provide useful guidance to policy makers, planners,designers, architects,and engineers, to choose proper methodology. Dr. K.M. Soni (2015) has detailed investigation Anchoring has very important role in repair, rehabilitation and seismic retrofitting as it provides unity action required between existing structural member and new section to be added. Anchoring can also be used in applications where new members are to be added in existing structures with quality and safety. Mechanical anchors are used in RCC structures while chemical anchors in load bearing structures. There is a need of IS code for design and installation of anchoring system.

Yasir Shaikh, Vishv K. Patel, Dhruv Patel, Vishv D. Patel (2018) has detailed investigation RCC-Wall joint cracks, a many of Beam-columns joint had vertical cracks line to line of concrete (column), above door and window horizontal crack due to lintel is not provided and flooring settlement. In this paper different types of cracks like vertical cracks, horizontal cracks, brick masonry cracks and diagonal cracks which are caused due to thermal expansion or contraction and vegetation in the foundation and also due to the expansion of brickwork and flooring settlement is everywhere at all floor in college building, it is caused during thermal expansion. It is also

caused due to less compaction of materials below the floor. Mainly the problem of termite is observed everywhere in the building. The main reason for this is that it is agricultural land and termite is found in mostly agricultural land. Chemical test analysis classified the test results of carbonation test, sulfate test and chlorination test, the initial corrosion of reinforcement in beam, column and slab is being observed. It can be seen that detailed visual inspection and Non Destructive Testing (NDT) play an important role in condition assessment of existing buildings. Level of distress can be determined using suitable NDT test along with detailed observation and with proper restoration methods the life period of structure can be enhanced. The admixtures used in repairing work are polymer modified mortar, water proofing chemicals, Dr. Fixit Epoxy Injection Grout, waterproofing adhesives,

Dr. Fixit Crack-X Shrink, Epoxy mortar and Epoxy resins, OPC43 grade cement, specified grade sand and clean water. The present paper focused on the condiand vegetation in the foundation and also due to the expansion of brickwork and flooring settlement is everywhere at all floor in college building, it is caused during thermal expansion. It is also caused due to less compaction of materials below the floor. Mainly the problem of termite is observed everywhere in the building. The main reason for this is that it is agricultural land and termite is found in mostly agricultural land. Chemical test analysis classified the test results of carbonation test, sulfate test and chlorination test, the initial corrosion of reinforcement in beam, column and slab is being observed. It can be seen that detailed visual inspection and Non Destructive Testing (NDT) play an important role in condition assessment of existing buildings. Level of distress can be determined using suitable NDT test along with detailed observation and with proper restoration methods the life period of structure can be enhanced. The admixtures used in repairing work are polymer modified mortar, water proofing chemicals, Dr. Fixit Epoxy Injection Grout, waterproofing adhesives, Dr. Fixit Crack- X Shrink, Epoxy mortar and Epoxy resins, OPC43 grade cement, specified grade sand and clean water. The present paper focused on the condition assessment, safety evaluation and possible repair and restoration methods for existing concrete tion assessment, safety evaluation and possible repair and restoration methods for existing concrete.

Various Types of Retrofitting Methods for Repair and Rehabilitation of Concrete Structure Failure

Guniting

Guniting is mechanically applied material consisting of cement, aggregates and water. The cement and sand are batched and mixed in the usual way and conveyed through a hose pipe with the help of compressed air. A separate pipe line brings water under pressure and the water and cement aggregate mix are passed through and intimately mixed in a special manifold and then projected at high velocity to the surface being repaired.

Shotcreting

Shotcrete is defined as “mortar or concrete pneumatically projected at high speed onto a surface” (American Concrete Institute, 1990). There are two basic types of shotcrete—dry mix and wet mix. In dry mix shotcrete, the dry cement, sand, and coarse aggregate, if used, are premixed with only sufficient water to reduce dusting. The two types of shotcrete produce mixes with different water contents and different application characteristics as a result of the distinctly different mixing processes. Dry mix shotcrete suffers high dust generation and rebound losses varying from about 15 percent to up to 50 percent. Wet mix shotcrete must contain enough water to permit pumping through the delivery line.

Concrete Stitching

Stitching is a rehabilitation method used at cracks to maintain aggregate interlock and provide added reinforcement to minimize the relative movement of concrete slabs at the cracks. It is also used at the longitudinal joints to keep the slabs from separating. There are three types of stitching used; cross-stitching, slot-stitching, and U-bar stitching. The stitching procedure consists of drilling holes on both sides of the crack, cleaning the holes, and anchoring the legs of the staples in the holes, with either a non shrink grout or an epoxy resin-based bonding system.

Resin Injections

Resin Injections are designed for injecting cracks in concrete and masonry where there is a need to consolidate a structure or exclude water and air from contact with reinforcement. Cracks greater than 0.2mm in width are injected with Low Viscosity resins. If a crack is clean, free of impacted debris or paint, and 0.088 in. (2.2 mm) or greater in width, pack the epoxy into the crack. No surface preparation, other than perhaps blowing loose particles from the crack, is required. Work the resin (a slick gel works best) into the crack using a flexible metal or plastic spatula. The seal should be placed to a minimum depth of twice the crack width. Packing the seal is faster and easier than shaping a cap over the crack. It also consumes a fraction of the material, yet is stronger because the epoxy is bound in shear by the rough sides of the crack. In fact, the concrete will give way before a packed seal will. Another plus is that there is no protruding seal to be removed after injection.

Dry packing

This is the method of ramming into a confined area a mixture of port land cement, aggregate, and enough water to make it moist. It is usually used as a method of repair. Thorough curing is required. This method is used for repairing holes having a depth nearly equal to greater than the least surface dimension, i.e. for any holes and narrow slots cut for the repair of cracks. This method is not used for shallow depressions; for filling patches where reinforcement is exposed or holes which extend through and through walls or

beams For better results and when water tightness is a requisite, the holes should be sharp and square at the surface edges, but corners within holes should be rounded. Holes for dry packs should have a minimum depth of 2.5 cm.

Polymer Impregnation

Polymer impregnation has been proven to increase environmental and mechanical resistance of tuff (a soft volcanic rock), suggesting its potential application for restoration of monuments or reinforcement of structures. Polymer impregnated concrete is one of the widely used polymers composite. It is nothing but a conventional precast concrete, cured and dried in an oven or by dielectric heating from which the air in open cells is removed by vacuum process. Then a low viscosity liquid monomer or pre polymer partially or fully is impregnated or diffused into the pore system of the hardened cement composites or cement concrete and then polymerised using radiation or by the application of heat or by chemical initiation. The partial or surface impregnation improves the durability and chemical resistance, but the overall improvement in the structural properties is modest. On the other hand in depth or full impregnation improves structural properties considerably.

Vacuum Impregnation

The metal casting process is very sophisticated, but it still has inherent imperfections. When liquefied and injected into a mold, metal creates gas bubbles that get trapped inside the molded form as the metal solidifies. Gas bubbles create air pockets, folds and inclusions. Depending on their size and their random placement within the casting, this porosity can cause metal parts to leak when placed under pressure. Herein comes, Vacuum impregnation. This technique seals porosity and leak paths that form during the casting or molding process. Vacuum impregnation stops casting porosity and allows manufacturers to use parts that would otherwise be scrapped. Vacuum impregnation is the preferred method to seal porosity in order to prevent fluids or gases from leaking under pressure.

III. METHOD USED IN STRENGTHENING THE STRUCTURAL ELEMENT

1. Jacketing

Jacketing is a method of structural retrofitting and strengthening it is used to increase bearing load capacity following a modification of the structural design or to restore structural design integrity due to a failure in the structural member. This technique is used on vertical surfaces such as walls, columns and other combinations such as beam sides and bottoms. It consists of added concrete with longitudinal and transverse reinforcement around the existing column. Jacketing is the process whereby a section of an existing structural member is restored to original dimensions or increased in size by encasement using suitable materials. A steel reinforcement cage or composite material wrap can be constructed around the damaged section onto which shotcrete or cast-in-place concrete is placed.

Jacketing is particularly used for the repair of deteriorated columns, piers, and piles and may easily be employed in underwater applications. The method is applicable for protecting concrete, steel, and timber sections against further deterioration and for strengthening. Jacketing improves axial and shear strength of columns and a major strengthening of the foundation may be avoided.

Need of Jacketing

Jacketing is the process of strengthening weak RCC columns which have deteriorated over some time due to adverse atmospheric conditions or due to poor maintenance of the structure. Other reasons during the construction phase include design errors, deficient concrete productions, bad execution process. During the service life, the need may arise due to an earthquake; an accident, such as collisions, fire, explosions; situations involving changes in the structure functionality; the development of more demanding code requirements.

- The load carried by the column is increased.
- When there is an error in design.
- Deterioration of column due to weathering action.
- Dilapidation of columns.
- Heavy damage due to other causes like earthquake and fire

Advantages of Jacketing

- It increases the seismic capacity of columns.
- Amount of work is less as foundation strengthening is not required.
- It increases the shear strength of the column.
- It also increases the confinement of concrete in circular columns.
- Does not increase the significant weight of the column and also saves construction time (curing).

IV. DIFFERENT TYPES OF JACKETING

1. Reinforced Concrete Jacketing

The strengthening of reinforced concrete members is a task that should be carried out by a structural engineer according to calculations. Here only a few suggestions are included to illustrate how the strengthening could be done. RC columns can best be strengthened by jacketing, and by providing additional cage of longitudinal and lateral tie reinforcement around the columns and casting a concrete ring. Jacketing a reinforced concrete beam can also be done in the above manner. For holding the stirrup in this case, holes will have to be drilled through the slab.

2. Steel Jacketing

Steel jacketing is also an effective method to increase basic strength capacity. Steel jacketing not only provides enough confinement but also prevents deterioration of shell concrete, which is the main reason for bond failure and buckling of longitudinal bars. Steel jacketing refers to encasing the section with steel plates and filling the gap with non-shrink grout. It is a very effective method to remedy the deficiencies such as inadequate shear strength and inadequate splices of longitudinal bars at critical locations. But, it may be costly and its fire resistance has to be addressed. In practice, the most commonly used strengthening technique is by steel strips and angles. Steel jacketing helps to restore the strength, ductility, and energy absorption capacity of columns thus it seems to be effective in retrofitting columns. And also the steel jacket helps to increase the flexural strength and ductile behavior of the lap-spliced column thus increasing the lateral performance of columns.

3. Fiber Reinforced Polymer (FRP) Jacketing

One of the most commonly used methods for retrofitting is Fiber Reinforced Polymer (FRP) jacketing. FRP is widely used for its properties such as high strength to weight ratio, stiffness, good impact properties, high resistance to corrosion in harsh environmental and chemical condition, and also it causes only a minimum alteration to the geometry of structural elements than other methods FRP is used to strengthen the corroded rectangular columns considering different levels of corrosion and various volumetric ratios and the test results indicate that shear resistance of FRP and column increases with the increase in volumetric ratio and decreases with increase in different levels of corrosion. Shrinkage is one of the factors responsible for the formation of cracks in structural elements like beams and slab. To reduce the shrinkage hybrid fiber-reinforced polymer (FRP) reinforced shrinkage compensating concrete is used. FRP Jacketing

4. Glass Fibre Reinforced Polymer Jacketing

The application of composite materials for jacketing has been developed in strengthening and retrofitting of concrete structures through recent years so that many concrete structures would be strengthened by these materials. One of these applications is Glass Fibre Reinforced Polymer (GFRP) material used in strengthening and retrofitting of reinforced concrete columns. The design of glass-fiber-reinforced contains basic properties under tensile, compressive, bending and shear forces, coupled with estimates of behavior under secondary loading effects such as creep, thermal response and moisture movement. Glass fiber-reinforced concrete consists of high-strength, alkali-resistant glass fiber embedded in a concrete matrix. In this form, both fibers and matrix retain their physical and chemical identities, while offering a synergistic combination of properties that cannot be achieved with either of the components acting alone.In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between the fibers and protecting them from environmental damage. Glass fibers can be incorporated into a matrix either in continuous or discontinuous lengths.GFRP JACKETING

5. Near-Surface Mounted (NSM) Fiber-Reinforced Polymer (FRP) Jacketing

In the NSM method, grooves are cut into the cover concrete, and FRP bars are placed in the grooves and bonded using an appropriate filler, such as epoxy paste or cement grout. NSM FRP bars are usually used in the longitudinal direction to enhance the flexural strength of the column. Mostly, the NSM method is used in conjunction with externally bonded FRP jacketing, resulting in a hybrid jacketing.

6. Hybrid Jacketing

Hybrid jacketing involves a combination of two or more different strengthening methods/materials for enhancing the seismic performance of a column and, thus, benefits from the advantages of both methods. This section summarizes the experimental studies utilizing the hybrid jacketing approach for the strengthening and repair of RC columns.

7. Shape Memory Alloy (SMA) Wire Jacketing

Shape memory alloys, that are characterized by their super elasticity, durability and shape memory effect have been considered for the strengthening of structural elements by different researchers. Moreover, SMA alloys are considered a more viable solution to FRP retrofitting due to the advantages such as no need for adhesive, easy installation and no danger of peel off. Shape Memory Alloy Jacketing

V. CONCLUSION

Concrete Jacketing is pivotal for strengthening to add or restore ultimate load capacity of reinforced concrete columns. It is used for seismic retrofitting, supporting additional live load or dead load that is not included in the original design, to relieve stresses generated by design or construction errors, or to restore original load capacity to damaged structural elements.

The method of RC Jacketing is suitable for the following situations:

- The old and existing building that are constructed without considering IS 1893:2002, are very liable for damage during an earthquake.
- The columns that are damaged in the past earthquake during an accident like fire, explosions.
- Situations involving change in the functionality of the structure.
- The weak columns of monumental buildings.

- The weak columns of soft storey and extremely soft storey.

Thus, Jacketing for these types of building becomes a necessity in order to minimize the effects of future seismic shaking. The Jacketing of the existing building is carried out by using IS 15988:2013. This code also provides the data for retrofitting of the buildings by means of adding shear wall and bracings.

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