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STUDY OF A G+6 STOREY HOSPITAL BUILDING RETROFITTING BY USING ETABS SOFTWARE

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ABSTRACT

Over the last three decades, earthquakes have struck several sections of the nation. It was discovered that many of the damaged buildings in the first three earthquakes were constructed using non-engineered masonry methods. In the event of an earthquake, unreinforced masonry constructions are the most susceptible. Typically, they are designed to support vertical loads, and since masonry has a sufficient compressive strength, the structures function well under vertical stresses. The walls of such a masonry building experience shear and flexural stresses when they are exposed to lateral inertial loads during an earthquake. Due to poor construction, some R.C.C. buildings have fallen during past earthquakes and are now deemed dangerous. Major collapse and damage to the R.C.C. buildings are caused by several additional factors.

The current research involves the retrofitting of a G+6-story hospital building in Karimnagar, Telangana State. The SAP 2000 program was used to do the study using the Response Spectrum approach, and the building was situated in low seismic zone II. The results are compared with the current structure and the retrofitting structure. These results include joint displacements, lateral loads, shear, bending, torsion, bending, time period, and frequency values.

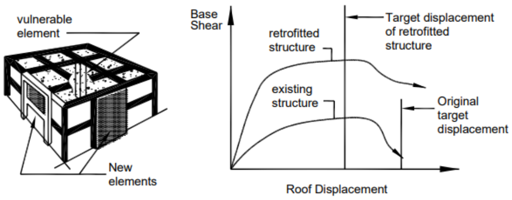
I. INTRODUCTION

1.1 General

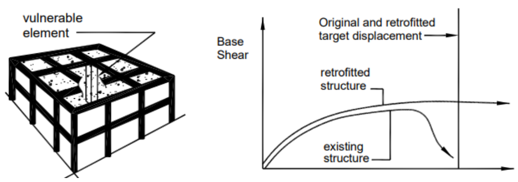
Retrofitting is the process of altering an existing structure to make it more resistant to earthquakes, strong winds, and floods. In order to address the growing frequency and severity of natural hazards and their impact on structures, retrofitting refers to advancements in construction technology, encompassing both techniques and materials. Many of the homes in existence today were constructed at a time when little was known about the locations and frequency of floods and other dangerous occurrences, as well as how structures should be secured. As new information becomes available, homes being constructed now may benefit from upgrades. Retrofitting has thus emerged as a crucial and essential instrument for hazard avoidance.

The term "rehabilitation" is often used to describe retrofitting particularly for seismic dangers.

Buildings with appropriate design and construction have withstood seismic shocks without collapsing in previous earthquakes. However, ancient buildings or those built without seismic design procedures have suffered significant damage or even collapsed, resulting in the irreversible loss of many lives. It has been thoroughly investigated that such buildings may be securely repurposed without endangering property or life safety if they are retrofitted to become earthquake-resistant constructions. In addition, this turns out to be a preferable alternative to replacing structures in order to address the urgent shelter issues and financial concerns. Furthermore, even in cases of significant structural damage, adapting buildings is often more cost-effective than demolishing and starting anew.



Global modification of the seismic deficient system



Local modification of the seismic deficient system

1.2 How the retrofitting is defined

Concepts including improving system behaviour and repairing or reinforcing components to anticipated performance—that is, the minimum needed strength and tolerable damage from an earthquake—are all included in seismic retrofitting. Repair, strengthening, retrofitting, remoulding, rehabilitation, rebuilding, and other terminology are used interchangeably with very slight variations;

Repairing

Rebuilding or renewing any portion of a deteriorated or damaged structure to restore its strength and ductility to its pre-damage state is known as repair. Repair may sometimes be linked to the building's ability to withstand earthquakes and return to its pre-earthquake condition.

Retrofitting

Retrofitting is the process of raising an old structure's seismic resistance to current requirements using the proper procedures, whether the building is earthquake damaged or seismically weak. Retrofitting also includes modernising certain building systems, including structural, mechanical, or electrical, to enhance functionality, performance, or attractiveness.

Remolding

Remoulding is the process of rebuilding or updating any area of an existing structure due to a change in occupancy or use.

Rehabilitation

Rebuilding or renovating an earthquake-damaged structure to its pre-damage level of functionality is referred to as rehabilitation. It also refers to strengthening an existing structure that has seismic deficiencies.

Repairing

Restoration may be used to indicate the rehabilitation of structures in a particular location.

Fortifying

Strengthening is the process of rebuilding or renovating any portion of an existing structure to give it more structural capacity, or more strength and ductility than the original. Retrofitting and strengthening are sometimes used interchangeably.

Objectives of the study

The goals of the research are as follows:

1. To compare the outcomes of old and retrofitted buildings and use response spectrum analysis to determine the design lateral pressures on G+6 story structures.
2. To investigate the building at Karimnagar, Telangana, which is situated in zone 2 seismic zone.
3. To determine how structures will react to low, middle, and high frequency ground vibrations, among other kinds of ground motions.
4. To examine the analytical findings for the old and new building models, including shear and bending torsion values.
5. To conduct research utilising the IS 1893:2002 code.

Summary

The most catastrophic, erratic, and unavoidable natural occurrence, earthquakes seriously harm buildings, property, and human life. Earthquake loading is quite unpredictable and is dependent on the seismic waves' length, amplitude, and frequency. The number of stories, the connection between the soil and the structure, the stiffness, the mass of the structure, the vertical, plan, and torsional irregularities, the re-entrant corners, and other elements all affect how a structure reacts to an earthquake. Zone II, Zone III, Zone IV, and Zone V are the four seismic zones that make up the Indian plateau, according to Bureau of Indian Standards Code 1893-Part 1 (2002). Nevertheless, because to a lack of knowledge about seismic behaviour, buildings constructed in India within the last ten years are only intended for gravity loading and are therefore seismically inadequate. Therefore, in order to reduce the loss ratio, various preventative measures have to be implemented. Retrofitting is one such method that may be used in building constructions. Numerous retrofitting methods are available for use. However, the RC jacketing approach is used in this project since it is practical and simple to create. This project involves retrofitting an existing structure and evaluating seismic certification. The structure is analysed using the equivalent static approach, and SAP 2000 software is used for modelling.

II. LITERATURE REVIEW

Singh Yogendra (2003) Many of India's current buildings are seriously inadequate against the power of earthquakes, and the number of these structures is increasing quickly. The recent earthquake brought this to light. Any existing building retrofitting is a difficult process that calls for expertise; RC structures are especially difficult to adapt because of the intricate behaviour of the RC composite material. The placement and detailing of the reinforcement have a significant impact on how the structures behave during an earthquake, in addition to the size of the members and quantity of reinforcement.

Jain, Sudhir K. (2002) The idea of pushover analysis, which is quickly gaining popularity in the field for designing new structures, assessing existing buildings for seismic activity, and creating suitable plans for seismic retrofitting structures, is discussed in this study. It is shown how this analytical method might be helpful in choosing seismic retrofitting methods and strategies.

D. Lakshmanan (2006) SAP 2000 conducted this Pushover study of the structures. The several repair techniques for enhancing the seismic performance of reinforced concrete buildings are evaluated by Sap 2000. It is addressed how repaired beams behave at beam-column junctions. Even after restoration, it is found that the beam-column couplings' fundamental detailed flaws still show up, despite the performance metrics showing a significant improvement. In these situations, the repair would not be as successful, as shown by two of the logical expansions.

Giuseppe Oliveto and Massimo Marletta (2005) examined seismic retrofitting for earthquake-prone structures and provided a quick overview of the main conventional and cutting-edge techniques. Out of all the seismic retrofitting techniques, the stiffness reduction approach received the most attention. The idea of springs in series was used to implement this technique in reality, which really resulted in base isolation. The structure was represented by one of the two springs in series, while the base isolation system was represented by the other. The success of the strategy was evident in the structures' increased resistance to the design earthquake, and the use also led to an overall improvement in seismic performance.

Amit R. Kalyani and Abhijit Mukherjee (2004) In addition to discussing the design of RCC components using FRC, a strategy for upgrading RCC frames, and the application of the proposed strategy for upgrading RCC frames based on the Capacity Spectrum technique, this study presents a technique for designing structural upgrades using FRC.

III. RETROFITTING

3.1. RETROFITTING

Retrofitting is the process of altering an existing structure to make it more resistant to earthquakes, strong winds, and floods. In order to address the growing frequency and severity of natural hazards and their impact on structures, retrofitting refers to advancements in construction technology, encompassing both techniques and materials. Many of the homes in existence today were constructed at a time when little was known about the locations and frequency of floods and other dangerous occurrences, as well as how structures should be secured. As new information becomes available, homes being constructed now may benefit from upgrades. Retrofitting has thus emerged as a crucial and essential instrument for hazard avoidance.

3.2. NEED FOR SEISMIC RETROFITTING

- To guarantee a building's personnel, structure, equipment, and merchandise are safe and secure
- Reducing risk and losses from non-structural aspects is crucial.
- Primarily focused on improving structures to lessen the risk of earthquakes.
- Important structures, such as hospitals, whose services are thought to be crucial immediately after an earthquake, need to be reinforced.

3.3. SEISMIC STRENGTHENING (RETROFITTING)

It will include taking steps to improve an existing building's seismic resistance in order to make it safer in the event of a likely future earthquake.

Existing buildings' seismic behaviour is influenced by their initial structural flaws, material deterioration from ageing, and modifications made over time while they are in use. Many social, cultural, and economic issues simply make it impossible to replace all of these structures in a particular location. As a result, existing structures that are either damaged or intact must be seismically strengthened. Although they often don't go over 12 to 15 percent, cosmetic repairs and seismic strengthening structural restoration may sometimes cost up to 25 to 30 percent of the rebuilding cost. Therefore, the financial justification for strengthening work must be thoroughly taken into account.

3.4. PROBLEMS FACED BY STRUCTURAL ENGINEERS

The biggest issue confronting structural engineers today is the absence of standards for retrofitting techniques and the fact that each method's efficacy varies greatly depending on factors such the kind of structure, material condition, degree of damage, etc.

3.5. EFFECTS OF EARTHQUAKES ON HIGH RISE BUILDINGS

To create a suitably representative model for study, a fair and accurate evaluation of the behaviour of a planned high-rise building is necessary. In essence, a high-rise construction is a vertical cantilever that experiences transverse strain from wind and earthquakes and axial loading from gravity. The slabs are subject to gravity loading, which is then transferred horizontally to vertical walls and columns before passing through to the foundation. Every level of the building experiences shear, moment, and sometimes torque due to horizontal stress. The highest values are found near the base of the building and rise quickly as it becomes taller. Compared to gravity loading, a structure's reaction to horizontal loading is more complicated. The most common issues are often identifying the structural behaviour under horizontal stress and creating the appropriate model.

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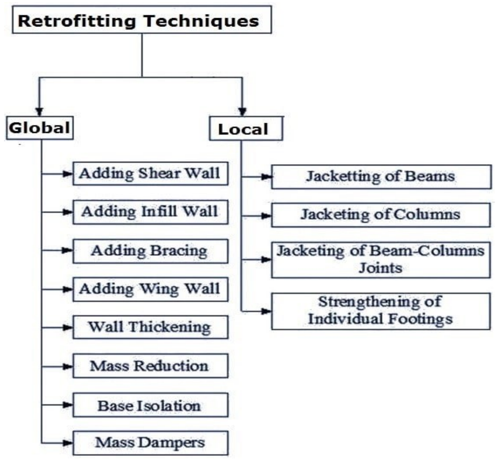
3.8. CLASSIFICATION OF RETROFITTING TECHNIQUES



3.9. ADDING NEW SHEAR WALLS

Vertical components of the horizontal force-resisting system are called shear walls. Usually, plywood or another structural sheathing material is used to cover the wood frame stud walls. The shear wall can withstand pressures applied throughout its length when the sheathing is securely attached to the stud wall frame. Properly built and constructed shear walls will be strong and stiff enough to withstand horizontal forces.

- Refitting non-ductile reinforced concrete frame structures is a common usage for this technique.
- The additional components may be precast concrete or cast-in-place concrete.
- New components should ideally be positioned outside the structure.
- It is not recommended to use inside mouldings in the building.

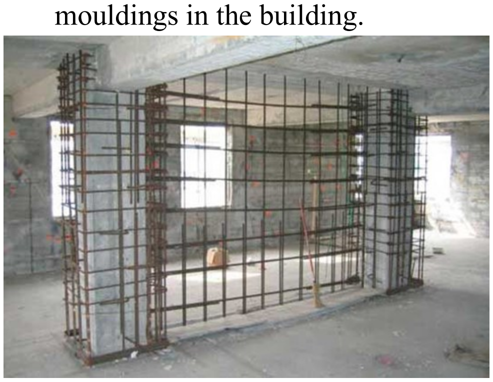


Fig 3.1 showing Additional Shear Wall

3.10. INFILL WALLS

The supported wall that encloses the outside of a building with a three-dimensional framework structure is called an infill wall; it is often composed of reinforced concrete or steel. Thus, although the infill wall fills the boxes of the outer frames and helps to divide inner and exterior space, the structural frame guarantees the bearing function. The infill wall's ability to support its own weight is a unique static function. An exterior vertical opaque closure type is the infill wall. In comparison to other types of walls, the infill wall is not the same as a load-bearing wall or a partition that separates two internal areas but is also non-load bearing. The latter serves the same hydro-thermal and acoustical purposes as the infill wall, but it also serves static purposes. RC frames with unreinforced masonry infill walls are often seen in developing nations with significant seismic activity. Because they may not be aware of the final distribution of these components or because masonry walls are thought of as non-structural features, engineers often overlook masonry infill walls during the design phase.

Because brick walls and frames are often not separated, they interact when there is significant ground motion. As a result, the structural reaction drastically deviates from the design's expectations.

For the buildings in the project that have open ground levels, adding brick infill walls is a feasible alternative. Of course, brick infill walls make the structure stronger and more rigid, but they don't make it more ductile. Shear walls may be formed from infill walls made of reinforced concrete masonry units.

The presence of dowels between a wall and the bounding frame is a crucial factor that determines the lateral strength of cast-in-place RC infill walls. Modular precast panels need less handling equipment and little on-site casting. Important connections must be made

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between the panels and the frame. Infill steel panels may be used as a substitute for bracing systems.

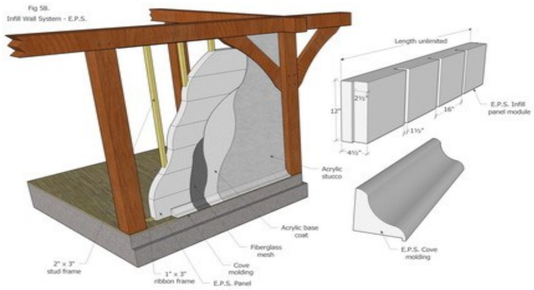

Fig 3.2 showing an Infill wall

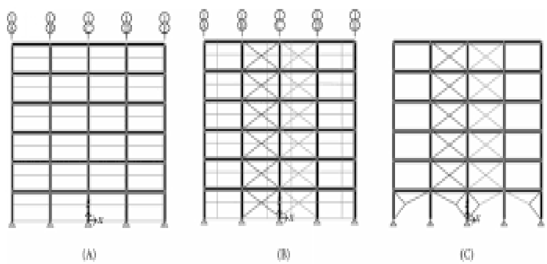

Fig 3.3 showing a structure retrofitted with bracings at various places

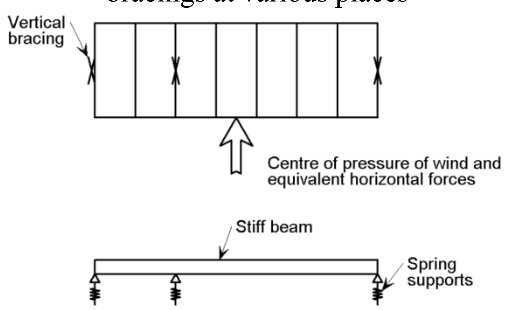

Fig 3.4 showing a Vertical bracing in a multi-Storey building

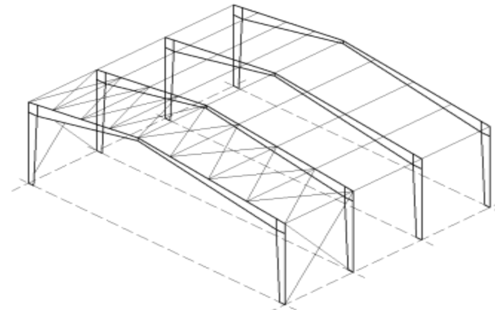

Fig 3.5 Horizontal bracing (in the roof) in a single Storey building

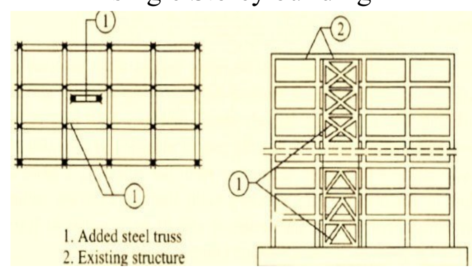

Fig 3.6 RC Building retrofitted by steel bracing

IV. EARTHQUAKE METHODOLOGY

4.1 EARTHQUAKE LOADING

The internal stresses of the building mass caused by a seismic disturbance shaking its base are known as earthquake loading. The translational inertial forces are the primary focus of earthquake-resistant design. These translational inertial forces have a greater impact on a structure than either the rotational or vertical shaking components. Other powerful earthquake forces include ground slide, subsidence, and liquefaction of the local subgrade due to vibration, among others. There is an inverse relationship between earthquake frequency and intensity. Even if a structure could be designed to withstand the worst earthquakes without suffering any damage, the large extra expense would not be justified by the building's lifetime requirement for such strength.

4.2 IMPORTANCE OF SEISMIC DESIGN CODES

Structures undergo deformations and stresses as a result of ground vibrations brought on by seismic activity. Therefore, buildings must be built to resist these kinds of stresses and deformations. Seismic codes aid in improving a structure's behaviour so that it can survive the impacts of an earthquake without suffering a large loss of life or property. Seismic codes in many nations provide guidelines for design engineers to follow while planning, creating, detailing, and building buildings.

4.3 ARCHITECTURAL FEATURES

Architects envision amazing and creative constructions in order to produce a structure that is both aesthetically pleasing and operationally effective. Sometimes the building's form draws a visitor in, and other times the structural system works in concert to create a marvel of a structure. Therefore, the selection of shapes and structures has a big impact on how well the structure performs during previous earthquakes across the globe. It's also highly instructive in determining which structural configurations are desired and which should be avoided.

4.4 SIZE OF BUILDINGS

High-rise structures with a considerable height to base size ratio experience significant horizontal floor displacement during ground shaking. The harmful effects of earthquake shaking are greater in structures that are short but extremely lengthy. Additionally, the horizontal seismic stress in large-plan structures, such as warehouses, may be too great for the walls and columns to support.

4.5 VERTICAL LAYOUT OF BUILDINGS

Any deviation or discontinuity in this load transfer path results in poor performance of the buildings, with a few stores wider than the rest causing a sudden jump in earthquake forces at the level of discontinuity. The shortest path is required to bring down the earthquake forces developed at different floor levels in a building along the height to the ground. Structures with an abnormally high storey or fewer columns or walls in that storey are more likely to sustain damage or collapse, which starts in that storey. During the 2001 Bhuj earthquake in Gujarat, several buildings with an open ground floor or basement that were used for parking either fell or suffered significant damage. Uneven height columns run the length of buildings over sloppy terrain, which may lead to problems like bending and damage to shorter columns. The weight transmission route is interrupted in buildings with columns that hang or float on beams at an intermediate storey and do not extend all the way to the foundation. Certain structures include reinforced concrete walls to support the foundation's weight during earthquakes; if these walls stop at a higher level rather than reaching the bottom, they are designed to sustain significant damage.

4.6 ADJACENT BUILDINGS

In the event of severe shaking, two buildings that are too near to one another may thud into one another. This collision may become a bigger issue as building height increases. It may be very hazardous when building heights are not equal since the roof of the lower building may pound at the middle of the taller structure's column.

4.7 DESIGN ASPECT

Anywhere there is a significant fault on the earth's surface, earthquakes may happen on land or at sea. When an earthquake strikes on land, it damages the surrounding metal structures, which might result in fatalities. Major earthquakes under the ocean or sea have an impact on nearby buildings, but they also create tsunamis, which are enormous tidal waves that have an impact on areas far from the source. In order to ensure that enough vertical and lateral strength and stiffness are attained to meet the structural criteria and permissible deformation levels specified in the governing building code, all of the structures are built for the combined impacts of gravity loads and seismic loads. The majority of buildings are often sufficiently secured from vertical shaking due to the inherent safety factor included into the design criteria. When designing big span structures or doing an overall stability study of structures, vertical acceleration should also be taken into account. The following three limit states are taken into consideration while

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designing a structure to withstand natural disasters like earthquakes or cyclones:

4.8 SERVICEABILITY LIMIT STATE

In this instance, the structure sustains little to no structural damage. Important structures that have an impact on a community, including hospitals, atomic power plants, gathering spots, etc., should be built to flexibly withstand anticipated seismic pressures. Even after an earthquake or typhoon occurs, these kinds of constructions need to remain functional.

4.9 DAMAGE CONTROLLED LIMIT STATE

In this instance, the structure may sustain some damage in the event of an earthquake or storm, but it may be restored even after the catastrophe has occurred. Since the majority of permanent structures should fall into this category, the structure should only be built for limited ductility response.

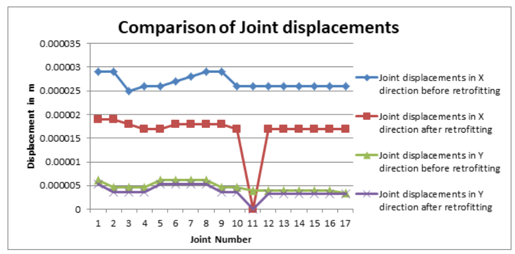
4.10 SURVIVAL LIMIT STATE

In this instance, the structure is permitted to sustain damage in the event of a storm or earthquake. However, in order to prevent the structure from collapsing in and causing fatalities, the supports must be able to withstand the constant stresses that are placed on it. We may accomplish the aforementioned behaviour by preventing the members from failing brittlely and making sure that supporting components, such as columns, do not collapse. Additionally, the building should be built to disperse earthquake energy by "full" ductile behaviour response.

V. RESULTS AND ANALYSIS

Joint displacements

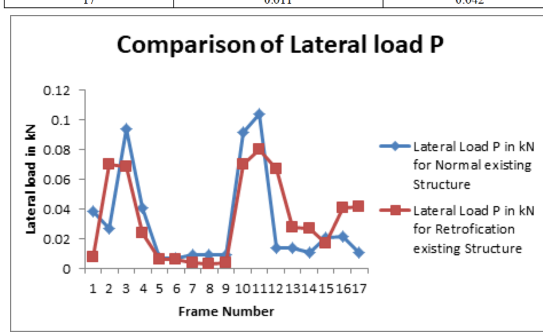
Joint Number	Load Case	Joint displacements in X direction before retrofitting	Joint displacements in X direction after retrofitting	Joint displacements in Y direction before retrofitting	Joint displacements in Y direction after retrofitting
1	RSA	0.000029	0.000019	0.000006251	0.000005358
2	RSA	0.000029	0.000019	0.000004643	0.000003652
3	RSA	0.000025	0.000018	0.000004639	0.00000366
4	RSA	0.000026	0.000017	0.000004627	3.667E-06
5	RSA	0.000026	0.000017	0.000006251	0.00000536
6	RSA	0.000027	0.000018	0.000006251	0.000005359
7	RSA	0.000028	0.000018	0.000006251	0.00000536
8	RSA	0.000029	0.000018	0.00000625	0.000005359
9	RSA	0.000029	0.000018	0.000004597	0.000003678
10	RSA	0.000026	0.000017	0.000004612	0.000003673
14	RSA	0.000026	0	0.000003978	0
15	RSA	0.000026	0.000017	0.00000397	0.000003251
16	RSA	0.000026	0.000017	0.000003983	0.000003236
17	RSA	0.000026	0.000017	0.00000398	0.000003262
18	RSA	0.000026	0.000017	0.000003971	0.000003254
19	RSA	0.000026	0.000017	0.000003948	0.000003235
20	RSA	0.000026	0.000017	0.000003464	0.000003183



Displacement Comparisons in Joints

Lateral load P

Frame Number	Lateral Load P in kN for Normal existing Structure	Lateral Load P in kN for Retrofication existing Structure
1	0.039	0.00751
2	0.027	0.07
3	0.094	0.069
4	0.041	0.024
5	0.006784	0.005964
6	0.006725	0.006368
7	0.009487	0.003679
8	0.009724	0.003611
9	0.009612	0.004184
10	0.092	0.07
11	0.104	0.08
12	0.014	0.067
13	0.014	0.028
14	0.011	0.027
15	0.021	0.017
16	0.022	0.041
17	0.011	0.042



Comparison of Lateral load P

Storey Shear

X Direction

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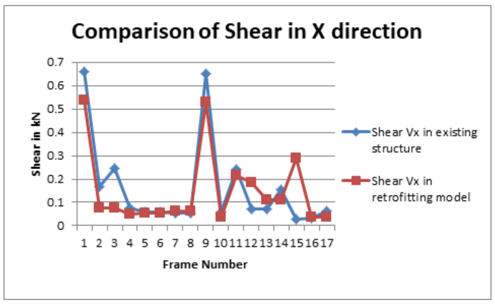
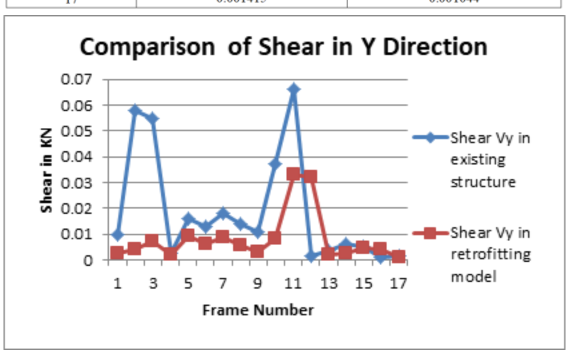
Frame Number	Shear Vx in existing structure	Shear Vx in retrofitting model
1	0.66	0.539
2	0.167	0.074
3	0.245	0.074
4	0.074	0.051
5	0.057	0.055
6	0.057	0.055
7	0.055	0.062
8	0.055	0.062
9	0.651	0.529
10	0.058	0.036
11	0.243	0.214
12	0.071	0.185
13	0.071	0.11
14	0.153	0.11
15	0.03	0.288
16	0.031	0.038
17	0.063	0.038



Y Direction

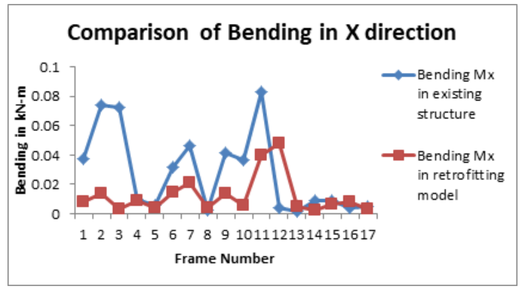
Frame Number	Shear Vy in existing structure	Shear Vy in retrofitting model
1	0.01	0.002568
2	0.058	0.004038
3	0.055	0.007033
4	0.002458	0.001969
5	0.016	0.00912
6	0.013	0.006134
7	0.018	0.008928
8	0.014	0.005941
9	0.011	0.003347
10	0.037	0.008087
11	0.066	0.033
12	0.001446	0.032
13	0.003778	0.002049
14	0.005981	0.002724
15	0.005067	0.004832
16	0.0009207	0.004258
17	0.001415	0.001044



Storey Bending

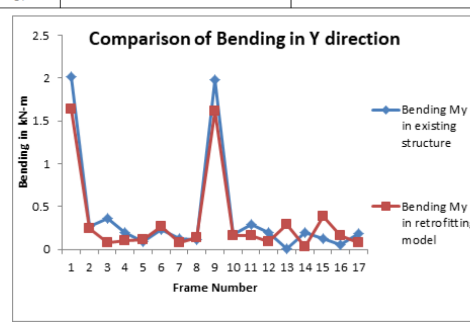
X Direction

Frame Number	Bending Mx in existing structure	Bending Mx in retrofitting model
1	0.0375	0.008
2	0.0738	0.0141
3	0.0728	0.0029
4	0.0096	0.0088
5	0.006	0.0036
6	0.0319	0.0148
7	0.0462	0.0209
8	0.0021	0.0036
9	0.0414	0.0139
10	0.0369	0.0055
11	0.0833	0.0395
12	0.0043	0.0479
13	0.0014	0.005
14	0.0089	0.0025
15	0.0087	0.0066
16	0.004	0.0077
17	0.0047	0.0033



Y Direction

Frame Number	Bending My in existing structure	Bending My in retrofitting model
1	2.0188	1.6424
2	0.2713	0.2459
3	0.3648	0.0804
4	0.2025	0.1061
5	0.0892	0.1157
6	0.2319	0.2687
7	0.1228	0.0753
8	0.1129	0.142
9	1.9772	1.6122
10	0.1747	0.1627
11	0.2971	0.1616
12	0.2041	0.0903
13	0.0107	0.2957
14	0.2039	0.0341
15	0.1263	0.3892
16	0.0519	0.1685
17	0.1818	0.0756



Building Torsion

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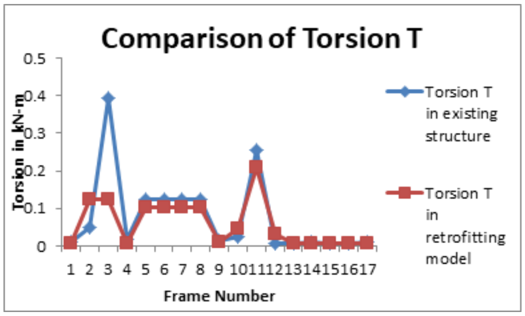
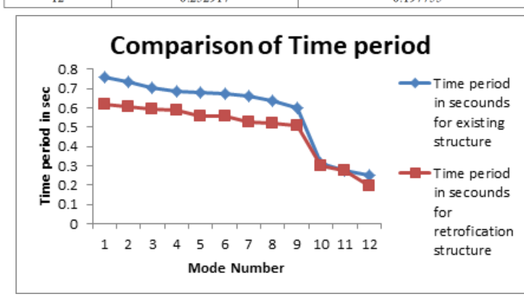
Frame Number	Torsion T in existing structure	Torsion T in retrofitting model
1	0.0109	0.0083
2	0.0503	0.1239
3	0.3955	0.1239
4	0.0166	0.0073
5	0.1251	0.1038
6	0.1251	0.1038
7	0.1245	0.1014
8	0.1245	0.1014
9	0.013	0.0097
10	0.0228	0.0446
11	0.2556	0.208
12	0.0078	0.0311
13	0.0078	0.0059
14	0.0087	0.0059
15	0.0079	0.0063
16	0.0079	0.0057
17	0.0087	0.0057



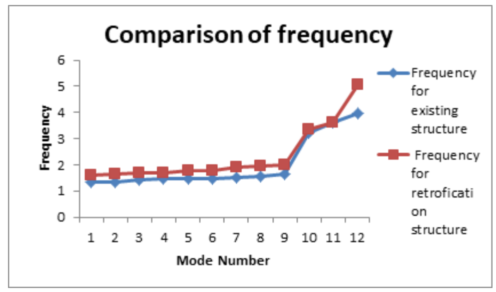
Time Period

Mode Number	Time period in seconds for existing structure	Time period in seconds for retrofication structure
1	0.758255	0.616615
2	0.735335	0.605778
3	0.704883	0.594992
4	0.687602	0.585646
5	0.678114	0.556233
6	0.674765	0.556143
7	0.660045	0.526662
8	0.638668	0.518104
9	0.600146	0.506095
10	0.309367	0.299687
11	0.276202	0.276779
12	0.252917	0.197755



Frequency

Mode Number	Frequency for existing structure	Frequency for retrofication structure
1	1.318818047	1.621757167
2	1.359923732	1.650770697
3	1.418675639	1.680695878
4	1.454330375	1.707516811
5	1.474678062	1.797807581
6	1.481997779	1.798098592
7	1.515048129	1.898752187
8	1.565758064	1.930116134
9	1.666260955	1.975914778
10	3.232403311	3.336812818
11	3.620533395	3.612989756
12	3.953869362	5.056755761



VI. CONCLUSION

The following findings were drawn from this investigation:

1. Following a thorough review of the literature and the revision of multiple Indian design projects for structural retrofit, it can be said that there are some outlines that aid in the design of a concrete jacketing retrofit scheme for a structure both qualitatively and quantitatively.
2. One efficient way to retrofit such connections is using reinforced concrete (RC) jacketing. The effectiveness of the RC jacketing approach for reinforcing weakly reinforced beam-column junctions is examined experimentally in this research.
3. An RC jacket was formed outside the column and the junction to strengthen a full-scale, minimally reinforced concrete beam-column sub-assembly. The improvement in the specimen's cyclic response brought about by the

retrofitting procedure was confirmed experimentally.

4. Response spectrum analysis is used in the modelling of the G+6 building with the aid of SAP 2000 software.
5. When comparing the retrofitting approach to the previous hospital building, the displacement, shear, bending, torsion, and time period values decrease.

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