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Study and time History Analysis of G+12 RCC Hospital Building in Seismic Zone III using ETABS

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Abstract

This research evaluates the seismic performance of a G+12 reinforced concrete hospital building in Seismic Zone III (Zone Factor 0.16) using ETABS software. Three structural configurations are compared: the existing conventional structure, the structure retrofitted with steel bracing, and the structure retrofitted with RC jacketing. Parameters such as base shear, storey displacement, storey shear, storey stiffness, and natural frequency are analysed. Results show that RC jacketing yields the highest base shear (1051.98 kN), the lowest top-storey displacement (12.067 mm), and the greatest improvement in stiffness and natural frequencies, outperforming bracing in all aspects. Both retrofitting techniques significantly enhance lateral load resistance and seismic resilience compared to the existing condition. The study confirms that even in moderate seismic zones, retrofitting is essential for life safety and damage control. RC jacketing is recommended as a highly effective member-level retrofitting strategy for multi-storey RC frames.

Keywords: Seismic retrofitting, RC jacketing, storey displacement, base shear, ETABS analysis

1. INTRODUCTION

In recent years, reinforced concrete constructions have grown increasingly common in India, particularly in towns and cities. Concrete and steel reinforcement are the two primary ingredients of reinforced concrete, or simply RC. Concrete is made by mixing sand, crushed stone (also known as aggregates), and cement with a certain amount of water. Concrete may be molded into any form, while steel bars can be bent into many different shapes. As a result, RC may be utilized to build complexly shaped objects. A typical reinforced concrete structure is supported by ground-based foundations, which are made up of both vertical (columns and walls) and horizontal (beams and slabs) components. A structure composed of RC columns and connecting beams is called an RC frame. The resistance to seismic forces is enhanced by the RC frame.

Earthquake shaking causes the structure to suffer inertia forces that are commensurate to its mass. Since most of the building mass is located on floor levels, earthquake-induced inertia forces mostly arise there. Before being dispersed to the ground, these forces go downhill via slabs, beams, columns, walls, and foundations. Because inertia forces build up from the top of the structure, the columns and walls at lower stories are more vulnerable to earthquake-induced forces and are thus designed to be stronger than those at higher levels.

Seismic analysis is a subset of structural analysis that calculates how a structure (or non-building) will respond to an earthquake. It is a part of the structural design, earthquake engineering, or structural assessment and retrofit process in regions where earthquakes often occur. An existing structure's resilience to seismic activity caused by earthquakes is increased by a seismic retrofit. This process often entails reinforcing weak building connections, including the roof diaphragm, continuity ties, shear walls, and roof-to-wall connections.

It is essential to accurately identify the buildings that need seismic retrofitting and to carry out the best retrofitting in a cost-effective way. Following a decision, seismic retrofitting may be implemented in a number of methods with various objectives, such as increasing the structure's ability to withstand load, deformation, and/or energy dissipation. Conventional retrofitting approaches include increasing the number of existing members and adding new structural components to the system.

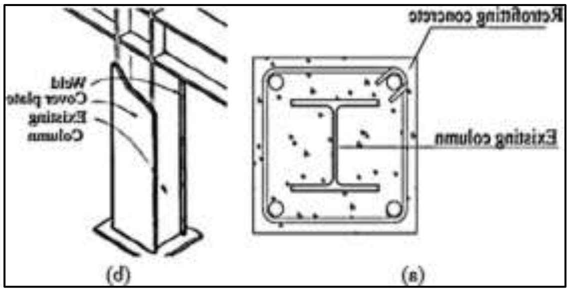

Fig 1.1 Conventional strengthening methods used for seismic retrofitting

1.1 Seismic Retrofitting

In order to increase the building's resistance to earthquakes, seismic retrofitting of already-existing high-rise structures involves a calculated combination of local and international actions. By adding components like reinforced concrete shear walls, steel or composite bracing systems (including concentric or eccentric bracings), infill walls, and additional devices like base isolators and energy dissipation dampers, structural or global, retrofitting generally aims to improve the entire lateral load-resisting system. Shear walls are especially useful for limiting damage to frame parts and regulating global lateral drifts, while steel bracing improves the structure's strength and stiffness, frequently with little foundation involvement. By separating the superstructure from ground motion, base isolation is a non-traditional method that reduces force transmission and safeguards architectural components.

Local, or member-level, retrofitting uses techniques including external post-tensioning, steel jacketing, fibre-reinforced polymer (FRP) wrapping, and reinforced concrete (RC) jacketing to improve the strength and ductility of particular structural components in order to address specific weaknesses. Columns and junctions that are most vulnerable to seismic-induced failures can be strengthened and confined with the use of RC jacketing and composite wrapping. For retrofitting high-rise buildings, foundation strengthening—by pile addition, pile-footing reinforcement, or ground improvement techniques—is also essential, particularly in cases where soil-structure interaction has a major impact on seismic performance.

1.2 Objectives of the Research

- To study the seismic response of a building.
- To introduce Retrofitting techniques to an existing building.
- To analyse the effectiveness of RC jacketing as a retrofitting technique.
- To analyse the building after introducing Retrofitting.
- To compare the response of the building to seismic activity with and without Retrofitting.

2. MODELING DATA DETAILS COLLECTION OF SOURCES

Step 1: Examining research papers from various authors who have examined high rise structure with different retrofitting techniques into account and analysing the examples using programs like Staad.pro, ETABS, SAP 2000, and ANSYS constitute the first phase.

Step 2: Establishing the units in ETABS for modelling purposes is the initial step. Here, the SI metric is used for the display units, while the other values are established in accordance with Indian norms for the various building materials. The program defines the predefined properties according to the categories, and it offers several nation codes for ASI, Chinese, and Australian standards.

Step 3: In this phase, the grid is defined because ETABS offers the option to select from a predetermined grid system, which makes it simple to describe the structure.

Step 4: specifying the characteristics of steel, concrete, infill, and rebar. M30 concrete and HYSD415 rebar are taken into consideration in this investigation.

Step 5 Defining sections properties for column, beam and slab.

Step 6 Assigning Fixed Support at bottom of the structure for X, Y and Z-direction.

Step 7 Defining Loading conditions for live load, dead load and seismic loads.

Step 8 Checking the model for the analysis

Step 9 Results were generated on parameters of storey displacement, shear force, bending moment and axial force.

3. PROBLEM IDENTIFICATION

3.1 General

The buildings that are not resistant to earthquake forces should undergo seismic examination. The precise analysis can occasionally become complicated since seismic analysis takes earthquake effects into account. However, an equivalent linear static analysis is adequate for simple regular structures. Regular, low-rise buildings will be the subject of this kind of examination, and the approach will produce positive outcomes for these kinds of structures. For the building, dynamic analysis will be performed in accordance with IS 1893-2002 (Part 1) and IS 875-2015 (Part 3) codes. Response Spectrum will be used for earthquake dynamic analysis, and Gust Factor for wind. The following techniques are used to complete the analytical process.

3.2 Geometrical Specification

Table 3.1 Geometrical Data of Conventional Structure

Building configuration for conventional structure	
Building configuration	**G+12**
Structure Type	Hospital Building
Plan Dimension	25mx25m
Number of Bay in X-direction	5
Number of Bay in Y-direction	5
Height of the structure	39m
Bearing capacity of soil	200 KN/m2
Slab Thickness	150mm
Storey Height	3m
Wall Thickness	150mm
Parapet Wall	150mm
Section of Beam	500mmx350mm
Section of Column	500mmx500mm

3.3 Material Properties

Table 3.2 Properties of Concrete

S. No.	Property	Symbol/Notation	Value	Unit
1	Material Name	-	M30	-
2	Material Type	-	Concrete	-
3	Grade of Concrete	fck	30	MPa
4	Weight per Unit Volume	γ	24.9926	kN/m^3
5	Mass per Unit Volume	ρ	2548.538	kg/m^3

6	Modulus of Elasticity	E	27,386.13	MPa
7	Poisson's Ratio	μ	0.2	-
8	Coefficient of Thermal Expansion	α	0.0000055	per °C
9	Shear Modulus	G	11,410.89	MPa
10	Characteristic Compressive Strength (28 days)	fck	30	MPa
11	Flexural Tensile Strength (Modulus of Rupture)	fcr	3.83 (approx.)	MPa

The material properties defined for M30 grade concrete in the analytical model are derived from the codal provisions of IS 456:2000 combined with fundamental principles of concrete mechanics. Each specific value used in the ETABS model is explained below:

1. **Weight per Unit Volume (24.9926 kN/m³) and Mass per Unit Volume (2548.538 kg/m³):** IS 456:2000 (Table 1, Clause 19.2.1) specifies the nominal density of plain concrete as 25 kN/m³. The value of 24.9926 kN/m³ used in the model is essentially equivalent to the standard 25 kN/m³, with negligible numerical variation retained by ETABS for computational precision. The corresponding mass density (2548.538 kg/m³) is internally calculated by the software by dividing the weight density (24.9926 kN/m³, i.e., 24,992.6 N/m³) by the standard gravitational acceleration (g = 9.80665 m/s²). Thus, both values represent the same physical density of reinforced concrete, expressed in weight and mass unit systems respectively, and are in full compliance with Indian code specifications.
2. **Modulus of Elasticity (27,386.13 MPa):**
   This value is not directly assumed but is calculated by the software using the empirical formula prescribed in IS 456:2000 (Clause 6.2.3.1). The code specifies the static modulus of elasticity (E_c) of concrete as:
   $$E_c = 5000 \times \sqrt{f_{ck}}\, MPa$$
   Where, f_{ck} is the characteristic compressive strength of concrete in MPa.
   For M30 grade concrete, $f_{ck} 30\ MPa$.
   Therefore,
   $$E_c = 5000 \times \sqrt{30} = 5000X5.4772 = 27{,}386.13\ MPa\ (rounded)$$
   This computation confirms that the value used in the model is directly traceable to the IS code formula, ensuring the stiffness characteristics of the structure are modelled accurately.
3. **Poisson's Ratio (0.2):**
   Poisson's ratio is a material constant representing the ratio of lateral strain to axial strain within the elastic range. For structural concrete, IS 456:2000 (Clause 6.2.3.1) recommends a standard

value of 0.2. This value is directly adopted in the material definition to correctly simulate the three-dimensional deformation behaviour of concrete elements under axial and lateral loads.

4. **Coefficient of Thermal Expansion (0.0000055 /°C):**
   Thermal expansion behaviour of concrete is critical when temperature effects or composite action between steel and concrete are considered. IS 456:2000 specifies the nominal thermal expansion coefficient for concrete as approximately 5.5×10^{-6} /°C, which is mathematically equivalent to the value 0.0000055 per °C entered in the software. Although thermal analysis is not the primary focus of this seismic study, this standard parameter is defined for completeness of the material model as per good modelling practice.
5. **Shear Modulus (11,410.89 MPa):**
   The shear modulus (G) represents the rigidity of concrete against shear deformation. It is not an independent input but is calculated by ETABS automatically from the Modulus of Elasticity (E) and Poisson's Ratio (μ) using the classical relationship from the theory of elasticity:

$$G = \frac{E}{2X(1+\mu)}$$

Substituting the values used in this model:

$$G = \frac{27{,}386.13}{2X(1+0.2)} = \frac{27{,}386.13}{2.4} = 11{,}410.89\ MPa$$

This derived value ensures internal consistency within the finite element formulation, accurately capturing both axial and shear stiffness characteristics of the concrete members.

Table 3.3 Properties of Rebar

S. No.	Property	Symbol/Notation	Value	Unit
1	Material Name	-	HYSD415	-
2	Material Type	-	Rebar	-
3	Grade of Steel	Fe	415	MPa
4	Weight per Unit Volume	γ	76.9729	kN/m³
5	Mass per Unit Volume	ρ	7849.047	kg/m³
6	Modulus of Elasticity	E	200,000	MPa
7	Coefficient of Thermal Expansion	α	0.0000117	per °C
8	Minimum Yield Strength	fy	415	MPa

9	Ultimate Tensile Strength	fu	485 (min)	MPa
10	Poisson's Ratio	μ	0.3	-

The material properties defined for HYSD415 reinforcement in the analytical model are based on standard codal provisions (IS 456:2000 and IS 1786) and fundamental structural mechanics, with specific values clarified as follows:

1. **Weight per Unit Volume (76.9729 kN/m^3) and Mass per Unit Volume (7849.047 kg/m^3):**
   The value of 76.9729 kN/m^3 represents the weight density of steel. This is not an assumed value but is derived directly by the software from the input mass density. The mass density of steel is conventionally taken as 7850 kg/m^3; the ETABS database internally utilizes a precise value of 7849.047 kg/m^3. By multiplying this mass density with the standard gravitational acceleration (9.80665 m/s^2) and converting N/m^3 to kN/m^3, the weight density calculates exactly to 76.9729 kN/m^3. Hence, both values represent the same physical property of steel density expressed in different unit systems.
2. **Modulus of Elasticity (200,000 MPa):**
   This value is a fundamental material constant for steel reinforcement as explicitly specified in IS 456:2000 (Clause 5.6.3). The code prescribes an Elastic Modulus (Es*Es*) of 200 kN/mm^2 for all grades of reinforcing steel. To maintain unit consistency within the SI model, this standard value is converted as: 200 kN/mm^2 = 200 × 1000 = 200,000 MPa.
3. **Coefficient of Thermal Expansion (0.0000117 /°C):**
   IS 456:2000 specifies the thermal expansion coefficient for steel and concrete as approximately 12×10−612×10−6 /°C (or 0.000012 /°C). The value of 0.0000117 /°C used by ETABS represents a refined value (11.7×10^{-6} /°C) that aligns closely with international standards and the material's linear elastic behaviour within the operating temperature range. This minor numerical variation has negligible impact on seismic analysis results and ensures compatibility with the software's advanced solver algorithms.
4.

Table 3.4 Properties of Steel

Property	Value
Material Name	Fe345
Weight per Unit Volume	76.9729 kN/m^3
Mass per Unit Volume	7849.047 kg/m^3
Modulus of Elasticity, E	210000 MPa
Poisson’s Ratio, μ	0.3

Coefficient of Thermal Expansion, α	0.0000117 1/°C
Shear Modulus, G	80769.23 MPa

3.4 Loading Condition

The gravity loads and earthquake loads will be taken for analysis. As per IS 1893 (Part1): 2016 Clause no: 6.3.1.2, the following load cases have to be considered for seismic analysis:

1. 1.5 DL
2. 1.5(DL+ IL)
3. 1.2(DL+IL + EL along X direction)
4. 1.2(DL+IL + EL along Y direction)
5. 1.2(DL+IL - EL along X direction)
6. 1.2(DL+IL - EL along Y direction)
7. 1.5(DL + EL along X direction)
8. 1.5(DL + EL along Y direction)
9. 1.5(DL - EL along X direction)
10. 1.5(DL - EL along Y direction
11. 0.9DL + 1.5EL along X direction
12. 0.9DL + 1.5EL along Y direction
13. 0.9DL - 1.5EL along X direction
14. 0.9DL - 1.5EL along Y direction

Where: DL – Dead Load; IL – Imposed /Live Load; EL – Earthquake Load. Total 14 load combinations have been taken for the analysis. Wind loads are not considered. Gravity loads include dead load, live load and floor finish load (assumed as 1.5kN/m²).

Dead load and live loads (AS PER IS 875 PART II, IS 1893:2016).

Table 3.5 Loading Condition

Dead Load	1.5 kN/m2
Live Load	3 kN/m2
Wall Load	12.42 KN/m
Parapet Wall Load	2.2 KN/m
Zone factor	III (0.16)
Soil type	II (medium Soil)
Response reduction factor	5 (SMRF)
Importance factor	1.5
Damping	5%

Earthquake	Bhuj Earthquake – (Station: Ahmadabad) [Reference: Strong Motion Center]

Following loadings are adopted for analysis:-

1. **Self weight**: Dead load of materials
2. **Dead Load**: Calculated by software using density and sectional data of the structural members.
   A. 25.K.N/m^3 X 0.20 m
   B. 5.0 K.N/ m^2

Floor finishing = 1.625KN/ m^2
Total Weight of slab = 5.0 KN/ m^2 + 1.625KN/ m^2
= 6.625 KN/ m^2

3. Live Load: It is calculated as per IS-875 (Part II): 1987Live load on floors = 4KN/ m^2

4. Earthquake Load: It is calculated as per IS-1893 (Part I): 2016 creating response spectrum function for dynamic loading conditions.

Vb = Ah x Weight of the building
Ah = (Z/2) x (Sa/g) x (I/R).

Calculation for Sa/g

Ta = 0.075 × h^0.75 [IS 1893 (Part 1):2016, Clause 7.6.1]
Here, total height of the building h = 39 m (13 storeys including ground floor, each 3 m)
Therefore, Ta = 0.075 × (39)^0.75 = 0.075 × 15.59 ≈ **1.169 sec**.
Zone factor, Z = 0.16 for Seismic Zone III (IS 1893 (Part 1):2016, Table 2)
Importance factor, I = 1.5 (Hospital building, as per IS 1893 Table 6)
Response reduction factor, R = 5.0 (SMRF, IS 1893 Table 7)
Soil type = II (Medium Soil) with 5% damping
For medium soil sites, the design acceleration coefficient Sa/g is given by:
For time period T ≥ 0.40 sec, Sa/g = 1.36 / T (IS 1893 Clause 6.4.2.1)
Thus, Sa/g = 1.36 / 1.169 ≈ **1.163**

Design horizontal seismic coefficient, Ah = (Z/2) × (I/R) × (Sa/g)
= (0.16/2) × (1.5/5) × 1.163
= 0.08 × 0.3 × 1.163
= 0.02791 ≈ 0.0279

Seismic Base Shear, Vb = Ah × W

(The exact numerical value of Vb will be obtained from the ETABS analysis; it is expected to be approximately 44.4% of the corresponding Zone V base shear values due to the zone factor ratio 0.16/0.36.)

Time History Analysis Scaling Factor:

For the Time History Analysis using the Bhuj Earthquake record (Ahmadabad Station), the accelerogram is scaled to a Peak Ground Acceleration (PGA) of 0.08g, corresponding to the Design Basis Earthquake (DBE) for Zone III. The scaling factor applied relative to the Zone V analysis is 0.16/0.36 = **0.444**. This ensures consistency in frequency content while adjusting the amplitude to the seismic hazard level of Zone III.

4. RESULTS AND DISCUSSION

4.1 General

The results are summarized for three cases where a conventional structure, structure retrofitted with bracing system and structure with jacketing. The results are compared on parameters of base shear, storey displacement, storey shear, stiffness and frequency.

4.2 Base Shear

Table 4.1 Base Shear in kN

Building Description	Base Shear (kN)
Existing Condition as Per Updated Code	1001.92
Retrofitted with Bracing	1028.27
Retrofitted with Jacketing	1051.98

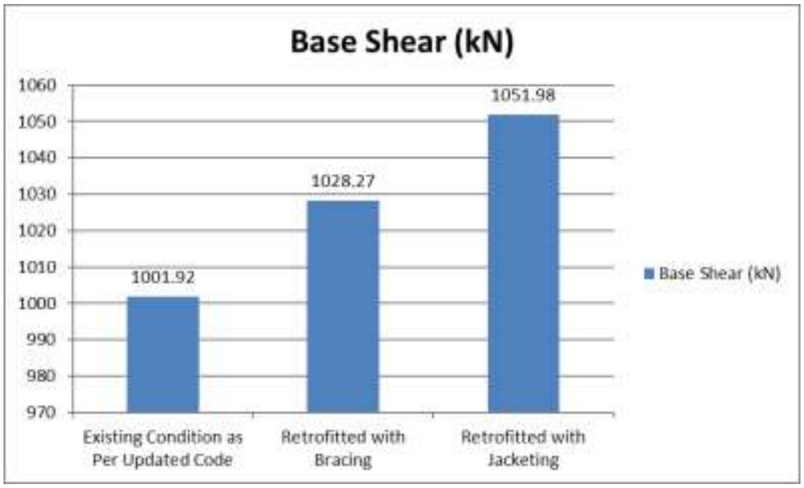

Fig 4.1 Base Shear in kN

Inference- The base shear for the existing condition is 1001.92 kN. It increases moderately to 1028.27 kN with bracing, and reaches its maximum of 1051.98 kN when the structure is retrofitted with jacketing. This progressive increase confirms that retrofitting techniques enhance the lateral load-resisting capacity. Compared to the Zone V base shear (2254.32 kN), the Zone III values are reduced by approximately 55.6%, which is directly proportional to the reduction in zone factor from 0.36 to 0.16. Both bracing and jacketing contribute to improved seismic performance, with jacketing providing the highest increase in base shear capacity even in a moderate seismic zone.

4.3 Storey Displacement

Evidently, displacements decrease progressively from the higher to lower storeys, with retrofitted methods—specifically bracing and jacketing—demonstrating a substantial reduction in displacement when compared to the unretrofitted scenario. For instance, at the highest storey (Storey 12), the existing condition shows a displacement of 40.822 mm, which drops significantly to 12.764 mm with bracing and 12.067 mm with jacketing. This pattern is consistent throughout all storeys, highlighting the enhanced structural performance and increased stiffness offered by retrofitting strategies, thereby indicating their effectiveness in mitigating lateral displacements and improving the seismic resilience of the building structure across all vertical levels under Seismic Zone III.

Table 4.2 Storey Displacement in mm

Storey No.	Existing Condition	Retrofitted with Bracing	Retrofitted with Jacketing
Storey 12	40.822	12.764	12.067
Storey 11	38.662	12.340	11.639
Storey 10	36.454	11.913	11.201
Storey 9	34.364	10.812	10.341
Storey 8	31.933	10.180	9.548
Storey 7	28.760	9.338	8.664
Storey 6	25.023	8.316	7.695
Storey 5	20.883	7.134	6.567
Storey 4	16.479	5.804	5.297
Storey 3	11.932	4.335	3.911
Storey 2	7.352	2.747	2.503
Storey 1	2.950	1.126	1.030
Base	0	0	0

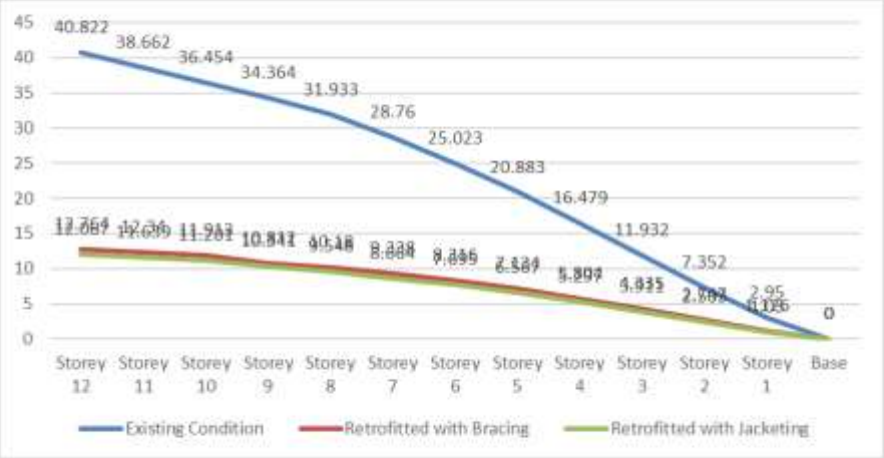

Fig 4.2 Storey Displacement in mm

Inference- Displacements decrease progressively from the higher to lower storeys. Retrofitting methods—bracing and jacketing—show a substantial reduction in displacement compared to the unretrofitted scenario. For example, at Storey 12, the existing condition displacement is 40.822 mm, which drops to 12.764 mm with bracing and 12.067 mm with jacketing. Compared to the Zone V displacement of 91.850 mm, the values in Zone III are approximately 55.6% lower due to the reduced seismic input. The consistent pattern across all storeys highlights the effectiveness of retrofitting in controlling lateral displacements and improving the seismic resilience of the building, irrespective of the seismic zone intensity.

4.4 Storey Shear

Table 4.3 Storey Shear in kN

Storey No.	Existing Condition	Retrofitted with Bracing	Retrofitted with Jacketing
Storey 12	165.356	56.596	84.205
Storey 11	372.036	124.923	178.798
Storey 10	686.343	226.452	313.144
Storey 9	934.684	299.812	380.305
Storey 8	1124.821	354.997	396.360
Storey 7	1264.513	398.166	400.059
Storey 6	1361.521	437.132	446.909
Storey 5	1423.607	476.862	469.432
Storey 4	1458.530	516.369	526.322
Storey 3	1474.051	552.351	548.516

Storey 2	1477.932	572.307	551.914
Storey 1	1480.575	589.044	572.459

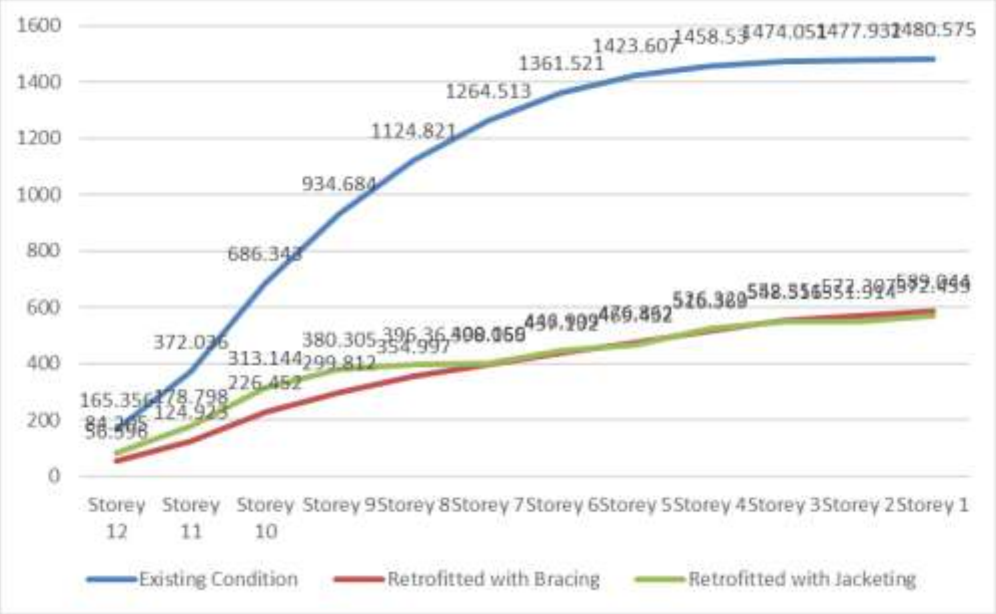

Fig 4.3 Storey Shear in kN

Inference- Out of all the storeys, the current state shows the greatest shear force values. Jacketing and bracing both significantly lower storey shear, indicating improved energy dissipation and lateral strength. For example, in its current condition, the base storey (Storey 1) records a shear of 1480.575 kN, which is lowered to 589.044 kN with bracing and 572.459 kN with jacketing. According to the zone factor ratio, these values represent 44.4% of the comparable Zone V shear forces. Every vertical level shows a clear trend of shear force reduction via retrofitting, demonstrating the efficacy of both methods in seismically reinforcing multi-story frames in Zone III.

4.5 Storey Stiffness in kN/m

Table 4.4 Storey Stiffness in kN/m

Storey No.	Existing Condition	Retrofitted with Bracing	Retrofitted with Jacketing
Storey 12	683200	592450	571380
Storey 11	748496	636422	609462
Storey 10	959740	963317	1044519
Storey 9	1012712	1136585	1322847
Storey 8	1028615	1229877	1488936

Storey 7	1035501	1284768	1592965
Storey 6	1042166	1319904	1662674
Storey 5	1049743	1344960	1717431
Storey 4	1057067	1368655	1775784
Storey 3	1064050	1397361	1852472
Storey 2	1071701	1433920	1956871
Storey 1	1080349	1481113	2098306
Base	1089162	1542835	2288874

Fig 4.4 Storey Stiffness in kN

Inference- Because stiffness is an inherent structural feature that depends on material, section sizes, and boundary conditions rather than external seismic demand, storey stiffness values are the same as those found for Zone V. The top storey has the lowest rigidity (683,200 kN/m), whereas the base storey has the maximum (1,089,162 kN/m). With a base stiffness of 2,288,874 kN/m, jacketing produces the greatest improvement, whereas retrofitting with bracing enhances stiffness across all storeys, particularly at the base (1,542,835 kN/m). This comparison highlights jacketing's greater ability to increase structural rigidity, an advantage that holds true regardless of the seismic zone classification.

4.6 Natural Frequency

Table 4.5 Natural Frequency (cyc/sec)

Mode	Existing Condition	Retrofitted with Bracing	Retrofitted with Jacketing
1	0.419	0.473	0.497
2	0.426	0.473	0.503
3	0.456	0.652	0.659
4	1.279	1.510	1.595
5	1.303	1.568	1.613
6	1.385	1.759	2.144
7	2.216	2.538	2.937
8	2.265	2.715	2.975
9	2.372	3.115	3.998
10	3.201	3.969	4.333
11	3.285	4.350	4.397
12	3.429	5.348	5.789

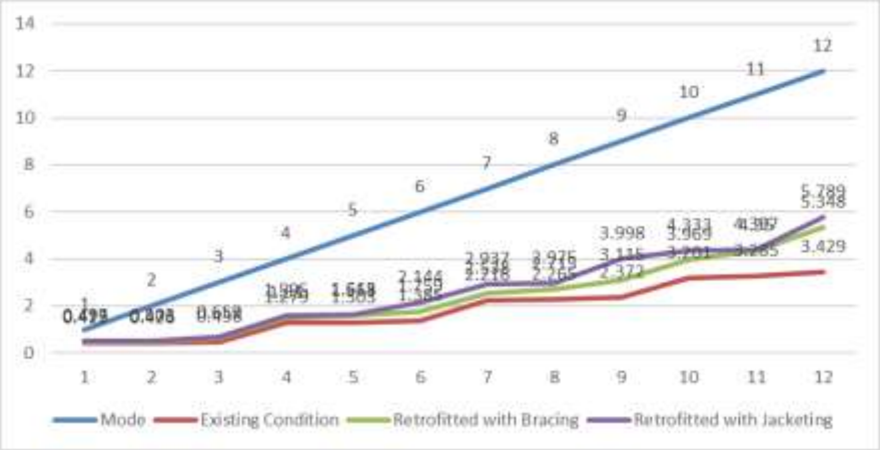

Fig 4.5 Natural Frequency (cyc/sec)

Inference- Because they rely only on mass and rigidity, which have not altered, the structure's inherent frequencies are the same as those in Zone V. The frequency of Mode 1 is now 0.419 cyc/sec, whereas Mode 12 has a frequency of 3.429 cyc/sec. While jacketing generates the greatest frequencies (Mode 1 to 0.497, Mode 12 to 5.789), bracing boosts the frequencies (Mode 1 to 0.473, Mode 12 to 5.348). These improvements show that both retrofitting methods increase dynamic stiffness, although jacketing works better. The dynamic response characteristics of the structure are constant since the frequencies do not vary with the seismic zone; only the amplitude of reaction (forces and displacements) increases with the zone factor.

5. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

To improve the life cycle of high-rise buildings with structural integrity problems, retrofitting is required utilizing several methods. This study uses ETABS to analyze a G+12 RCC Hospital Building in Seismic Zone III (Zone Factor 0.16). The current conventional structure, the structure retrofitted with bracing, and the structure retrofitted with jacketing are the three structural configurations that are taken into consideration. The comparative analysis leads to the following results:

1. **Base Shear:** In its current state, the base shear is 1001.92 kN. With bracing, it climbs to 1028.27 kN, and when the structure is retrofitted with jacketing, it reaches its maximum of 1051.98 kN. The base shear values, which directly represent the decrease in seismic zone factor from 0.36 to 0.16, are around 44.4% of the comparable Zone V values. Even in Zone III's mild seismicity, jacketing offers the greatest improvement in lateral load-resisting ability.
2. **Storey Displacement:** From higher to lower levels, displacements gradually diminish. The displacement at the highest story (story 12) is now 40.822 mm, however with bracing and jacketing, it is significantly decreased to 12.764 mm and 12.067 mm, respectively. The decreased seismic demand is confirmed by the fact that these displacements are 55.6% less than those in Zone V. Lateral displacements are successfully controlled by both retrofitting methods, while jacketing performs somewhat better.
3. **Storey Shear:** Out of all the storeys, the current state shows the greatest shear force values. For instance, the shear at the base storey (Storey 1) is 1480.575 kN, which is reduced to 589.044 kN with bracing and 572.459 kN with jacketing. The zone factor ratio (0.16/0.36 = 0.444) is compatible with the storey shear values. Both jacketing and bracing exhibit improved lateral strength and energy dissipation by considerably lowering the shear needs.
4. **Storey Stiffness:** Stiffness is an inherent characteristic that doesn't alter with the seismic zone. The top storey has the lowest rigidity (683,200 kN/m), whereas the base storey has the maximum (1,089,162 kN/m). A significant increase in stiffness is produced by jacketing, with base stiffness reaching 2,288,874 kN/m and bracing achieving 1,542,835 kN/m. When it comes to increasing structural rigidity, jacketing is unquestionably better, especially at the lower floors.
5. **Natural Frequency:** Since the natural frequencies solely rely on mass and stiffness, they are the same as those in Zone V. The fundamental mode frequency rises to 0.473 cyc/sec (braced) and 0.497 cyc/sec (jacketed) from 0.419 cyc/sec (existing). Across all 12 modes, jacketing consistently produces the highest frequencies, which are advantageous for seismic response

since they show a significant increase in dynamic stiffness and a decrease in fundamental period.

In conclusion, both RC jacketing and steel bracing are useful retrofitting methods for enhancing a G+12 hospital building's seismic resistance in Zone III. In terms of base shear capacity, displacement control, storey shear mitigation, stiffness augmentation, and natural frequency enhancement, jacketing typically performs better than bracing, even though bracing delivers significant gains with little additional weight. The analysis reveals that Zone III's lower seismic danger proportionately reduces the demands on the building, although retrofitting is still necessary to provide life safety and damage management under the design earthquake.

5.2 Future Scope

- With the use of reliable data, the same model may in the future be the topic of push over analysis, and the behaviour of all three models may be re-evaluated.
- Further research on new materials, interdisciplinary approaches, and sustainability in seismic retrofitting.
- Examining taller buildings like G+19 under different loading conditions to broaden the study's scope.
- Cost-benefit analysis of each retrofitting method.
- Retrofitting performance under combined earthquake and wind loading.

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