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# Seismic Analysis of a Building with and Without Retrofitting

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**ABSTRACT:** This study presents a comprehensive seismic analysis of a building, initially a ten-story (G+10) structure, both before and after retrofitting measures. Non-destructive testing (NDT) was conducted, revealing significant deficiencies in column and beam integrity. Retrofitting was implemented by upgrading the building to M30 grade concrete. Column dimensions were increased uniformly by 75mm on all sides to enhance structural integrity. Various seismic analysis techniques, including static equivalence analysis, response spectrum analysis, and time history analysis, were performed using ETABS software. This study compares and evaluates the seismic performance of the building before and after retrofitting, shedding light on the effectiveness of the retrofitting strategies.

**KEYWORDS:** Seismic Performance | Retrofitting | ETABS | Static equivalence analysis | Response spectrum analysis | Time history analysis | NDT.

## I. INTRODUCTION

In regions prone to seismic activity, retrofitting plays a critical role in enhancing structural resilience against earthquakes. Retrofitting involves modifying existing structures to improve their ability to withstand seismic forces, thereby reducing potential damage. Conversely, in areas with low seismic risk, such measures may not be as necessary, as structures typically adhere to standard building codes and design practices without specific seismic retrofitting. Retrofitting in seismic zones is motivated by the need to safeguard lives, property, and infrastructure from earthquake-related hazards. This process entails a thorough evaluation of existing structures, identification of vulnerabilities, and the implementation of strengthening measures. In contrast, construction practices in non-seismic zones may prioritize factors like cost efficiency and aesthetics, with seismic considerations taking a backseat due to the lower earthquake risk. Overall, retrofitting serves as a proactive strategy in seismic zones to fortify structures against earthquake damage, while construction practices in non-seismic zones may focus on other aspects given the reduced seismic threat. In India, retrofitting existing buildings and addressing their structural safety concerns have not received sufficient attention. Currently, there are no established guidelines or codes of practice for retrofitting in the country. The methods for seismic assessment of existing buildings are also underdeveloped. Over the past two decades, however, there has been increasing research on repair and retrofitting. Various techniques have been developed and utilized in practice.

These retrofitting techniques primarily focus on:

a) Enhancing the lateral strength of the structure. b) Improving the ductility of the structure. c) Increasing both strength and ductility.

While these approaches aim to bolster the resilience of structures against seismic forces, there's still a need for standardized guidelines and codes to streamline retrofitting practices in India.

### Seismic Retrofitting

Seismic retrofitting is a critical issue with significant political and social implications, particularly for constructions vulnerable to earthquakes. In Italy, despite being located in areas historically considered high seismic hazard zones, much of the building stock remains susceptible to seismic action. Over the past three decades, Italy has experienced moderate to severe earthquakes every 5 to 10 years, highlighting the vulnerability of its buildings and built environment. The recurrence of these events underscores the long-known seismic hazard in affected areas.

Seismic retrofitting involves upgrading existing structures to enhance their resistance to seismic loading, ground motion, and soil failure caused by earthquakes. Various strategies are employed for this purpose, including reducing seismic demands on structural elements and overall structures, as well as improving member stiffness, ductility, and overall strength. The choice of retrofitting strategy depends on factors such as material availability, cost considerations, technological feasibility, project deadlines, and architectural, aesthetic, and functional constraints.

Addressing seismic retrofitting comprehensively is essential to mitigate earthquake risks and ensure the safety and resilience of structures and communities

### Need for Seismic Retrofitting

- Ensuring the safety and security of buildings, employees, structural functionality, machinery, and inventory is paramount.
- It is crucial to mitigate hazards posed by non-structural elements.
- Retrofitting primarily focuses on structural enhancements to mitigate seismic risks.
- Priority should be given to strengthening critical buildings, such as hospitals, whose services are deemed essential immediately following an earthquake.
- Retrofitting techniques aim to upgrade the lateral strength, increase ductility, and enhance the lateral stiffness of structures.

## II. LITERATURE REVIEW

The study examines buildings with an "open ground" design, characterized by flexible ground floors and increased horizontal movement during earthquakes, using ETABS software for analysis of floor displacement and drift<sup>[1]</sup> This research program aims to create a Seismic Retrofit Manual, addressing the lack of national expertise on seismic retrofitting for multi-storey buildings. It focuses on different building classes based on age and construction materials, with the goal of improving community resilience and safety during earthquakes. The manual's findings will be shared through educational programs, contributing to economic benefits by preventing building damage and ensuring social benefits through saved lives. Rehabilitation involves preserving historical, cultural, or architectural values while making properties compatible for use<sup>[2]</sup>. The paper offers a thorough examination of seismic analysis, design, and retrofit practices, encompassing background on building response to earthquakes, legal design standards, retrofit procedures, case studies, and technical validation through laboratory tests and finite element analysis<sup>[3]</sup> They have provided a study focuses on re-engineering seismic analysis. It proposes a new self-based trust code for constructive behaviours. Addressing earthquake vulnerabilities in the Kashmir region, which has experienced significant seismic activity, including a major earthquake in 2005 (M 7.2). The concept emphasizes the need for adherence to earthquake resistance principles and BIS guidelines in developing countries. It aims to assess existing structures in Kashmir, particularly vital ones like health facilities and schools, proposing scientific and technological solutions for their retrofitting and economic reorganization. The goal is to create user-friendly, reusable, high-quality structures for Kashmir<sup>[4]</sup> The study emphasizes the necessity of seismic protection in Indian buildings, advocating for innovative retrofitting techniques like Fiber Reinforced Polymers to enhance structural resilience and mitigate long-term disaster risks<sup>[5]</sup> The paper highlights the vulnerability of existing reinforced concrete structures to earthquakes due to outdated design standards, advocating for seismic retrofitting as the primary solution. It employs advanced analysis techniques and discusses various retrofitting methods, emphasizing the importance of achieving enhanced strength and ductility to exceed seismic requirements for effective risk mitigation<sup>[6]</sup> The research evaluates and strengthens a seven-storey building in Stockholm using innovative retrofitting methods to improve seismic resilience, showcasing the efficacy of steel bracings and prefabricated reinforced concrete walls in reducing displacements and enhancing structural performance<sup>[7]</sup>

## III. METHODOLOGY

### Methods use for structural analysis on Etabs:

1. Prepare AutoCAD centreline plan
2. Import in Etabs
3. Define material properties, section properties, load patterns load cases, diaphragms, mass source, RS function, TH function
4. Draw Beam, Columns, Slab
5. Assign Frame load, shell load, joints restraints
6. Analysed the models, Set active of freedom
7. Set load cases to run
8. Run Analysis, last analysis run log
9. By using static and dynamic analysis
  1. Equivalent static analysis: Base Reaction, Scale Factors
  2. Response spectrum analysis: Story displacement, Story Drift, Story Shear,

Overturning, Stiffness

1. And check seismic result.

### Design data

In this project we consider the following data from IS-1893-2016.

1. Type of Structure : Multi Storied G+10  
(Special RC Framed Structure)
2. Seismic Zone : III (Table 2. IS 1893 Part 1: 2016)
3. Town : Nashik
4. zone factor : 0.16
3. Number of Stories : (G +10)
4. Floor Height : 3.m
5. Imposed Load : 3 KN/m<sup>2</sup> (Typical Floor)
6. Imposed Load : 1.5 KN/m (Roof Floor)
7. Materials : Concrete M25 and M30 and Reinforcement  
(Fe 500)
8. Size of Columns : (400 x 650) mm
9. Jacketing width : 75mm
10. Retrofitted columns : (600x750)mm
9. Size of Beams : (300 x 600) mm
10. Depth of Slab : 150 mm thick
11. Specific Wt. of RC Slab : 25 KN/m
12. Specific Wt. of RC bricks : 20 KN/m
13. Type of Soil : Medium SOIL
14. Response Spectra : As per IS 1893 (Part I: 2016)
15. Time History : Compatible to IS 1893 (Part I - 2016)  
Spectra at Medium Site as per 5% Damping
16. Height of structure : 33.6m

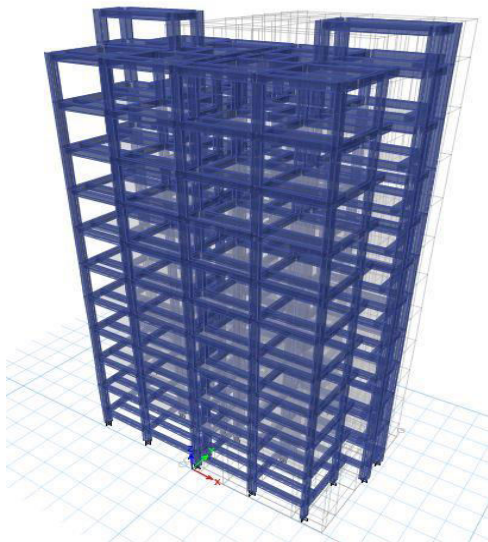


Fig 1 With Retrofitting Building

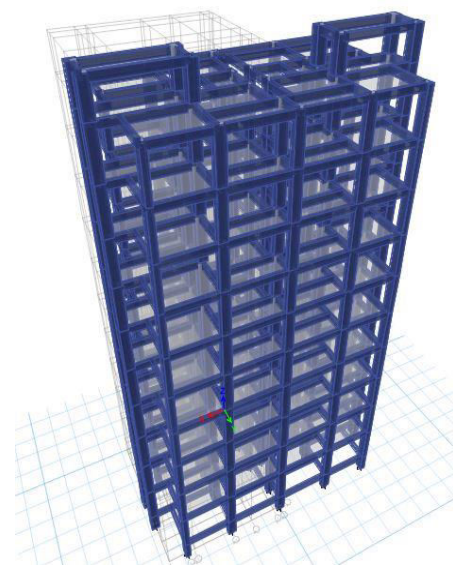


Fig 2 Without Retrofitting Building

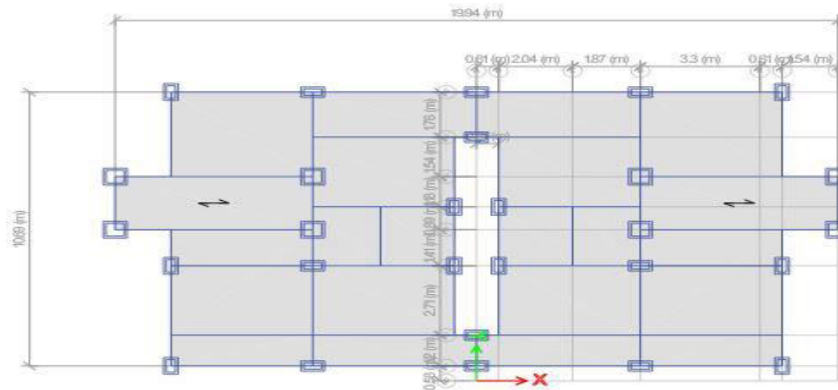


Fig 3 Grid plan of typical floor

#### IV. ANALYTICAL RESULT

Table I-Seismic Analysis for Without Retrofitting

	Equivalent static analysis	For response spectrum method
Story Displacement (mm)	148.92	25.27
Story drift(mm)	0.006014	0.001095
story Shear (KN)	0.00012	1633.98
Overturning (KN.m)	0.00001	31811.05

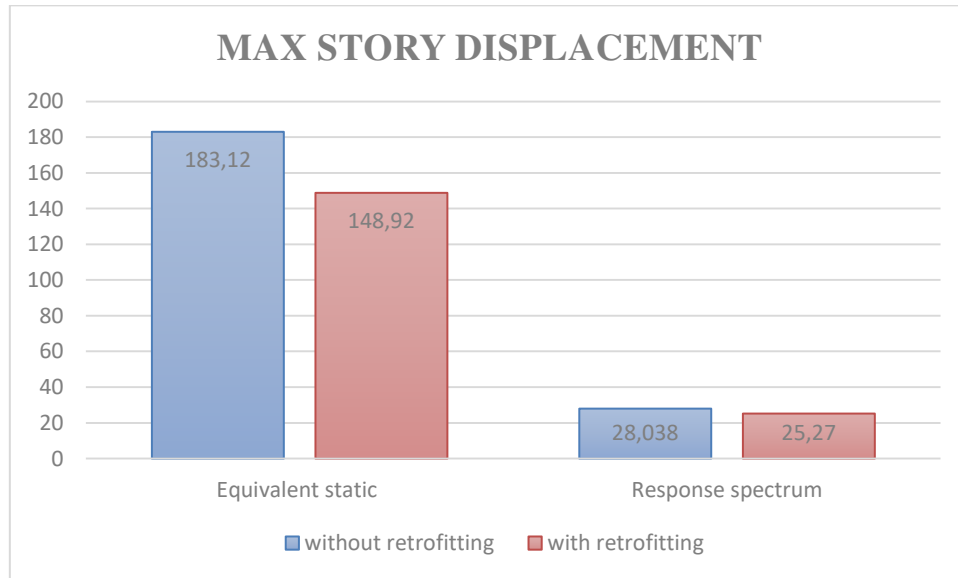
Table II-Seismic Analysis for With Retrofitting

	Equivalent static analysis	For response spectrum method
Story Displacement (mm)	183.72	28.0388
Story drift(mm)	0.007385	0.001255
story Shear (KN)	0.000000197	1510.668
Overturning (KN.m)	0.000001	29634.94

#### Storey displacement comparison

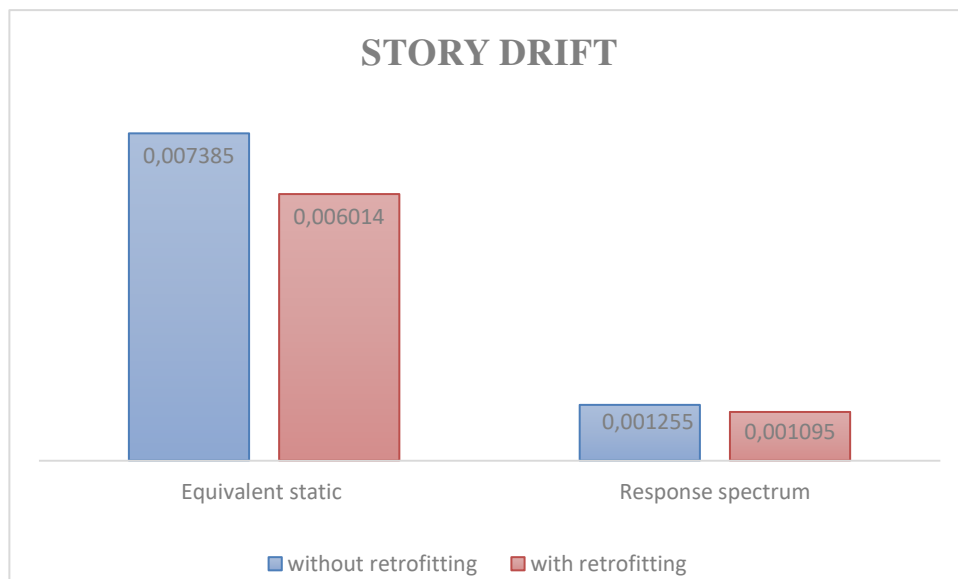
In Equivalent static analysis the maximum storey displacement was significantly lower in the RC frame with retrofitting (148.92 mm) compared to the bare RC frame (183.12mm), and in response spectrum method the maximum

storey displacement was significantly lower in the RC frame with retrofitting (25.27 mm) compared to the bare RC frame (28.038mm)



## 2. Story drift comparison

In Equivalent static analysis the maximum storey drift ratio was found to be significantly higher at 0.007385mm in reinforced concrete (RC) frames with retrofitting, compared to just 0.006014mm in bare without retrofitting. In response spectrum the maximum storey drift ratio was found to be significantly higher at 0.001255mm in reinforced concrete (RC) frames with retrofitting, compared to just 0.001095mm in bare without retrofitting. This notable decrease in the storey drift ratio in bare RC frames can be attributed to their increased stiffness relative to RC frames that include with retrofitting.



## V. CONCLUSION

Based on the seismic damage assessment results, the following conclusions can be drawn:

1. Incorporating with retrofitting significantly reduces maximum storey displacement, indicating enhanced lateral stiffness.

2. ETABS was used to study the deformation of building structure when subjected to seismic load.
3. With retrofitting exhibit minimal storey drift ratio, reflecting their inherent stiffness
4. With retrofitting overturning moment is high than the without retrofitting structure in seismic analysis methods.
5. Base shear increases with retrofitting column due to greater stiffness, emphasizing the importance of structural rigidity.
6. The time period of the structure decreases with retrofitting, indicating their higher stiffness.
7. Storey shear is notably lower in bare RC frames, suggesting reduced lateral forces and potential structural stress.
8. Overall, with retrofitting method effectively boost lateral stiffness, minimize displacements, and distribute seismic forces uniformly.
9. Retrofitting building helps handle more movement which is crucial for surviving earthquake.

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