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Retrofitting of an Existing Open Ground Storey Building Using Shear Walls

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ABSTRACT: Using the retrofitting techniques mentioned here, natural disasters like cyclones, tornadoes, and strong winds from thunderstorms can be reduced. Currently, seismic retrofitting mainly focuses on strengthening buildings to lower earthquake risks, but reducing damage from non-structural elements is equally important. Even with good design or later improvements, no structure can be completely earthquake-proof. In this project, an attempt has been made to strengthen an existing G+4 building using external shear walls. These shear walls are placed parallel to the outer walls of the structure. Many old and existing buildings in India were either not designed to withstand earthquakes or have already been damaged, making them vulnerable to future quakes. There are various methods to improve these buildings to minimize earthquake damage, and adding shear walls is one of the most effective and simple solutions. To evaluate the strength and performance of the building, this project follows the equivalent static and dynamic analysis methods as per Indian Standards. The addition of shear walls has improved the building's strength, stiffness, and earthquake resistance.

KEYWORDS: Retrofitting, Open Ground Storey (OGS) Buildings, Shear Walls, Soft Storey Effect, Seismic Performance, Lateral Stiffness, Structural Vulnerability, Seismic Retrofitting

I. INTRODUCTION

Earthquakes have the most significant impact on civil structures, especially high-intensity earthquakes that severely affect RCC buildings. Among these, soft-storey buildings are highly vulnerable and can collapse easily. After the Nepal earthquake, many neighboring countries updated their building codes, making newly designed buildings safer. However, the challenge remains for existing structures that were built before these updates. Earthquakes occur due to sudden movements in the Earth's crust at fault zones, releasing strain energy and generating seismic waves. These waves cause ground shaking, which is the primary concern for structural engineers. Historical and geological earthquake records help estimate the likelihood of ground shaking at a specific location, which is used to develop seismic hazard maps. Unlike other structural loads, earthquake forces are dynamic rather than static. When the ground shakes, the building above the ground does not experience any direct applied force; instead, earthquake forces are generated due to the building's inertia. Engineers use design response spectra, such as those specified in ASCE-7, to predict how structures will react to earthquakes. Seismologists and geotechnical engineers determine the maximum response of a structure based on specific ground motion, using response functions like acceleration, velocity, or displacement. The main goal of earthquake-resistant design is to prevent building collapse and reduce the risk of injury or death. Since severe earthquakes have a low probability of occurring within a building's lifetime, traditional structural design does not allow stresses to exceed the elastic limit. However, in earthquake-resistant design, structures are designed to go beyond the elastic limit, using ductility and energy dissipation to avoid collapse. If buildings were designed to remain fully elastic during strong earthquakes, they would require highly expensive lateral load-resisting systems. Instead, engineers rely on controlled inelastic deformation to ensure structural safety during major seismic events. Seismic activity poses a significant threat to buildings, especially in regions prone to earthquakes. Open Ground Storey (OGS) buildings, commonly found in urban areas, are highly vulnerable to seismic forces due to their lack of lateral stiffness at the ground level. The absence of infill walls in the ground storey, often used for parking or commercial spaces, creates a "soft storey" effect, making these structures susceptible to collapse during strong

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earthquakes. The devastating impact of past earthquakes has highlighted the need for strengthening such buildings through effective retrofitting techniques. Retrofitting is a crucial strategy to enhance the seismic resilience of existing buildings that were not originally designed to withstand earthquake forces. Among various retrofitting methods, the addition of shear walls has been proven to be one of the most effective and practical solutions. Shear walls provide lateral stiffness, improve load distribution, and significantly enhance the overall structural integrity of buildings.

This study focuses on retrofitting an existing G+4 OGS building using external shear walls. The shear walls are strategically placed parallel to the outer walls of the structure to improve its seismic performance. The project evaluates the structural behavior using equivalent static and dynamic analysis methods as per Indian Standard (IS) codes. The primary objective is to mitigate the risks associated with soft storey failures and ensure the safety and longevity of the building.

II. LITERATURE REVIEW

[1] Analysis And Design of A Multi Storey Building with Flat Slab (C+G+9) Using ETABS Syed Asim Aman, Mohd Abdul Khaliq , Mohd Jameel Uddin , Syed Imranuddin , Syed Khaja Rizwanuddin5, Syed Sabeel Pasha [2018]- A widely used method of concrete building construction employs a flat concrete slab as the floor system, eliminating the need for beams. This system is straightforward to construct and efficient, as it minimizes the overall building height for a given number of stories. However, past earthquake events have revealed its vulnerability to failure when not properly designed and detailed. The primary risk involves the thin concrete slab fracturing around the supporting columns, causing a progressive collapse where one floor cascades onto the floors below. Although flat slab construction has been in use for over a century, its analysis and design remain active areas of research, with no universally accepted design approach. The current Indian Standard Code (IS 456:2000) provides design guidelines primarily for flat slabs with regular geometry and layouts. However, modern construction often deviates from regular configurations due to space constraints, height limitations, and other practical considerations. Additionally, the seismic behavior of flat slabs remains a critical concern. This study evaluates the lateral behavior of a typical flat slab building designed according to IS 456:2000 using dynamic analysis. The performance of flat slab structures is compared with conventional beam-column framing to identify potential inadequacies. A grid slab system is selected for comparison, and the effect of drop panels on flat slab behavior under lateral loads is analyzed using a flat plate system. Furthermore, key factors such as seismic zone classification and soil conditions, which significantly influence structural response, are examined. ETABS software is utilized for this analysis, and the study establishes relationships between the number of stories, seismic zone, and soil conditions, providing valuable insights into the structural performance of flat slab systems under lateral loads.

[2] Comparative Analysis of Design Methodologies for Design of Gravitational RCC Framed Structure via Using Staad Pro Series 4.0 and E-Tabs 2015 Rishanksharma ,Mahendra Saini [2019]- With advancements in technology, the use of computers has become essential in every field, including structural engineering. Modern structural design heavily relies on specialized software to enhance efficiency and accuracy. Among the most widely used structural design software are ETABS and STAAD.Pro. In this research, we design a reinforced concrete (RCC) framed structure according to IS 456:2000, considering only gravitational loads—i.e., live load and dead load—without the influence of lateral forces such as seismic or wind loads. The structural design is carried out using both ETABS and STAAD.Pro, following a systematic approach to compare their methodologies and performance. The study is structured into key aspects of the design process, including graphical user interface (GUI), modeling, properties assignment, loading, analysis, and design. Each of these aspects is evaluated to compare the user experience, accessibility, modeling efficiency, application of material properties, load assignment, and computational approach in both software. Additionally, the research highlights the advantages and limitations of each software, identifies potential challenges encountered during the design process, and analyzes how each software responds to those challenges. Based on these comparisons, we determine which software is more suitable for designing a gravitationally loaded RCC structure and provide insights into their respective strengths and weaknesses.

[3] Wilkinson et al - A nonlinear plane-frame model is presented, capable of analyzing high-rise structures subjected to seismic forces. The model represents each floor of the structure as an assembly of vertical and horizontal beam elements. It incorporates yield hinges with ideal plastic properties in a typical plane frame configuration. The displacements are represented by the lateral translation of each floor and the rotation of beam-column intersections. The mass is primarily associated with these translations, allowing the analysis to be performed as a static condensation of the rotations, combined with the integration of dynamic equations for translations. The dynamic integration is carried out using the Runge–Kutta method. This approach enables the structure to be modeled with m(n + 2) degrees of freedom, where m represents the number of stories and n denotes the number of bays. The condensed stiffness matrix has a dimension of approximately m, and its formulation requires the inversion of a motion-related stiffness matrix of rank m(n + 1). However, this inversion is only necessary at time steps where the yielding pattern differs from the previous step. This model is particularly effective for nonlinear response history analysis of tall structures, as it is computationally efficient, allows for different redundancies at each floor, and accommodates various connection configurations. Three validation examples are provided, comparing static pushover analysis results with time-history analysis results obtained from the simplified model. The outcomes confirm that the proposed model is well-suited for nonlinear response history analysis of typical high-rise buildings.

[4] Naser, M The first essential in basic designing is that the style of simple fundamental components and individuals from structure viz., pieces, bars, sections and footings. the essential advance in any style is to settle on a choice the mastermind of the genuine structure. the arrangement of pillars and segments square measure decided. At that point the vertical hundreds like dead The greater part of the sections structured amid this task were thought of to be pivotally stacked with uniaxial twisting. At long last, the footings square measure structured bolstered the stacking from the section and conjointly the dirt bearing capacity cost for that singular space. All component parts square measure checked for quality and strength. The structure was abdominal muscle initio planned according to IS 456: 2000 while not considering quake hundreds abuse STAAD.pro PC code. At that point the structure was broke down for seismic tremor hundreds according to Equivalent static examination procedure and once getting the base shear according to IS1893.

[5] Mohammad Adil Dar, et al. Catastrophes are unpredicted activities which have negatively influenced human's existence due to the fact that the start of the day of our reality. due to such occasions, there have been endeavors to alleviate overpowering impacts of these fiascos. results of such endeavors are very guide in urbanized countries however tragically and miserably terrible in developing international locations collectively with our personal. Seismic tremors are one of the nature's most outstanding dangers on our planet that have taken overwhelming toll on human lifestyles and belongings considering the fact that antiquated activities . The abrupt and sudden nature of the tremor event aggravates it even on mental dimension and shakes the lesson of the overall populace. man views the mom earth for safety and power beneath his feet and whilst it itself trembles, the stun he receives is in reality scary. Notwithstanding the primary seismic tremor configuration IS code 1893 the BIS (Bureau of Indian Standards) has distributed other pertinent quake configuration codes for tremor safe development Masonry structures (IS-13828 1993).

[6] Seismic Analysis of Multi-Storey Building with and without Floating Column (2015)- In present scenario buildings with floating column is a typical feature in the modern multi storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. Earthquakes occurred in recent past have indicated that if the structures are not properly designed and constructed with required quality may cause great destruction of structures. This fact has resulted in to ensure safety against earthquake forces of tall structures hence, there is need to determine seismic responses of such building for designing earthquake resistant structures by carrying seismic analysis of the structure. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the floating columns. Time history analysis is one of the important techniques for structural seismic analysis especially when the evaluated structural response is nonlinear. In the present work dynamic analysis of G+14 multistoried RCC building considering for Sumatra earthquake is carried out by time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modeled with the help of ETABS software. The floor displacement, inter storey drift, base shear are computed for both the building with and without floating column.

[7] Seismic Behaviour of Building with Soft Storey: Review (2023)
A high-rise building with an open ground storey is known as a Soft Storey Building. The presence of a soft storey significantly impacts the seismic performance of the structure due to the sudden reduction in lateral stiffness and strength at that level. In modern urban environments, where population density is increasing and parking spaces are limited, constructing multi-story buildings with an open first floor has become a common practice. These buildings, which have masonry-infilled walls on all upper storeys but lack such walls in the ground storey, are referred to as Soft Storey or Open Ground Storey Buildings. Compared to regular buildings, irregular structures exhibit reduced drift when larger columns are used, but this comes at the cost of increased shear force and bending moments on the first

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floor. During severe earthquakes, soft storey buildings are particularly vulnerable, often performing poorly under seismic loads. The primary objective of this study is to understand the seismic behavior of such buildings in active seismic zones and assess critical parameters, including storey overturning moments, storey drift, displacement, and base shear. For comparative analysis, a G+15 storey building is modeled in five distinct configurations: square, L-shaped, T-shaped, plus-shaped, and C-shaped buildings. The entire set of models is analyzed using ETABS 2018, employing dynamic analysis to evaluate deformations in structures with and without a soft storey at different levels. The results indicate that when the soft storey is positioned at a higher level, displacement is significantly reduced. This study also reviews previous research on the topic, providing insights into existing findings and serving as a foundation for future investigations. Understanding the effects of soft storey placement and structural irregularities will contribute to developing better seismic-resistant design strategies for high-rise buildings.

[8] A Review on Seismic Analysis of Multi-Story Building with underneath Satellite Bus Stop having Service Soft Storey and Moment Transfer Beams (2016)

Generally, RC framed high rise structures are designed without regards to structural action of masonry infill walls present. Masonry infill walls are widely used as partitions. They are considered as non- structural elements. RC frame building with open first storey is known as soft storey, a similar soft storey effect can also appear, at intermediate storey level if a storey used as a service storey. The soft storey located in the lower part of the high rise building especially the first storey is very undesirable as it attracts severely large seismic forces. In satellite bus stops the ground soft story is of double height than the normal buildings and has sufficiently larger spans for movement of buses, so the effect will be more. At the same time, the soft storey located in the upper part of the high-rise building does not significantly affect the performance compared to the performance of the fully infill frame.

[9] Analysis of Multi-Story Buildings Infill and Without Infill Walls by Simulation Tool (2018)

The present study attempts to estimate typical variations in magnification factor of a mid rise open ground storey building accounting for the variability of compressive strength and modulus of elasticity of infill walls with various infill arrangements so that it can help designers facing trouble with heavy designs for a structure of mid-size, with the given material properties, geometry and loadings in particular. For the present study Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is considered for the comparative study. The building will be analyzed for two different cases: i) Considering infill mass but without considering infill stiffness. ii) Considering both infill mass and infill stiffness. From the present results it is found that building with soft storey will exhibit poor performance during a strong shaking. But the open ground storey is an important functional requirement of almost all the urban multi-storey buildings and hence cannot be eliminated. Alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to this problem is in i) increasing the stiffness of the ground storey; ii) provide adequate lateral strength in the ground storey. The possible schemes to avoid the vulnerability of open ground storey buildings under earthquake forces can be by providing stiff columns in open ground storey buildings or by providing adjacent infill walls at each corner of soft ground storey buildings.

[10] Seismic Analysis of Multistorey Building with and Without Soft Storey (2018)

To resolve the issues of parking in congested metropolitan cities, the concept of soft storeys can be adopted in high rise buildings. But, through the conclusion of this report, it can be found that using soft storeys in earthquake prone areas can make the entire structure less sustainable during an earthquake. For this project, a model of G+12 storeys was created and analysed for tall structure including soft storey for different levels using ETABS . More over ,for Zone 5 ,and other ten models were created and the performance of the structure was analysed by considering ground storey, ground and 1st storey, 3rd and 4th storey, ground and 6th storey , 6th storey , ground , 12th storey , 12th storey and ground, 1st and 2nd storey as soft storeys. To understand further the characteristic point the soft storey Equivalent static method and Response spectrum method has been used in this report.

[11] Seismic Analysis and Retrofit of Existing Multistoreyed Buildings in India – An Overview with a Case Study (2004) By Amlan K. Sengupta, Chemuru Srinivasulu Reddy, Badari Narayanan V T, Asokan A

Sengupta et al. (2004) presented an overview and case study on the seismic analysis and retrofit of existing multistoreyed buildings in India at the 13th World Conference on Earthquake Engineering. The study highlights the post-Bhuj earthquake initiatives in India, which emphasized assessing the seismic vulnerability of reinforced concrete (RC) structures and developing retrofitting strategies. Common structural deficiencies identified include inadequate shear capacity, poor column confinement, and design irregularities such as soft storeys. The authors propose retrofitting solutions such as the addition of shear walls, infill walls, and steel braces to address these vulnerabilities. Their work

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underscores the critical need for adopting these strategies to enhance the structural integrity and seismic resistance of multistoreyed buildings in earthquake-prone regions. This study serves as a significant contribution to the development of retrofit frameworks tailored to Indian construction practices and seismic demands.

[12] Case Study: Retrofitting of an Existing Residential Building by Using Shear Wall (2015) By Nikita Gupta, Poonam Dhiman, Ashok Kumar Gupta

Gupta, Dhiman, and Gupta (2015) conducted a detailed case study on the retrofitting of an existing residential building by using shear walls, published in the Journal of Civil Engineering and Environmental Technology. The study emphasizes the effectiveness of retrofitting with exterior shear walls in enhancing the seismic performance, overall strength, and stiffness of structures. By employing retrofitting techniques in compliance with the Indian Standard (IS) codes, the authors demonstrate a systematic approach to upgrading the structural resilience of aged or deficient buildings. Their findings underscore that exterior shear walls can significantly improve a building's ability to withstand seismic forces, offering a cost-effective and reliable solution for structural rehabilitation. This research serves as a valuable reference for adopting IS code-based methodologies for retrofitting residential structures in seismic-prone regions.

[13] Retrofitting Solutions for Existing Open Ground Storey RC Buildings (2022) By K. Bharadwaj, J. Pathak

Bharadwaj and Pathak (2022) presented a study on retrofitting solutions for open ground storey (OGS) reinforced concrete (RC) buildings in the ASPS Conference Proceedings. The research focused on improving the seismic performance of OGS buildings, which are inherently vulnerable due to the absence of infill walls on the ground floor. Retrofitting techniques such as the addition of masonry infill walls and steel braces were analyzed for their effectiveness. These methods not only enhanced the seismic resilience of the structures but also preserved maximum parking space, a critical design requirement for OGS buildings. The analysis was conducted using Seismostruct, providing detailed insights into structural behavior and performance improvements. This study underscores the importance of targeted retrofitting strategies to address the unique challenges posed by OGS buildings in seismic zones.

[14] Seismic Evaluation and Retrofitting of Open Ground Storey (2024) By Samruddhi Sanjay Borkar, N. H. Pitale

Borkar and Pitale (2024) conducted a seismic evaluation of G+5 open ground storey (OGS) buildings in seismic zone V, published in the IJSTE - International Journal of Science Technology & Engineering. The study utilized linear dynamic response spectrum analysis and non-linear static pushover analysis to assess the seismic behavior of these structures. Findings revealed that the absence of infill walls in the ground storey results in a soft storey effect, significantly increasing vulnerability to collapse under lateral seismic loads. This research underscores the critical need for retrofitting measures to mitigate the soft storey effect and enhance the seismic resilience of OGS buildings in high-risk seismic zones.

[15] Seismic Retrofitting of Existing Reinforced Concrete Buildings Using Aluminium Shear Links and Eccentric Steel Chevron Braces (2024) By Ahmed Elgammal, Saher El-Khoriby & Ayman Seleemah

Elgammal, El-Khoriby, and Seleemah (2024) proposed an innovative seismic retrofitting method for reinforced concrete buildings using aluminum shear links and eccentric steel chevron braces, published in the Arabian Journal for Science & Engineering. The retrofitting approach is based on a capacity design philosophy, aiming to dissipate seismic energy efficiently while protecting the primary structural elements from excessive damage. The study utilized advanced numerical analyses, including pushover and nonlinear time-history analyses, to evaluate the performance of the retrofitted structures. The results demonstrated a significant reduction in displacements and structural damage, effectively enhancing seismic resilience and minimizing building fragility. This research highlights the potential of aluminum shear links and steel braces as cost-effective and efficient solutions for improving the seismic safety of existing RC buildings.

III. PROPSED METHODOLOGY

The methodology followed in this study involves several key steps, from model creation to analysis. Initially, the plan and structural configuration of the G+4 building were finalized, and the model was developed in ETABS software with the necessary specifications. Structural components such as slabs, columns, and beams were assigned based on codal provisions. Dead loads and imposed loads were applied according to IS 456:2000 and IS 875 (Part II), while lateral and vertical loads were considered as per IS 1893. After assigning the loads, a gravity load analysis was conducted to check

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the structural stability under vertical loading conditions. Following this, lateral loads were applied, with walls modeled as struts, ensuring that all lateral forces acted on them. Axial hinges were provided at the center of the strut, and nonlinear axial properties such as displacement and yield forces were defined. Plastic hinges were introduced at beam ends and at axial and biaxial moment locations of columns. The pushover analysis was then performed, and the hinge formation curve was examined to determine the performance point of the structure. Finally, the obtained results were analyzed to assess the structural behavior under various loading conditions.

1. Building description:
Building type: Reinforced concrete frame
Usage: Residential apartment
Location: Nagpur, Maharashtra
Year of construction: 1999
Number of stories: G+4
Plan dimensions: 25.2 m X13.95 m
Building height: 15 m

1.2 Grade of Materials:
Concrete: M 15
Reinforcing Steel: Fe 415

IV. PUSHOVER ANALYSIS

Pushover analysis is based on the assumption that the structure has one dominant eigenvalue and mode shape, which remains unchanged during both elastic and inelastic responses. It is a nonlinear static analysis method used to estimate the seismic capacity of a structure.

Capacity Curve (Pushover Curve): The capacity curve, also known as the pushover curve, represents the relationship between the base shear and the roof displacement of the structure. The overall structural capacity is governed by the capacity of individual members. To determine capacities beyond the elastic limits, nonlinear analysis is required. This process involves performing sequential elastic analyses and superimposing the results to approximate the force-displacement behavior of the structure. The yielding resistance of structural members is reduced using a modified mathematical model, and lateral forces are reapplied to induce additional yielding in the members. This approach helps in understanding the progressive failure mechanism and the overall deformation capacity of the structure under seismic loads.

4.1 PUSHOVER ANALYSIS BY ETABS

4.1.1 Retrofitting

As discussed above, retrofitting is the process of strengthening an existing RCC structure, primarily using reinforcement bars in most cases. The retrofitting process is designed and analyzed using ETABS software. Figure 4.1 illustrates the model of the retrofitted structure, showcasing the modifications made to enhance its load-bearing capacity and overall stability.

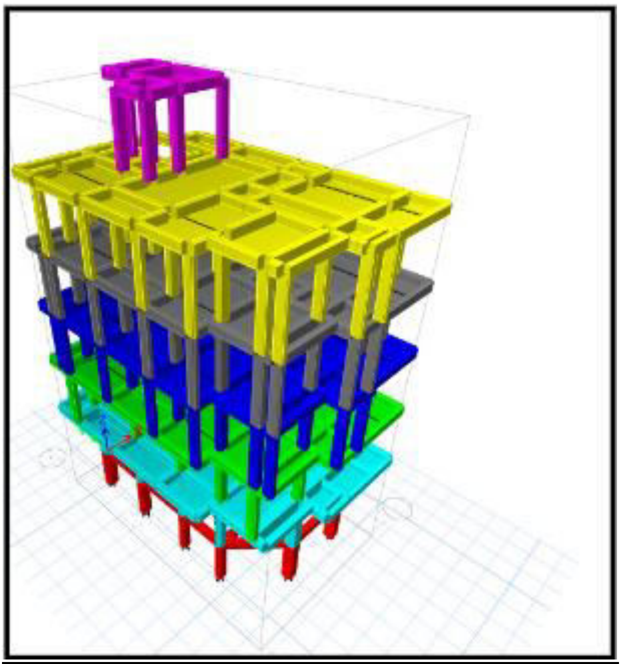
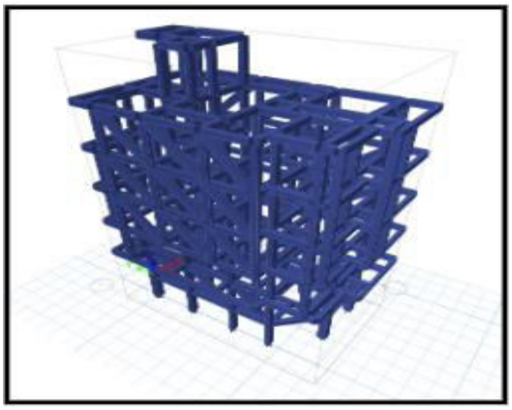


Figure 4.1 illustrates the model of the retrofitted structure

4.1.2 Bracings

Bracing is the support to a structure for lateral loads or by wind loads the given figure no. 4.2 as shows the bracing arrangement of same structure.



[Fig.4.2: Model of Bracing on E-tabs]

4.1.3 Shear wall

Shear wall is also provided an existing support to the structure for that purpose also we show the structure with shear wall in the given figure No. 4.3.

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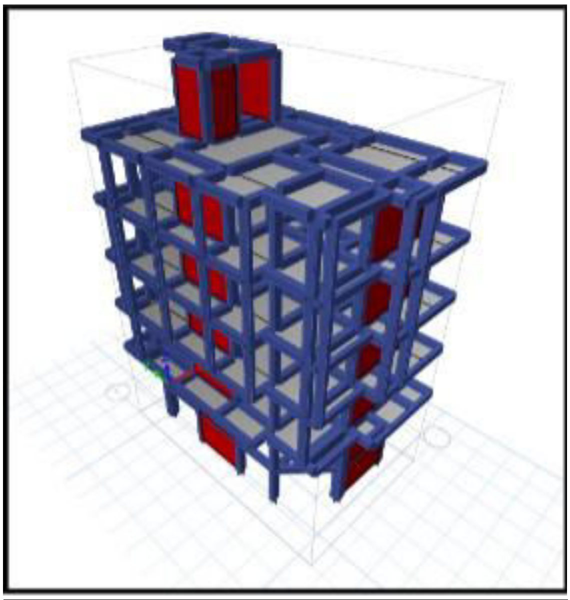

[Fig.4.3: Model of Shear Wall on E-tabs]

4.1.4 Plastic Hinge

As the loads is apply to the structure it is automatically transfer to the column and forms a plastic hinge on every beam column junction or on every node of the structure. Figure shows the Plastic Hinge Formation and Figure shows the response of Hinge for the column.

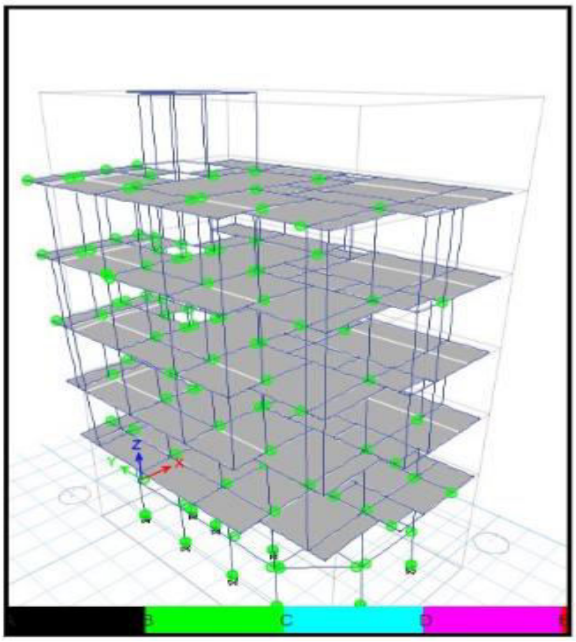

Fig No.4.4 Plastic Hinge Formation

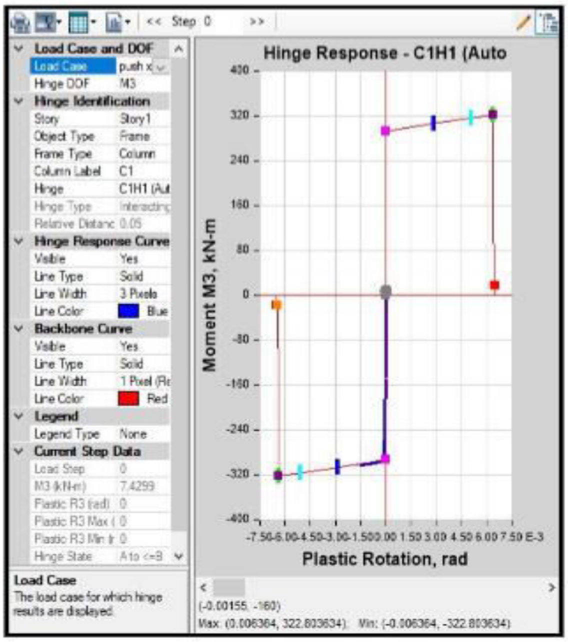

Fig No. 4.5 Hinge Response for Column

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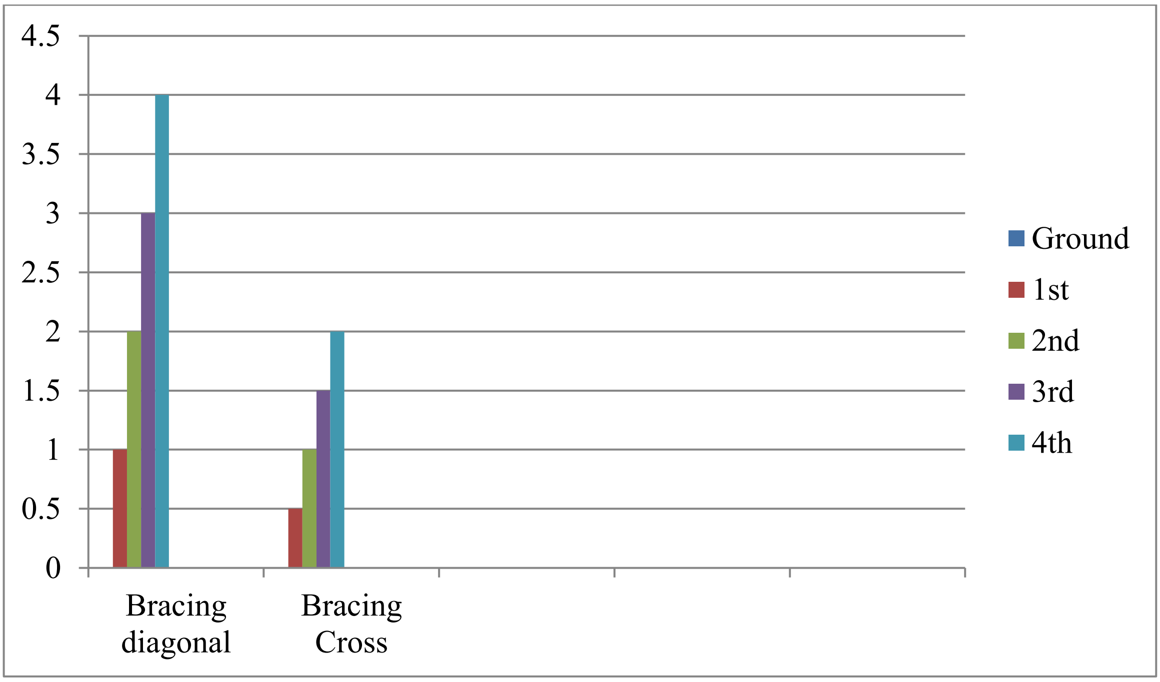
4.1.5 Storey Displacement

The lateral displacement of the story in relation to the basis is known as story displacement. The building's excessive lateral displacement can be limited by the lateral force-resisting system. For a wind load situation, the acceptability lateral displacement limit might be H/500 (others may choose H/400).

4.1.6 Storey Drift

The relative displacement between two consecutive storeys of a building is known as **storey drift**. It plays a crucial role in the design of **partitions and curtain walls**, as excessive drift can cause structural and non-structural damage. During an earthquake, the **storey drift ratio** must be evaluated and kept within the permissible limit of **2.0%**, as specified by building codes. Typically, the **maximum storey drift** occurs at intermediate levels of the building rather than at the top, making it a critical factor in structural analysis and design.

Components	Base structure	Parallel Shear Wall	Corner Shear Wall	Bracing Diagonal	Bracing Cross
Story Drift	0-35	0-5	0-7	0-8	0-5



Graph-1 Story Drift

4.1.7 Storey Shear

The Storey Shear Factor is defined as the ratio of the storey shear force at the onset of storey collapse to the storey shear force at the point of total structural collapse. Through a series of dynamic analyses, simplified formulae have been proposed to determine the required storey shear safety factor, which can be used to prevent storey collapse. Ensuring an adequate storey shear safety factor is crucial for enhancing the seismic resilience of buildings and mitigating the risk of progressive collapse.

Components	Base structure	Parallel Shear Wall	Corner Shear Wall	Bracing Diagonal	Bracing Cross
Story Drift	0-35	0-38	0-39	0-33	0-33

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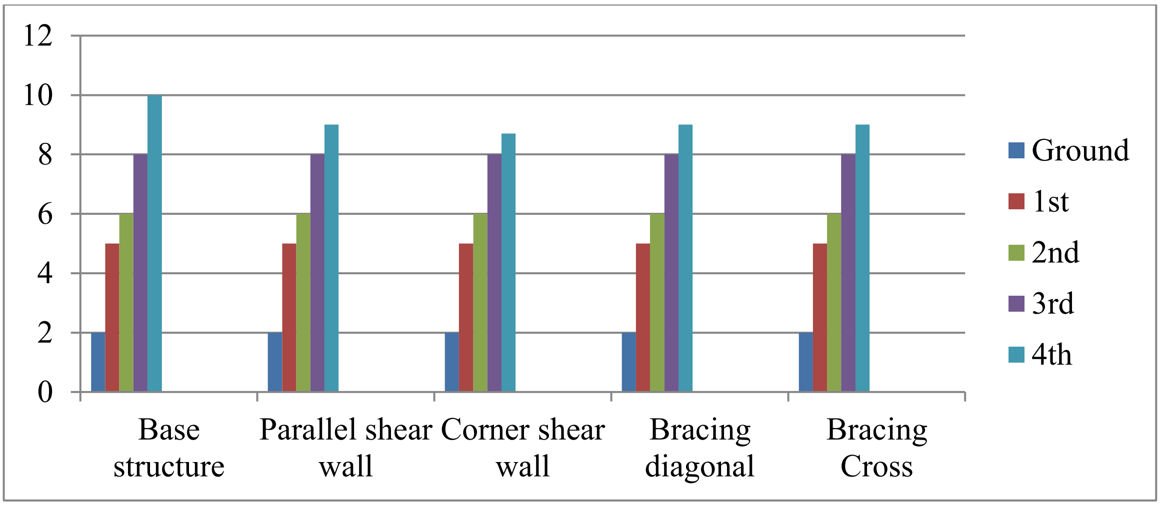
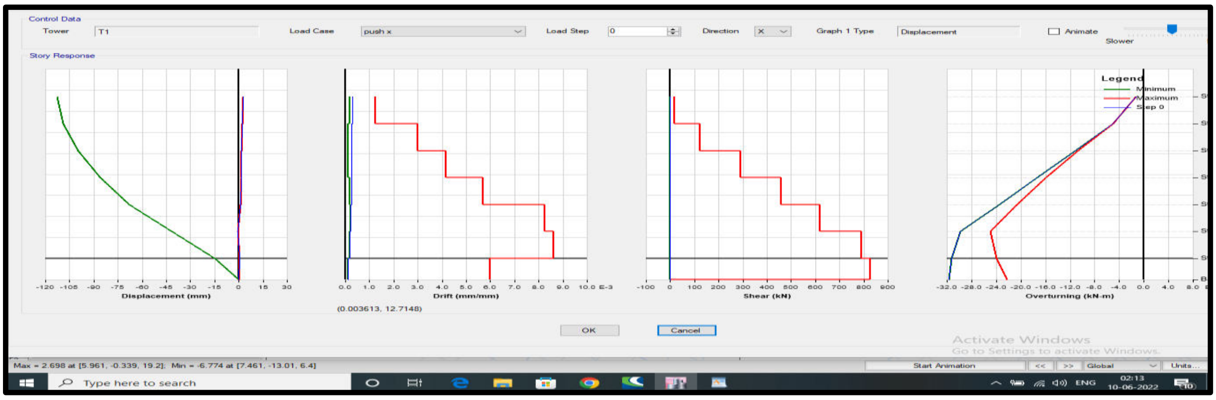
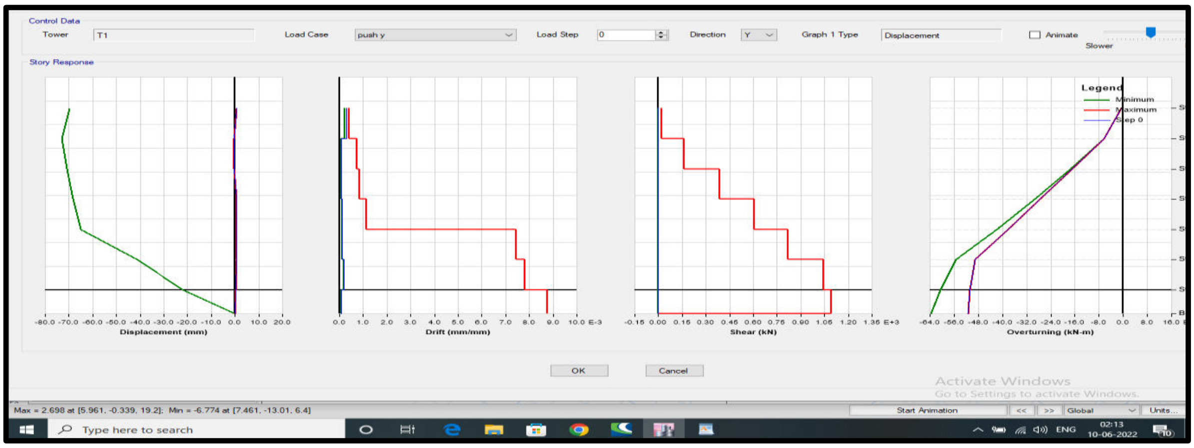


Graph-2 Story Shear



Maximum Storey Displacement of Bracing



Maximum Storey Displacement of Bracing in X Direction

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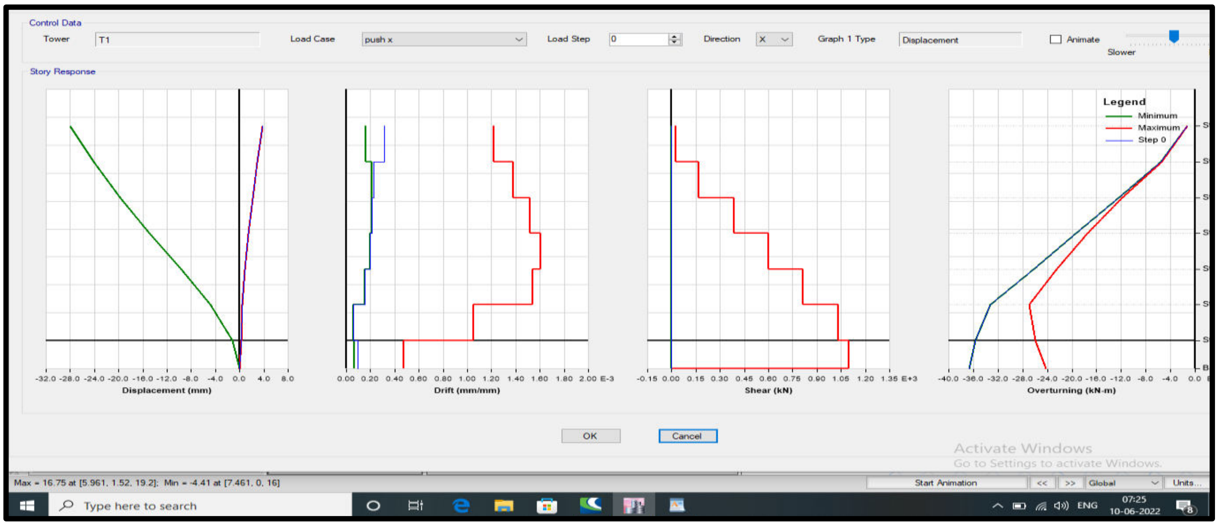

V. CONCLUSION

The study highlights the significance of retrofitting techniques in enhancing the structural performance of open ground storey (OGS) buildings, which are highly vulnerable to seismic forces. Through the introduction of external shear walls, the structural behavior of the G+4 building has been significantly improved in terms of lateral stiffness, strength, and overall seismic resistance. The results obtained from both equivalent static and dynamic analyses indicate that adding shear walls effectively mitigates the soft storey effect, reducing excessive lateral displacements and improving load distribution across the structure. This retrofitting method not only enhances the building's resilience against earthquakes but also extends its service life by minimizing potential damage. In conclusion, the use of shear walls as a retrofitting measure is a practical and efficient solution for strengthening OGS buildings, particularly in seismically active regions. Further studies can explore optimization techniques, cost-effectiveness, and alternative retrofitting methods to ensure sustainable and safe structural modifications.

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