Comparative Study of Static and Dynamic Analysis of RCC Structures under Indian Seismic Condition

Submitted in partial fulfillment of the requirements for the award of degree of

MASTER OF TECHNOLOGY
in
STRUCTURAL ENGINEERING

by

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CANDIDATE'S DECLARATION

I ,**Vishnu Pore ,2K24/STE/21** Of M.tech (structural engineering) certify that the work which is presented in this thesis entitled "**comparative study of Static and Dynamic Analysis of Rcc structure under Indian seismic condition** ", submitted to the **Delhi Technological University(DTU), New Delhi**, In partial fulfillment of the requirements for the award of the degree of **Master of Technology** in the **Civil Engineering Department**,has been carried out independently under the supervision of **Prof.B.R.G.Robert**.To the best of my knowledge, the content of this thesis has not been submitted, either in part or in full,for the award of any other academic degree or diploma. Proper citations and acknowledgements have been provided wherever the work is based on contributions or findings of other researchers.

Place: New Delhi

Date: 16.06.2026

Vishnu Pore

VISHNU PORE

This is to certify that the student has incorporated all the corrections suggested by the Examiners in the thesis and the statement made by the candidate is correct to the best of our Knowledge.

PROF.B.R.G. ROBERT
Signature of supervisor

Signature of external examiner

CERTIFICATE BY THE SUPERVISOR

This is to certify that the thesis entitled **"Comparative Study of STATIC AND DYNAMIC Analysis of RCC Structures Under Indian Seismic Condition"**,submitted by **VISHNU PORE (2K24/STE/21)** to the **Delhi Technological University**, in partial fulfillment of the requirements for the award ofthe degree of **Master of Technology in Structural Engineering**,is a genuine and original record of the research work carried out under my supervision in the **Civil Engineering Department**, Delhi Technological University.

To the best of my knowledge,the contents of this thesis have not been submitted, either in part or in full, to any other institution for the award of any degree or diploma.

Prof.B.R.G.Robert
(professor and supervisor)
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Date: 16 June 2026

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ABSTRACT

The increasing occurrence of earthquakes in different seismic regions has emphasized the necessity for reliable structural analysis methods in reinforced cement concrete (RCC) buildings. This study presents a comparative evaluation of static and dynamic analysis techniques for RCC structures under Indian seismic conditions. The goal of the research is to explore the structural behavior, seismic performance, and response characteristics of RCC buildings when subjected to earthquake forces as specified in Indian seismic design provisions, primarily based on Bureau of Indian Standards code recommendations such as IS 1893 and IS 456.

In this research, multi-storey RCC structures are modeled and analyzed using ETABS. Pushover analysis and time history analysis, are used to assess the seismic response of the structures. Important response parameters such as storey displacement, storey drift, base shear, are compared for seismic zones IV .

This dissertation presents a detailed comparative study of the pushover analysis of RCC structures with rigid joints under Indian seismic conditions. The primary aim of the study is to evaluate, compare, and interpret the nonlinear seismic behavior of multistorey RCC buildings by considering key performance parameters such as base shear, terrace displacement. The buildings are designed in accordance with the provisions of IS 456:2000 for reinforced concrete design and IS 1893 (Part 1):2016 for earthquake-resistant design of structures. The seismic performance is assessed using the concepts of performance-based seismic design as defined in international guidelines such as FEMA 356 and ATC-40.

For the purpose of analysis, three-dimensional numerical models of RCC buildings are developed using ETABS software. Gravity loads and seismic loads are applied as per Indian Standard codes. Nonlinear hinge properties are assigned to beams and columns to simulate realistic material behavior under increasing lateral loads. The pushover analysis is carried out by applying incremental lateral load patterns in both principal horizontal directions until the target displacement or collapse mechanism is achieved.

A comparative assessment of different structural configurations is performed to investigate their influence on seismic behavior. The study highlights how changes in stiffness, strength, and ductility affect the overall performance of RCC structures. Storey-wise displacement, drift ratios, and plastic hinge distribution patterns are critically examined to identify vulnerable zones and potential failure mechanisms.

Special emphasis is placed on understanding the nonlinear response characteristics of rigid jointed RCC frames, which are extensively used in Indian construction practice.

The results obtained from the analysis clearly demonstrate that PA is highly effective in capturing the progressive damage behavior and post-elastic response of RCC buildings, which cannot be adequately assessed through linear static or dynamic methods. The study reveals that the formation and progression of plastic hinges follow distinct patterns that govern the ultimate collapse mechanism of the structure. It is observed that structures designed strictly as per code provisions still exhibit significant nonlinear deformations under severe seismic excitation, emphasizing the importance of performance-based evaluation.

The outcomes of this study provide valuable insights into the seismic performance of RCC buildings under Indian seismic conditions and confirm the reliability of pushover analysis as a practical and efficient tool for seismic evaluation. The findings of this research are expected to assist structural engineers in identifying seismic deficiencies, improving structural configurations, and adopting safer design practices. The study also highlights the importance of incorporating nonlinear analysis procedures into routine seismic design and assessment workflows to enhance the safety, resilience, and sustainability of reinforced concrete structures in earthquake-prone regions of India.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

One of the most damaging natural disasters that has a significant impact on both human lives and economic growth is an earthquake. Many multi-story reinforced cement concrete (RCC) structures have been built in earthquake-affected areas in recent years due to increasing urbanization and industrial growth. Due to the fact that a major portion of India is located inside several seismic zones as defined by Indian Standard codes, the country is extremely vulnerable to seismic activity. Buildings were severely damaged by previous earthquakes.
like the Nepal earthquake occur in 2015, and the Kashmir earthquake occur in 2005, underscoring the significance of earthquake-resistant structural design. In order to make the structure safe and
occupants of the structure safe ,seismic analysis are necessary.

Because of its strength, durability, affordability, and adaptability to different architectural needs, reinforced cement concrete buildings are frequently utilized in contemporary construction. Although RCC buildings may successfully withstand vertical loads, they are exposed to additional lateral forces during earthquakes, which, if improperly built, may result in excessive displacement, cracking, instability, and even structural collapse. Stiffness, mass distribution, building geometry, height, soil condition, ductility, and structural configuration are some of the variables that affect a structure's seismic reaction. To comprehend how structures behave under earthquake stress circumstances, precise seismic analysis is also required.
The primary objective of seismic analysis is to evaluate the response of structures subjected to ground motion and to ensure that the building can safely withstand earthquake forces without significant structural failure. Over the years, different analysis procedures have been developed to estimate the seismic behavior of structures. Among these methods, static analysis and dynamic analysis are the most commonly used techniques in structural engineering practice.

Dynamic analysis methods provide a more realistic representation of structural behavior under seismic excitation by considering the vibration characteristics of buildings. These methods include response spectrum analysis and time history analysis. Dynamic analysis considers important parameters such as natural time period, mode shapes, damping, and inertia forces, which significantly influence the seismic response of structures. Dynamic analysis methods have become more practical and reliable for evaluating the performance of RCC buildings located in severe seismic zones.

Indian seismic design provisions are mainly governed by Bureau of Indian Standards through codes such as IS 1893 (Part 1): 2016, IS 456: 2000, and IS 13920: 2016. These standards provide guidelines for calculating seismic loads, designing earthquake-resistant structures, and ensuring ductile detailing of RCC members. The selection of an appropriate analysis method according to these code provisions plays a vital role in achieving safe and economical structural design.

In the present study, a comparative evaluation of Pushover and Time history analysis methods for RCC structures under Indian seismic conditions is carried out using ETABS software. The study aims to analyze and compare important structural response parameters such as storey displacement, storey drift, base shear, and natural time period obtained from both methods. The research also investigates the effectiveness and applicability of static and dynamic analysis approaches for multi-storey RCC buildings subjected to seismic loading. The findings of this study are expected to provide useful insights for structural engineers and researchers in understanding the seismic performance of RCC structures and selecting suitable analysis techniques for earthquake-resistant design.

1.2 **Reinforced Cement Concrete (RCC) Structures**

In Rcc structures we get the combination of the tensile strength of steel reinforcement with the compressive strength of concrete.Due to their affordability, durability, and structural efficiency, RCC constructions are frequently used for institutional, commercial, industrial, and residential buildings. RCC constructions must be carefully built to resist both lateral seismic forces and gravity loads in earthquake-prone areas. For RCC buildings to survive better during earthquakes, proper reinforcement detailing, ductile design, and sufficient stiffness are crucial..

1.3 **Earthquake and Seismic Forces**

An earthquake is a sudden ground vibration caused by the release of energy within the earth’s crust. The seismic waves generated during an earthquake create inertia forces in structures, causing lateral motion and structural deformation. The magnitude of seismic forces acting on a building depends on several factors such as seismic zone, soil condition, structural mass, height of the building, and dynamic properties of the structure. If these forces are not properly considered during design, severe structural damage or collapse may occur during seismic events.

The intensity and effect of seismic forces on a structure depend upon several parameters such as earthquake magnitude, distance from the epicenter, soil condition, structural mass, building height, and structural configuration. Tall and irregular structures are generally more vulnerable to seismic effects because of higher flexibility and complex dynamic behavior. Earthquake forces act rapidly and unpredictably, making seismic analysis one of the most critical aspects of structural engineering.

India is highly susceptible to earthquakes because a large portion of the country lies in different seismic zones defined by IS 1893 (Part 1): 2016 issued by Bureau of Indian Standards. According to the code, India is divided into Zone II, Zone III, Zone IV, and Zone V based on seismic intensity. Structures located in higher seismic zones experience larger earthquake forces and therefore require more detailed analysis and stronger earthquake-resistant design provisions.

During an earthquake, seismic forces generate storey displacement, storey drift, overturning moments, and base shear in buildings. If these forces exceed the structural capacity, severe cracking, instability, and collapse may occur. Hence, proper seismic analysis is necessary to estimate the response of structures accurately and ensure the safety of occupants and infrastructure during earthquake events.

1.3 **Static Analysis Method**

Static analysis is one of the simplest and most commonly used methods for evaluating the seismic response of structures. In this method, the dynamic effects of earthquake motion are represented by equivalent lateral static forces acting at different floor levels of the building. The equivalent static method assumes that the structure behaves mainly in its fundamental mode of vibration and that the seismic forces can be distributed along the height of the building based on its mass and stiffness characteristics.

Pushover analysis is a method used by structural engineers to evaluate how a building or structure will behave when subjected to earthquake forces. In simple terms, the structure is pushed sideways with a gradually increasing horizontal force on a computer model, and its response is observed at every step — until the target terrace displacement reach or collapses.

The analysis provides important structural response parameters. These results help engineers design structural components capable of resisting seismic loads safely. However, static analysis has certain limitations because it does not accurately capture higher mode effects, torsional behavior, and time-dependent dynamic characteristics of buildings.

For tall, irregular, or complex structures, static analysis may produce less accurate results.The equivalent static method remains an important preliminary and design-level analysis technique for many conventional RCC buildings.

1.4 **Dynamic Analysis Method**

Dynamic analysis is a more advanced and realistic approach for finding the response of structures under earthquake loading. Unlike static analysis, dynamic analysis considers the actual vibration behavior of structures by including parameters. Since earthquakes generate rapidly varying ground motion, the structural response also changes continuously with time. Dynamic analysis provides a more accurate estimation of this response.

Time history analysis, evaluates the structural response using actual or simulated earthquake ground motion records. It provides highly detailed information regarding displacement, acceleration, and force variation with time.

Dynamic analysis is especially important for high-rise buildings, irregular structures, and buildings located in severe seismic zones because such structures are significantly affected by higher mode participation and dynamic amplification effects. Compared to static analysis, dynamic analysis produces more realistic results for storey displacement, storey drift, base shear, and internal member forces.

With the advancement of computer technology and structural analysis software such as ETABS, dynamic analysis has become more practical and efficient for engineering applications. Although dynamic analysis requires greater computational effort and detailed modeling.

1.5 **Indian Seismic Design Codes**

The seismic analysis and design of RCC structures in India are governed by various standards developed by Bureau of Indian Standards. These codes provide guidelines and procedures for calculating seismic loads, designing earthquake-resistant structures, and ensuring structural safety under seismic conditions. The main objective of these codes is to minimize structural damage and prevent collapse during earthquakes.

IS 1893 (Part 1): 2016 is the primary code used for earthquake-resistant design of structures in India. It specifies seismic zone factors, importance factors, response reduction factors, design spectra, and methods for calculating seismic loads. The code also provides guidelines for static and dynamic analysis procedures based on the type and height of the structure.

IS 456: 2000 provides the general provisions for the design of reinforced concrete structures, including material specifications, load combinations, durability requirements, and structural detailing. Another important code, IS 13920: 2016, deals with ductile detailing of reinforced concrete structures subjected to seismic forces. Ductile detailing improves the energy absorption and deformation capacity of structural members during earthquakes.

The Indian seismic ensure safe and economical structural design. Proper implementation of these standards helps engineers design RCC buildings capable of resisting earthquake effects effectively while maintaining structural stability and occupant safety.

1.6 **Need for Comparative Study**

The selection of an appropriate seismic analysis method is one of the most important aspects of earthquake-resistant structural design. Different analysis methods produce different results depending on the structural configuration, height, stiffness, and seismic characteristics of the building. Therefore, a comparative study between static and dynamic analysis methods becomes necessary to understand the variation in structural response and evaluate the accuracy of different approaches.

Static analysis methods are simpler and faster but may not accurately represent the actual dynamic behavior of structures during earthquakes. Dynamic analysis methods provide more realistic results because they consider vibration characteristics and modal participation effects. However, dynamic analysis requires more computational effort and detailed modeling procedures. Comparing these methods helps engineers determine the suitability of each approach for different structural conditions.

In the present study, important seismic response parameters are compared using static and dynamic analysis methods. The comparison helps in understanding the influence of analysis techniques on structural performance under Indian seismic conditions. Such studies are useful for improving design accuracy, structural safety, and economy in earthquake-resistant construction.

1.7 Need for Nonlinear Static (Pushover) Analysis

Traditional linear static and linear dynamic methods of seismic analysis assume that the structure remains within the elastic range during earthquake loading. These methods distribute earthquake forces based on simplified assumptions and are unable to capture the actual sequence of member yielding, stiffness degradation, and redistribution of internal forces.

The primary advantage of pushover analysis lies in its ability to:

- Identify weak structural components,
- Estimate displacement demand and ductility capacity,
- Evaluate overall collapse mechanism of the structure.

This method provides a clear relationship between base shear and terrace displacement in the form of a capacity curve, which can be further used to determine performance points and assess whether the structure meets desired performance objectives. Hence, pushover analysis is particularly suitable for seismic performance evaluation of RCC buildings under Indian seismic conditions.

1.8 **Need for Performing Nonlinear Time History Analysis**

Nonlinear Time History Analysis is required to accurately evaluate the seismic performance of RCC structures under actual earthquake ground motions. Conventional static analysis methods are often unable to represent the real dynamic behavior of buildings during severe seismic events because earthquake forces vary continuously with time. Therefore, performing nonlinear time history analysis becomes essential for understanding the realistic structural response, especially for high-rise, irregular, and earthquake-resistant structures.

The primary need for nonlinear time history analysis arises from the requirement to study the behavior of structures beyond the elastic limit. During strong earthquakes, structural members such as beams and columns may experience cracking, yielding, stiffness degradation, and plastic hinge formation. Linear analysis methods cannot accurately capture these nonlinear effects, whereas nonlinear time history analysis considers both material and geometric nonlinearities, providing a more realistic simulation of structural behavior under seismic excitation.

Another important reason for performing nonlinear time history analysis is to evaluate important seismic response parameters and internal member forces at every instant of time during the earthquake. This method allows engineers to identify critical structural components, weak zones, and possible failure mechanisms within the building. It also helps in assessing the stability, ductility, and energy dissipation capacity of RCC structures under severe seismic loading.

Nonlinear time history analysis is especially necessary for performance-based seismic design, where the actual performance level of the structure must be evaluated under different earthquake intensities. It is widely used for important structures such as hospitals, tall buildings, bridges, industrial facilities, and structures located in high seismic zones. The method enables engineers to verify whether the structure satisfies performance objectives such as io, Ls, and Cp during earthquake events.

With the advancement of computational techniques and structural analysis software such as ETABS, performing nonlinear time history analysis has become more practical and efficient. Although the method requires detailed modeling, earthquake records, and higher computational effort, it provides highly accurate and reliable results for seismic evaluation and earthquake-resistant structural design.

1.4 Indian Seismic Design Philosophy

India follows a zone-based seismic design approach as specified in IS 1893 (Part 1):2016, which categorizes the country into four seismic zones—Zone II, III, IV, and V—based on seismic risk. The design philosophy adopted in Indian codes is primarily life-safety oriented, meaning that the structures should not collapse during major earthquakes but may suffer significant damage. While this approach ensures life protection, it does not necessarily guarantee immediate post-earthquake functionality.

In recent years, there has been a growing shift from conventional force-based design to **performance-based seismic design**, which aims to achieve targeted performance levels under different earthquake intensities. Pushover analysis plays a crucial role in this transition by enabling engineers to verify whether the designed structure satisfies specific performance objectives such as:

- Immediate Occupancy (IO),
- Life Safety (LS),
- Collapse Prevention (CP).

1.6 Objectives of the Present Study

The main goal of the present study is to evaluate the seismic performance of multi-storey RCC structures under Indian seismic conditions by using advanced seismic analysis procedures such as pushover analysis and time history analysis. The study aims to investigate the nonlinear and dynamic behavior of RCC buildings subjected to earthquake loading and to understand the structural response under different seismic conditions. Modern earthquake-resistant design requires accurate prediction of structural behavior beyond the elastic range; therefore, advanced analysis techniques are necessary to evaluate the actual performance of structures during strong ground motion.

One of the primary objectives of this research is to model and analyze RCC buildings using ETABS software according to Indian Standard code provisions. The study focuses on performing nonlinear static pushover analysis to evaluate the strength, stiffness, ductility, and collapse performance of the structure. Pushover analysis helps in identifying weak zones, hinge formation, performance points, and failure mechanisms in buildings during seismic excitation. Through this analysis, the progressive behavior of the structure from the elastic stage to the inelastic stage can be studied effectively.

Another important objective of the study is to perform time history analysis using earthquake ground motion records to examine the actual dynamic response of RCC structures under seismic loading. Time history analysis provides detailed information regarding variation of displacement, acceleration, velocity, and internal forces with respect to time. This method helps in understanding the real-time behavior of structures during earthquakes and provides more accurate results compared to conventional static methods.

The study also aims to compare important seismic response parameters and performance levels obtained from analysis. The comparison helps in evaluating the effectiveness, reliability, and applicability of these advanced seismic analysis methods for RCC buildings located in earthquake-prone regions of India.

Another goal of this research is to study the influence of seismic loading on the overall stability and performance of RCC structures. The investigation further aims to identify suitable seismic analysis procedures for achieving safe, economical, and earthquake-resistant structural design. The outcomes of the study are expected to assist structural engineers, researchers, and designers in understanding the nonlinear seismic behavior of RCC buildings and improving the performance-based design approach in structural engineering.

CHAPTER 2

LITERATURE REVIEW

1. The study presents a detailed evaluation of reinforced concrete (RC) structures using nonlinear static pushover analysis to assess their seismic performance. The research investigates the influence of infill percentage, shear wall configuration, and soft-storey location on structural behavior. Results show that increasing infill enhances stiffness and base shear capacity, while shear walls—especially periphery types—provide maximum lateral resistance. Conversely, soft storeys at lower levels increase vulnerability to seismic damage, whereas mid-level soft storeys perform comparatively better. The study, based on FEMA 356 and ATC-40 guidelines, concludes that proper integration of infill and shear walls significantly improves seismic performance. However, further research considering dynamic analysis and local design codes, such as IS 1893:2016, is necessary for more realistic modeling and region-specific design recommendations

2. The reviewed study contributes to this body of knowledge by examining how the height at which a soft storey occurs influences the behaviour of an L-shaped RC building. Results indicate that soft storeys located near the base attract higher deformation and hinge activity, whereas shifting the soft storey upward reduces time period and improves overall performance. This aligns with existing findings while providing additional insight into the effect of vertical soft storey placement.

One of the most critical irregularities affecting seismic performance is the presence of a soft storey, where a sudden reduction in stiffness leads to excessive drift and concentration of damage. Previous research consistently shows that buildings with soft storeys are more vulnerable during earthquakes, especially when the soft storey is located at the lower levels. Studies using software such as ETABS confirm that such buildings undergo larger displacements and exhibit early hinge development in columns.

3. Recent research has focused extensively on the seismic performance of reinforced concrete (RC) buildings using nonlinear analytical procedures, particularly pushover analysis. Several studies have examined how structural irregularities influence deformation patterns and overall seismic capacity. Ahmed and Raza (2014) explored various plan-irregular RC building configurations and reported that irregular geometries, such as diaphragm discontinuities and Y-shaped layouts, show reduced

base shear capacity and higher displacement demands compared to regular plans. Their findings highlight the sensitivity of torsional irregularities to lateral loading. Similarly, Hamraj (2014) evaluated different unsymmetrical building plans of multiple heights and demonstrated that modeling strategies—whether including infill walls or replacing them with equivalent struts—significantly affect performance levels and the ability of buildings to achieve immediate occupancy under seismic loading.

4. The literature reviewed in this chapter is strictly limited to the study presented in the selected *Comparison–2 research paper*, which focuses on the comparative seismic performance evaluation of reinforced concrete (RCC) buildings using Pushover Analysis and Nonlinear Time History Analysis. The study goal to examine the accuracy, reliability, and behavioral differences of these two nonlinear analysis methods when applied to RCC structures subjected to earthquake loading.

The research highlights the restriction of conventional linear static and dynamic analysis methods and establishes the necessity of nonlinear procedures for realistic prediction of structural behavior under strong seismic excitations.

5.R. Kavitha et al. (2022) have done seismic analysis and design of multilevel car parking structure using ETABS software. The structure was analysed under different load conditions as per Indian Standard, namely dead load, live load, wind load and earthquake load. Response spectrum analysis was adopted to determine the seismic response of the building. The study highlighted the need for correct modelling, diaphragm action and moment resisting frames to enhance the seismic performance of RCC structures. The authors found that it is crucial to use the right analysis and design methods to guarantee the stability and safety of multistorey structures under earthquake loadings.

6.the study investigated seismic vulnerability of RC buildings with different irregularities in plan using pushover analysis. Rectangular, diaphragm discontinuity, and Y-shaped buildings were analyzed by using ETABS software. The study was based on the parameters such as capacity spectrum, plastic hinge formation, lateral displacement etc. to evaluate seismic performance. The results revealed that irregular buildings are more vulnerable to seismic damages than regular buildings. In particular, the presence of openings in the structure led to larger values of displacement in the diaphragm discontinuity models. The study found that the regular building configuration gives better performance in earthquake situations.

7. The study examine pushover analysis of medium-rise RCC frame buildings with and without vertical irregularity in ETABS software. The research compared the seismic performance of regular and irregular buildings based on guidelines provided by ATC-40 and FEMA-273. Structural behavior was evaluated through parameters like base shear, storey displacement and drift ratio. The results showed that the lateral load resistance and seismic performance of the vertically irregular buildings were lower than that of regular buildings. It was also noticed that the overall stability and earthquake resistance of RCC buildings were found to reduce significantly with the increase in irregularity.

CHAPTER 3

RCC FRAMED STRUCTURE

A Reinforced Cement Concrete (RCC) framed structure is one of the most widely used structural systems in modern construction due to its strength, durability, flexibility, and economy. In this structural system, the loads acting on the building are transferred through interconnected structural members. RCC framed structures are commonly used for residential buildings, commercial complexes, industrial buildings, and multi-storey structures because they provide better stability and resistance against both vertical and lateral loads. In earthquake-prone regions, RCC framed structures are preferred because they possess good rigidity, ductility, and load-carrying capacity, which are essential for resisting seismic forces.

The basic principle of an RCC framed structure is that the entire load of the building is carried by the structural frame rather than by load-bearing walls. The beams transfer the load from slabs to columns, while columns transfer the load to the foundation, which ultimately distributes the load safely to the soil. This load transfer mechanism makes RCC framed structures highly efficient for supporting heavy loads and large spans. The frame action between beams and columns provides structural continuity and improves the overall stiffness and stability of the building.

RCC framed structures are particularly important in seismic-resistant construction because they can effectively resist lateral forces generated during earthquakes. During seismic excitation, the frame experiences horizontal displacement, inertia forces, bending moments, shear forces, and torsional effects. Proper design of beams, columns, and joints is necessary to ensure that the structure can absorb energy and maintain stability during earthquake loading. The seismic behavior of RCC framed structures depends on factors such as building geometry, stiffness, mass distribution, reinforcement detailing, and ductility.

3.1 ASSUMTIONS IN DESIGN

- The p.s.f for loads is taken as $\Upsilon_t = 1.5$, according to clause 36.4 of IS 456-2000
- As per clause 36.4.2 of IS 456-2000, the partial safety factor for materials is 1.5 for concrete and 1.15 for steel.

Load combinations are considered using the partial safety factors specified in clause 36.4 of IS 456-2000.

3.2 LOAD COMBINATION FOR LIMIT STATE OF COLLAPSE AS PER IS 456:2000

According to IS 456:2000 (Clause 36.4.2)**,** the following load combinations are considered for the Limit State of Collapse:

1. Combination of Dead Load (DL) and Live Load (LL)= 1.5(DL+LL)
   This combination is used when both dead load and live load act together.

2. Combination of Dead Load (DL) and Earthquake Load (EL)= 1.5(DL+EL)
   This is considered when seismic force acts along with dead load.

3. Combination of Dead Load and Live Load and Earthquake Load = 1.2(DL+LL+EL)
   This combination is used when all loads act simultaneously.

4. Combination for Stability Check = 0.9DL+1.5EL
   This load combination is used to check overturning, uplift, and stability of the structure.

3.3 DEAD LOAD,LIVE LOAD AS PER INDIAN STANDARD

In the study we take the Live load as 2 KN/M^2

CHAPTER 4

DETAILS OF THE MODEL STUDIED

4.1 Structural Details:-

In the study ,the type of structure we used is Reinforced cement concrete Building. Our sample RCC building is G+5 storey. The story height of the building is 3m each The Bay length of the RCC Building is 5 m × 5 m in both directions.

4.2 Structural Elements

The cross section of column is taken to be 400mm x400mm and the beam cross section is taken as 300mm x 500mm and depth of the beam is 500mm which includes the thickness Of slab.

The thickness of slab is taken as 125mm.

4.3 Material Properties

The grade of the concrete used to model the rcc structure is M25 and the grade of the steel used is Fe 415.

4.4 Masonry Infill Modeling

The Masonry infill modeled as an equivalent diagonal strut and the strut width is taken as 485 mm.

The thickness of strut is Taken as 125 mm and the compressive strength masonry infill is taken as 1 MPa.

4.5 Shear Wall Model

- Two common shear wall forms studied:
  - Parallel shear wall
  - Periphery shear wall
- Modeled using:
  - 10-inch wall thickness
- Shear walls considered with half bay length = 2.5 m

4.1 MODELLING AND ANALYSIS OF MODEL

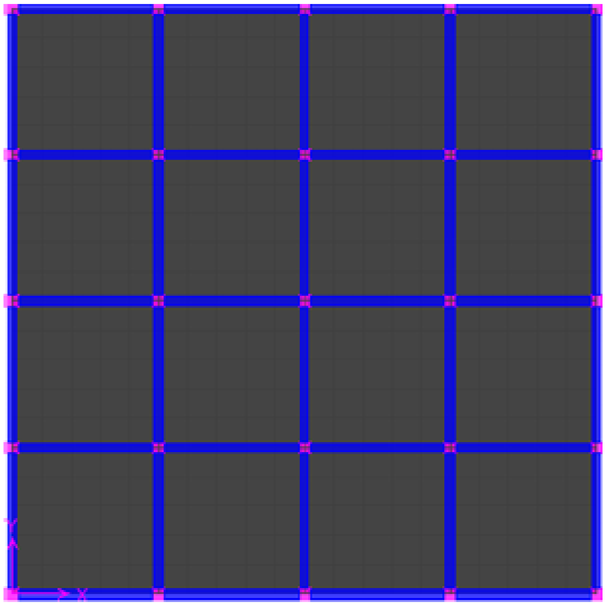


Fig 4.1 Plan of the building

The structure is of G+5 Story building having bay length of 5m x 5m.In this structure shear wall is placed at corners and another case shear wall is placed at center.The infill walls we take it as a struts.

The column sizes are 400mm x 400mm

The beam size are 300mm x 500mm

The story height is 3m.

Moment M3 are assigned to beams and P-M2-M3 are assigned to columns at both ends.

The pushover analysis is performed in X direction and Y direction.

□ The time history analysis are also performed in x direction and Y direction.

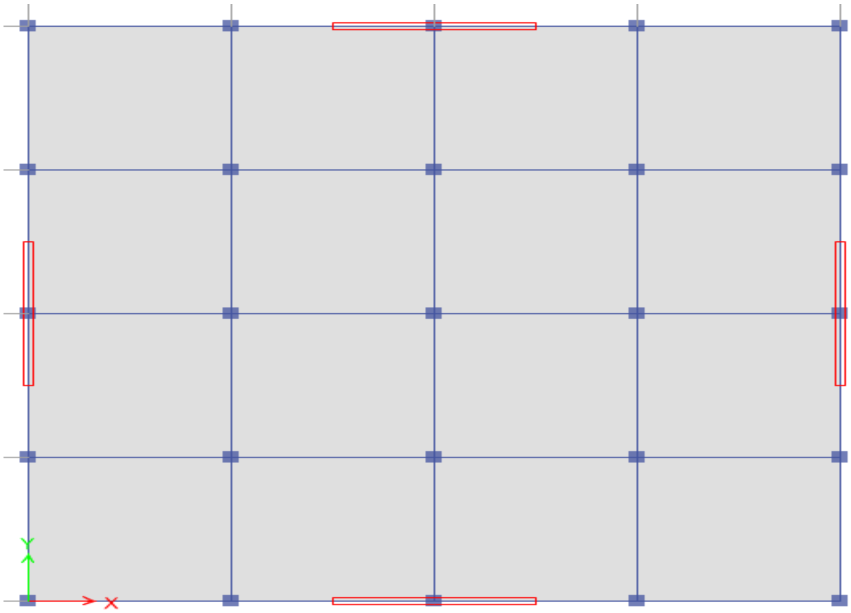


Fig 2 sw at center

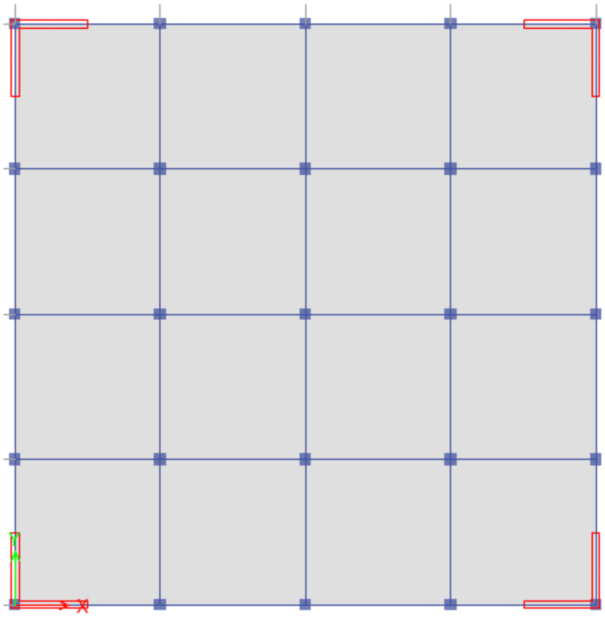


Fig 2 Sw at corner

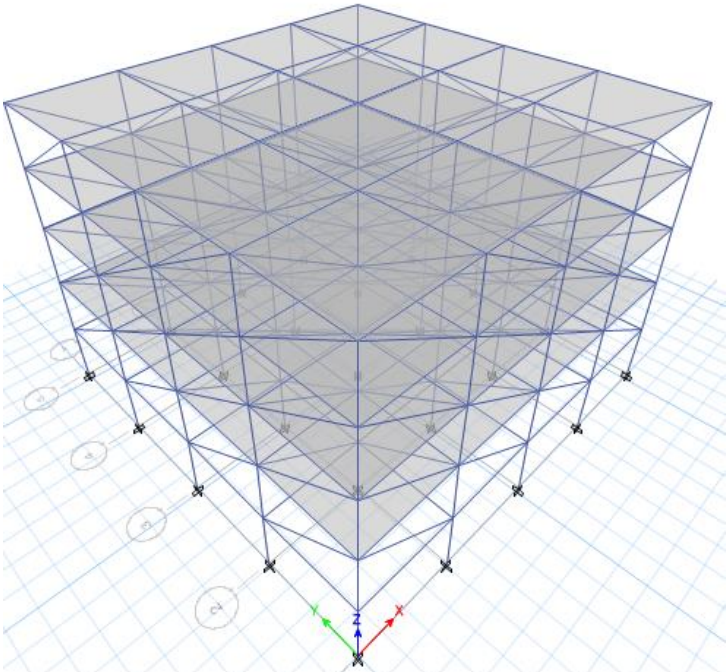


Fig 3 building with infill walls(strut)

CHAPTER 5

METHODOLOGY

5.1 RESEARCH METHODOLOGY

This chapter describes the complete methodology adopted for carrying out the nonlinear static pushover analysis of RCC structures and time history analysis under Indian seismic conditions. The methodology includes selection of building models, determination of material properties, application of gravity and seismic loads as per Indian Standard codes, modeling procedures in ETABS software, assignment of nonlinear hinge properties, and execution of pushover analysis and time history analysis. The purpose of this methodology is to ensure realistic representation of structural behavior and accurate evaluation of seismic performance in terms of displacement, base shear, inter-storey drift, and performance levels.

5.2 Selection of Building Models

For the present study, typical multistorey RCC frame buildings are selected. The buildings are assumed to be located in a seismic region zone IV as defined by IS 1893 (Part 1):2016. The selected buildings represent commonly constructed residential or commercial RCC frame structures in India.

The following assumptions are made for the building models:

- Floor slabs act as rigid diaphragms.
- The foundation is assumed to be fixed at the base.

The buildings are modeled using ETABS software.

5.3 Material Properties

The material properties used for modeling the RCC structures are adopted as per IS 456:2000.

5.3.1 Concrete Properties

The Grade of concrete used is M30.The Characteristic compressive strength is 30 MPa The Poisson's ratio is taken as 0.2 and the density of concrete is taken as 25 kn/m^2

5.3.2 Steel Properties

The Grade of reinforcing steel is taken as Fe 415 and Yield strength is 415 MPa.
Modulus of elasticity,is taken as 2×10^5 MPa

These material properties are used for both linear and nonlinear modeling of the structure.

5.4 GEOMETRIC PROPERTY OF BUILDINGS

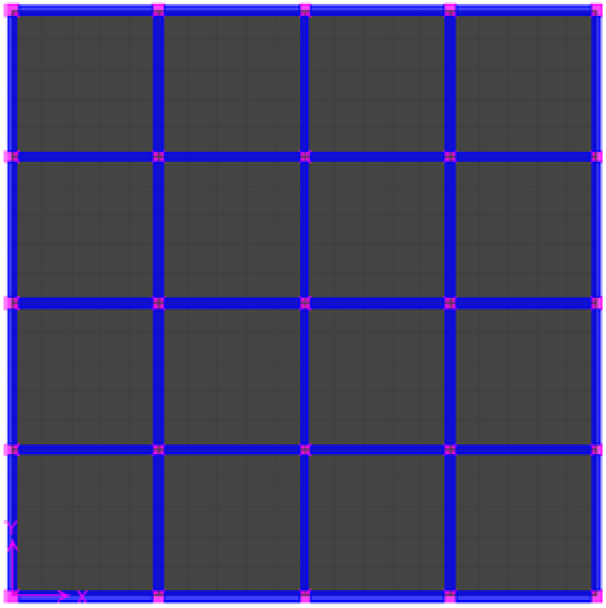


Fig 2 Typical plan of the building

5.5 Loading Details

The following types of loads are considered in the analysis:

5.5.1 Dead Load (DL)

Dead load includes:

Self-weight of beams, columns, and slabs which is calculated by etabs software and Floor finishes.

5.5.2 Live Load (LL)

Live load is applied as per IS 875 (Part 2) depending on occupancy type (residential or commercial). The live loads are taken as 2kN/m^2

5.5.3 Seismic Load (EL)

Seismic loads are applied as per IS 1893 (Part 1):2016 .

Important seismic parameters considered: Seismic zone factor (Z), Importance factor (I), Response reduction factor (R) and soil type

5.6 Load Combinations

Load combinations are generated as per IS 456:2000 and IS 1893 (Part 1):2016.

The load combinations are used for design verification before conducting pushover analysis.

5.7 Modeling Procedure in ETABS

The modeling of RCC structures is carried out using ETABS software. The following steps are followed:

1. Definition of grid lines and storey levels
2. Assignment of material properties

3. Definition of frame and slab sections
4. Modeling of beams, columns, and slabs
5. Assignment of boundary conditions
6. Application of loads and load combinations
7. Linear analysis and design verification

After satisfactory completion of linear analysis and design, the model is converted into a nonlinear model for pushover analysis.

5.8 Nonlinear Hinge Properties

Nonlinear behavior of structural members is represented using plastic hinges as per FEMA 356 guidelines.

5.8.1 Beam Hinges

M3 are assigned at both ends of beams at a distance of 0.1 and 0.9 to simulate flexural yielding.

5.8.2 Column Hinges

P-M2-M3 are assigned at both ends of columns at a distance of 0.1 and 0.9.

The hinge properties define the force–deformation behavior and classify the performance levels into: IO,LS, CP.

5.9 Pushover Load Pattern

Pushover analysis is carried out by applying incremental lateral loads in a predefined pattern. In this study, the following lateral load patterns are considered: Uniform load pattern and First mode shape load pattern

The lateral loads are increased gradually while keeping gravity loads constant until target displacement or collapse condition is reached.

5.10 Pushover Analysis Procedure

The step-by-step pushover analysis procedure adopted in this study is as follows:

1. Apply full gravity load on the structure.
2. Assign nonlinear hinge properties to beams and columns.
3. Apply lateral loads incrementally in the chosen direction.
4. Monitor base shear and terrace displacement for a target displacement of 600mm.
5. Track formation and progression of plastic hinges.
6. Continue the analysis until collapse mechanism or target displacement is achieved.

5.11 Performance Evaluation Criteria

The seismic performance of the RCC structures is evaluated based on the following parameters:

- terrace displacement
- Plastic hinge distribution
- Global performance levels (IO, LS, CP)

The acceptance criteria for these parameters are adopted from FEMA 356 and ATC-40.

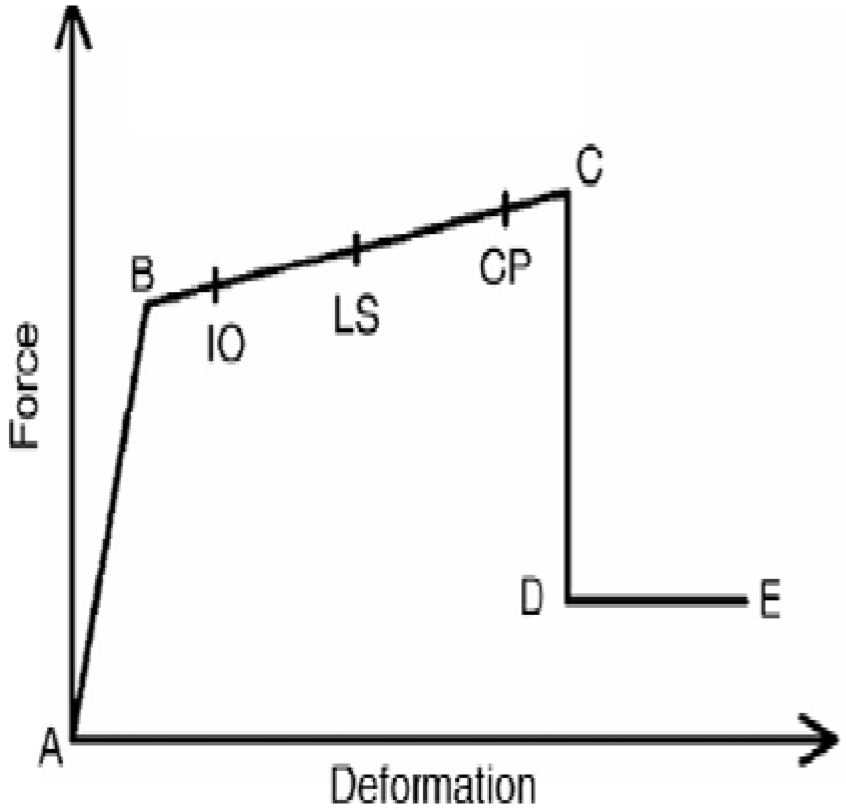


Fig 6 force deformation for pushover analysis

5.12 Comparative Analysis Framework

For comparative evaluation, pushover analysis results of different building models such as SW at periphery,SW at center and building with infill walls are compared based on:

Maximum base shear resistance, Maximum Terrace displacement, Drift distribution along height, Sequence of plastic hinge formation and failure mechanism.

These comparisons help in identifying the most efficient and vulnerable structural configurations.

5.13 Limitations of the Methodology

The present methodology is subject to the following limitations:

1.Soil–structure interaction is not considered.
2. Foundation flexibility is ignored
3. Material degradation and cyclic loading effects are not explicitly modeled.

5.14 TIME HISTORY ANALYSIS methodology

THA is the most rigorous and realistic method of seismic analysis available to structural engineers. Unlike pushover analysis, which applies a slowly increasing static force, THA subjects the structural model to actual or simulated earthquake ground motion records — that is, the variation of ground acceleration with time — and computes the response of the structure at every instant during the earthquake.

It is also referred to as Dynamic Nonlinear Analysis when material and geometric nonlinearities are considered, which is the case for most modern seismic performance evaluation

1. Structural Modeling

A three-dimensional RCC rigid-joint building model was developed in ETABS to study seismic behavior under Indian earthquake loading conditions.

Building specifications considered are G+5 storey building and the storey height is 3m each and bay spacing is 5m x 5m. the beam size is 300 mmx500mm and coloumn size is 400mm x400mm and the slab thickness is 125mm.
The building was modeled as a regular moment-resisting RC frame.

2.Material Properties

the grade of concrete used is M25 and the grade of steel used is Fe 415.

3. Assign Damping Properties

Use 5% damping ratio for reinforced concrete structures as commonly specified by codes

3. Select and Process Ground Motion Records

Select recorded accelerograms from databases such as **ELCENTRO.**

4. Apply Gravity Loads

Apply dead loads and a code-specified fraction of live loads statically before dynamic analysis

This establishes the correct initial stress state in all members

5. Run the Dynamic Analysis

Input the scaled ground motion as a **time-varying base acceleration**

6. Extract Response Quantities

7. Post-Process the Results

8. Revise and Repeat if Required

CHAPTER 6

MODELING AND ANALYSIS OF RCC STRUCTURES

6.1 INTRODUCTION ‘

This chapter presents a brief description of the modeling and analysis of RCC structures with rigid joints carried out in ETABS software. The building models are generated based on typical Indian construction practice and are analyzed under gravity and seismic loading conditions as per the provisions of Indian Standard codes. The purpose of this chapter is to describe the modeling approach and analysis procedure adopted for the present study.

6.2 Description of Building Models

Three-dimensional models of multistorey RCC frame structures with rigid beam–column joints are developed. The buildings are assumed to be regular in plan with uniform storey height and bay spacing. All the structural components such as beams, columns, slabs, and rigid diaphragms are modeled accurately. The support conditions are assumed to be fixed at the base, and soil–structure interaction is neglected.

6.3 Load Application

Dead loads, live loads, and seismic loads are applied to the structures as per IS 875 and IS 1893 (Part 1):2016. The self-weight of the structure is automatically calculated by the software. Appropriate load combinations as specified by Indian codes are used for analysis and design verification.

6.4 Nonlinear Modeling

After completing linear static analysis and design, nonlinear hinge properties are assigned to beams and columns as per FEMA 356 guidelines. Moment hinges (M3) are assigned to beams, and P–M2–M3 interaction hinges are assigned to columns to simulate inelastic behavior during pushover analysis.

6.5 Pushover Analysis

Nonlinear static PHA was conducted by applying the lateral force progressively in the X and Y direction on the structure with the same gravity loading applied throughout the analysis. The lateral loading was incrementally applied in successive phases to observe the structural response in phases of growing seismic demand. The analysis was continued until the building's displacement was equal to the pre-defined target displacement or until a critical failure state was reached. The results obtained were used to draw the capacity curves showing the relation between base shear and terrace displacement, which assisted in the evaluation of the stiffness, strength and deformation capacity of the structure under nonlinear loading.

6.6 Time History analysis

After modeling of structure and adding the load cases of time history in X and Y Direction. We run the analysis of the model in Etabs of TH-X And TH-Y.

We are then get the response of the structure.

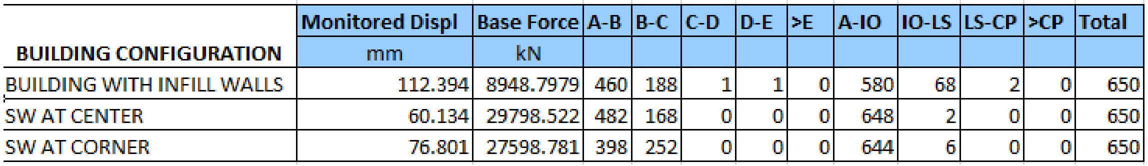
CHAPTER 7

RESULT AND DISCUSSION

This chapter presents a brief discussion of the results obtained from the nonlinear static pushover analysis of RCC structures with rigid joints under Indian seismic conditions. The key parameters are evaluated. The results are used to assess and compare the overall seismic performance of the building models.

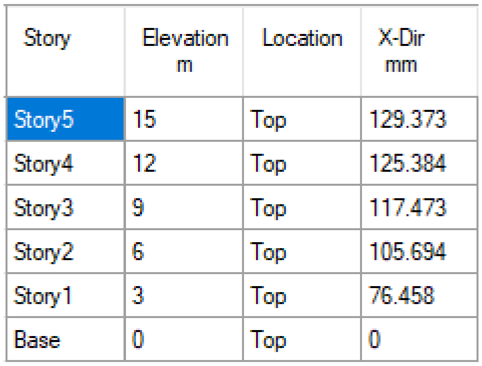
Plastic Hinge Formation

Plastic hinges initially form at the ends of beams, indicating a desirable ductile beam–sway mechanism. As the lateral load increases, hinges gradually develop in columns, especially at the lower storeys. The sequence of hinge formation provides insight into the expected failure mechanism of the structure.



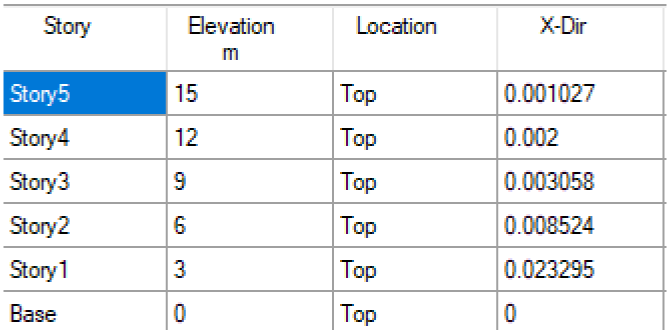
BUILDING CONFIGURATION	Monitored Displ	Base Force	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	Total
	mm	kN										
BUILDING WITH INFILL WALLS	112.394	8948.7979	460	188	1	1	0	580	68	2	0	650
SW AT CENTER	60.134	29798.522	482	168	0	0	0	648	2	0	0	650
SW AT CORNER	76.801	27598.781	398	252	0	0	0	644	6	0	0	650

TABLE 1 PLASTIC HINGES FORMATION



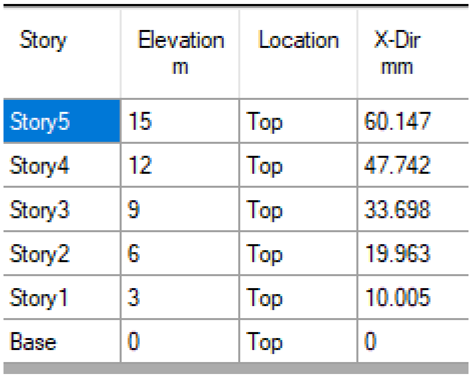
Story	Elevation m	Location	X-Dir mm
Story5	15	Top	129.373
Story4	12	Top	125.384
Story3	9	Top	117.473
Story2	6	Top	105.694
Story1	3	Top	76.458
Base	0	Top	0

Table 2 MAXIMUM STORY DISPLACEMENT (BUILDING WITH INFILL WALLS)



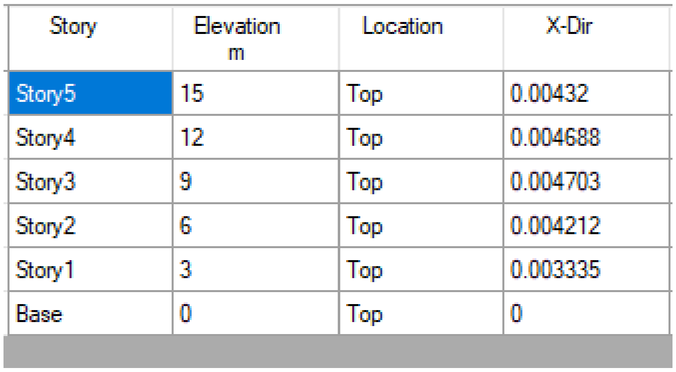
Story	Elevation m	Location	X-Dir
Story5	15	Top	0.001027
Story4	12	Top	0.002
Story3	9	Top	0.003058
Story2	6	Top	0.008524
Story1	3	Top	0.023295
Base	0	Top	0

Table 3 MAXIMUM STORY DRIFT(BUILDING WITH INFILL WALLS)



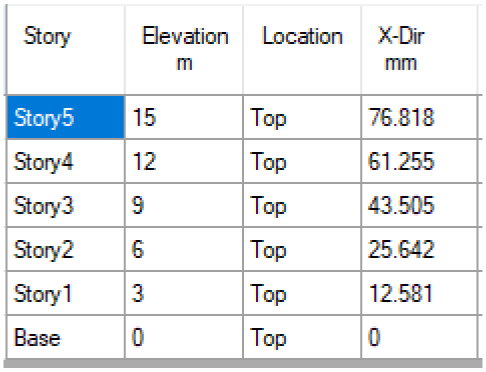
Story	Elevation m	Location	X-Dir mm
Story5	15	Top	60.147
Story4	12	Top	47.742
Story3	9	Top	33.698
Story2	6	Top	19.963
Story1	3	Top	10.005
Base	0	Top	0

TABLE 4 MAXIMUM STORY DISPLACEMENT (SW AT CENTER)



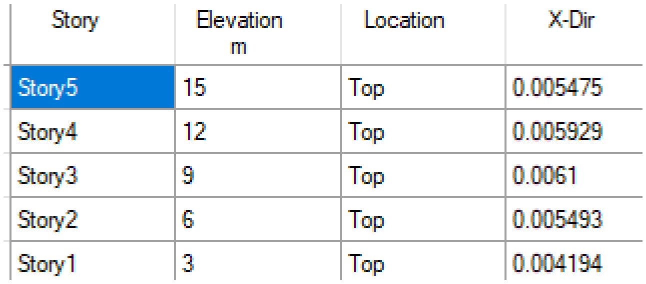
Story	Elevation m	Location	X-Dir
Story5	15	Top	0.00432
Story4	12	Top	0.004688
Story3	9	Top	0.004703
Story2	6	Top	0.004212
Story1	3	Top	0.003335
Base	0	Top	0

TABLE 5 MAXIMUM STORY DRIFT (SW AT CENTER)



Story	Elevation m	Location	X-Dir mm
Story5	15	Top	76.818
Story4	12	Top	61.255
Story3	9	Top	43.505
Story2	6	Top	25.642
Story1	3	Top	12.581
Base	0	Top	0

Table 6 maximum story displacement (sw at corner)



Story	Elevation m	Location	X-Dir
Story5	15	Top	0.005475
Story4	12	Top	0.005929
Story3	9	Top	0.0061
Story2	6	Top	0.005493
Story1	3	Top	0.004194

Table 7 maximum story drift (sw at corner)

Results of Pushover Analysis

Three structural configurations were analyzed using nonlinear static (pushover) analysis:

1. RCC Building with Infill Walls
2. RCC Building with Shear Wall at Center
3. RCC Building with Shear Wall at Corner

1. Building with Infill Walls

The maximum base shear capacity achieved was approximately 12,015 kN at a roof displacement of about 129.6 mm.

The maximum roof displacement recorded was 129.37 mm.

The maximum inter-storey drift was 0.0233, occurring at the first storey.

Plastic hinges were primarily concentrated in the Immediate Occupancy (IO) and Life Safety (LS) ranges, indicating acceptable seismic performance.

2. Building with Shear Wall at Center

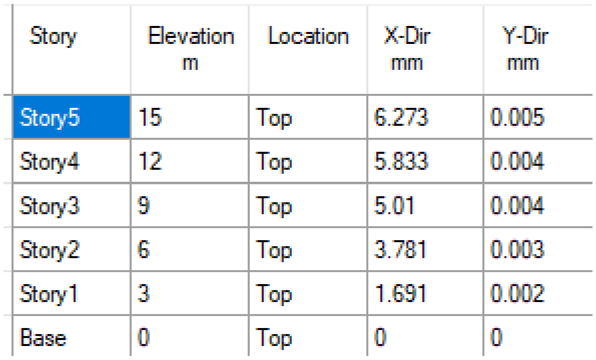
- The structure developed the highest base shear capacity of approximately 29,798 kN at a roof displacement of about 60.13 mm.
- The maximum roof displacement was reduced to 60.15 mm.
- The maximum inter-storey drift was 0.00488, significantly lower than the infill wall model.
- The centrally located shear wall increased lateral stiffness and improved seismic resistance, resulting in better overall structural performance.

3. Building with Shear Wall at Corner

- The maximum base shear capacity reached approximately 27,599 kN at a roof displacement of about 76.80 mm.
- The maximum roof displacement was 76.82 mm.
- The maximum inter-storey drift was 0.00610.
- The corner shear wall configuration provided substantial improvement over the infill wall model but was slightly less effective than the centrally placed shear wall.

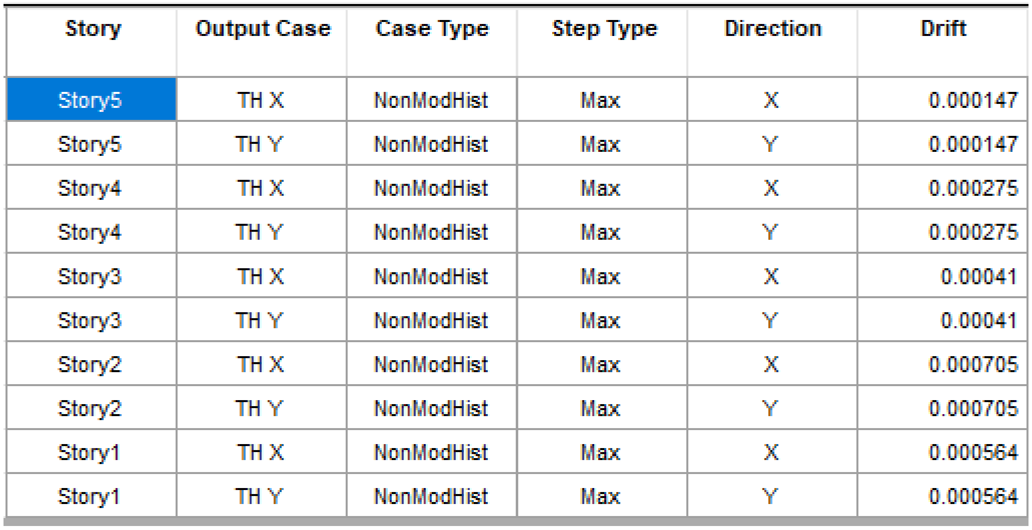
Among the three configurations, the **shear wall at the center** exhibited the best seismic performance due to its highest base shear capacity and lowest displacement. The **corner shear wall** also significantly improved structural behavior compared to the infill wall model. Therefore, providing shear walls, particularly at the center of the building, is the most effective configuration for enhancing the seismic resistance and overall stability of the RCC structure.

RESULT OF TIME HISTORY ANALYSIS



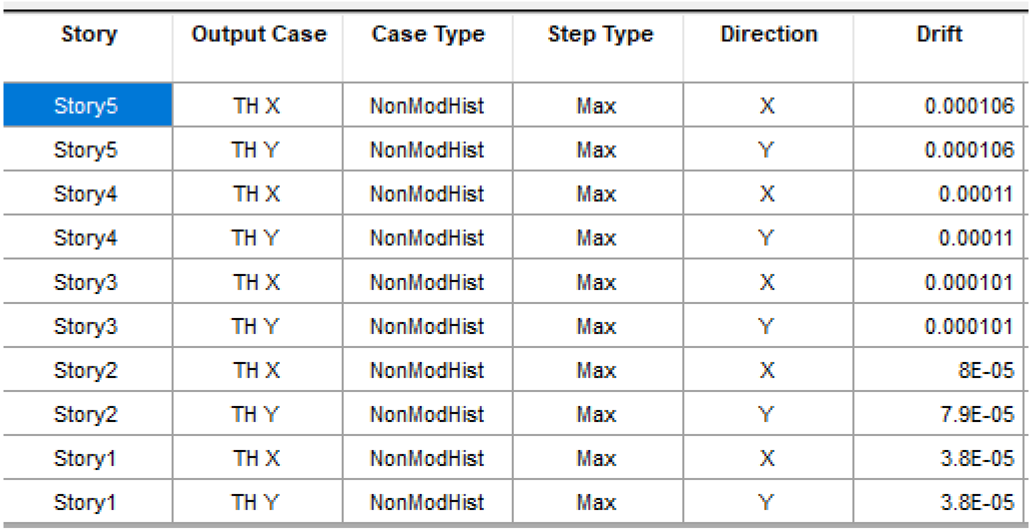
Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story5	15	Top	6.273	0.005
Story4	12	Top	5.833	0.004
Story3	9	Top	5.01	0.004
Story2	6	Top	3.781	0.003
Story1	3	Top	1.691	0.002
Base	0	Top	0	0

TABLE 8 MAXIMUM STOREY DISPLACEMENT (INFILL WALL)



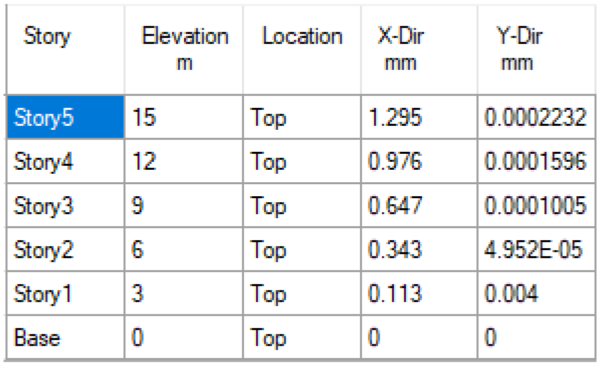
Story	Output Case	Case Type	Step Type	Direction	Drift
Story5	TH X	NonModHist	Max	X	0.000147
Story5	TH Y	NonModHist	Max	Y	0.000147
Story4	TH X	NonModHist	Max	X	0.000275
Story4	TH Y	NonModHist	Max	Y	0.000275
Story3	TH X	NonModHist	Max	X	0.00041
Story3	TH Y	NonModHist	Max	Y	0.00041
Story2	TH X	NonModHist	Max	X	0.000705
Story2	TH Y	NonModHist	Max	Y	0.000705
Story1	TH X	NonModHist	Max	X	0.000564
Story1	TH Y	NonModHist	Max	Y	0.000564

Table 9 maximum storey drift (INFILL WALL)



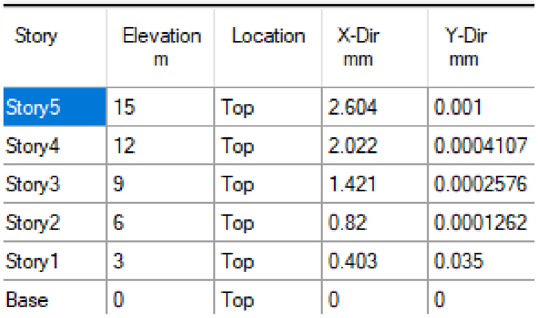
Story	Output Case	Case Type	Step Type	Direction	Drift
Story5	TH X	NonModHist	Max	X	0.000106
Story5	TH Y	NonModHist	Max	Y	0.000106
Story4	TH X	NonModHist	Max	X	0.00011
Story4	TH Y	NonModHist	Max	Y	0.00011
Story3	TH X	NonModHist	Max	X	0.000101
Story3	TH Y	NonModHist	Max	Y	0.000101
Story2	TH X	NonModHist	Max	X	8E-05
Story2	TH Y	NonModHist	Max	Y	7.9E-05
Story1	TH X	NonModHist	Max	X	3.8E-05
Story1	TH Y	NonModHist	Max	Y	3.8E-05

Table 10 story drift (SW AT CENTER)



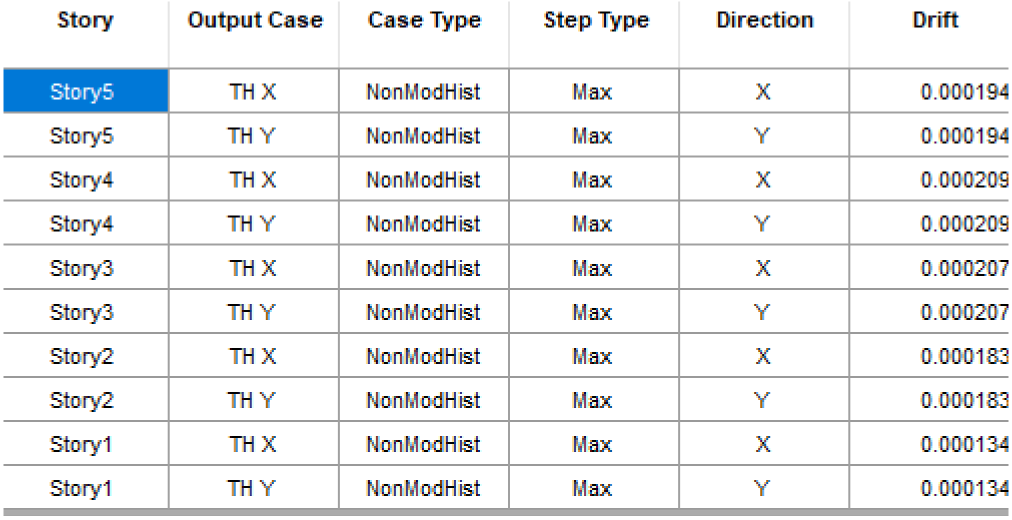
Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story5	15	Top	1.295	0.0002232
Story4	12	Top	0.976	0.0001596
Story3	9	Top	0.647	0.0001005
Story2	6	Top	0.343	4.952E-05
Story1	3	Top	0.113	0.004
Base	0	Top	0	0

Table 11 story displacement (sw at center)



Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story5	15	Top	2.604	0.001
Story4	12	Top	2.022	0.0004107
Story3	9	Top	1.421	0.0002576
Story2	6	Top	0.82	0.0001262
Story1	3	Top	0.403	0.035
Base	0	Top	0	0

TABLE 12 MAXIMUM STORY DISPLACEMENT (SW AT CORNER)



Story	Output Case	Case Type	Step Type	Direction	Drift
Story5	TH X	NonModHist	Max	X	0.000194
Story5	TH Y	NonModHist	Max	Y	0.000194
Story4	TH X	NonModHist	Max	X	0.000209
Story4	TH Y	NonModHist	Max	Y	0.000209
Story3	TH X	NonModHist	Max	X	0.000207
Story3	TH Y	NonModHist	Max	Y	0.000207
Story2	TH X	NonModHist	Max	X	0.000183
Story2	TH Y	NonModHist	Max	Y	0.000183
Story1	TH X	NonModHist	Max	X	0.000134
Story1	TH Y	NonModHist	Max	Y	0.000134

TABLE 13 STOREY DRIFT (SHEAR WALL AT CORNER)

Time history analysis was carried out on three different RCC building configurations, namely the building with infill walls, the building with a shear wall at the center, and the building with a shear wall at the corner. The seismic performance of each model was evaluated in terms of maximum storey displacement and inter-storey drift.

Building with Infill Walls

The maximum storey displacement was observed at the roof level (Storey 5) with a value of 6.273 mm in the X-direction, while the displacement in the Y-direction was negligible. The displacement increased progressively from the base to the top storey, indicating the expected deformation pattern under seismic excitation.

The maximum inter-storey drift was found to be 0.000705 at Storey 2. The drift values reduced towards the upper storeys and remained significantly below the permissible limit specified in IS 1893. Therefore, the structure with infill walls exhibited satisfactory seismic performance and adequate lateral stiffness.

Building with Shear Wall at Center

The introduction of a centrally located shear wall significantly reduced the lateral displacement of the structure. The maximum storey displacement at the roof level was 1.295 mm in the X-direction, which is considerably lower than that of the infill wall model.

The maximum inter-storey drift was observed at Storey 4 with a value of approximately 0.00011. The drift values remained almost uniform throughout the height of the building and were well within the allowable limits. The reduction in both displacement and drift demonstrates the effectiveness of the centrally located shear wall in enhancing the seismic resistance of the structure.

Building with Shear Wall at Corner

For the corner shear wall configuration, the maximum roof displacement was found to be 2.604 mm in the X-direction. Although the displacement was greater than that of the central shear wall model, it was substantially lower than that of the infill wall model.

The maximum inter-storey drift was approximately 0.000209 at Storey 4. All drift values remained within the permissible limits prescribed by IS 1893. The corner shear wall improved the seismic performance of the building; however, its effectiveness was slightly lower than that of the centrally located shear wall due to the possibility of torsional effects caused by the asymmetric arrangement.

Therefore, among all the configurations studied, the building with a centrally located shear wall demonstrated the most efficient behavior under dynamic earthquake loading and can be considered the optimum configuration for seismic resistance.

CHAPTER 8

CONCLUSION

The present study investigated the seismic behavior of RCC buildings under Indian seismic conditions using both static (pushover) and dynamic (time history) analysis methods. Three structural configurations were considered: a building with infill walls, a building with a centrally located shear wall, and a building with a corner shear wall. The analyses were carried out using ETABS to evaluate parameters such as storey displacement, inter-storey drift, base shear, and overall structural performance.

The results indicate that the inclusion of shear walls significantly enhances the seismic resistance of RCC structures by increasing lateral stiffness and reducing lateral deformations. Both pushover and time history analyses demonstrated that the structures with shear walls performed better than the conventional infill wall model.

From the pushover analysis, it was observed that the shear wall models exhibited higher base shear capacity and improved structural stability. The capacity curves showed that the buildings with shear walls were capable of resisting greater seismic forces before reaching performance limits. The centrally located shear wall provided a more uniform distribution of stiffness and exhibited superior seismic performance compared to the corner shear wall arrangement.

The time history analysis further confirmed the effectiveness of shear walls in controlling structural response during earthquake excitation. The models with shear walls recorded lower storey displacement and inter-storey drift values than the infill wall model. All the structural configurations satisfied the drift requirements prescribed by IS 1893; however, the central shear wall model consistently produced the lowest displacement and drift values, indicating the highest lateral stiffness and stability.

A comparison of the results obtained from static and dynamic analyses revealed similar performance trends among the structural configurations. The dynamic analysis provided a more realistic representation of structural behavior under earthquake loading, whereas pushover analysis offered valuable insight into the nonlinear capacity and performance levels of the structures.

Based on the overall findings, it can be concluded that the provision of shear walls considerably improves the seismic performance of RCC buildings. Among the configurations studied, the building with a centrally located shear wall exhibited the most efficient behavior under seismic loading and can be considered the optimum structural arrangement for earthquake-resistant design.

REFERENCES

[1] Y. Dinar, M. I. Hossain, R. K. Biswas, and M. M. Rana, “Descriptive Study of Pushover Analysis in RCC Structures of Rigid Joint,” *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, vol. 11, no. 1, pp. 60–68, Jan. 2014.

[2] A. Kasabe and V. Shelar, “Pushover Analysis of Building Using Soft Story at Different Levels,” *World Journal of Advanced Engineering Technology and Sciences*, vol. 9, no. 1, pp. 203–210, 2023, doi: 10.30574/wjaets.2023.9.1.0160.

[3] R. Kavitha, M. C. Sundarraja, M. R. Vivekananthan, C. Vinodhini, P. Thiruvishnu, and P. Deepan, “Seismic Analysis and Design of Multilevel Car Parking Using ETABS,” *Materials Today: Proceedings*, vol. 62, pp. 2351–2356, 2022, doi: 10.1016/j.matpr.2022.04.212.

[4] M. Faiz and R. Kumar, “Comparative Effectiveness of Equivalent Static Analysis & Response Spectrum Analysis in Extreme Seismic Zones,” *IOP Conference Series: Earth and Environmental Science*, vol. 1110, no. 1, Art. no. 012013, 2023, doi: 10.1088/1755-1315/1110/1/012013.

[5] S. D. Maniyar and P. J. Salunke, “Comparative Study of Response Spectrum and Pushover Analysis for G+8+T RCC Buildings,” *International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET)*, vol. 12, no. 8, pp. 10698–10706, Aug. 2023, doi: 10.15680/IJIRSET.2023.1208024.

[6] M. A. M. Akberuddin and M. Z. M. Saleemuddin, “Pushover Analysis of Medium Rise Multi-Story RCC Frame With and Without Vertical Irregularity,” *Int. J. Eng. Res. Appl.*, vol. 3, no. 5, pp. 540–546, 2013.

[7] J. Ahmed and S. A. Raza, “Seismic Vulnerability of RC Buildings by Considering Plan Irregularities Using Pushover Analysis,” *Global Journal for Research Analysis*, vol. 3, no. 9, pp. 42–47, 2014.

[8] Bureau of Indian Standards, *IS 456:2000, Plain and Reinforced Concrete – Code of Practice*, 4th Revision, New Delhi, India: BIS, 2000.

[9] Bureau of Indian Standards, *IS 1893 (Part 1):2016, Criteria for Earthquake Resistant Design of Structures – Part 1: General Provisions and Buildings*, 6th Revision, New Delhi, India: BIS, 2016.

Comparative Study of Static and Dynamic Analysis of RCC Structures under Indian Seismic Condition

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