SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH PERFORATED SHEAR WALLS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF MASTER OF TECHNOLOGY IN STRUCTURAL ENGINEERING

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CANDIDATE'S DECLARATION

I, Subham kumar singh, Roll No. 2K20/STE/22 student of M.Tech. (Structural Engineering). Hereby declare that the project dissertation titled "**SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH PERFORATED SHEAR WALLS**" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship or other similar title or recognition.

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CERTIFICATE

I, hereby certificate that the Project titled "**SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH PERFORATED SHEAR WALLS**" which is submitted by Subham Kumar Singh, Roll No. 2K/20/STE/22, Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any degree or diploma to this university or elsewhere.

Place: Delhi
Date:

Sh. G.P AWADHIYA
(Associate Professor)
Supervisior

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At the outset, I would like to express my sincere and deep gratitude to my supervisor, Sh. G.P Awadhiya, Associate Professor for his enlightening and inspiring guidance to complete my project work under her valuable guidance and supervision. His guidance has taught me valuable lesson for my career.

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Apart from this, I would like to extend a token of thanks to my family with whose support and love enabled me complete my course.

SUBHAM KUMAR SINGH

ABSTRACT

For many years, shear walls have been integrated as part of the resisiting lateral loads system in buildings, especially in the mid-rise to high-rise range because of their ability to control structural displacements. As the concept of design codes evolved from strength-based to performance-based, engineers became increasingly concerned about nonlinear behavior of shear walls. So, many researchers are now striving to improve and forecast how shear walls would behave during strong earthquakes.

This study shows the findings of nonlinear static (pushover analysis) assessments of an 11-story structure with solid shear walls and perforated shear walls perforated in three different patterns, each varying in percentage by 10%, 15%, and 20%.

Pushover analysis was conducted using ETABS 2019. The analysis reveals that shear wall systems are performing less well. With a reduction of 29 percent in the ductility reduction factor and a reduction of 36 percent in the ductility factor, the efficiency of a wall with perforated patterns has decline.

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CHAPTER 1

INTRODUCTION

1.1. REINFORCED CONCRETE SHEAR WALL

Shear walls are utilised in many structures to resist lateral loads induced by wind, earthquakes, and other occurrences.. It functions as cantilever walls built to withstand lateral loads and is strong in the length direction. It starts at the foundation and continues up to the top of the building. RC shear walls can be anything from 150mm to 400mm thick. It is responsible for carrying earthquake loads to the foundation.

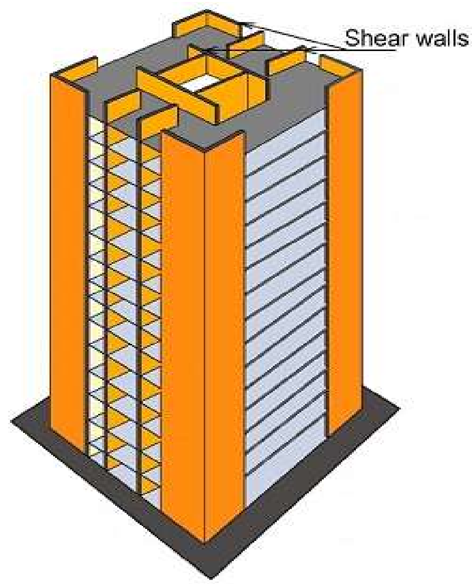


Fig.1.1 Shear wall configuration (Source:www.designingbuildings.co.uk)

Advantages of Shear walls in RC Buildings

The shear wall improves lateral stiffness and strength, allowing for the controlling of inter-storey drift and adequate energy dissipation. Proper detailing of the longitudinal, transverse, and special confining reinforcement ensures a reliable ductile response during a significant earthquake.

1.2. Shear Wall Types

Shear walls can be squat, slender, or a combination of the two depending on the height-to-width ratio. If the height to width ratio of shear wall is greater than 2. It has the appearance of a thin vertical cantilever wall, with bending as the main source of deformation, shear deformation is minor and can be ignored. Flexural strength influences the construction of a slender shear wall. Squat shear walls have a height-to-width ratio of less than half. In comparison to bending deformation, shear deformation is the most common mode of deformation. Shear is the governing criterion for such a wall.

Failure modes of a slender shear wall

Flexural strength is the determining factor for these types of walls. After a few cycles of inelastic deformation, such walls create a largely horizontal crack pattern in the lower hinging zone. Main flexural reinforcement along the wall edges fracturing, concrete crushing in the compression zone, or lateral compression zone instability all limit the flexural strength of slender shear walls.

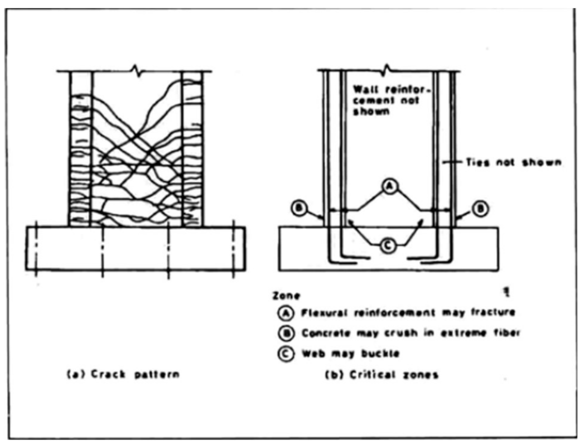


Fig.1.2 The critical zone and crack pattern of the shear wall (Source:The Indian concrete journal)

Failures modes of Squat shear wall

Shear strength is the determining factor for this sort of wall. For each direction of loading, these walls generate web cracks that form a diagonal compression strut system. Shear transfer occurs as a result of the truss motion, resulting in a stiffer structure than a slender wall.

Diagonal tension, diagonal compression, or sliding shear limit the shear strength of such a wall.

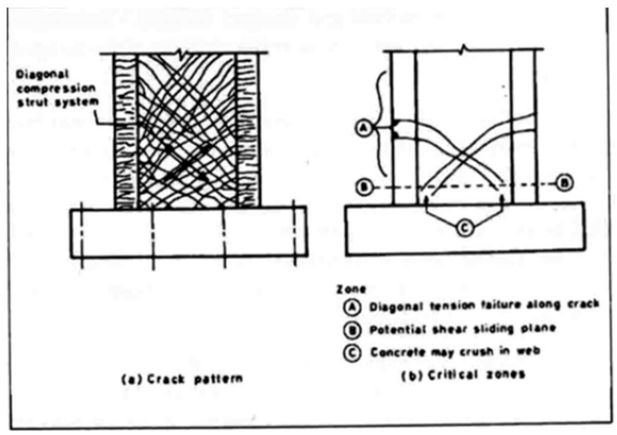


Fig.1.3 The critical zone and crack pattern of the shear wall (Source: The Indian concrete journal)

1.3 Shear wall functions

One of the more successful methods is to construct earthquake-resistant reinforced concrete buildings with numerous stories using shear walls. The column widths are massive, as is the amount of steel necessary, when an RC Multi-Story Building is planned without shear walls. As a result, there is a great deal of congestion at these joints, making it difficult to add concrete and shake it, and the displacement is huge, creating substantial forces in the members. In order to save money and manage horizontal displacement, shear barriers may be required. Earthquakes continue to inflict damage to the structure for a variety of reasons. The weight distribution, strength, and lateral stiffness of a structure determine how it reacts to an earthquake in both horizontal and vertical planes. To mitigate the effects of earthquakes, reinforced concrete shear walls are employed in construction. These can be used to improve the seismic performance of a structure. In seismic structural design, the key focus is structure safety during large earthquakes. To withstand lateral forces, high-rise structures must have sufficient lateral stiffness. Shear walls have been proved to be a cost-effective and effective approach to provide lateral rigidity to structures. Buildings with well-built and detailed shear walls have seemed spectacular during large earthquakes.

Shear wall's components

Walls constructed of reinforced concrete or masonry are rarely straightforward. When a wall has doors, windows, or other openings, it must be treated as a combination of slightly flexible sections, such as column segments and wall piers, and relatively inflexible elements, such as wall segments.

1.3.1 Column Segment

A column segment is a vertical component having a height higher than three times its thickness and a breadth less than two-thirds its thickness. The load is axial the majority of the time. Although its stiffness may have a modest impact on the shear wall's lateral force resistance, it must be taken into account. The section of a column that protrude from the face of the wall is called a pilaster when it is integrated integrally with a wall. In the case of concrete, the column section must be constructed in line with the manufacturer's specifications (IS 456-2000).

1.3.2 Wall Piers

A wall pier is a wall section with a clear height of two times its horizontal length and a horizontal length of two and a half to five times its thickness.

1.3.3 Wall segment

Wall segments refer to the components that seem to be longer than that of the wall piers. They are the principal resistance components of the shear wall.

1.4 BUILDING A SHEAR WALL: ARCHITECTURAL CONSIDERATION

Between column lines, elevator wells, stairwells, and utility shafts, shear walls are commonly produced. Columns are structural members that primarily carry gravity loads created by the building's contents and self-weight Shear walls give buildings considerable strength and stiffness in the direction of their orientation, decreasing lateral tilt and, as a result, preventing damage to the structure and its contents. The chances of them overturning are higher since they will be subjected to large horizontal earthquake stresses. As a result, the design of their foundations must be given special attention. Shear walls were created along the length and width of the structure. If they're only going to be used in one direction, a beam and column grid should be provided.

Shear walls must be symmetrically arranged to reduce the harmful effects of twist in buildings. In plan, they are symmetrical in one or both directions. It will be more efficient if it is installed around the building's external perimeter.

Door or window apertures might offer the shear wall. If it is provided in a smaller size, it will provide the least amount of interference with the force flow through the wall. Furthermore, openings must be symmetrical. A specific design inspection should be done to make sure that the cross sectional area of the shear wall at the aperture is large enough to support the horizontal earthquake force.

1.5 An Overview of the shear wall's geometry

Shear walls have an oblong cross section, which is a flat shape with four sides and four 90° opposed sides of equal length. The rectangular cross section is by far the most common. Sections like the L and U are also employed. The wall hollow shafts that enclose a building's elevator core also act as shear walls, allowing it to withstand earthquake forces.

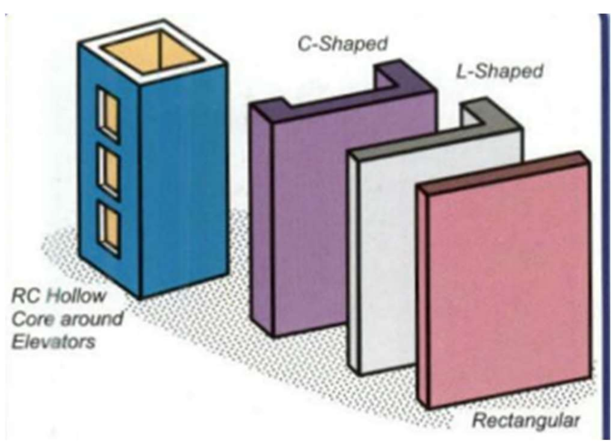


Fig.1.4 Shear wall in RC buildings(Source: IITK-BMTPC Earthquake Tips)

1.7 Ductile design of shear walls

Shear walls require ductile detailing, the IS code (IS 13920:2016) is utilised as specific design guidelines.

1.7.1 Reinforcement bars in RC walls

Steel reinforcing bars are installed in walls in vertical and horizontal grids that are evenly spaced. In one or two parallel layers termed curtains, the reinforcements are supplied in walls in regularly spaced vertical and horizontal grids. At the ends of walls, horizontal reinforcement should be anchored. In each horizontal and vertical direction, the minimum area of reinforcement is stated as 0.0025 times the cross sectional area. Vertical reinforcement is evenly distributed over the cross section of the wall.

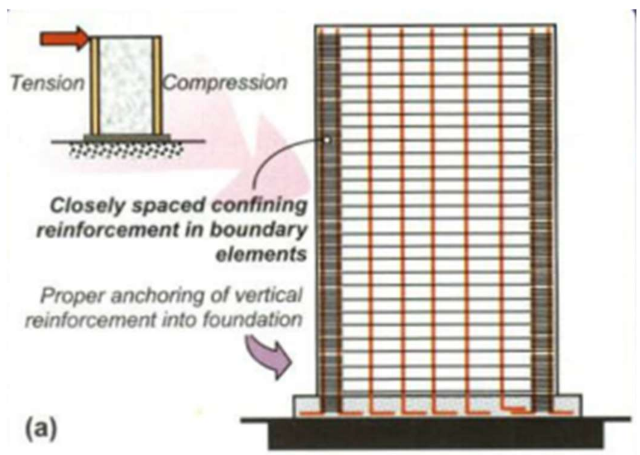


Fig.1.5 Shear wall main reinforcement layout according to IS:13920-2016 (Source: IITK-BMTPC Earthquake Tips)

1.8 Boundary elements

Due to earthquake forces, the shear wall undergoes massive overturning, and the edges of shear walls are subjected to extreme compressive and tensile stresses. The concrete in the wall ends should be strengthened in a unique way to handle load reversals without losing strength to ensure that the walls are ductile. The final parts of the walls that have additional confinement are known as boundary elements. The limited transverse reinforcement applied to the border element is the same as that used in RC frame columns.

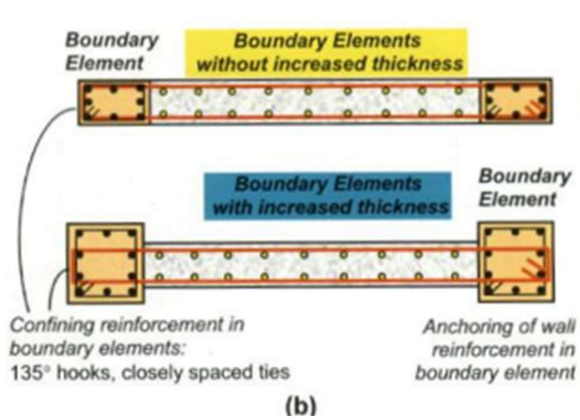


Fig.1.6 Boundary elements(Source: IITK-BMTPC Earthquake Tips)

1.9 Seismic design philosophy

Due to the switch from a strength-based to a performance-based design code, an initial assessment of existing buildings or designing structures against possible earthquake loads was completed.

Current building codes include design objectives for life safety, damage control in minor and moderate earthquakes, and collapse prevention in major earthquakes. However, the design's real reliability in attaining the goal is unknown.

In shortened, the following steps are recognized in the performance based building design of a new building.

- Define the performance goals for each of the inputs to be considered.
- Begin with the initial design.
- Verify that the anticipated outcomes have been achieved.

The performance level can be determined using the guidelines provided in FEMA 356. It's commonly analyzed in terms of the lateral displacement of the structure or the development of hinges.

FEMA 356 specifies three different occupancy levels.

1. Immediate occupancy
2. Life safety
3. Collapse prevention

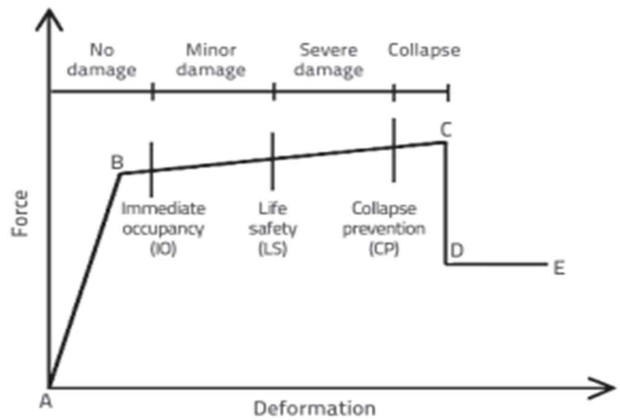


Fig.1.7 Structural performance level(Source:FEMA 356)

I. **Immediate occupancy**

People can instantly occupy the building following a sudden earthquake at this level. There is modest structural deterioration and no major cracks. If there are cracks, they are slight. There is no structural distortion that is permanent.

II. **Life safety performance level**

It has something to do with the decrease of initial stiffness. The framework develops major cracks. The structure, on the other hand, is repairable. If it is repaired, it will cost a lot of money.

III. **Collapse prevention performance level**

The structure is not collapsing at this stage because we do not build structures to collapse. These types of damages occur when a structure is subjected to extremely high lateral loads or when the structure's stiffness is insufficient to withstand the lateral stresses. Some structural elements or parts have failed and collapsed. It is not possible to repair or reuse the structure.

1.10 Objectives of Present study

In many buildings, the shear wall is an integral part of the horizontal load resisting system. It's very useful because it can manage lateral movement of structures.

The focus of this research is to predict the behavior of shear wall both with perforation and without perforation. For this we required to assess the non-linear behavior of shear wall.

The nonlinear static (pushover) analysis of an 11-story structure with shear walls perforated in three different patterns was carried out in this study.

The principle goal of research work are

I. To show how the structure with perforated shear wall will perform under earthquake load condition.
II. To show how perforation affects a shear wall structure's ductile capacity.

The Dissertation titled **"SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH PERFORATED SHEAR WALLS"**is composed of five chapters.
Following are the chapters included in this dissertation.

Chapter 1 consists of the Introduction of the Reinforced concrete shear wall, in which objective, scope and limitation of thesis is also given.

Chapter 2 comprises of literatures which have been reviewed, during the study.

Chapter3 Discussed about method used in this project work & elaborated with the given guidelines.

Chapter4 contains details about the results obtained from the analysis and their interpretation in the form of tables and graphs

Chapter 5 Conclusion and recommendations

Bibliography of the literatures which have been referred in the study is also provided.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Structure with reinforcement Shear walls are well-known as an effective lateral load resisting structure in mid- to high-rise buildings, and they play a vital role in managing the lateral loads.There are circumstances when it is necessary to create apertures in shear walls due to architectural requirements.This study attempts to present methods for predicting perforated shear wall behaviour before they are built, as well as strategies for enhancing perforated shear wall behavior utilising conventional nonlinear analysis. This chapter contains the results of several authors' studies as well as their conclusions.

2.2 CODAL REQUIREMENTS

Due to the lack of a codal provision for multi-story building design, the design conditions and requirements were determined and computed using existing codes. IS **The code of practise for ductile detailing of reinforced concrete structures subjected to seismic stresses is 13920:2016 Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.**

We can specify numerous components such as beams, columns, and shear walls under IS 13920:(2016). This will ensure that the structural elements work as intended when subjected to cyclic loads like earthquakes.

IS 875 (Parts 1-3):1987 Code of Practice for Design Loads in Buildings and Structures (Other Than Earthquake).

It aids in the calculation of Dead Loads (unit weights of construction and storage materials)(Part 1), Imposed Loads (Part 2), and Wind Loads (Part 3).

2.3 LITERATURE REVIEW

Asghari, B. Azimi, A.H.Gandami(2003), This work emphasises the use of perforation as a cost-effective approach to minimise the shear demand of coupling beams, resulting in a shift in coupling wall system behaviour from flexural to shear. This change in behaviour promotes rectification in coupling wall system hysteretic response. In this study, three perforated designs (rhombic, chess, and rectangular) are constructed in a shear wall, and a 2D non linear time history analysis is performed using the SAP 2000 programme. The results show that the chess and rhombic patterns increase the hysteretic response the most.

H.S kim,D.G lee(2003), The purpose of this study is to provide an efficient analytical approach for shear walls with apertures that uses super elements derived from fictitious beams. The applicability of the suggested strategy was determined by examining a range of example structures. The findings are summarised as follows:

1. Choi and Bang proposed a modal that uses a plane stress element with an aperture and has a lateral displacement similar to a fine mesh model. There was a time when there was a small opening. The lateral displacement inaccuracy increased as the opening grew larger.

2. The proposed method's analysis yielded results that were remarkably comparable to those of the fine mesh model. The suggested method's memory and computing time are independent of the number, size, and location of the apertures.

F.V. Yanez, R. Park & T. Pauley(2003), The purpose of this study is to provide an efficient analytical methodology for shear walls with openings that uses super elements derived from the finite element method. In this experiment, six reinforced concrete walls with varying sized and ordered openings are cast. Reversed cyclic was used to put these walls to the test. A vertical reinforcement ratio of 0.5 percent was provided in both horizontal and vertical directions. The results of the tests suggest that walls with staggered apertures can be as ductile and perform as well as walls with regular openings. Methods based on strut and tie models have been shown to be viable for the construction of reinforced concrete walls with irregular apertures under reversed cyclic lateral stresses.

Masato SAHURAI, Hirosi KURAMOTO,Tomaya MATSUI and Tomofusa AKITA(2008), The purpose of this research is to explore how various aperture numbers and layouts effect static loading testing on RC shear walls with openings. The perimeter ratio of all of the specimens utilised in the analysis is 0.4. According to the test results, the number and pattern of openings had a significant impact on the shear strength, failure mode, and deformability of RC shear walls with openings. The shear wall openings at the bottom had a smaller overturning moment than the walls without apertures. The hysteresis loops and failure progression of the shear wall with openings were simulated using a FEM investigation.

Abdul Kadir Marsono and Somaich Hatami(2014), The goal of this study is to develop a new opening configuration for reinforced concrete coupled shear walls that will increase the ultimate strength of the structure. In order to evaluate the recommended technique, many different dimensions of haunches were applied to shear walls with rectangular apertures. The models were submitted to nonlinear finite element analysis (NLFEA) using ABAQUS software, as well as analytical analysis based on the total moment concept and continuous connection technique (CCM). Using this strategy, the following findings are achieved.

1. In both analytical and NLFE evaluations, the ultimate strength of shear wall systems increases significantly as the diameters of the haunches increase.
2. According to the findings of the ABAQUS programme, adding haunches causes fractures to shift from the corners of rectangular holes to the corners of octagonal openings, reducing the effective length of coupling beams.
3. Octagonal holes in shear wall systems are confidently worth using since the percentage increase in the total weight of the building in the presence of haunches is so minimal. when weighed against an increase in ultimate load

Hyun-Ki Choi(2016), This experimental study looked at the structural behaviour of reinforced concrete shear walls with holes and slabs. As part of a set of three half scale shear wall specimens, a solid wall, a wall with opening and slab, and a wall with opening but no slab were tested. The test results also show that due to the loss of cross section in order to provide opening, slabs and remaining walls contribute approximately 30% to the lateral load resisting system, and the test results also show that slabs and remaining walls contribute approximately 30% to the lateral load resisting system.

Abazar Asghari, Behnam azimi zarnagh(2017), This study presents the results of linear, non-linear static (pushover), and non-linear time history investigations of a 10-story structure with connected shear wall and three unique perforation patterns. According to nonlinear –static analysis, perforation raises the coupled shear wall's response modification factor by up to 33%. Furthermore, the results of the linear analysis show that perforation minimises the need for coupling beam strengthening. Perforation also improves hysteretic response and helps a system to absorb more energy during a severe earthquake, according to a non-linear inelastic time history analysis.

CHAPTER 3

METHODOLOGY

3.1 General

A structure may be subjected to stresses that exceed its elastic limit during a major earthquake. As a result, the relationship between lateral shear force and RC wall lateral deformation must be established. When inelastic structural analysis is combined with seismic hazard assessment, these relationships can be described more simply due to the availability of fast computers. This research project involves nonlinear modelling of shear walls, which ranges from two-dimensional nonlinear shell components to simpler models based on frame elements.

3.2 Nonlinear Static Analysis(Pushover analysis)

Nonlinear static analysis is used to explore the nonlinear behaviour of suggested shear wall models . It's a nonlinear static process that increases the magnitude of lateral forces on a structure in a predictable pattern. It can also be used to create performance-based designs. For each increament of force, the structure's failure mechanisms, base shear, and maximum roof displacement are computed. A capacity curve is plotted using the relationship between the base shear force at all increaments and the roof displacement.

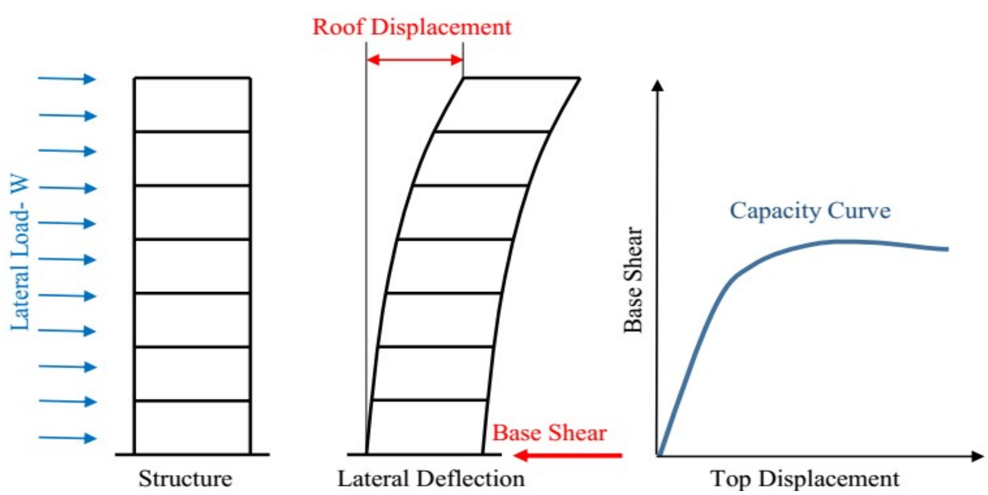


Fig.3.1 Pushover analysis

3.3 Types of Pushover analysis method

The displacement coefficient method (DCM), which is described in FEMA-356, and the capacity spectrum method (CSM), which is defined in ATC-40, have lately been employed for nonlinear static analysis. Both methods rely on nonlinear static analysis under gravity loading to obtain lateral load-deformation variation.

The inelastic relationship of force-displacement of the model in this experiment was derived using FEMA 356 criteria.

The ductility factor(**μ**) is one of the essential parameters used to indicate the ductile character of the shear wall model during a strong earthquake.

The ductility factor is the ratio of the structure's final displacement before collapse to its yield displacement, and it is defined as the structure's ductility capability in an inelastic response during a strong earthquake:

$$\mu = \delta_u / \delta_y \quad (1)$$

The ductility reduction factor, R_μ, is another metric that may be computed using pushover analysis. It is the ratio of a structure's ultimate elastic force to its yield point force. This is depicted in Figure 3.2.

$$R_\mu = V_e / V_y \quad (2)$$

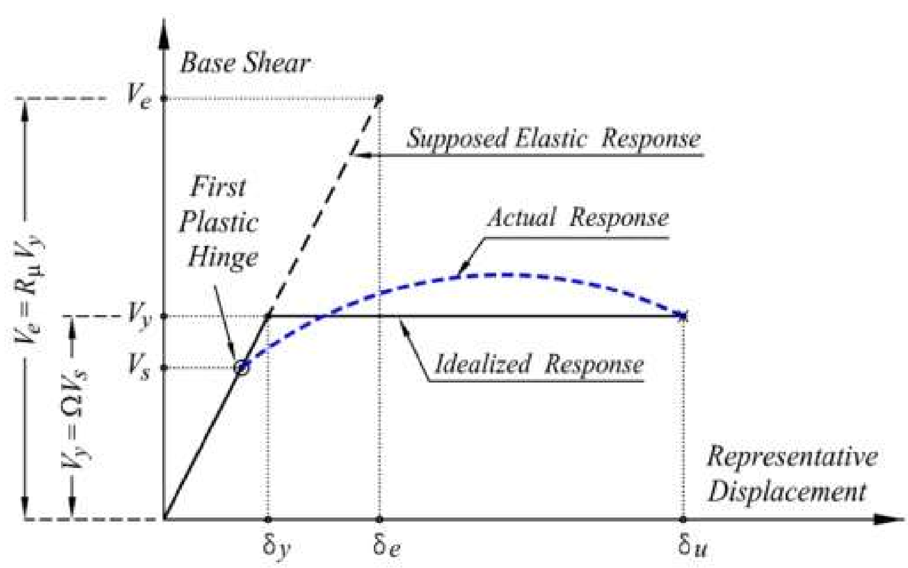


Fig.3.2 Inelastic and elastic responses

Non-linear static analysis (pushover analysis), as mentioned in FEMA 356, is one of the finest approaches for estimating a structure's ductility reduction factor. In recent years, numerous studies have been undertaken to establish the ductility reduction factor of structures, two of which are mentioned here.

1. **An approach based on displacement equality**

According to this method, if the fundamental period is more than 1 second, the maximum elastic and inelastic displacements are quite close to each other. As a result, we can calculate $\mathbf{R_\mu}$, the ductility reduction factor:

$$\mathbf{R_\mu = \mu} \qquad \mathbf{(3)}$$

For structural systems with basic periods shorter than 0.5s, the ductility reduction factor R_μ can be calculated as follows.

$$\mathbf{R_\mu=(2\mu- 1)^{1/2}} \qquad \mathbf{(4)}$$

2.Mirenda and bertero method

The following equation can be used to derive ductility reduction factor $\mathbf{R_\mu}$, as mentioned in this technique.

$$\mathbf{R_\mu = ((\mu-1)/\phi) +1 \geq 1} \qquad \mathbf{(5)}$$

Use the following equation to determine the above equation based on the kind of soil.

$$\mathbf{\Phi=1 +(1/(12T- \mu T))-(2/5T)e-2(ln(T)-0.2)^\wedge 2} \qquad \mathbf{(6)}$$

In accordance with FEMA -356, for the purpose of determining ductility reduction factor,Initially target displacement must be calculated. After that capacity curve obtained from pushover analysis must be idealized. Subsequently ductility reduction factor can be determined by using idealized capacity curve . The following equation can be used to compute the target displacement.

$$\mathbf{\delta_t= C_0C_1\ C_2\ C_3S_a\ (T_e^2/\ 4\pi^2)g} \qquad \mathbf{(7)}$$

Equation must be used to determine the strength ratio R.

R= Sa/(Vy/W) *Cm

The Mirenda and Bertero approach is employed in this study to assess the ductility reduction factor of the frames under consideration.

3.4 How to Idealize capacity curve as bilinear curve

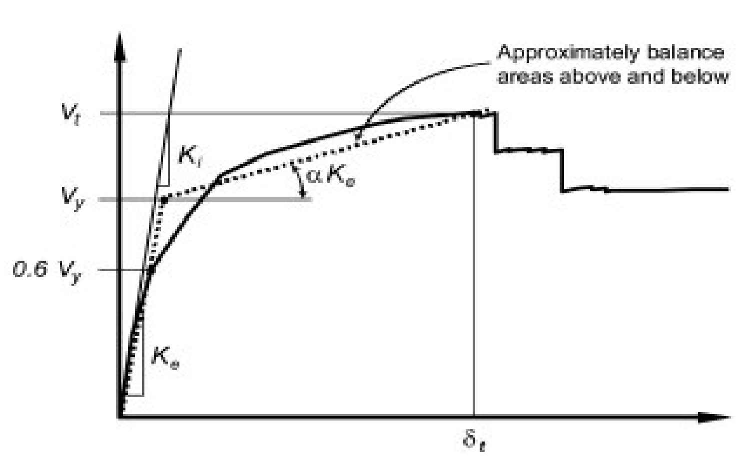


Fig.3.3 Idealized Force- displacement curve(source:FEMA 356)

As shown in Fig.3.3, a bilinear curve begins with an initial slope, Ke, which is the secant stiffness calculated at a base shear force equal to 60% of the structure's effective yield strength. At any point along the capacity curve, the effective yield strength shall not exceed the maximum base shear force. The positive slope following the structure yield is represented by the second line of the bilinear curve, which is drawn from point (δ_t, V_t) to another point on the first line in such a way that the area under the bilinear graph equals the area under the capacity graph to the point

(δ_t , V_t).

3.5 How to perform pushover analysis in ETABS 2019

When applying the inelastic relationship between force and deformation, the inelastic deformations of members are concentrated on plastic hinges, while the remainder of the member stays elastic, according to the programme. Plastic hinges are employed at the start and end of beams, as well as at the column and point load positions in this study. Type M, type V, or a combination of P-M hinges can be used. For flexural system beams, type M3 is employed. Composite hinges of type P-M2-M3 are utilised for members with axial behaviour, such as columns. They are placed at the start and end of a member's list. The Auto fibre P-M3 hinge is used for RC shear walls.

3.6 Basic Modelling Assumptions

These are the main modelling assumptions used in this study .A rigid column on a rigid foundation are considered to be fixed at their base. The influence of soil structure interaction is not considered in this study.When columns and floor diaphragms intersect, only one direction of earthquake response value is applied.Because of the fixed base assumption,all supports are assumed to move in phase.Structures are not translated vertically.

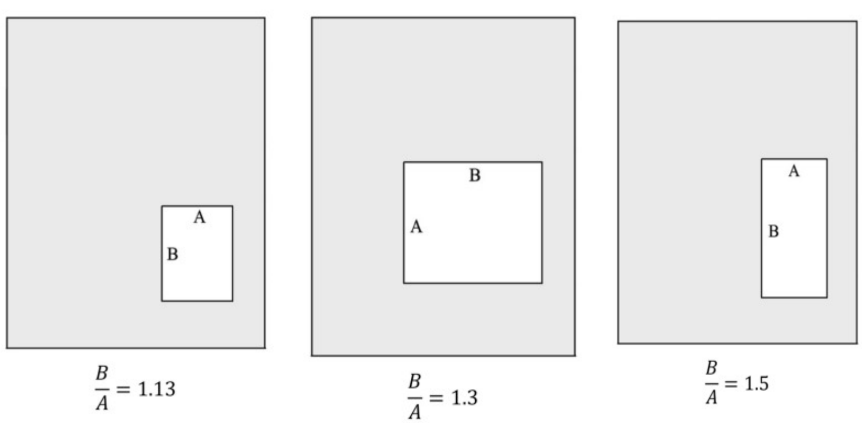
Lumped mass at floor level: Massess and rotational moments of inertia of the structure are consider to be grouped together at the floor levels.

Rigid diaphragm: Each floor is a Rigid diaphragm

3.7 Problem Statement

A structure in an earthquake-prone area was chosen for the prototype frame, which has 11 floors and a story height of 3.5 metres. The dual system of special moment resistant frames and shear walls used in the construction of the building resists lateral loads. Frame and shear wall properties were investigated. The characteristics of the investigated frame, such as the structural elements section shown in the table below. This study employs the recently released Etabs 2019 software for frame model modelling and analysis.

This study uses three perforation patterns , each of which varies in percentage by 10%, 15%, and 20% for inelastic analysis,as shown in the figure below



(a) **(b)** **(c)**

Fig.3.4 Perforation patterns : (a) pattern 1,(b) pattern 2 &(c) pattern 3

Table no.3.1 Description of the structure

Particulars	Dimension/size/value
Number of stories	11
Types of frame	Special moment resisting frame(SMRF)
No. of grids in X direction	8
No. of grids in Y direction	7
Floor height	3.5m
Ground floor height	3.5m
Depth of slab	150mm
Size of beam	350x575
Size of column	450X750
Thickness of masonry wall	230mm
Thickness of shear wall	230mm
Materials	M25 concrete, Fe 500 rebar
Density of concrete	25 KN/m3
Density of infill	19 KN/m3
Live load on each floor	3 KN/m2
Floor finish	1 KN/m2
Wall load	12.78 KN/m
Seismic zone	IV
Type of soil	Medium and stiff soils
Importance factor	1.2
Response reduction factor	5
Damping of structure	5%

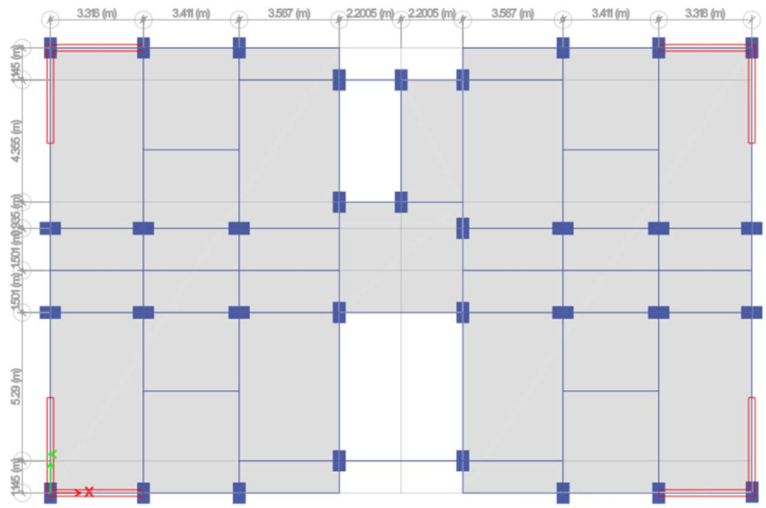


Fig.3.5 Building plan for G+10

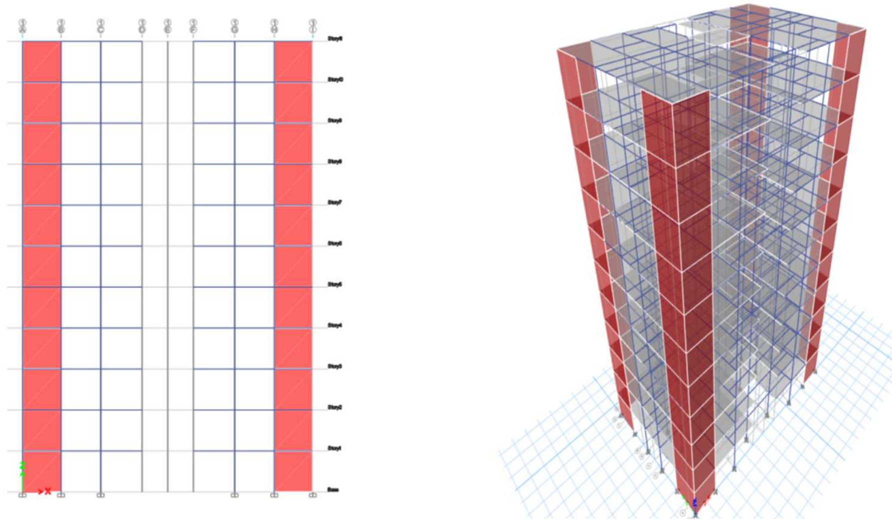


Fig.3.6. Two-dimensional and three-dimensional views of a multi-story construction with a solid shear wall

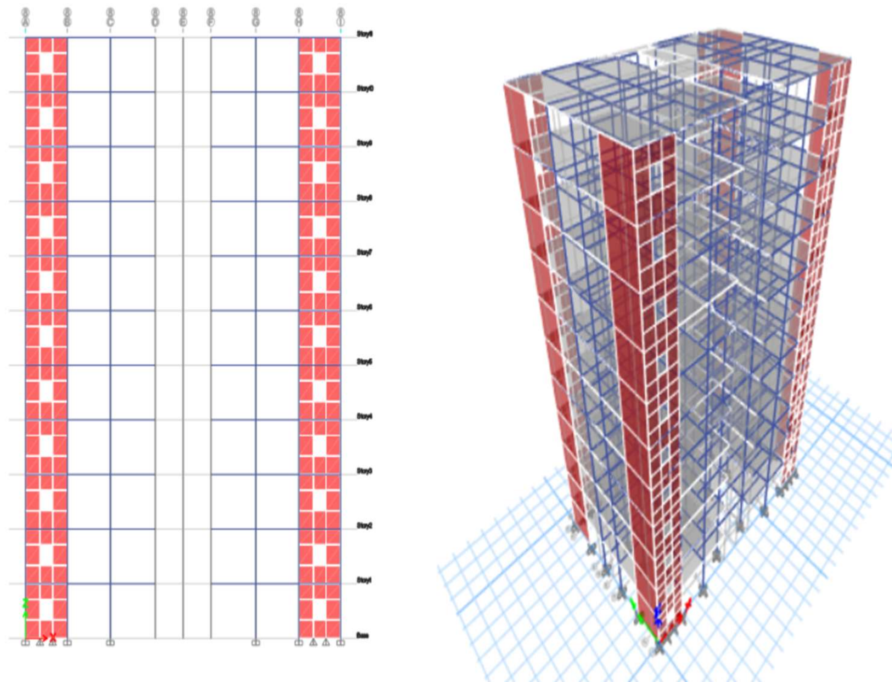


Fig.3.7. Two-dimensional and three-dimensional views of a multi-story construction with a perforated shear wall (pattern 1)

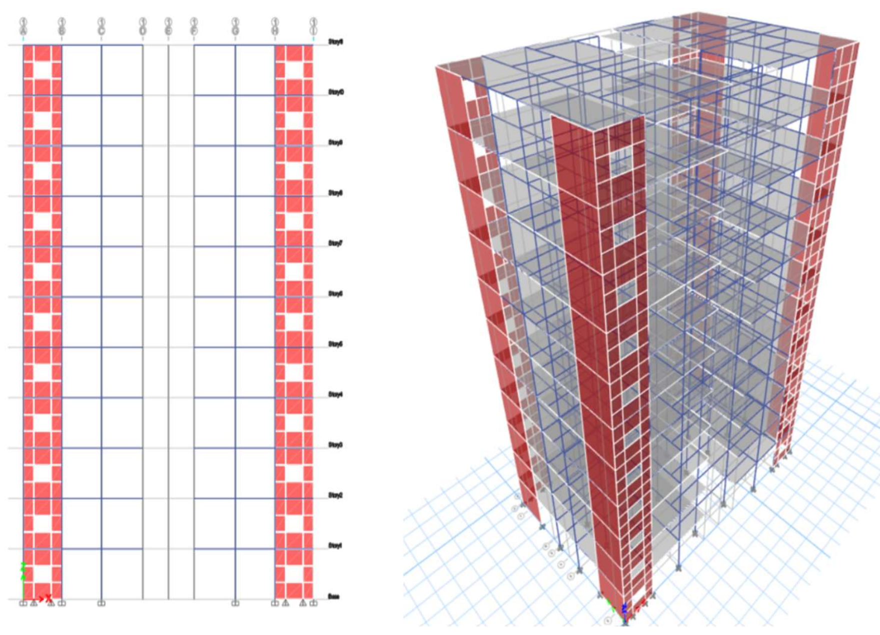


Fig.3.8. Two-dimensional and three-dimensional views of a multi-story construction with a perforated shear wall (pattern 2)

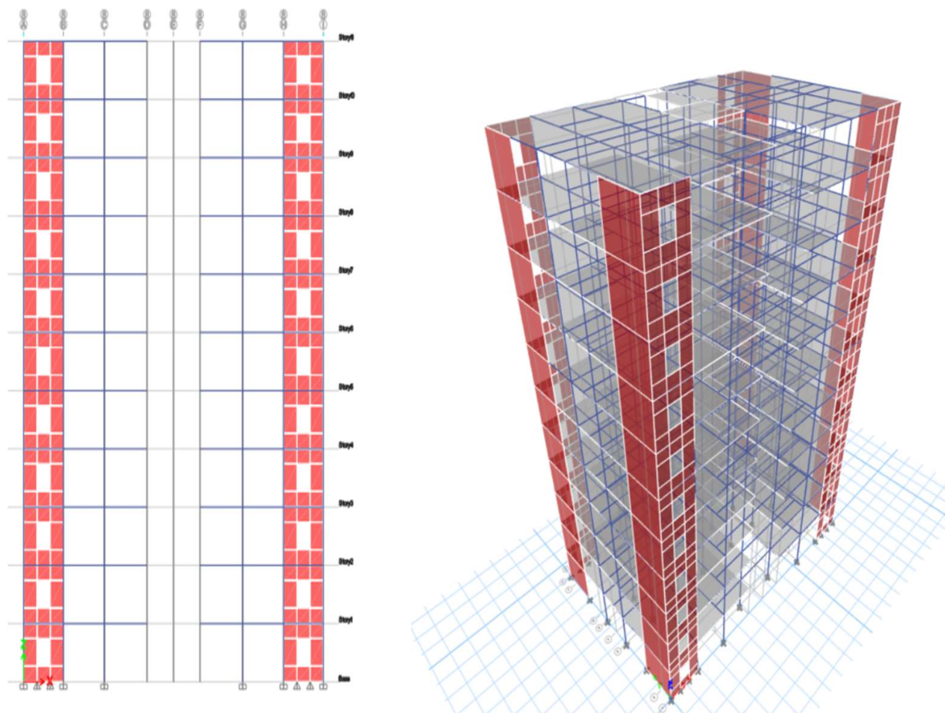


Fig.3.9. Two-dimensional and three-dimensional views of a multi-story construction with a perforated shear wall (pattern 3)

CHAPTER 4

RESULTS & DISCUSSION

4.1 Multistorey building with solid shear wall

Table 4.1.1 Multistorey building with solid shear wall

Target displacement,mm	740.184
Base shear at Target displacement,kN	7927.5852
C0	2.616
C1	1
C2	1
Cm	1
Sa	0.355036
Te(sec)	1.798
δ_y, mm	46.042
Vy, kN	5733.1635
Weight W ,kN	207585.9498
μ	16.07
R	12.85

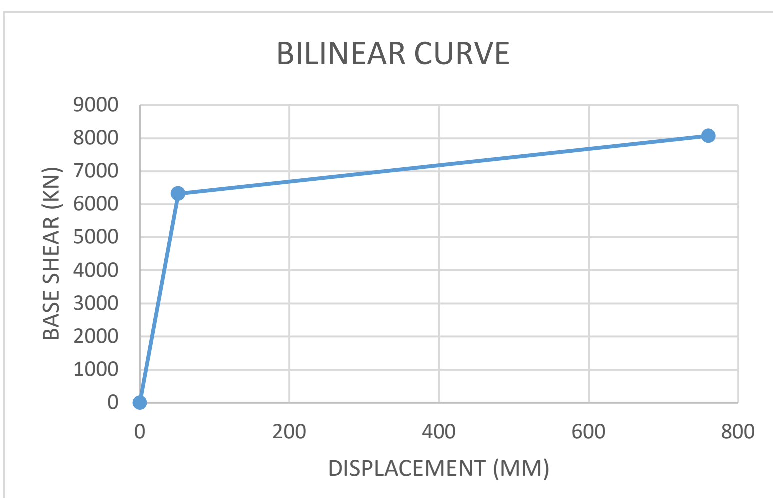


Fig .4.1 Bilinear curve for multistory building with solid shear wall

4.2 Shear wall with perforation pattern 1

Table 4.2.1 Shear wall with 10% perforation

Target displacement,mm	396.758
Base shear at Target displacement,kN	7132.9562
C0	1.3778
C1	1
C2	1
Cm	1
Sa	0.349
Te(sec)	1.828
δ_y, mm	38.859
Vy, kN	4726.088
Weight W ,kN	206572.51
μ	10.21
R	9.08

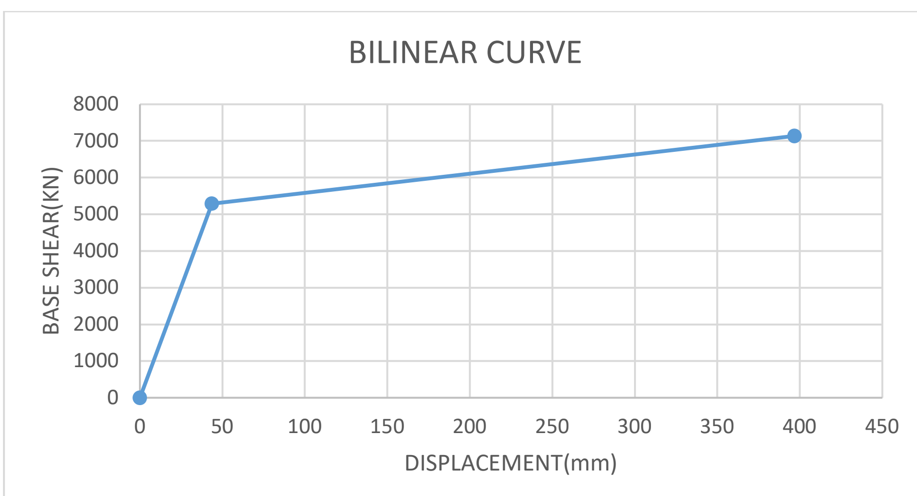


Fig .4.2 Bilinear curve for shear wall with 10% perforation(perforation pattern 1)

Table 4.2.2 Shear wall with 15% perforation (pattern 1)

Target displacement,mm	394.855
Base shear at Target displacement,kN	7125.4905
C0	1.359
C1	1
C2	1
Cm	1
Sa	0.346
Te(sec)	1.843
δ_y, mm	39.024
Vy, kN	4695.3635
Weight W ,kN	206248.1731
µ	10.11
R	9.06

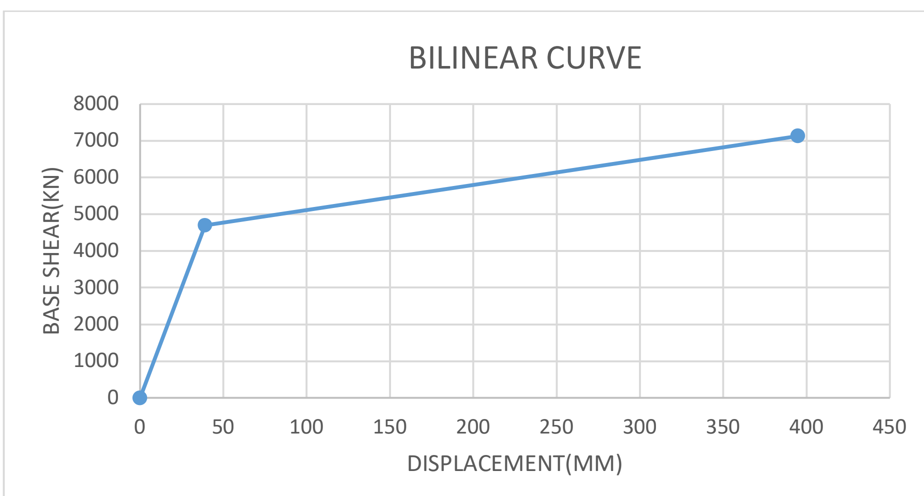


Fig .4.3 Bilinear curve for shear wall with 15% perforation(perforation pattern 1)

Table 4.2.3 Shear wall with 20% perforation (pattern 1)

Target displacement,mm	396.227
Base shear at Target displacement,kN	6927.5156
C0	1.347
C1	1
C2	1
Cm	1
Sa	0.342
Te(sec)	1.865
δ_y, mm	38.73
Vy, kN	4590.4878
Weight W ,kN	205834.3954
µ	10.23
R	9.03

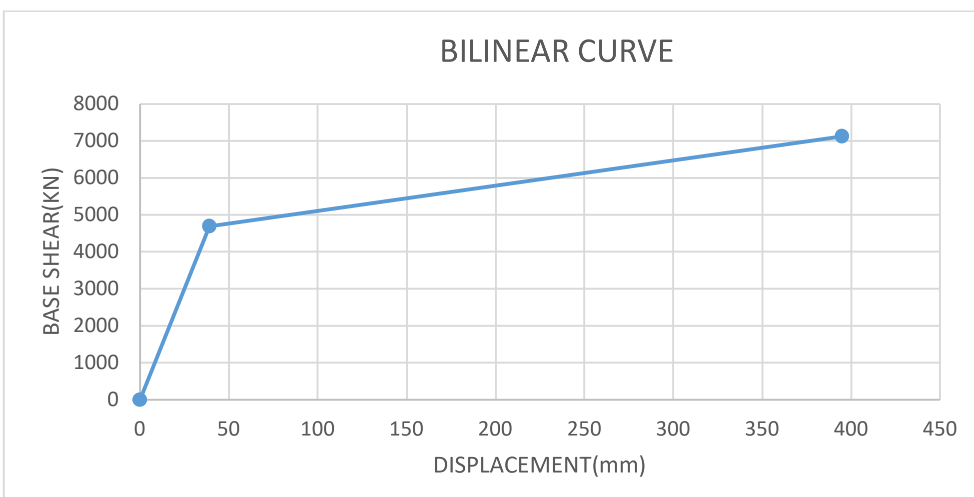


Fig .4.4 Bilinear curve for shear wall with 20% perforation(perforation pattern1)

4.3 Shear wall with perforation pattern 2

Table 4.3.1 Shear wall with 15% perforation

Target displacement,mm	394.45
Base shear at Target displacement,kN	7111.65
C0	1.3563
C1	1
C2	1
Cm	1
Sa	0.346
Te(sec)	1.845
δ_y, mm	38.605
Vy, kN	4637.8045
Weight W ,kN	206263.7696
μ	10.22
R	9.02

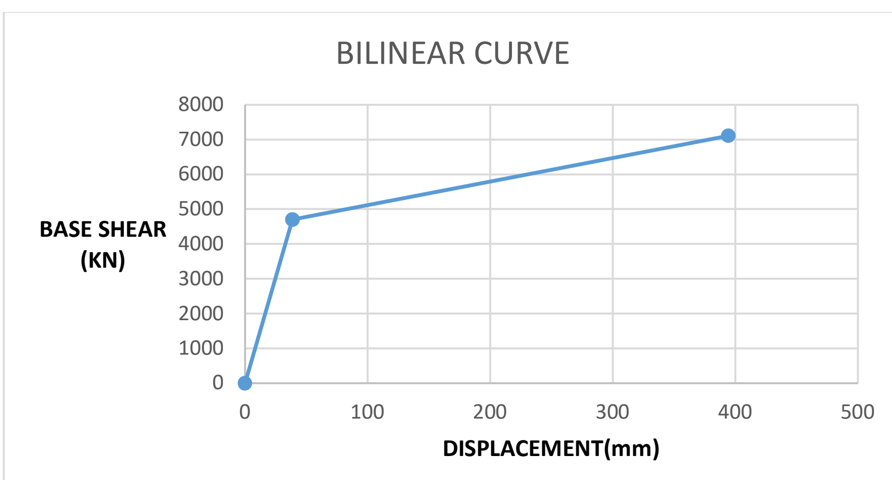


Fig. 4.5 Bilinear curve for shear wall with 15% perforation(perforation pattern 2)

Table 4.3.2 Shear wall with 20% perforation

Target displacement,mm	396.635
Base shear at Target displacement,kN	7037.569
C0	1.3447
C1	1
C2	1
Cm	1
Sa	0.346
Te(sec)	1.87
δ_y, mm	39.216
Vy, kN	4626.909
Weight W ,kN	205817.9917
μ	10.11
R	9.06

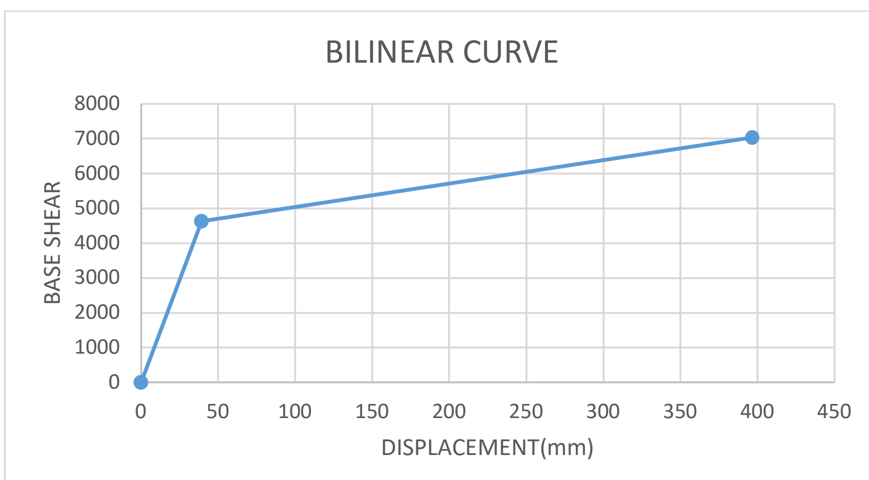


Fig .4.6 Bilinear curve for shear wall with 20% perforation(perforation pattern 2)

4.4 Shear wall with perforation pattern 3

Table 4.4.1 Shear wall with 10% perforation

Target displacement,mm	393.844
Base shear at Target displacement,kN	7050.6617
C0	1.3702
C1	1
C2	1
Cm	1
Sa	0.349
Te(sec)	1.824
δ_y, mm	38.477
Vy, kN	4693.0583
Weight W ,kN	206682.32
μ	10.23
R	9.03

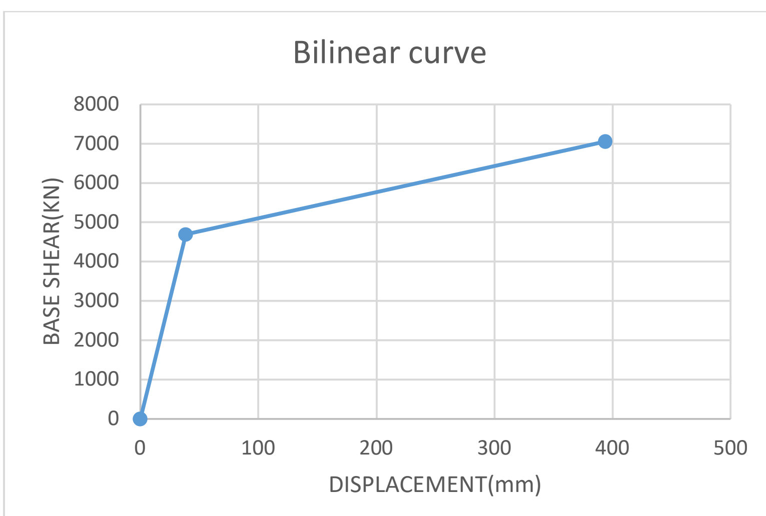


Fig .4.7 Bilinear curve for shear wall with 10% perforation(perforation pattern 3)

Table 4.4.2 Shear wall with 15% perforation

Target displacement,mm	393.83
Base shear at Target displacement,kN	6988.3737
C0	1.3537
C1	1
C2	1
Cm	1
Sa	0.346
Te(sec)	1.845
δ_y, mm	38.477
Vy, kN	4654.1197
Weight W ,kN	206191.326
µ	10.17
R	9.04

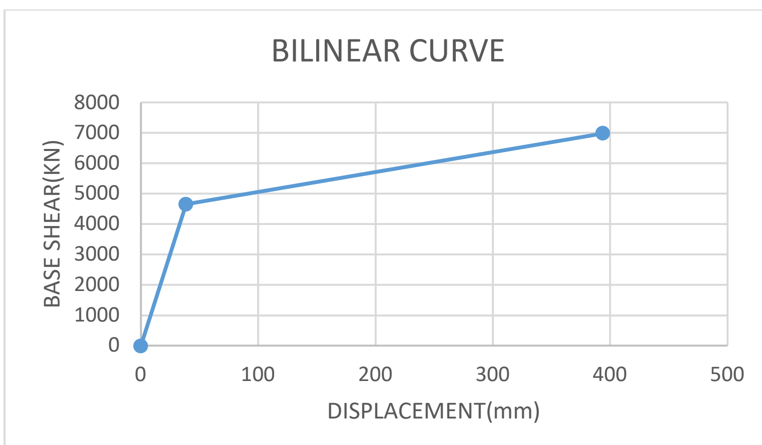


Fig .4.8 Bilinear curve for shear wall with 15% perforation(perforation pattern 3)

Table 4.4.3 Shear wall with 20% perforation

Target displacement,mm	400.859
Base shear at Target displacement,kN	6538.8587
C0	1.3646
C1	1
C2	1
Cm	1
Sa	0.342
Te(sec)	1.864
δ_y, mm	37.063
Vy, kN	4394.5259
Weight W ,kN	205870.1699
μ	10.82
R	9

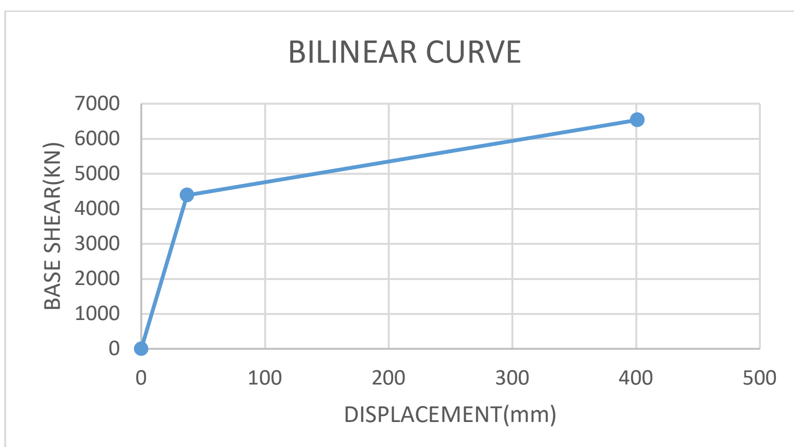


Fig .4.9 Bilinear curve for shear wall with 20% perforation(perforation pattern 3)

CHAPTER 5

Conclusion

Shear walls are considered an important part of lateral load resisting systems for mid-to-high-rise buildings. Due to the transition of design codes from strength-based to performance-based codes, predicting and improving nonlinear behavior of shear walls is now one of the major challenges. Numerous research efforts are currently directed at improving the nonlinear response of shear walls under severe earthquakes.

Perforation patterns varying by 10%, 15%, and 20% are used in the study to perforate the Shear walls. Perforation has a different effect on shear walls than other approaches, according to data. Perforation reduces ductility and the ductility reduction factor, both of which are significant in seismic design, according to a pushover analysis. It also reduces the structure's capacity to manage seismic demand.

Using the target displacement as a variable to demonstrate the performance of shear wall systems, we can conclude that a structure with perforated shear walls has a 46.39 percent reduction in performance. The efficiency of a wall with perforated patterns has decreased, with a reduction of 29 percent in the ductility reduction factor and a reduction of 36 percent in the ductility factor.

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