DETERMINATION OF SEISMIC PARAMETER OF RCC TALL BUILDING USING SHEAR CORE , SHEAR WALL AND SHEAR CORE WITH OUTRIGGER

A PROJECT REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY
IN
STRUCTURAL ENGINEERING

Submitted by:

Arun Kumar Gupta

2k19/Ste/04

Under the supervision of

Dr. Nirendra Dev

(Professor)

DEPARTMENT OF CIVIL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Bawana Road, Delhi-110042

JULY, 2021

M. Tech. Structural Engineering
Arun Kumar Gupta
2021

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CANDIDATE'S DECLARATION

I **Arun Kumar Gupta**, 2K19/STE/04 student of M. TECH Structural Engineering, hereby declare that the project Dissertation titled **"Determination of seismic parameter of RCC tall building using shear core , shear wall and shear core with outrigger",** which is submitted by me to Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, in original and not copied for any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or similar recognition.

ArunGupta

Place: Delhi Signature:

Date: 22/07/2021 (Arun Kumar Gupta)

CIVIL ENGINEERING DEPARTMENT

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana road, Delhi-110042

CERTIFICATE

This is to certify that the project report entitled “DETERMINATION OF SEISMIC PARAMETER OF RCC TALL BUILDING USING SHEAR CORE , SHEAR WALL AND SHEAR CORE WITH OUTRIGGER**”,** is the bonafide work of **Arun Kumar Gupta** for the award of Master of Technology in Structural Engineering from Department of Civil Engineering, Delhi Technological University, Rohini, Delhi. The work has been carried out fully under my supervision. The content and results of this report, in full or in parts has not been submitted to any other institute or university for the award of a degree.

Nirendra Dev
22/07/2021

SUPERVISOR

Date: 22/07/2021

DR. NIRENDRA DEV

(Professor of civil department)

Department of Civil and Engineering

Delhi Technological University

ACKNOWLEDGEMENT

It gives us a great sense of pleasure to present the report of the M. Tech Project undertaken during M. Tech. Final Year. We owe special debt of gratitude to "**Prof**. **NIRENDRA DEV**", Department of Civil Engineering, for his constant support and guidance throughout the course of our work. His sincerity, thoroughness and perseverance have been a constant source of inspiration for us. It is only his cognizant efforts that our endeavors have seen light of the day.

We also take the opportunity to acknowledge the contribution of Professor "**Prof. V. K. Minocha**", Head of Department of Civil Engineering, for allowing us to utilize the department facilities and his full support and assistance during the development of the project.

We also do not like to miss the opportunity to acknowledge the contribution of all faculty members of the department for their kind assistance and cooperation during the development ofour project. Last but not the least, we acknowledge our friends for their contribution in the completion of the project.

Signature: ArunGupta

Name: ARUN KUMAR GUPTA

Roll No.: 2K19/STE/04

Date: 22 JULY 2021

ABSTRACT

This report covers the detailed explanation about the determination of seismic parameter of RCC tall building using shear core, shear wall and shear core with outrigger. Building are subjected to various loads such as dead load, live load ,wind load and seismic load. Seismic load has extreme adverse effect on building so it is necessary to perform seismic analysis This paper describe about the response of building when it is subjected to seismic load , this response can be shown by story drift and base shear. Seismic analysis has been performed on (G+30) building which is located in zone 4 using ETABS software. Analysis has been performed according to IS 1893 PART 1 (2016). This paper gives total rule to manual as wells programming examination of seismic coefficient technique.

Keywords: Tall building, seismic force, Response spectrum analysis, shear core,
shear wall, shear core with outrigger, Etabs.

Table of contents

1. Chapter 1 – Introduction

2. Chapter 2 – Literature studies

3. Chapter 3- Different method of analysis

4. Chapter 4 – Modeling Description

5. Chapter 5 – Geometric parameter

6. Chapter 6 - Result

7. Chapter 7

List of figures

List of tables

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The seismic action of the earth on multi-storey building located around the area of epicentre, the wave creates severe harmful effect on structure.

As height of the building increase, building becomes more crucial to provide sufficient stiffness against the lateral loads. In modern tall building lateral load is caused by wind load and seismic/earthquake load. The parameter that to check are strength of structure, resistance against the lateral deflection of structure. These wind load & seismic load action are often resisted by different types of system, that is braced frame structure system, rigid frames structure system, shear wall structure system, couple wall system, core and outrigger structure system etc. Sometime moment resisting frames and braced frame system become inadequate to resist all lateral forces and inefficient to provide stiffness against the wind load and seismic load. The deflections cause by lateral forces should be prevented both structure and non-structural damage to maintain the building strength and also the building stiffness against the lateral forces in the analysis of rcc tall building and also for design

In this paper wind load and seismic load is resisted by shear/stiff core, shear wall and shear core with outrigger-braced system.

Stiff shear core is provided in mid of the structure by stiff truss arm that will help in resisting the complete structure and transfer its all the lateral load to the beam and column connection with stiff shear core.

1.2 Definition of tall building

According to IS-16700(2017) reinforced concrete (RC) building of height taller than 50m but smaller than or equal to 250m comes under the category of tall building. If the height of reinforced concrete building is greater than 250m then it comes under the category of super tall building.

However, from a structural engineering perspective, a tall building can be defined as a building whose structural system should be design so that it is sufficiently economical to resist all the lateral forces. The capability of tall buildings should be design so that it withstand against all lateral loads is the reason for its existence. In tall buildings, the lateral load created by wind load and seismic load becomes more significant. That is because of the increase of overturning effect of forces, increase of lateral displacement, and inters story displacements. These displacements may risk the overall structural stability and cause disturbance to the tall buildings.

1.3 Classification of tall building structural system

Classification the structural systems with respect to its lateral load resistance capability. This classification has divided the into the following structural system as:-

1. Braced frame structural system
2. Rigid frame structural system
3. Shear wall system
4. Coupled wall system
5. Wall-frame system (dual system)
6. Core and outrigger structural system
7. Tube structural system

8. Hybrid structural system
9. Buttressed core

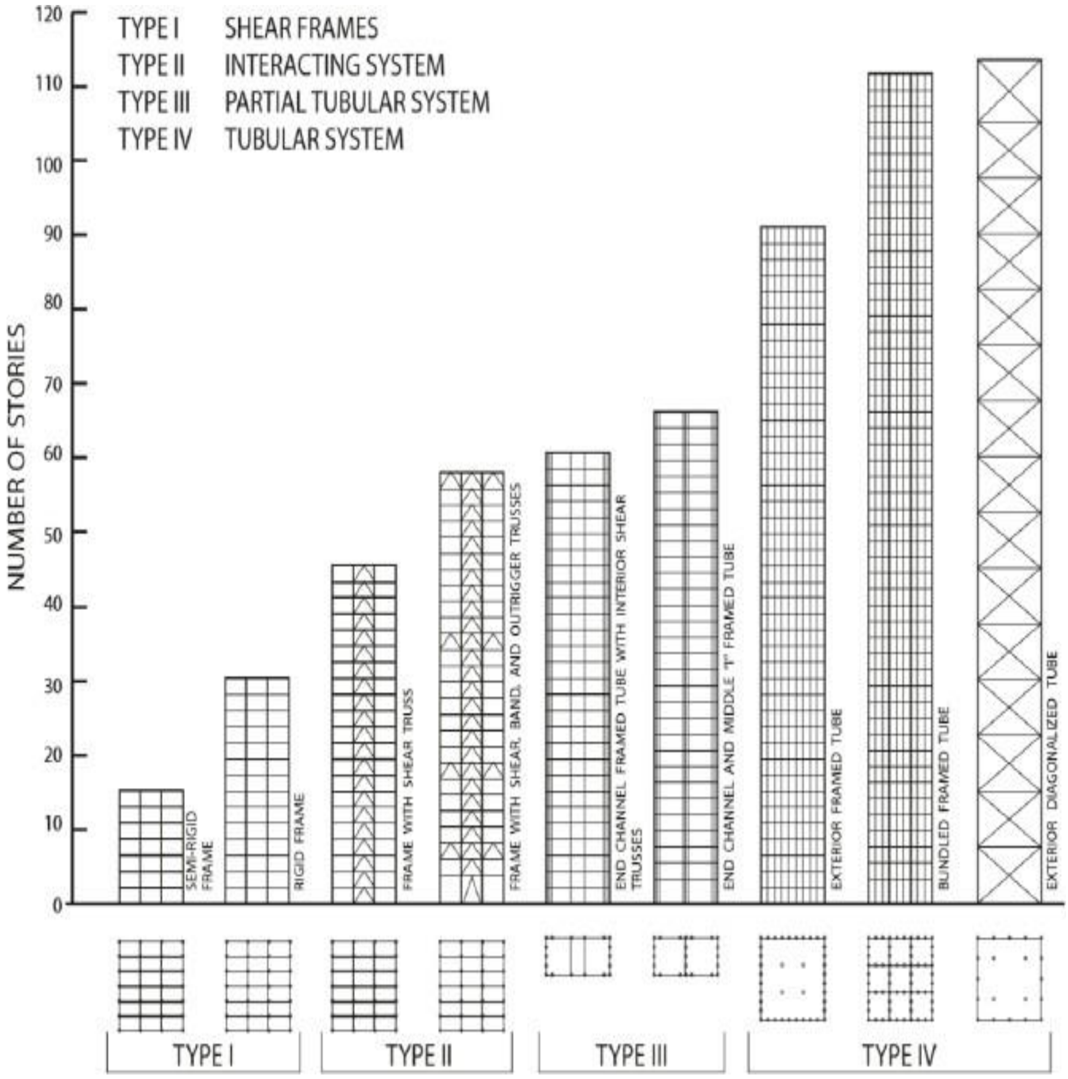


Fig 1.1:- structural system of tall system

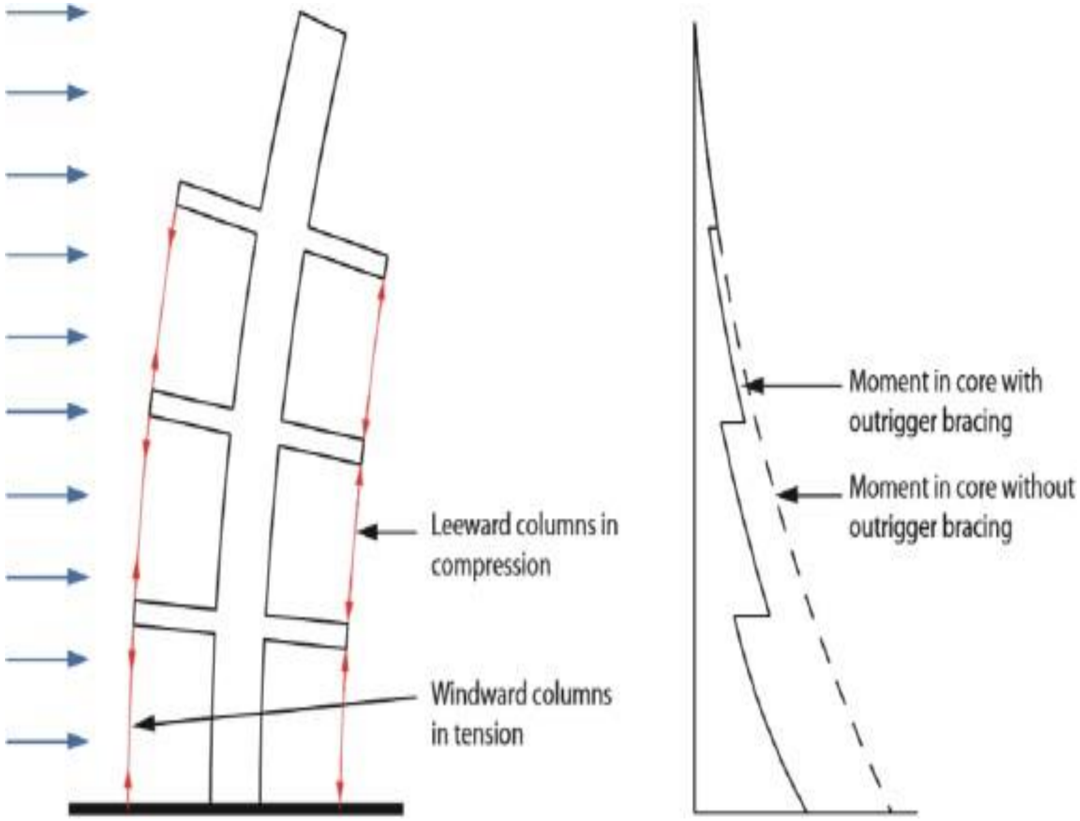
1.3.1 Shear wall system

To resist all the lateral load acting on the building we use shear wall system , which can be design as a vertical oriented wide beam in a reinforced concrete frame structure. These shear wall provide the adequate stiffness to the high rise building or residential building. The thickness of shear wall may vary from 150 mm to 500 mm depending upon the requirement and it is easy to construct as compare to conventional method. Shear wall is provided in addition to beams, column and slabs of the building . In tall building beam and column dimension and design are to heavy so in the joint of beam and column clogging at joint formed so to remove it shear wall is used and it provide stiffness to the building. Shear wall have been employed widely in high-rise building for the past two decade. Shear wall are extremely significant in structure, particularly tall ones, since they are particularly vulnerable to lateral load and seismic pressures.

1.3.2 Outrigger system

Outrigger systems are lateral load-resisting systems that successfully reduce lateral loads while also strengthening tall structures. The external and interior structures in this system work together to with stand lateral stress. Outrigger trusses serve as stiff arms that connect the building's core to the exterior columns.

When all the lateral loads are act on the face of the building, the core tries to rotate generating force to the outrigger trusses, which cause tension in wind-ward columns and cause compression in the lee-ward columns. As a result of this response, a restoring moment operate on core at the position of outriggers, increasing the effective depth of the structure to resist the bending moment. To further strengthen outrigger truss rotation constraint, all outside columns can be mobilized with a one or two storey deep wall around the structure known as a "belt wall." Due to the rotation of the core and the overturning moment, floor diaphragms above and below the belt truss will try to shift right and left. The belt truss or braced system connected to the floors will move in return & rotate itself by one face-up and one face-down. The exterior columns of structure will constrain this movement by developing opposing forces.



. **Fig 1.2**:- outrigger and core interaction

. **Fig 1.3**:- building with outrigger system

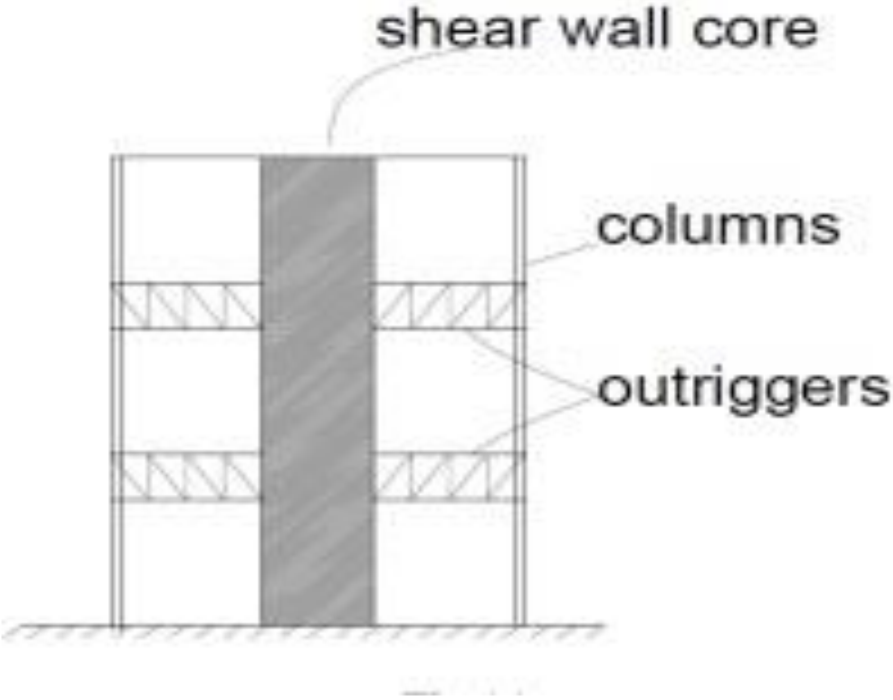


Fig 1.4:- outrigger system with central shear core

1.3.3 Type of outrigger system

They are classified into two groups depend on how the outrigger systems connect to the core. The conventional or direct outrigger system is the first. These outriggers are directly attached to the braced shear core or shear walls to the outer columns, as the name implies. On the other hand, virtual or indirect outrigger and the belt truss system eliminate the direct connections to the building core walls with outer columns. As shown in figure below.

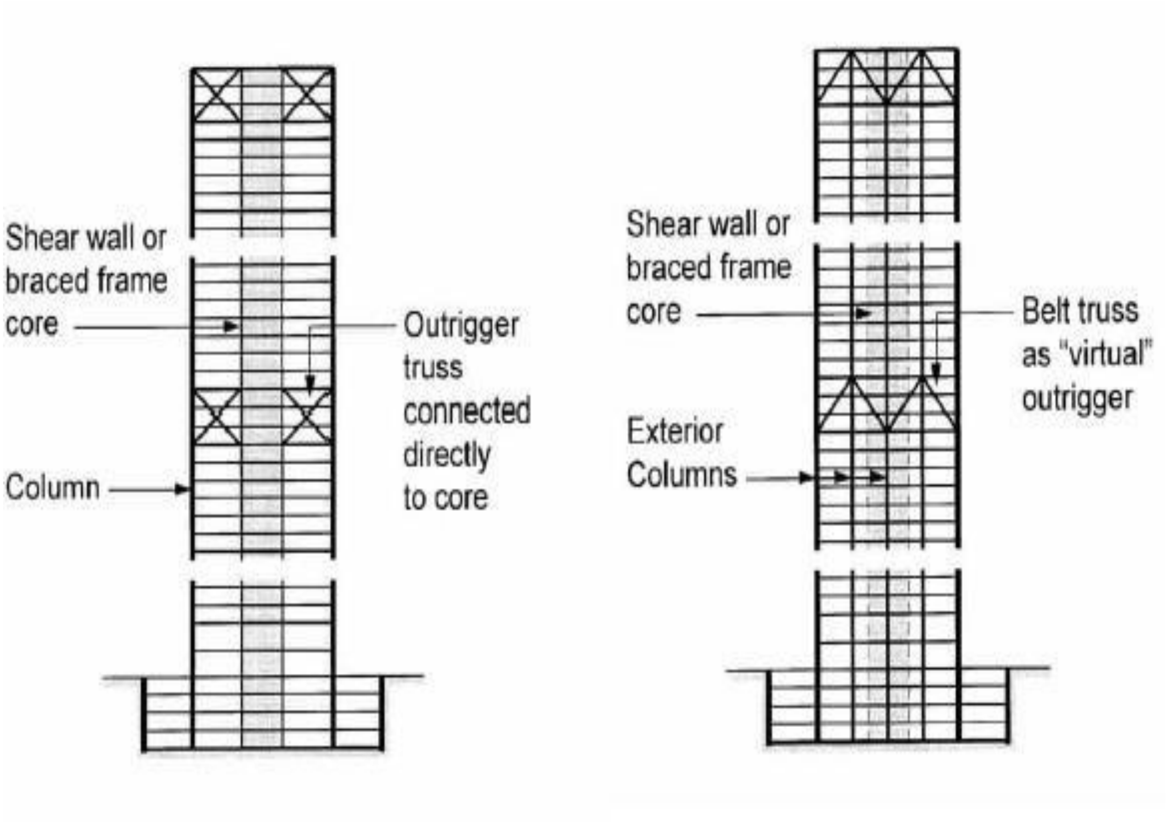


Fig 1.5:-Conventional outriggers (left) and virtual outriggers (right).

The decision between these two sorts is based on the building's current state. Without a doubt, conventional outriggers are stiffer and more efficient than virtual or indirect outriggers due to the shorter load paths from columns to core. More indirect outriggers on more levels are necessary to get the same benefits as direct outriggers.

It's also feasible that the two types of outriggers are used by the same structure. To prevent complexity in connections between the core and the outside column, virtual outriggers can be chosen. In fact, in some contexts, some levels with a building are not suited for direct outriggers, and the differential shortening is more problematic in direct outriggers than indirect outriggers at particular floors.

1.4 OBJECTIVE

- To perform seismic analysis on tall building in zones IV.
- To analyse the effect of various load imposed on tall building for different model such as regular SMRF building , building with shear wall at the four corner, building with shear core in the middle of structure, building with shear core with outrigger braced structural system.
- To ensure safety of building of different models from seismic wave in zones IV.
- To observe the impact of earthquake on tall building with different type of structural system.
- To obtain the result of base shear, story drift and movement of building in different type of structural system.
- To find out which structural system is more efficient to resist lateral loads, whether shear core system is better or shear wall system or shear core with outrigger at an optimum outrigger height of structure.

1.5 LIST OF SOFTWARE USED

- AUTO CADD
- ETABS

1.6 LIST OF IS-CODE USED

- IS 456-2000 (reinforced concrete design)
- IS 1893 (PART-I) 2016, (criteria for earthquake resistant design of structure)
- IS 16700 (tall building design)
- IS 875 -2015 (wind load)

CHAPTER 2

LITERATURE REVIEW

2.1 Research Study

Srinivas B. N, Abdul KarimMulla (2015): The usage of outriggers in a regular and vertical irregular building under seismic and wind loads, as well as a comparison of structures with and without outriggers installed at two different levels of the building as steel bracing in a R.C tall building and found that in tall RC buildings, displacement reduction at the top floor is smaller when outriggers are installed at the middle floors, and concrete outriggers are found to be more efficient in decreasing lateral storey displacement than steel outriggers (X bracing).

O. Esmaili, S. Epackachi, M. Samadzadand S.R. Mirghaderi(2014): Objective of this paper is to investigate the structural behaviour of one of the world's tallest RC structures, with G+56 stories and located in the high seismic zone v. Under both lateral and gravity loads, shear wall systems with irregular openings are used in this Tower, which may cause some unique concerns in the behaviour of structural parts like as shear walls and coupling beams.

He discovered that in tall building analyses, taking into account both the time dependency of concrete and the construction sequence loading, the critical demands are found to occur in the middle height of the structure (i.e. between the 25th and 35th storey) and that increasing the axial load level decreases R factor. As a result, the design base shear will be raised, as well as the section's moment of inertia. To put it another way, the lower the axial load, the greater the cross-sectional area.

Archit Dangi, Sagar Jamle(2018):- Determine the effective case among general, shear core outrigger and belt wall supported system and also shear core outrigger and truss supported system in the structure when seismic forces act on the structure are applied in X, Y and Z direction to the high rise building.

They discovered that the wall belt system is more efficient as compare to the truss belt system, as illustrated in this case study, and that the Shear Core outrigger and wall belt supported system will be more effective in shear forces for both Y and Z in members. Buildings should be designed as Shear Core outriggers to withstand moment, and the wall belt supported system has the lowest value of all the options.

Shaik Akhil Ahamad, K.V. Pratap(2020): Explained the G+20 building in terms of base shear of building, displacements of building, and storey Drifts and Torsional abnormalities can be reduced by dynamically adjusting the stiffness of the structure along its height in different seismic zones and locating the shear wall in the building to efficiently resist any lateral loads or forces. It was found that the building with four shear walls, produced effective results in terms of max. displacement of building, storey drift, and the base shear of building, leading to the conclusion that buildings with uniform stiffness produce superior results.

Bayati, Z.,& Rahaei, A. (2008: Conducted a research on optimized use of multi-outriggers system to stiffen tall buildings and founded that belt-trusses system used as indirect outriggers give many of the benefits of outrigger system concept, while ignoring conventional outriggers as problem associate with that is more. However, with the same outrigger system column sizes and locations, virtual-outriggers will be less efficient than conventional-outrigger system because of the decreasing stiffness of the in-direct force transfer by the truss system.

Denge, S. V., & Raut, S. P. (2016). Examined that Outrigger and belt truss is active and cost effective structural system which is one of the most demanding structural systems. The current study will be valuable to various researchers who are active in designing tall structures employing outrigger and belt truss systems and determining the best structural system position for deflection criteria that differ from bending moment requirements. Researchers propose that the best position for an outrigger system is in the middle of a building.

Moudarre, F. R. (1985): The influence of a stiffening outrigger on the behaviour of a pair of coupled shear walls is investigated, and it is discovered that the stiffening outrigger is more efficient in minimising the drift of the coupled walls due to the mobilisation of the outer columns' axial stiffnesses. In comparison to its effect on the drift of the shear walls, the outrigger has a minor impact on the base moments of the structure's walls.

Santhosh, S., & Mathew, L. A. (2017): The Seismic Analysis of Multi-Story Buildings of G+14 and G+29 with Shear Walls of Different Shapes was investigated, and it was discovered that G+14 buildings with H-shape shear walls perform well in terms of storey drift, while G+29 buildings with W and H shape shear walls perform better in terms of both storey drift and base shear.

CHAPTER 3

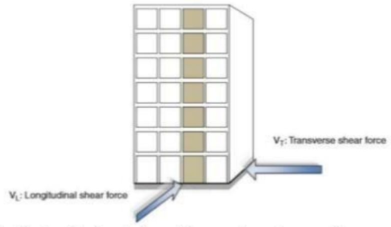
DIFFENENT METHOD OF ANALYSIS

- Linear static analysis
- Nonlinear static analysis
- Linear Dynamic Analysis
- Non-linear dynamic analysis

3.1 LINEAR STATIC ANALYSIS

It is also called as equivalent static analysis

- ☐ This is the methods to calculate the seismic loads. In practical, it does not take into account all the factors that are the important for the foundation condition.
- ☐ A equivalent static analysis is prefer to design only for the low rise building. Only one-mode is taken for each direction in this method.
- ☐ The equivalent static method is sufficient for earthquake resistant design of low-rise structures. It is assumed that construction operates in its most basic mode.



Equivalent lateral shear force along two orthogonal axis

(Source: Nouredine Bourahla, *"Equivalent Static Analysis of Structures Subjected to Seismic Actions"*, Encyclopedia of Earthquake Engineering, Springer-Verlag Berlin Heidelberg, 2013)

Fig 3.1:- equivalent lateral shear force along orthogonal axis

PROCEDURE:

- Calculation of the building's Design Seismic Base Shear, VB
- Base shear is distributed vertically along the structure's heights.
- Level forces are distributed horizontally across the width and breadth of the structure.
- Determination of structural drift, overturning moment, and P-Delta effect.

Calculation of Seismic Base Shear, V_B

$$V_B = A_h W$$

where, W – seismic weight of structure

Ah – horizontal seismic constant

Seismic coefficient

$$A_h = (Z/2)*(S_a/g)*(I/R)$$

Where, Z - Zone factor

I - Importance factor

R- Response Reduction factor

Sa/g - Average response acceleration coefficient

T - Undamped Natural period of the structure

3.2 NON LINEAR STATIC ANALYSIS

- It is also called as PUSHOVER ANALYSIS
- Used to calculate the strength and drift capacity of existing structures, as well as the seismic effect for structures that have been exposed to a certain earthquake.
- Also used to assess the suitability of a new structural design.
- It is a type of analysis in which a mathematical model incorporates the nonlinear load-deformation characteristics of individual components and elements of a structure that would be subjected to increasing lateral loads reflecting earthquake inertia forces until a "target displacement" is exceeded.

3.3 LINEAR DYNAMIC ANALYSIS

- It is also known as RESPONSE SPECTRUM ANALYSIS
- This method allows for the consideration of a structure's many forms of response. These modes for a building can be determined through computer analysis.

- A response is created for each mode from the design spectrum, based on the modal frequency and mass.

- Using modal combination methods, they are then merged to offer an approximation of the building's entire reaction.

Factor Influencing Response Spectral:

I. Richter magnitude
II. Time period
III. Focal length
IV. Soil condition
V. Damping

3.4 NON-LINEAR DYNAMIC ANLYSIS

.

- Both elastic and inelastic analysis is applicable for time history method.
- A sample earthquake time history for the structure being studied is necessary to perform time history analysis.
- In this procedure, the structure's mathematical model is subjected to accelerations derived from prior earthquake data, which represent the expected earthquake at the structure's base.
- This method considers step-by-step direct integration across a time interval.
- The stiffness characteristics of the building are believed to be constant during the earthquake in elastic analysis.
- However, in an inelastic analysis, the stiffness of the structure is assumed to remain constant solely throughout time.

CHAPTER 4

4.1 STRUCTURE MODELLING

In this paper we have taken G+30 storey tall building of height 99.7 m (tall building, above 50m and below 250 m) with five different cases.

4.1.1 CASE -I MODEL

Regular RC building with special moment resisting fame .

4.1.2 CASE-II MODEL

Regular RC building with shear wall at the corner of the building to provide stiffness against the lateral load such as seismic and wind load.

By limiting lateral sway/deflection and damage to the RC structure, the shear wall in tall buildings will offer strength and lateral stiffness to the RC structure in the direction of building orientation.

4.1.3 CASE-III MODEL

Regular RC building with shear core at centre of the building.

Stiff core is provided in the middle of the structure connect with beam and transfer all the lateral load by beam and column connected with stiff shear core.

4.1.4 CASE-IV MODEL

Regular RC building using shear core with single outrigger –braced system.

Outriggers with steel bracings are installed to strengthen the axial rigidity of the building's periphery columns, preventing overturning moments and lateral deflection. The system performs admirably in terms of lateral load resistance (seismic & wind load). The shear core concept is coupled with outriggers and bracings to reduce bending moments in beams and shear forces in columns by enhancing column axial compression. The structure is constructed up of a central shear core connected to the building's outside columns by horizontal girders or cantilever type trusses called outriggers built of steel bracing. Extending outriggers on both sides of the shear core help to place it in the centre. When lateral loads operate on an RC building, the outriggers cause lateral deflection, preventing the core wall or shear core from rotating and limiting the effect of the loads on the building.

4.1.5 CASE-V MODEL

Regular RC building using shear core with double outrigger–braced system.

The outrigger braced system is provided at two location in the building , first location at 15th floor and second location at 29th floor. The concept of providing double outrigger system is to increase more stiffness than single outrigger system against lateral forces.

The outrigger system provides excellent flexural stiffness, while the shear core resists shear in the structure.

CHAPTER 5

MODEL SPECIFICATION

5.1 Geometric Properties

Typical stories height	3.3 m
Bottom story height	4 m
Spacing in X direction	5 m
Spacing in Y direction	6 m
Beam Sizes	650X600mm
Column sizes	(900X900)mm, (800X800)& (600x600)
Slab Thickness	300mm
Shear wall thickness	450 mm
Number of bays in x- direction	7 bays
Number of bays in Y- direction	7 bays
Number of stories	G+30

5.2Material Properties

Concrete Grade : M40 (for beam and column)

M45 (for shear wall& shear core)

Compressive strength of Concrete : 40000 KN/m^2 (for beam and column)

45000 KN/m^2 (for shear wall& shear core)

Rebar : Fe500

Characteristic strength of reinforcing steel *fy* :500000KN/m^2

Density of concrete :2548.531 Kg/m^3

5.3 Gravity Loads

Gravity loads are loads that act vertically downward as a result of gravitational force. the gravitational loads are further subdivided into the following categories:

Dead load:

Self-Weight of structure: Self weight is calculated by the software based on material constants and section properties provided. The structure's own weight refers to the self weight of the structural parts in the structure. These are the constant loads that the structure is subjected to at all times.

Superimposed load: The model includes a superimposed load on the floor finish, partition walls, and other elements.

Outer wall (super dead load) : 13.75 KN/m

Partion wall(super dead load) : 9.75 KN/m

Floor load/super dead load : 2.75 KN/m^2 (including Floor finishing)

LIVE LOAD:

The self-weight of humans makes up the live load on the building, which is very changeable. As a result, the Indian standards of practise recommend a load of 3-4 kN/m2 for residential constructions.

Live load on Slab = 3 KN/m^2

5.4 Lateral loads:

i) Seismic load

ii) Wind load

5.4.1 SEISMIC LOAD

For seismic analysis in ETABS we have use IS-1893 (part-I) 2016 recommendation.

In this paper the structure is analysis by response spectrum method.

All the values taken in response spectrum method is mention below

Response Spectrum Method:

For seismic response spectrum analysis, the spectra for medium soil as per IS 1893 (Part 1) 2016 are used.

Seismic Zones: In this study, the behaviour of the model is evaluated for all of the seismic zones listed in the Indian codes of practise IS 1893 (Part I) 2016. The zone factor and seismic intensity are taken from IS 1893 (Part I) 2016 table.

In this current paper we have taken zone IV for our project.

Soil Type: It is necessary to know the kind of soil or soil factor in order to calculate lateral load. The average response spectrum coefficient (Sa/g) is affected by the kind of soil as well as the natural time period (Ta).

Therefore in this paper type of soil is taken as medium soil = II

Damping ratio: It is dimensionless parameter which describe how an structure which oscillating or vibrating structure come to rest.

In this paper damping ration is taken as 5% damping.

Importance factor of structure: The select structure is used as residential or commercial building, with occupancy more than 200 persons, the importance factor for the tall rc building is taken as, I=1.2 from table 8, clause 7.2.3 of IS 1893(Part I)2016.

Type of building: In this paper structure is used as special moment resisting frame. Therefore response reduction factor is taken as, R=5

The following are the values for the spectral acceleration coefficient (Sa/g). for the medium soil site,

Sa/g = 1 + 15T, (0.00 T 0.10), (T= time period in seconds)

= 2.50, (0.10 T 0.55) for medium soil sites.

= 1.36/T (0.55 T 4.00).

The structure is analysis for different acceleration at different period generated by etabs software.

Scale factor is calculated by :-

S = (I*g)/(2R)

5.4.2 WIND ANALYSIS

For wind analysis in ETABS we have use IS-875 (2015) recommendation.

Following values have been taken for wind analysis from the IS-code given below:-

Building is supposed to be plan for the Delhi region.

The wind speed considered for Delhi region	47 m/s (acc. To IS-875).
Terrain category	3
Importance factor	1.3
Risk coefficient (k1)	1
Topography (k2)	1

The structure should be exposure from extents of diaphragms.

For which,

Windward coefficient, Cp	0.8
Leeward coefficient, Cp	0.5

5.5 Other parameter for tall building analysis

5.5.1 Stiffness modification factor :-

For slab where bending is always in the out of plane direction then, modification m11,m22, m12 are required to model cracking behavior

For slab modeled as shell then, m11, m22, m12, f11,f22,& f12= 0.25

For beam and column modeled as frame then stiffness modification is as follow:

Beam, I22 & I33 = 0.35

Column, I22 & I33 = 0.7

wall-uncracked, f11,f22 =0.7

m1, m22, m12 = 0.7 (when considered out-of-plane bending)

5.5.2 P-Delta effect

Checking for P-Delta is one of the most efficient checks in high-rise buildings.

When a sufficiently tall structure or structural component is subjected to significant lateral displacement, the P-Delta effect refers to sudden changes in ground shear, overturning moment, and axial force distribution at the base.

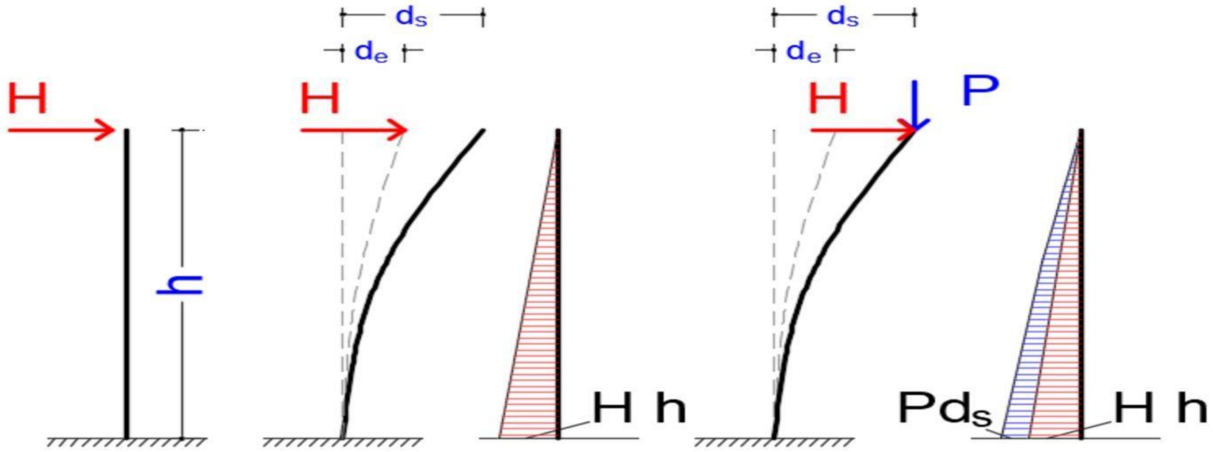


Fig 5.1:- P-Delta effect on high rise structure

$\theta = (Px*\Delta)/(Vx*hsx*Cd)$ $\theta max = 0.5/(\beta*Cd) \leq 0.25$

If „θ‟ comes out greater than 0.25 then we have to introduce p-delta effect in the high rise structure.

5.6 Models considered for the Analysis

5.6.1 CASE I model

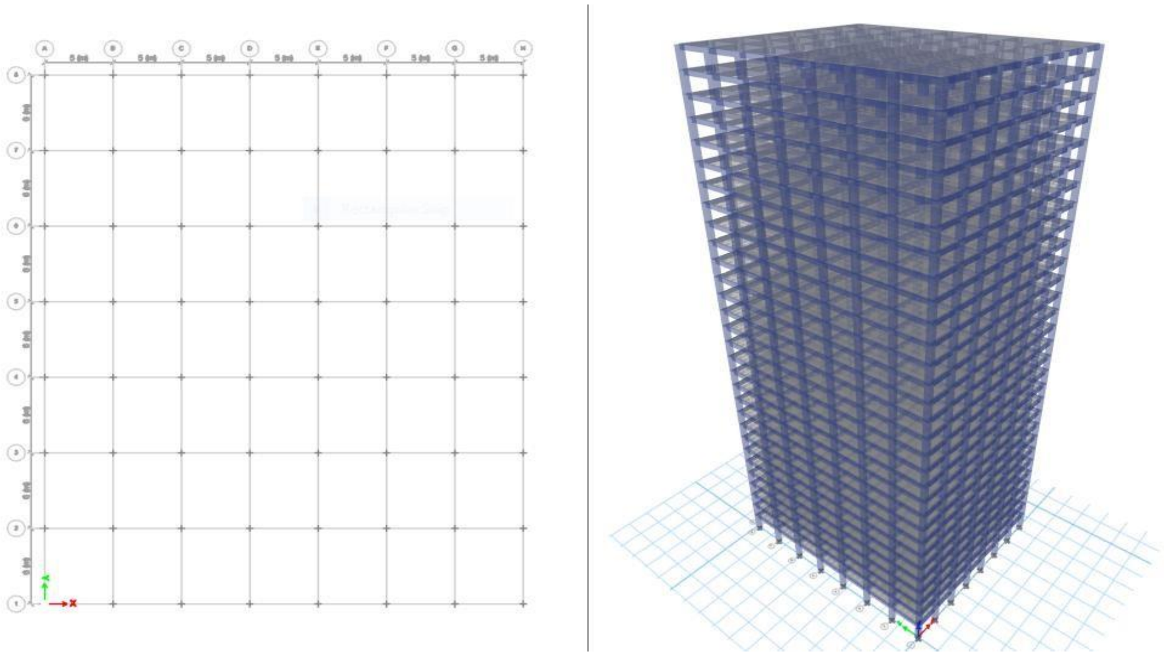


Fig 5.2:- plan and elevation for case I

5.6.2 CASE II MODEL

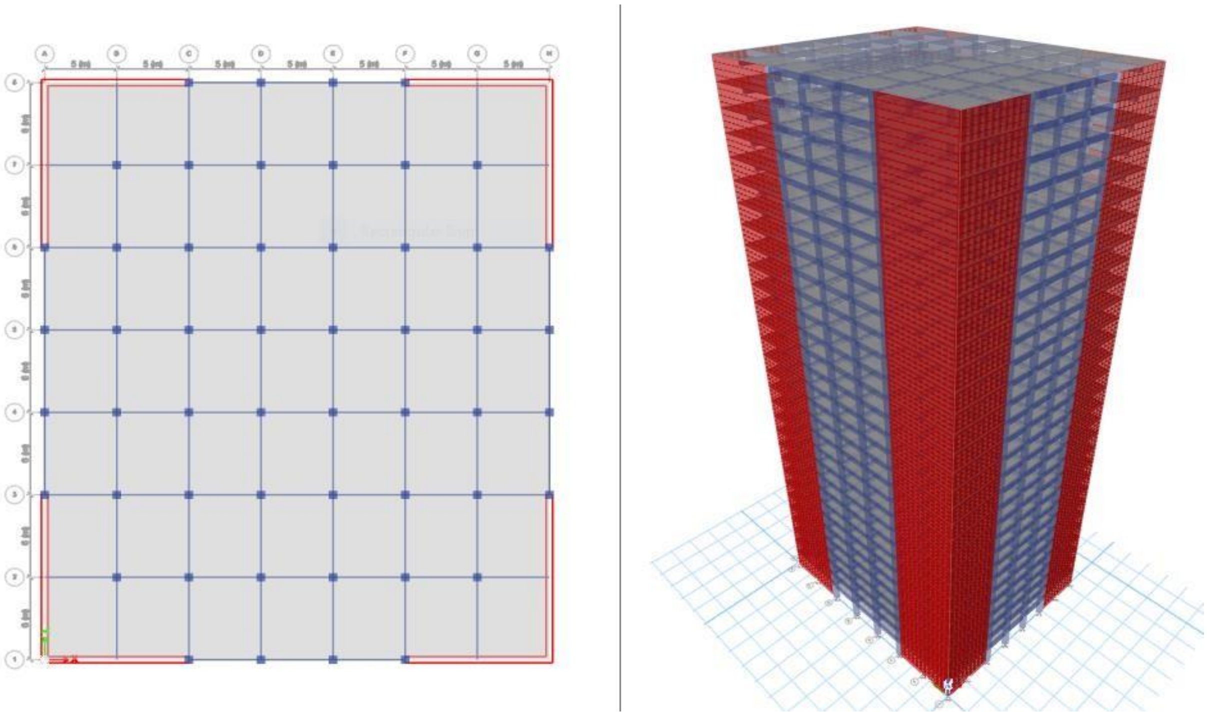


Fig 5.3:- plan and elevation for case II

5.5.3 CASE III MODEL

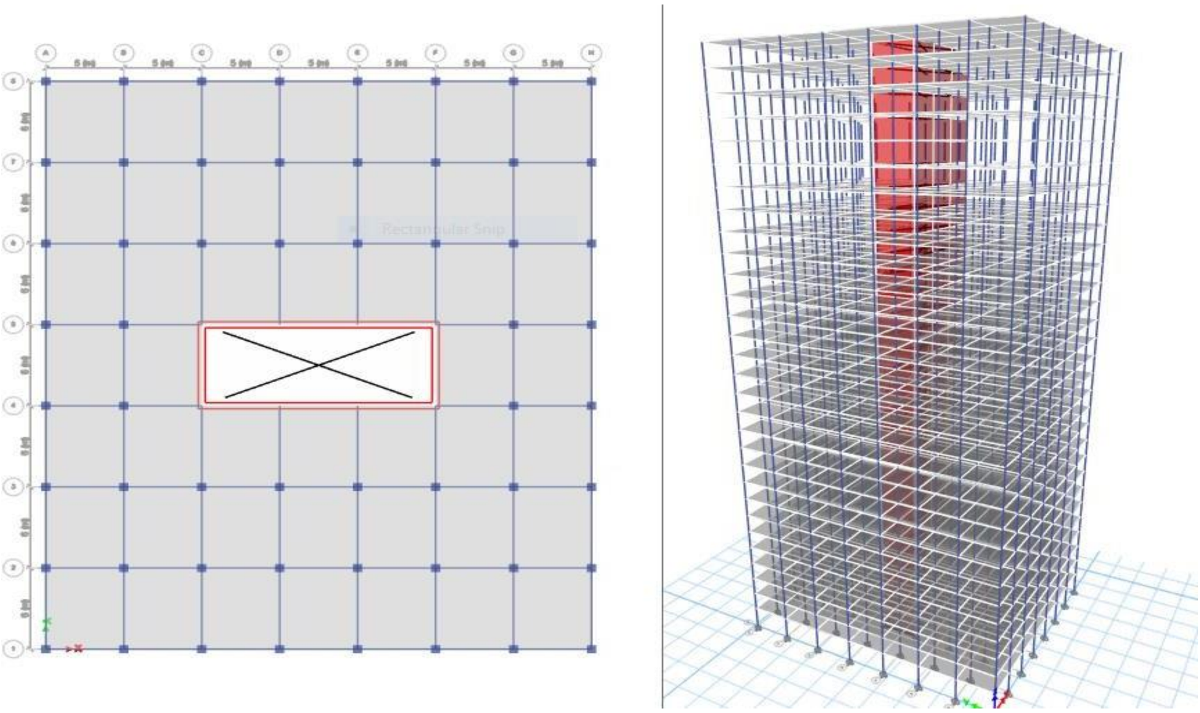


Fig 5.4:- plan and elevation for case III

5.6.4 CASE IV MODEL

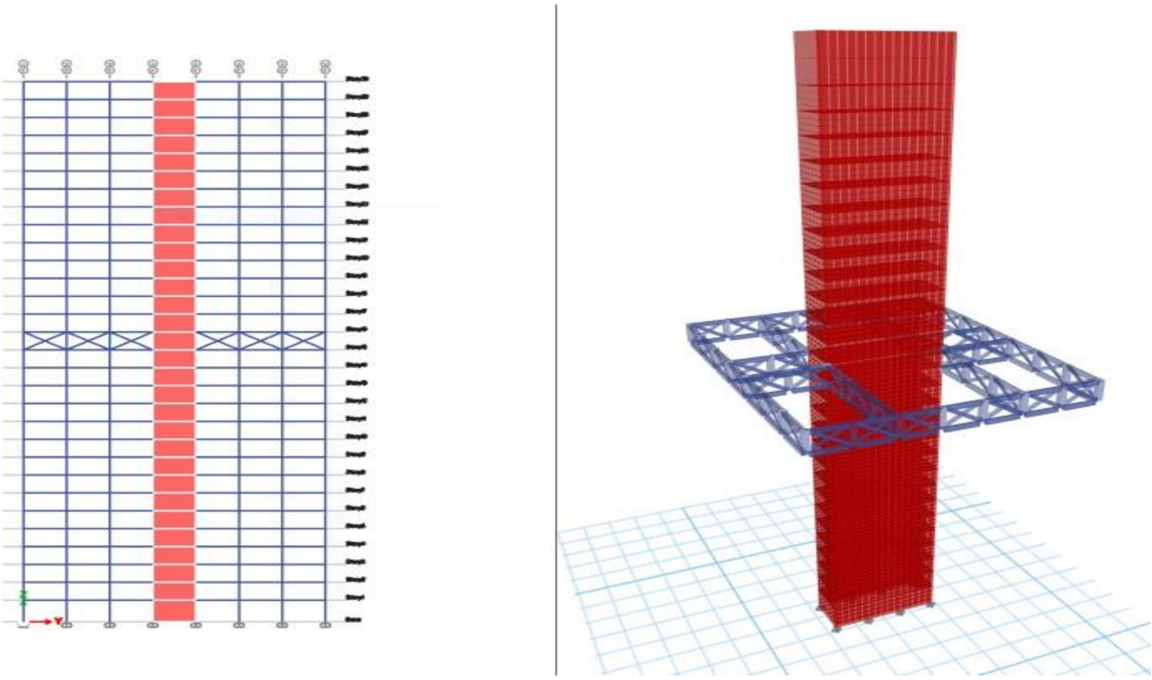


Fig 5.5:- plan and elevation for case IV

5.6.5 CASE V MODEL

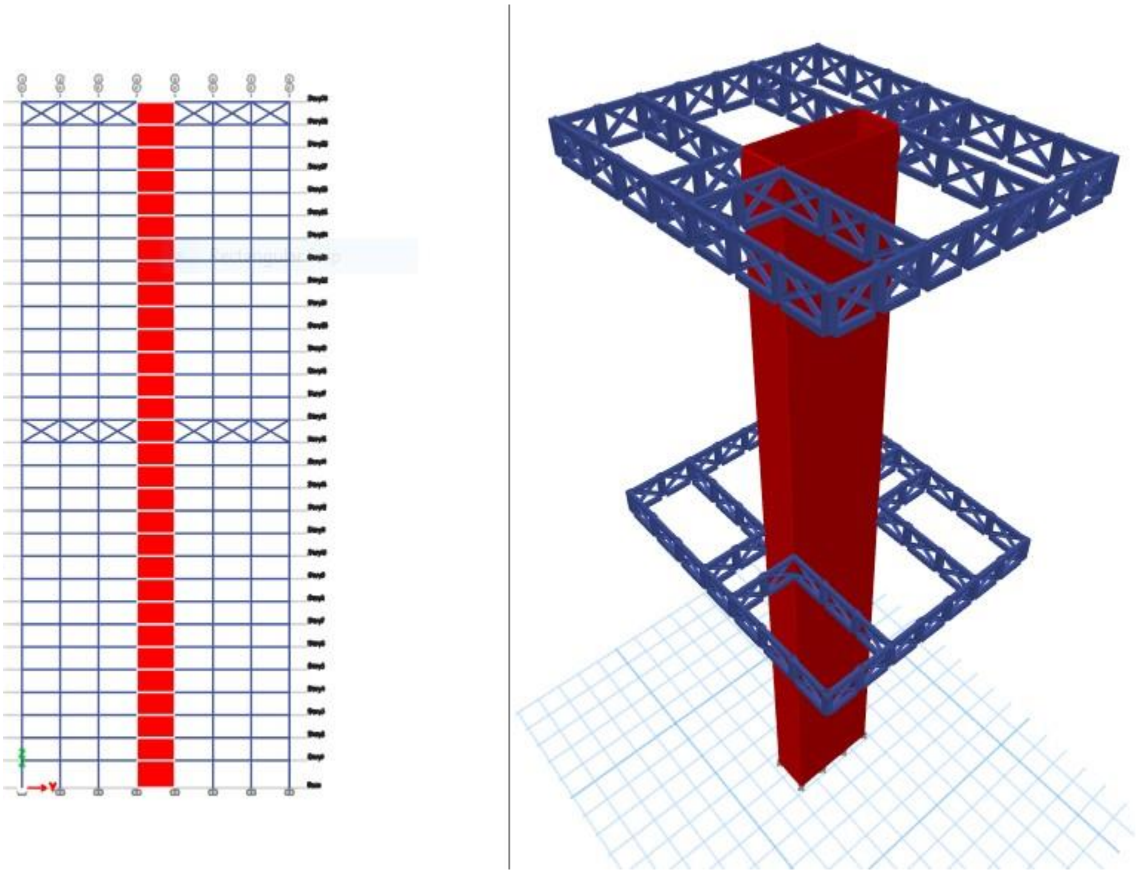


Fig 5.6:- plan and elevation for case V

5.7 Analysis of structural system

The proposed structural model is analysed using ETABS software. For zone IV, the models are examined using an equivalent static approach and a dynamic analysis approach, which is the only response spectrum approach. The software calculates the lateral load for the model based on the type of analysis utilised, and then this computation is applied to the study of these models. Based on the behaviour of the structural systems that were used, the results are summarised. The structure is subjected to lateral loads in this study, and due to the structure's symmetry, the analysis is performed utilising the Equivalent static method and Response spectrum approach method.

CHAPTER 6

RESULT

6.1 MAX STORY DISPLACEMENT FOR DIFFERENT LOAD PATTERN

LOAD PATTERN	REGULAR RC BUILDING WITH SMRF (mm)	RC BUILDING WITH SHEAR WALL (mm)	RC BUILDING WITH SHEAR CORE (mm)	RC BUILDING WITH SINGLE OUTRIGGER SYSTEM(mm)	RC BUILDING WITH DOUBLE OUTRIGGER SYSTEM (mm)
Linear static X	173.952	78.039	82.226	84.114	75.720
Linear static Y	174.886	71.183	100.184	99.222	81.311
Wind load	145.886	54.70	57.640	55.435	41.079
Response spectrum X	162.075	46.354	56.288	55.67	42.910
Response spectrum Y	156.456	65.779	70.650	68.930	61.040

Table 6.1:- Maximum story displacement for different load pattern

6.2 GRAPHICAL REPRESENTATION OF MAXIMUM DISPLACEMENT FOR DIFFERENT MODEL

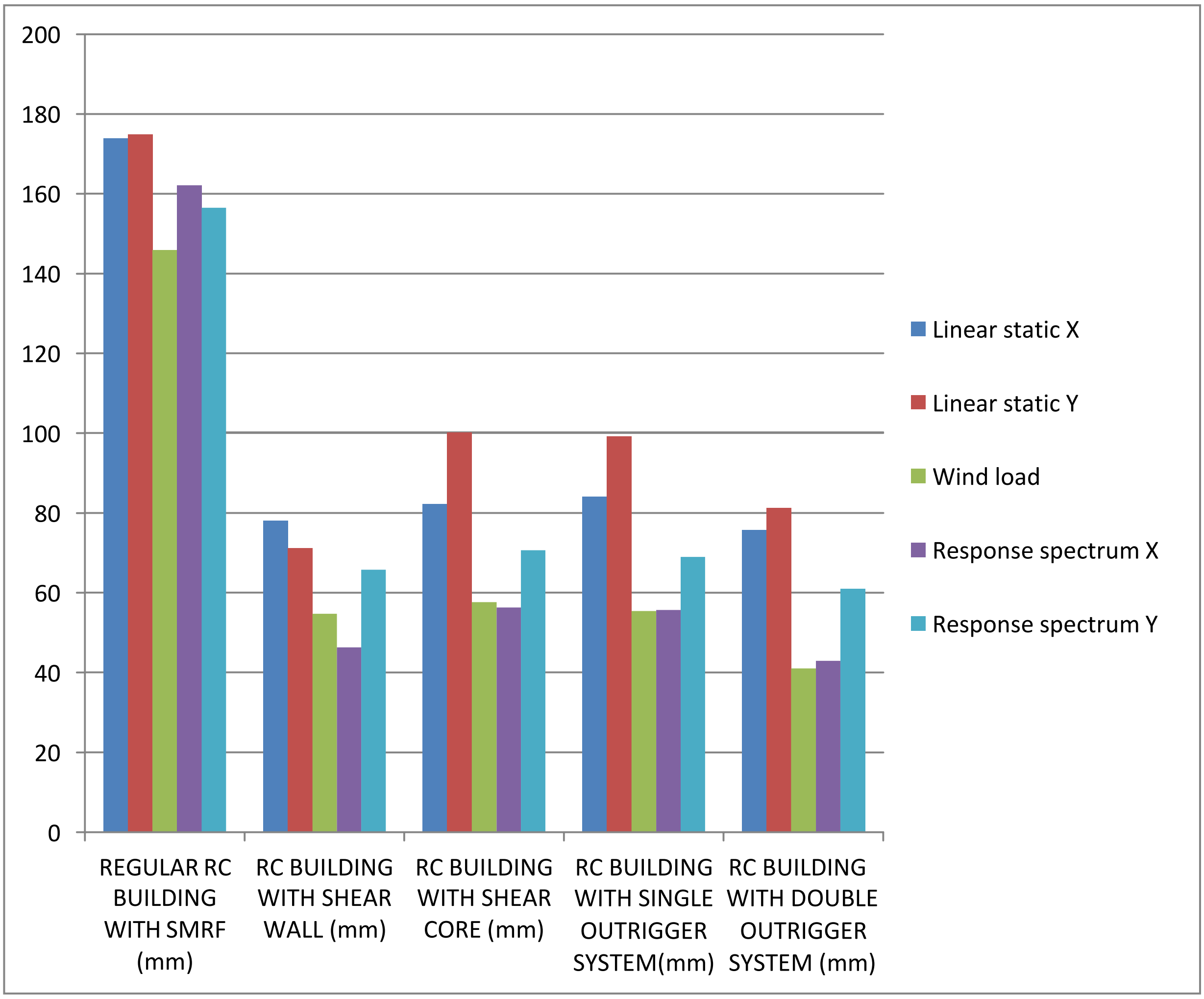


Fig 6.1:- Graph of Maximum story displacement for different model for different load pattern

6.2.1 Story Displacement of RC Building with SMRF for Different Load Pattern

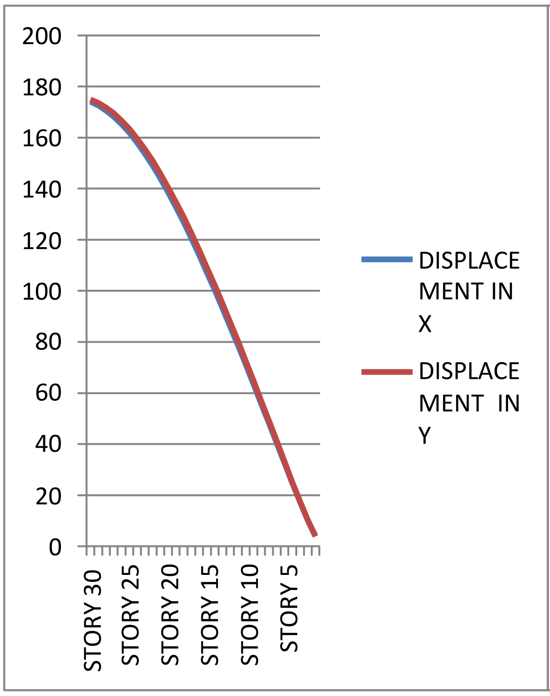


Fig 6.2:- Linear static in X&Y-direction

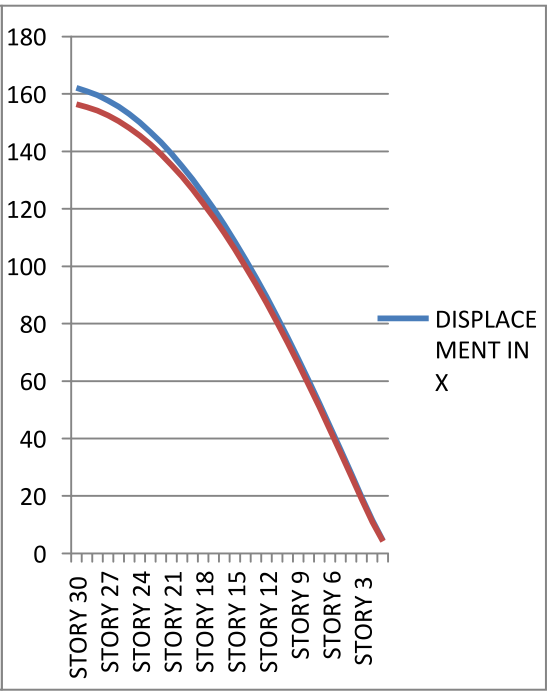


Fig 6.3:- Response spectrum in X&Y dir.

6.2.2 Story Displacement of RC Building with SHEAR WALL for Different Load Pattern

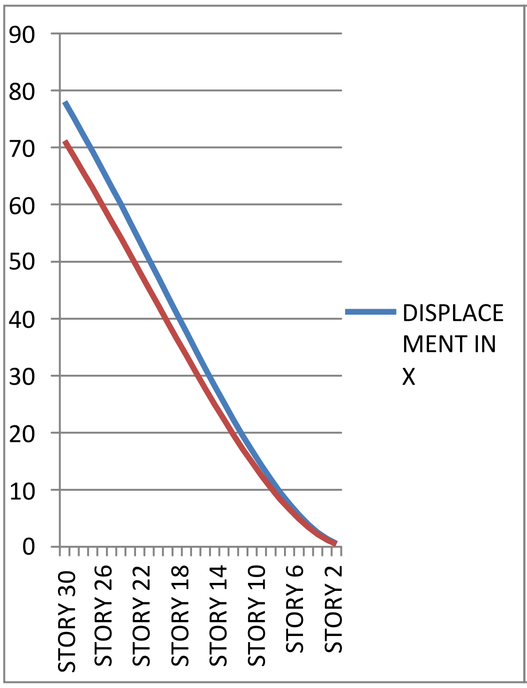


Fig 6.4:- Linear static in X&Y-direction

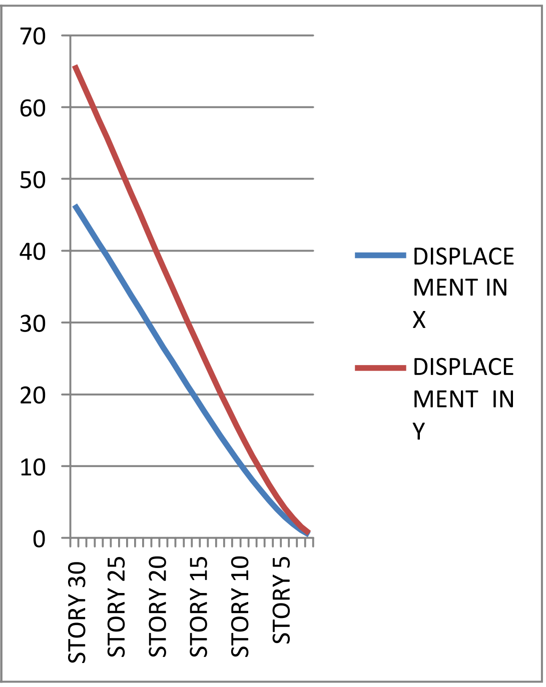


Fig 6.5:- Response spectrum in X&Y- dir.

6.2.3 Story Displacement of RC Building with SHEAR CORE for Different Load Pattern

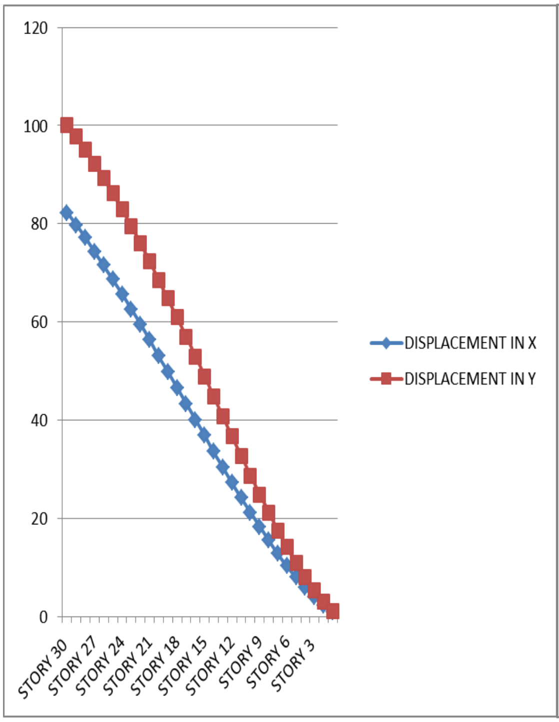


Fig 6.6:- Linear static in X&Y-direction

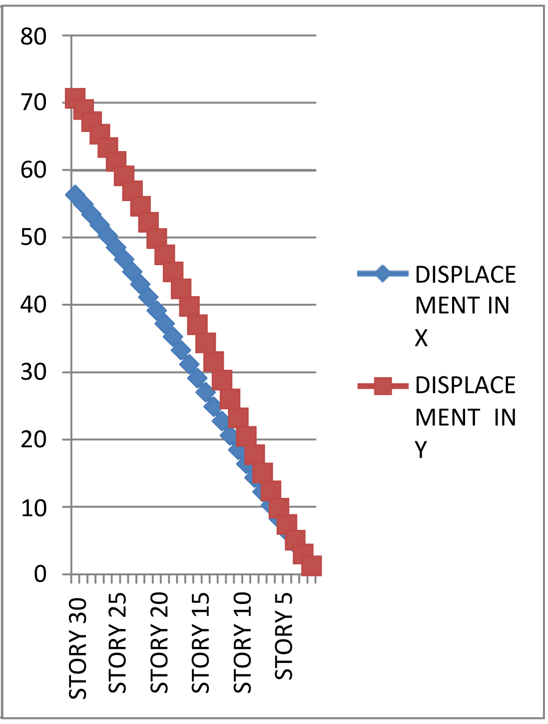


Fig 6.7:- Response spectrum in X&Y-dir.

6.2.4 Story Displacement of RC Building with SHEAR CORE with single outrigger braced system for Different Load Pattern

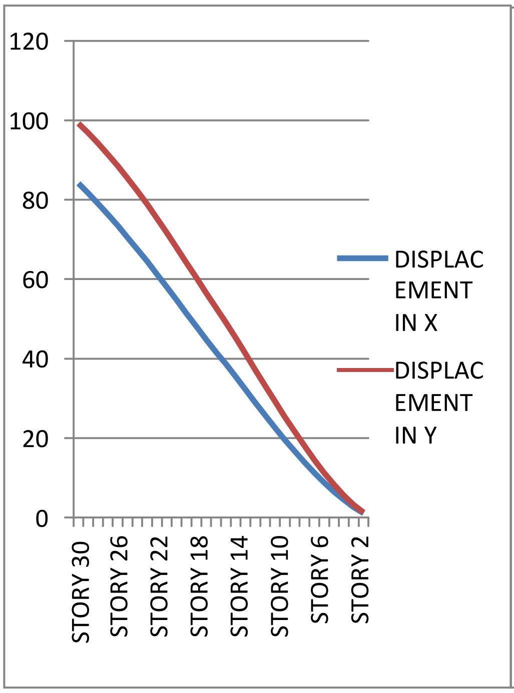


Fig 6.8:- Linear static in X&Y-direction

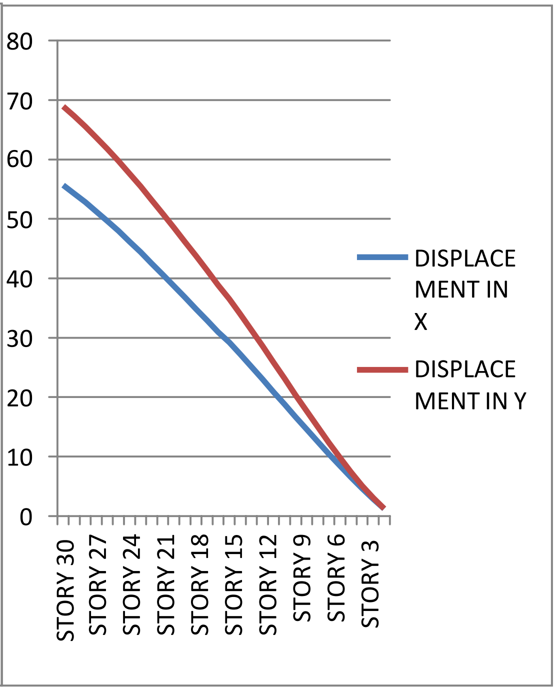


Fig 6.9:- Response spectrum in X&Y-dir.

6.2.5 Story Displacement of RC Building with SHEAR CORE with double outrigger braced system for Different Load Pattern

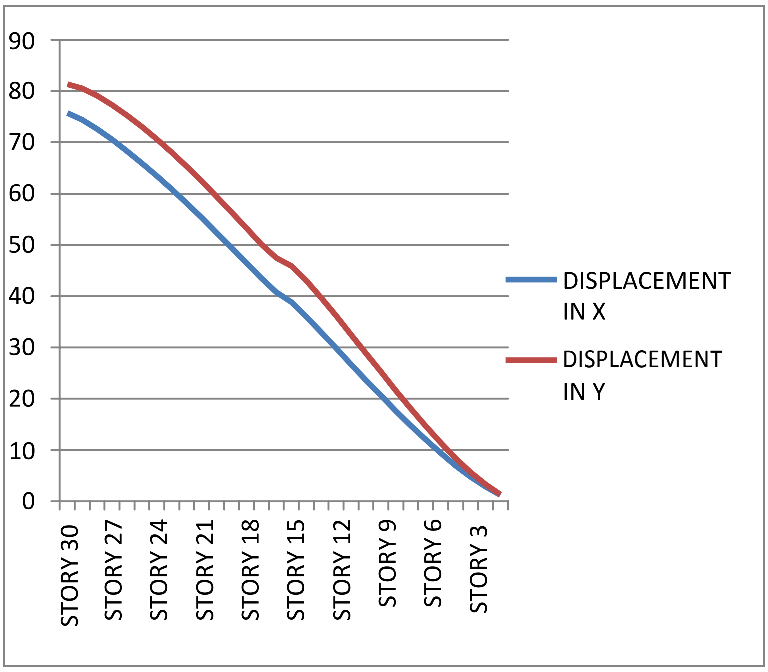


Fig 6.10:- Linear static in X&Y-direction

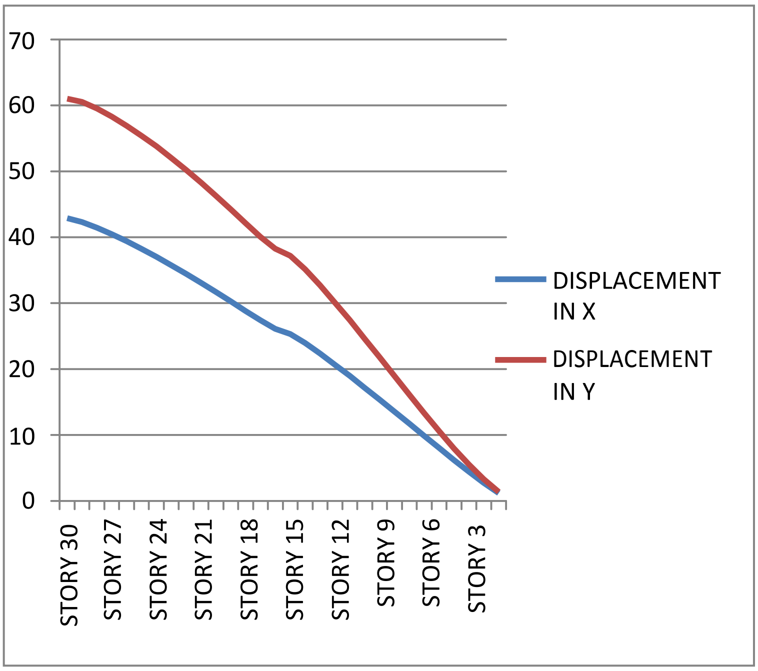


Fig 6.11:- Response spectrum in X&Y-direction

6.3 MAX STORY SHEAR FOR DIFFERENT MODEL

STORY	REGULAR RC BUILDING WITH SMRF (KN)	RC BUILDING WITH SHEAR WALL (KN)	RC BUILDING WITH SHEAR CORE (KN)	RC BUILDING WITH OUTRIGGER AT LOCTION 1ST(KN)	RC BUILDING WITH OUTRIGGER AT LOCTION 2ST(KN)
STORY 01	9409.1756	12470.0178	11474.3766	11666.3130	11065.3029
STORY 02	9364.7371	12386.3761	11377.0863	11566.9400	10976.1679
STORY 03	9262.0586	12203.1255	11174.6764	11360.5490	10792.3802
STORY 04	9110.2942	11912.3842	10865.4134	11045.8790	10515.0833
STORY 05	8932.1291	11520.0539	10460.9526	10635.4960	10158.3170
STORY 06	8750.2361	11044.1940	9984.4824	10153.8100	9746.4405
STORY 07	8577.4057	10512.1837	9467.2408	9633.3468	9309.7444
STORY 08	8412.763	9956.9207	8943.8284	9109.7141	8878.9725
STORY 09	8245.0533	9411.9746	8446.4891	8615.4823	8479.4083
STORY 10	8060.4872	8906.1093	7999.277	8174.0449	8126.0072
STORY 11	7850.5775	8462.9753	7618.0093	7799.4825	7821.2824
STORY 12	7616.113	8085.1496	7296.414	7483.3346	7557.0077
STORY 13	7365.8323	7762.8334	7018.5699	7207.6883	7319.2461
STORY 14	7110.9336	7482.9521	6769.1739	6955.9153	7094.8138
STORY 15	6858.4421	7231.4685	6536.107	6715.5854	6876.4143
STORY 16	6607.0745	6999.4599	6315.3184	6483.5840	6666.2338
STORY 17	6347.9595	6786.5446	6112.4497	6273.0324	6498.5138
STORY 18	6069.7541	6600.4483	5940.5096	6092.5346	6358.8314
STORY 19	5765.1659	6452.5653	5813.7843	5956.3846	6246.1248
STORY 20	5435.2713	6350.5482	5739.3719	5872.6253	6159.3045
STORY 21	5089.2572	6291.3055	5709.7914	5834.5793	6086.7336
STORY 22	4739.2765	6250.3029	5695.8416	5813.1089	6005.1972
STORY 23	4392.3883	6189.7167	5659.2201	5769.4171	5882.0789
STORY 24	4043.5674	6062.1233	5555.0217	5657.9641	5680.0028
STORY 25	3674.0878	5816.8743	5337.3135	5432.1005	5362.1300
STORY 26	3256.8039	5407.0507	4964.4897	5049.5685	4896.7288
STORY 27	2765.5982	4794.2790	4402.8775	4476.1698	4260.3895
STORY 28	2184.2283	3951.2876	3628.6893	3687.7236	3439.8624
STORY 29	1511.0733	2862.5974	2628.7115	2670.7389	2432.1805
STORY 30	758.4645	1523.4512	1399.6427	1421.7278	1233.2752

TABLE 6.2:- Story shear force for different model case.

6.3.1 GRAPHICAL REPRESENTATION OF MAX STORY SHEAR FOR DIFFERENT MODEL

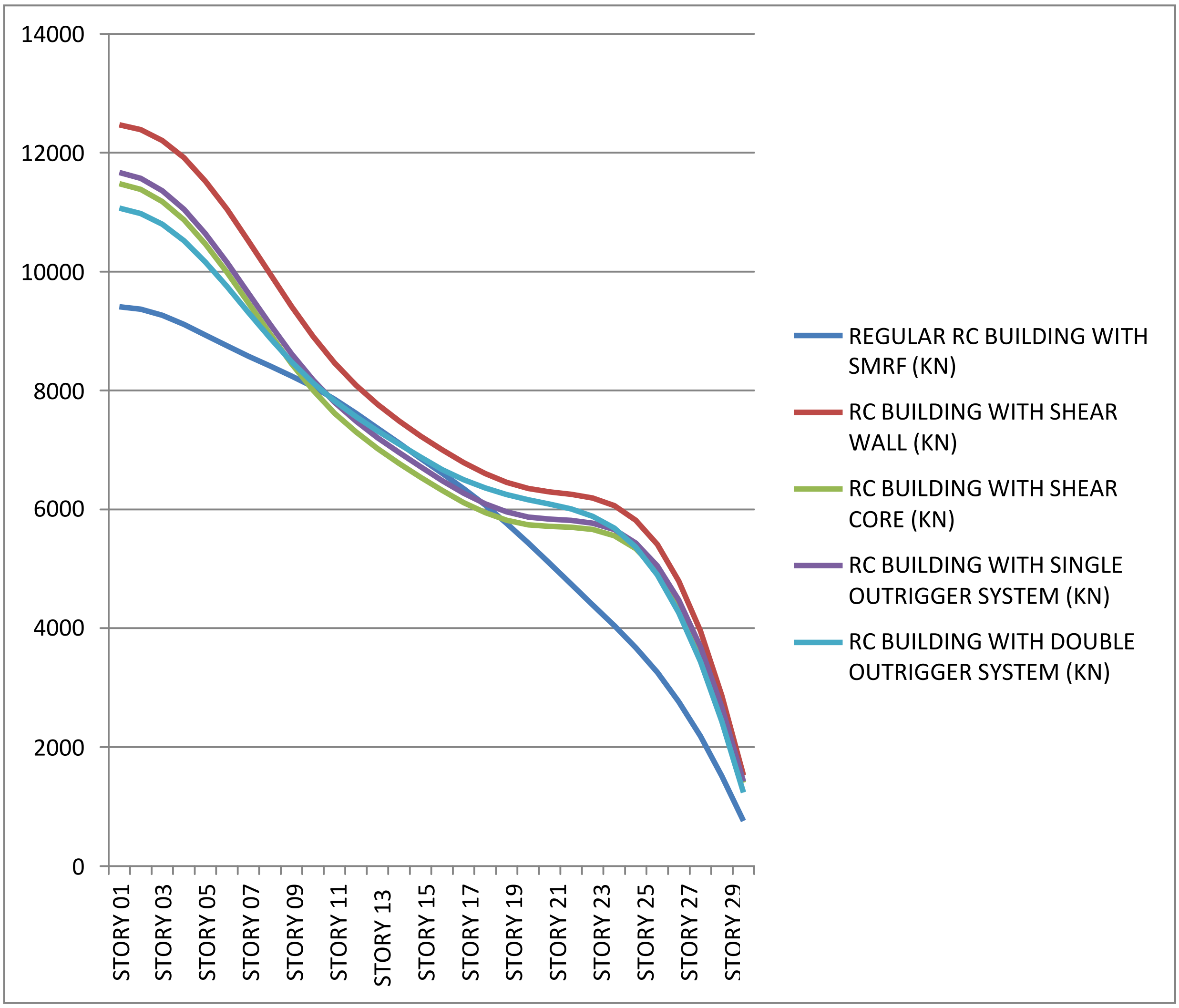


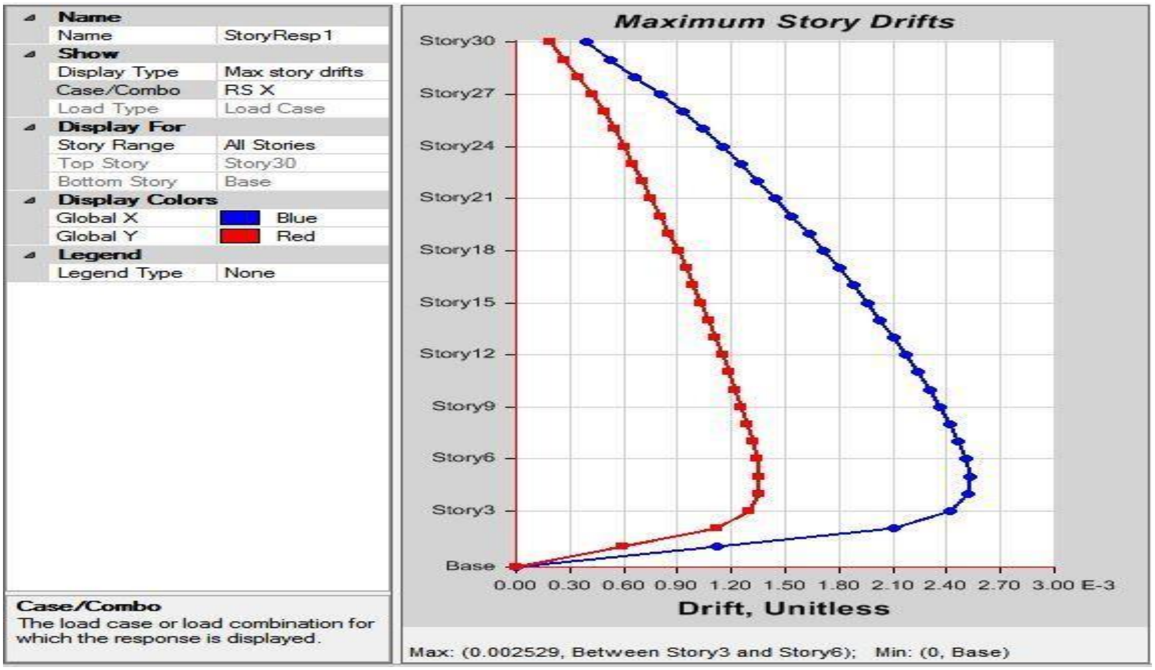
Fig 6.12:- Story Shear force for different model case.

6.4 SERVICE MODEL

6.4.1 STABILITY CHECKS FOR DIFFERENT MODEL CASE

- Inter storey drift ratio should be less than 0.004 (As per IS 1893: 2016, Clause 7.11.1)

i) CASE-I MODEL STABILITY CHECK

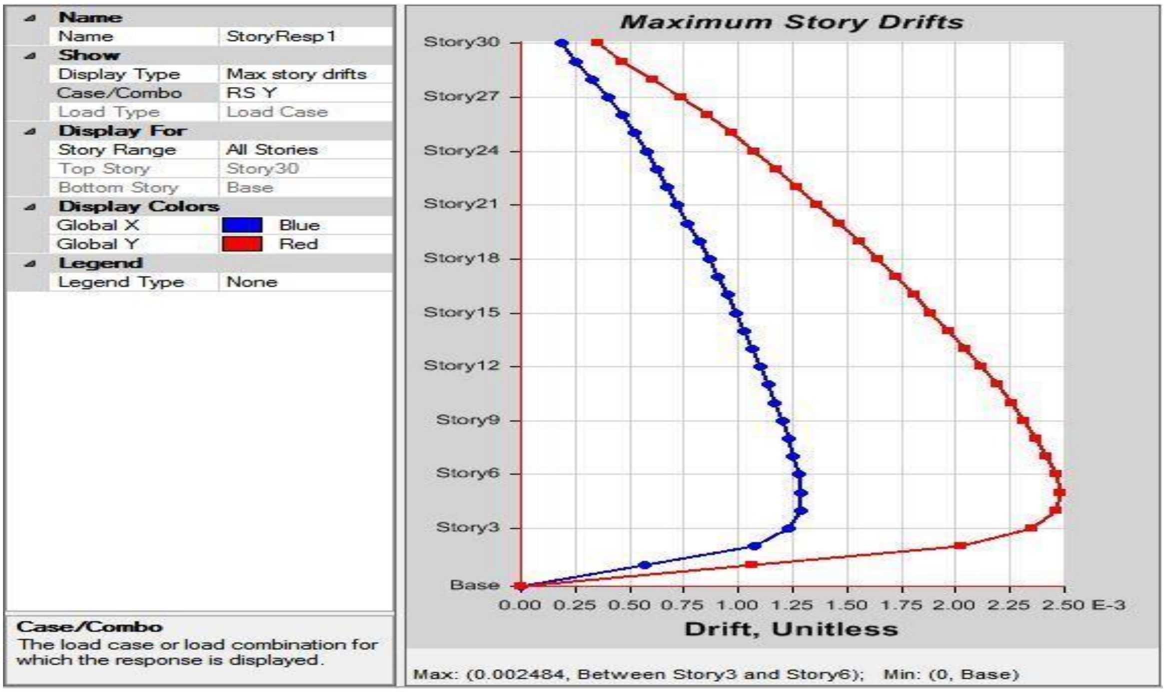


Name	
Name	StoryResp1
Show	
Display Type	Max story drifts
Case/Combo	RS X
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the response is displayed.

Max: (0.002529, Between Story3 and Story6); Min: (0, Base)

Fig 6.13: Maximum story drift ratio for response spectrum in X-direction



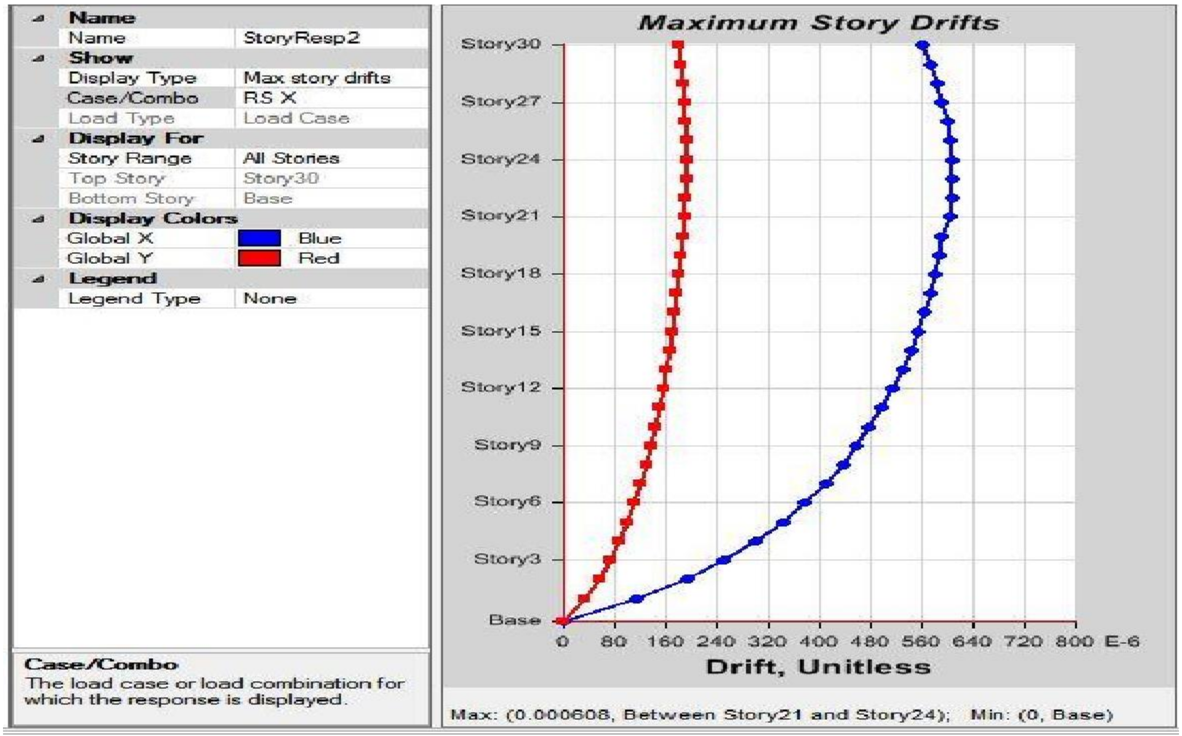
Name	
Name	StoryResp1
Show	
Display Type	Max story drifts
Case/Combo	RS Y
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the response is displayed.

Max: (0.002484, Between Story3 and Story6); Min: (0, Base)

Fig 6.14: Maximum story drift ratio for response spectrum in Y-direction

ii) CASE-II MODEL STABILITY CHECK

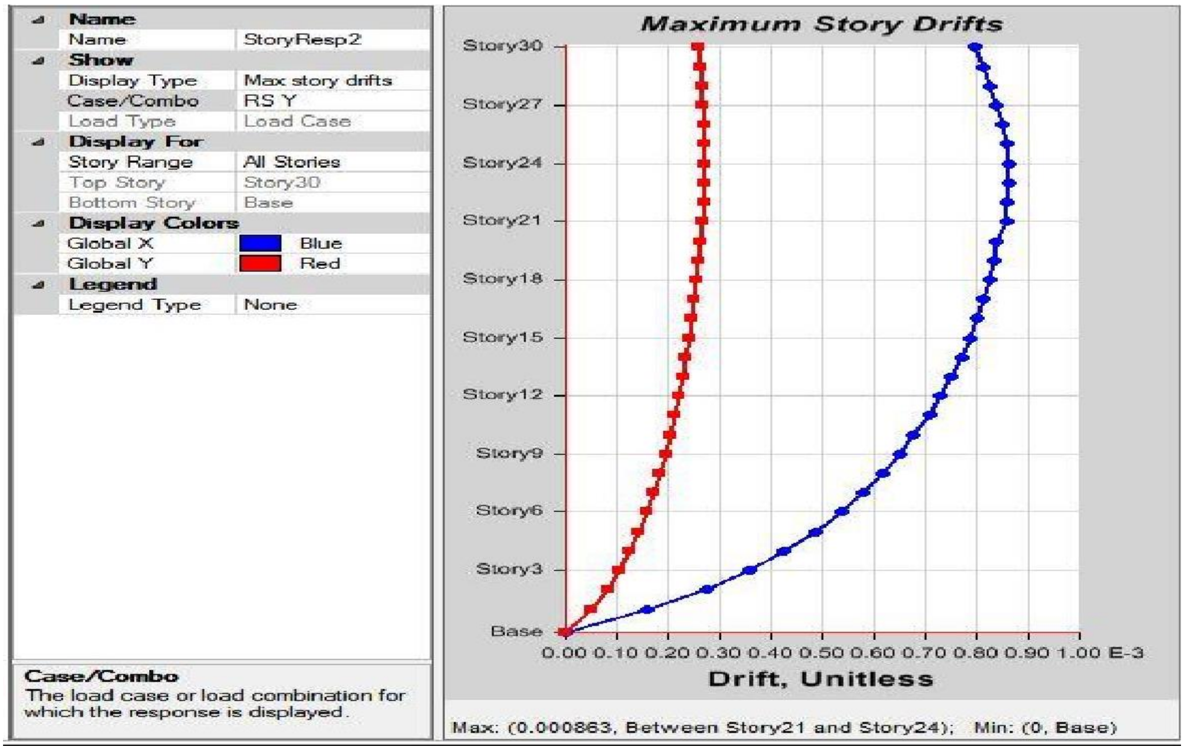


Name	
Name	StoryResp2
Show	
Display Type	Max story drifts
Case/Combo	RS X
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the response is displayed.

Max: (0.000608, Between Story21 and Story24); Min: (0, Base)

Fig 6.15: Maximum story drift ratio for response spectrum in X-direction



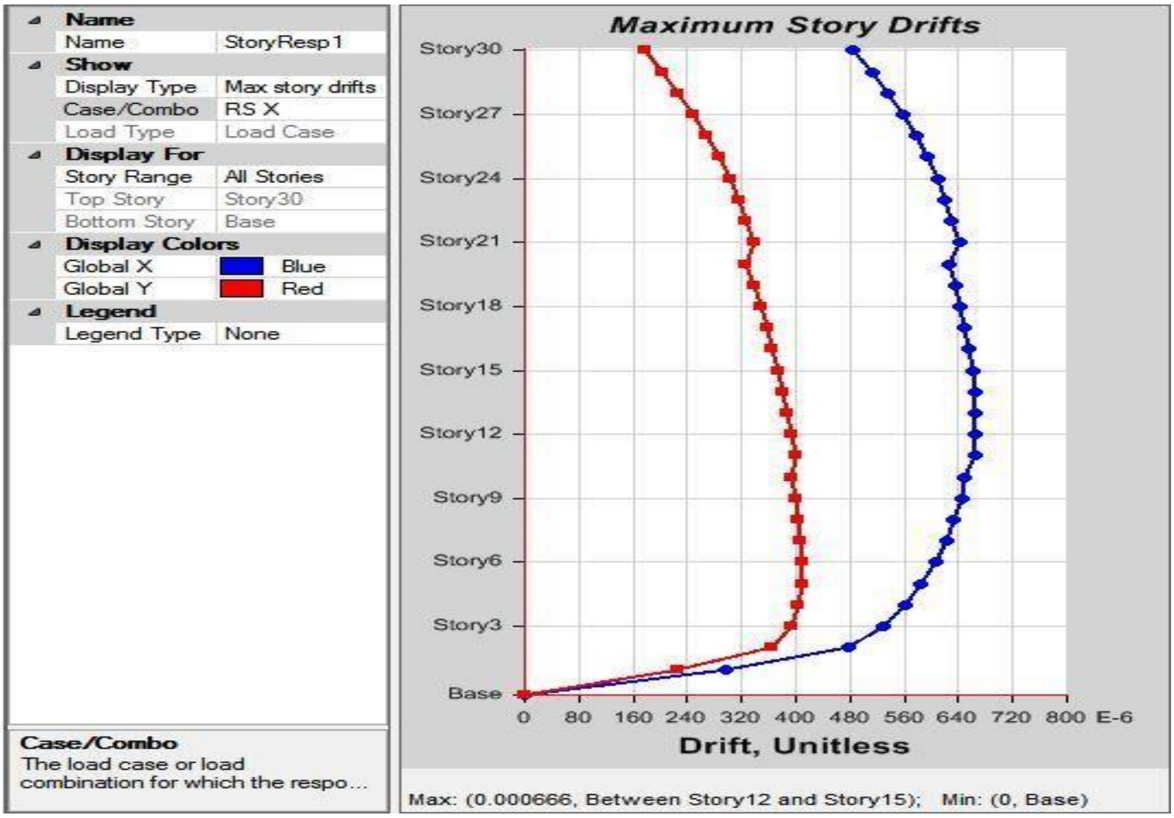
Name	
Name	StoryResp2
Show	
Display Type	Max story drifts
Case/Combo	RS Y
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the response is displayed.

Max: (0.000863, Between Story21 and Story24); Min: (0, Base)

Fig 6.16: Maximum story drift ratio for response spectrum in Y-direction

iii) CASE-III MODEL STABILITY CHECK

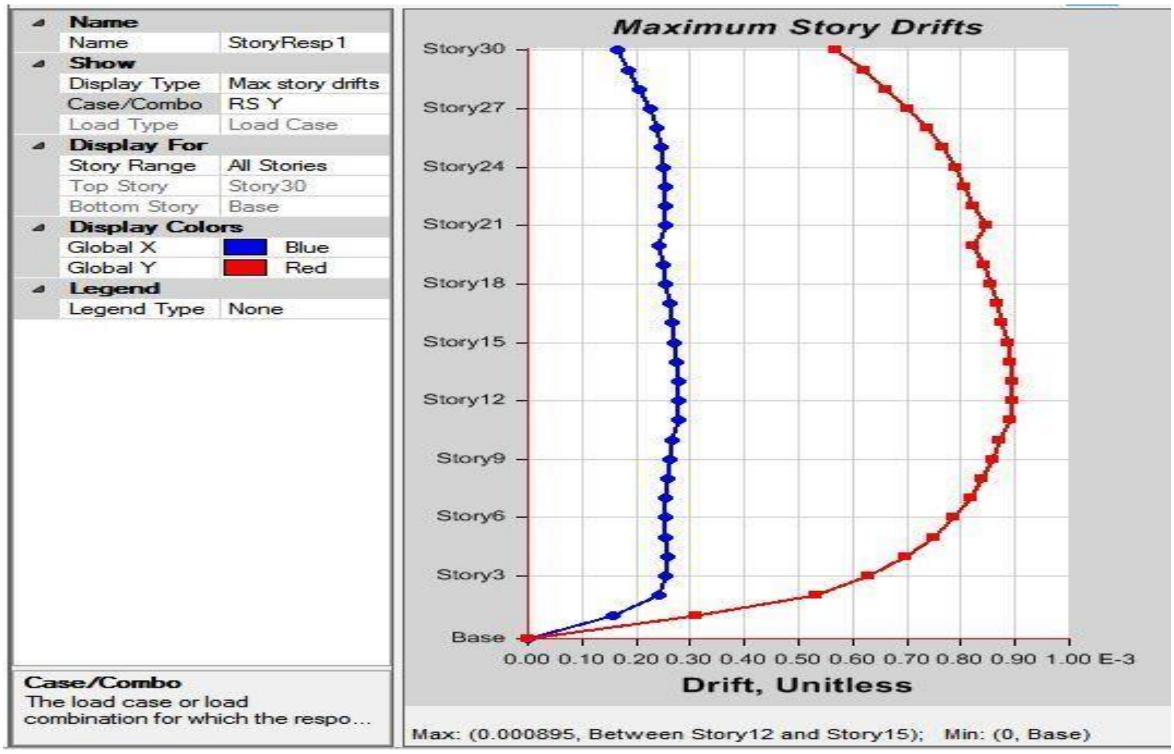


Name	
Name	StoryResp1
Show	
Display Type	Max story drifts
Case/Combo	RS X
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the respo...

Max: (0.000666, Between Story12 and Story15); Min: (0, Base)

Fig 6.17: Maximum story drift ratio for response spectrum in X-direction



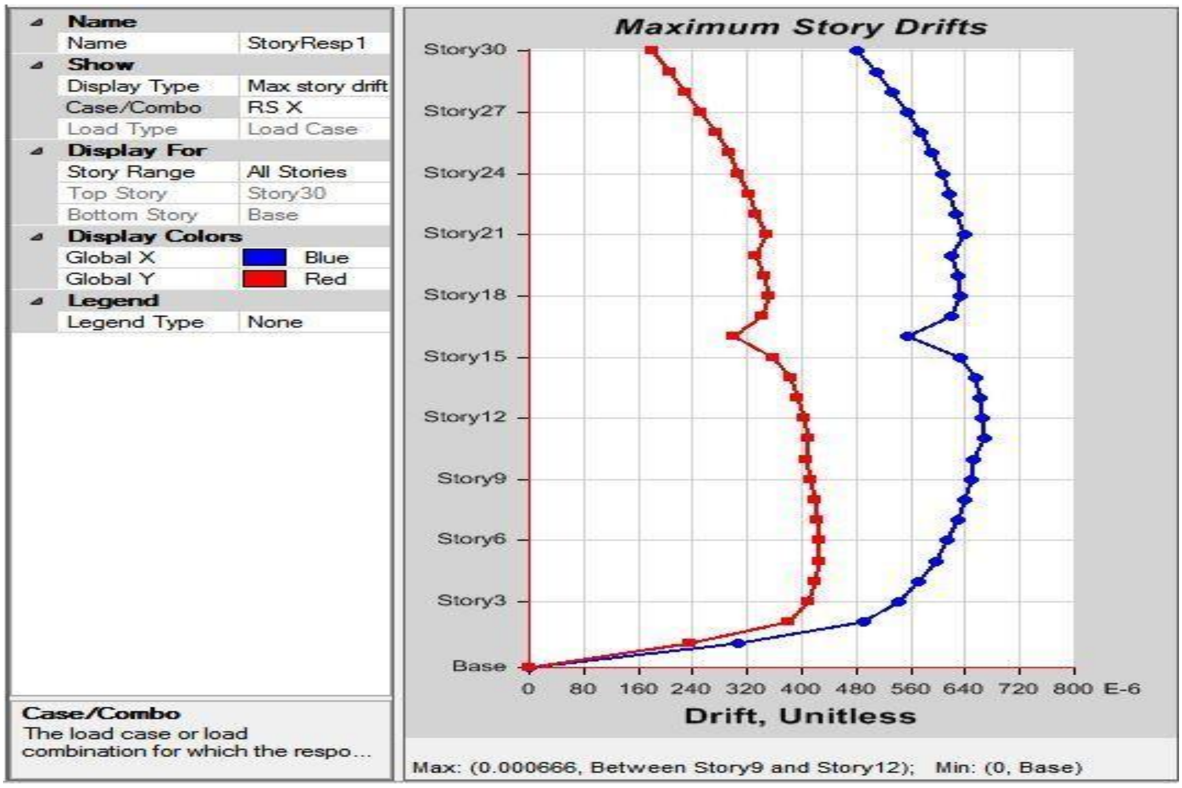
Name	
Name	StoryResp1
Show	
Display Type	Max story drifts
Case/Combo	RS Y
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the respo...

Max: (0.000895, Between Story12 and Story15); Min: (0, Base)

Fig 6.18: Maximum story drift ratio for response spectrum in Y-direction

iv) CASE-IV MODEL STABILITY CHECK

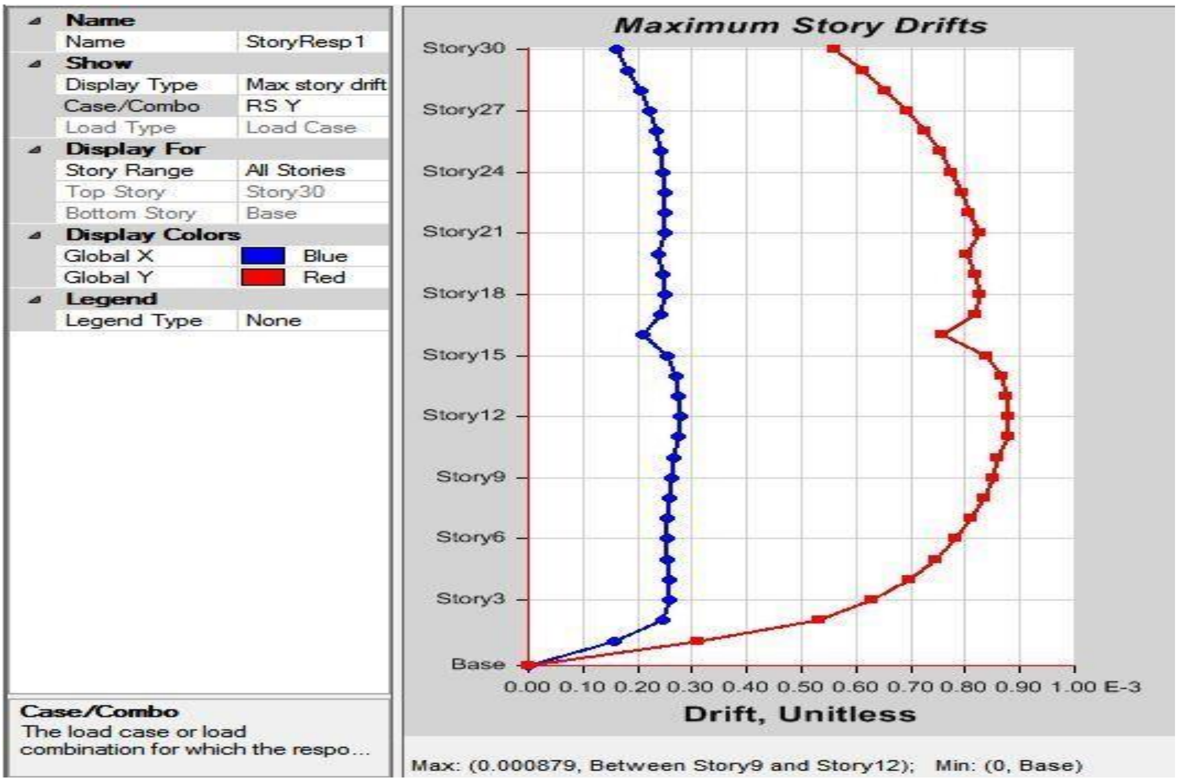


Name	
Name	StoryResp1
Show	
Display Type	Max story drift
Case/Combo	RS X
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the respo...

Max: (0.000666, Between Story9 and Story12); Min: (0, Base)

Fig 6.19: Maximum story drift ratio for response spectrum in X-direction



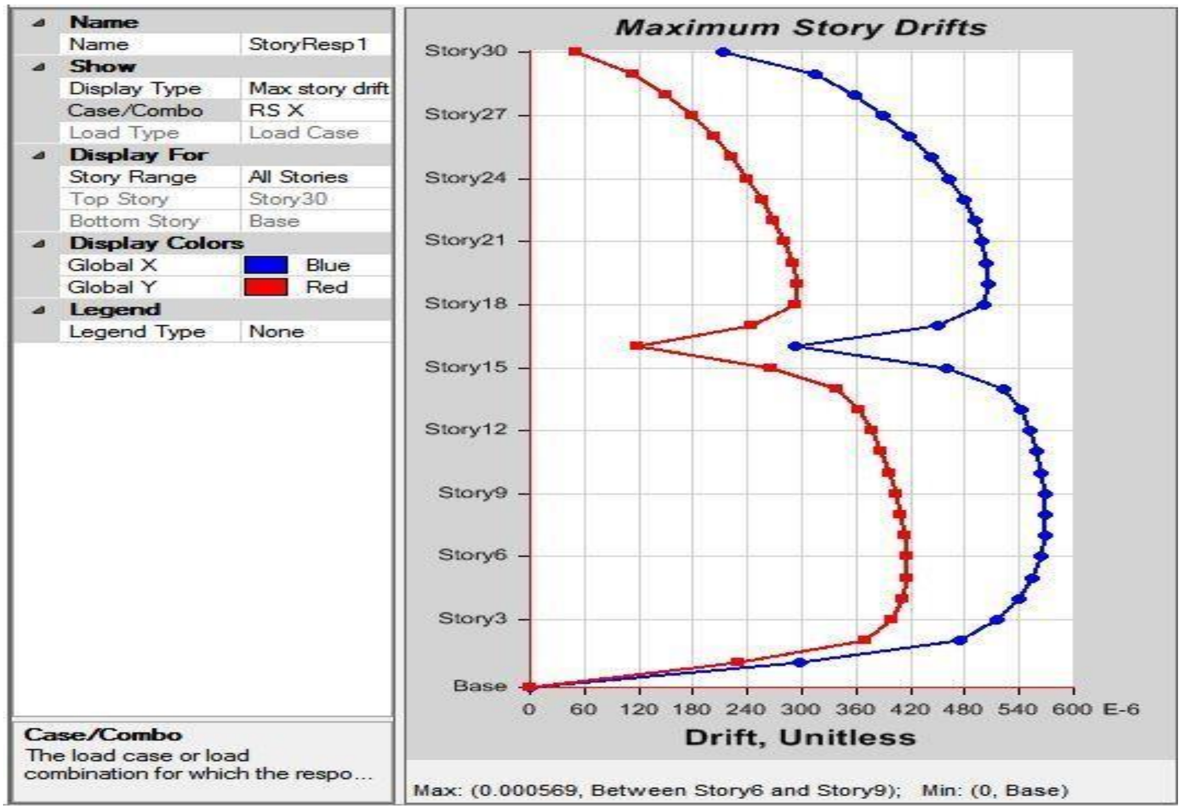
Name	
Name	StoryResp1
Show	
Display Type	Max story drift
Case/Combo	RS Y
Load Type	Load Case
Display For	
Story Range	All Stories
Top Story	Story30
Bottom Story	Base
Display Colors	
Global X	🟦 Blue
Global Y	🟥 Red
Legend	
Legend Type	None

Case/Combo
The load case or load combination for which the respo...

Max: (0.000879, Between Story9 and Story12); Min: (0, Base)

Fig 6.18: Maximum story drift ratio for response spectrum in Y-direction

v) CASE-V MODEL STABILITY CHECK

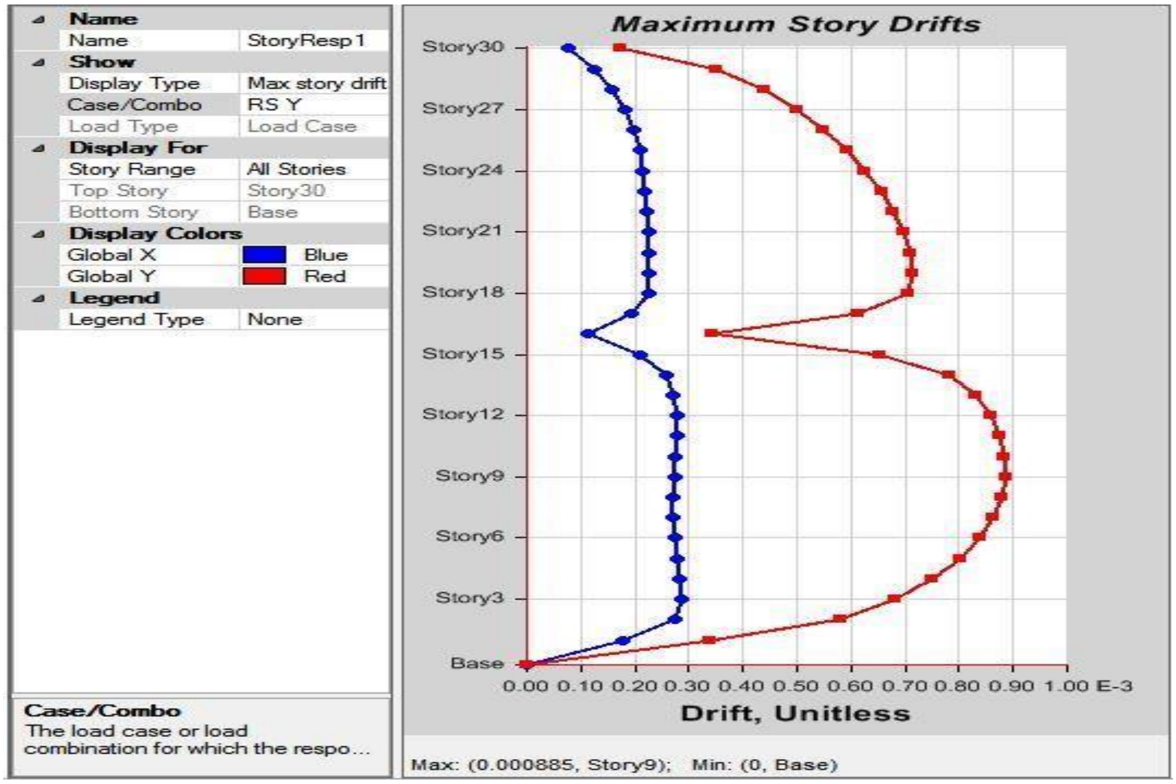


Name
Name StoryResp1
Show
Display Type Max story drift
Case/Combo RS X
Load Type Load Case
Display For
Story Range All Stories
Top Story Story30
Bottom Story Base
Display Colors
Global X 🟦 Blue
Global Y 🟥 Red
Legend
Legend Type None

Case/Combo
The load case or load combination for which the respo…

Max: (0.000569, Between Story6 and Story9); Min: (0, Base)

Fig 6.21: Maximum story drift ratio for response spectrum in X-direction



Name
Name StoryResp1
Show
Display Type Max story drift
Case/Combo RS Y
Load Type Load Case
Display For
Story Range All Stories
Top Story Story30
Bottom Story Base
Display Colors
Global X 🟦 Blue
Global Y 🟥 Red
Legend
Legend Type None

Case/Combo
The load case or load combination for which the respo…

Max: (0.000885, Story9); Min: (0, Base)

Fig 6.22: Maximum story drift ratio for response spectrum in Y-direction

CHAPTER 7

7.1 CONCLUSION

- **Following conclusions can be made from the analysis**

i. These analysis are carried out by considering different model cases, medium soil type for zones IV Different response like lateral force, overturning moment, story drift, displacements, base shear are plotted in order to compare the results of the equivalent static and response spectrum analysis.

ii. In making the structure stiff shear core with double outrigger system is most efficient than any other cases.

iii. We found that the value of story displacement is minimum in shear core with double outrigger-braced system in both equivalent static and response spectrum analysis as compared with different model for different load cases.

iv. We found that the value of peak story shear is minimum in double outrigger-braced system except regular building with SMRF. Hence regular building with double outrigger system seem to be very effective during seismic or lateral load effect.

v. Other than regular building, regular building with double outrigger-braced system shows minimum value of base shear that is **11065.3029** KN, so it is founded that the efficient Case for this parameter (base shear) will be double outrigger-braced system.

REFERENCES

Esmaili, O., Epackachi, S., & Samadzad, M. (2008). Study of Structural RC Shear Wall System in a 56-Story RC Tall Building. *World Conference on Earthquake Engineering*.

Ahamad, A. S., & Pratap, K. V. (2020). Dynamic analysis of G + 20 multi storied building by using shear walls in various locations for different seismic zones by using Etabs. *Elsevier Ltd.*

Bayati, Z., Mahdikhani, M., & Rahaei, A. (2008). OPTIMIZED USE OF MULTI-OUTRIGGERS SYSTEM TO STIFFEN TALL BUILDINGS. *World Conference on Earthquake Engineering*.

Dangi, A., & Jamle, S. (2018). Determination of Seismic parameters of R.C.C. Building Using Shear Core Outrigger, Wall Belt and Truss Belt Systems. *International Journal of Advanced Engineering Research and Science (IJAERS), Vol.5*(Issue 8).

Duggal, S. K. (2013). *Earthquake-resistant design of structure* (2nd ed.). oxford university press.

Khanorkar, A., Sukhdeve, S., Denge, S. V., & Raut, S. P. (2016). Outrigger and Belt Truss System for Tall Building to Control Deflection: A Review. *Global Research and Development Journal for Engineering, Vol. 1*(Issue 6).

Moudarre, F. R. (1985). OUTRIGGER-BRACED COUPLED SHEAR WALLS. *Journal of Structural Engineering, ©ASCE, Vol. 110*.

Mulla, A. K., & Srinivas, B. N. (2015). A Study on Outrigger System in a Tall R.C Structure with Steel Bracing. *International Journal of Engineering Research & Technology (IJERT), Vol. 4*(Issue 07).

Santhosh, S., & Mathew, L. A. (2017). Seismic Analysis of Multi Storied Building with Shear Walls of Different Shapes. *International Journal of Engineering Research & Technology (IJERT), Vol. 6*(Issue 06).

Sarkisian, M., & Hassan, W. (2013). Performance-Based Engineering of Core Wall Tall Buildings. *Structures Congress 2013 © ASCE.*

IS 16700:2017, “criteria of structural safety of tall concrete building”.

IS 875 -2015, “Design Loads (Other than Earthquake) for Buildings and Structures — part 3 wind load”

IS 456-2000, “Plain and reinforced concrete design”

IS 1893: 2016, “Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1 General provisions and buildings”, Bureau of Indian Standards, New Delhi.

A.K Chopra "Dynamic of structures theory and Earthquake Engineering" fourth edition, Prentice Hall, 2012.