Behavior of Structural Systems for High Rise Buildings

Lipi Rathod and Rahul Shah*

School of Engineering and Technology, Navrachna University, Vadodara-391 410,Gujarat,India

Corresponding Author: rahuls@nuv.ac.in

Abstract

Rapid growth of population has encouraged development of tall buildings around the world. For higher ductility and energy dissipation under lateral forces, effective structural systems like rigid frame and shear wall systems are employed in buildings.

The structural system of a tall building is designed to deal with vertical gravity loads and mainly the lateral loads caused by wind and seismic activity. The structural system consists of only the members designed to carry loads. All other members which do not participate in carrying loads are referred to as non-structural members.

This study focuses on choice of structural system with different parameters like storey drift, storey shear and maximum storey displacement.

Key words

storey drift, storey shear, maximum storey displacement,structural system

Introduction

Population of India is increasing at an alarming rate (about 1.2% per year) and now we are1.34 billion people. This large population not only needs jobs but also needs housing and other infrastructure facility. Tall structures may serve the requirement in metropolitan cities. As the height of the building increase the lateral resisting system becomes more important than the structural systems that resist the gravitational loads. There is various types of structural system are used in high rise building.

The lateral resisting systems are widely used in the world are rigid frame system, Shear wall system, Braced structures, Tubular system, Core system, Outrigger system. This work focuses on study of various parameters compare with different structural system. Analysis of

building involves parametric study of maximum storey displacement, storey drift, and storey shear.

Storey Drift: It is defined as ratio of displacement of two consecutive floors to height of that floor. It is very important term used for research purpose in earthquake engineering.

Storey Displacement: Total displacement of any storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings.

Storey Shear: It is the sum of design lateral forces at all levels above the storey under consideration.

Objective

1) To understand behavior of various structural system used in high rise building.
2) Comparative study on various structural system used in conventional practice approach.
3) Parametric study and its response comparison for considered structural system.
4) To study of performance on different structural system used in tall structure.

Building System under Study

The building has been modeled considering the building data as tabulated.

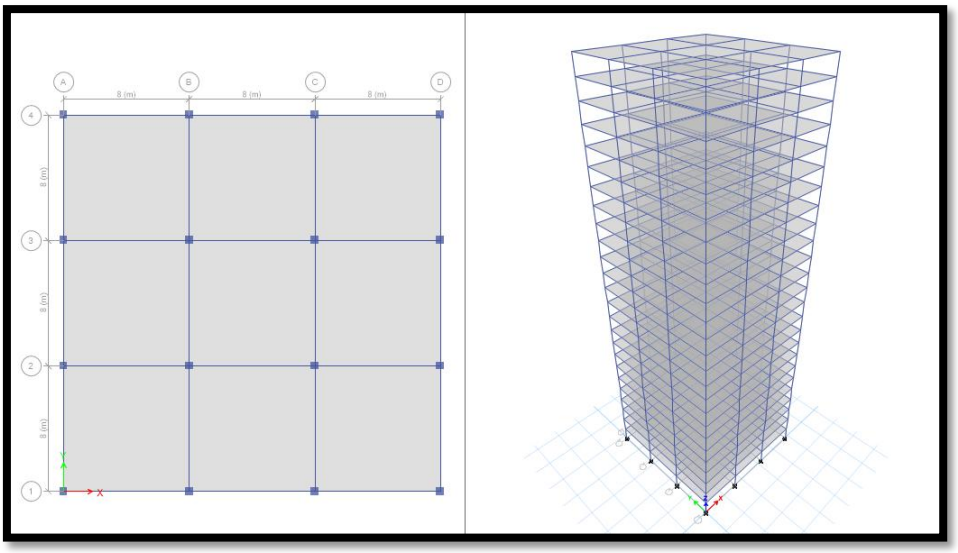

Figure 1: Plan and Elevation of building

Plan dimension	24 m X 24 m
Height of typical storey	3 m
Height of base storey	3 m
Number of bays in X direction	3
Number of bays in Y direction	3
Width of each bay in X direction	8m
Width of each bay in Y direction	8m
Slab thickness	150 mm
Column size	500 mm X 500 mm
Beam size	500 mm X 300 mm
Shear wall thickness	250 mm
Live load	3 KN/m^2
Location	Vadodara
Earthquake data	IS 1893 (part 1) – 2002
Type of soil	Medium soil
Importance factor	1.5
Response reduction factor	5
Type of structural systems	1) Rigid frame structural system 2) Shear wall structural system
Seismic Zone Factor	0.36
Dead load	as calculated by the software

Table 1: Building data

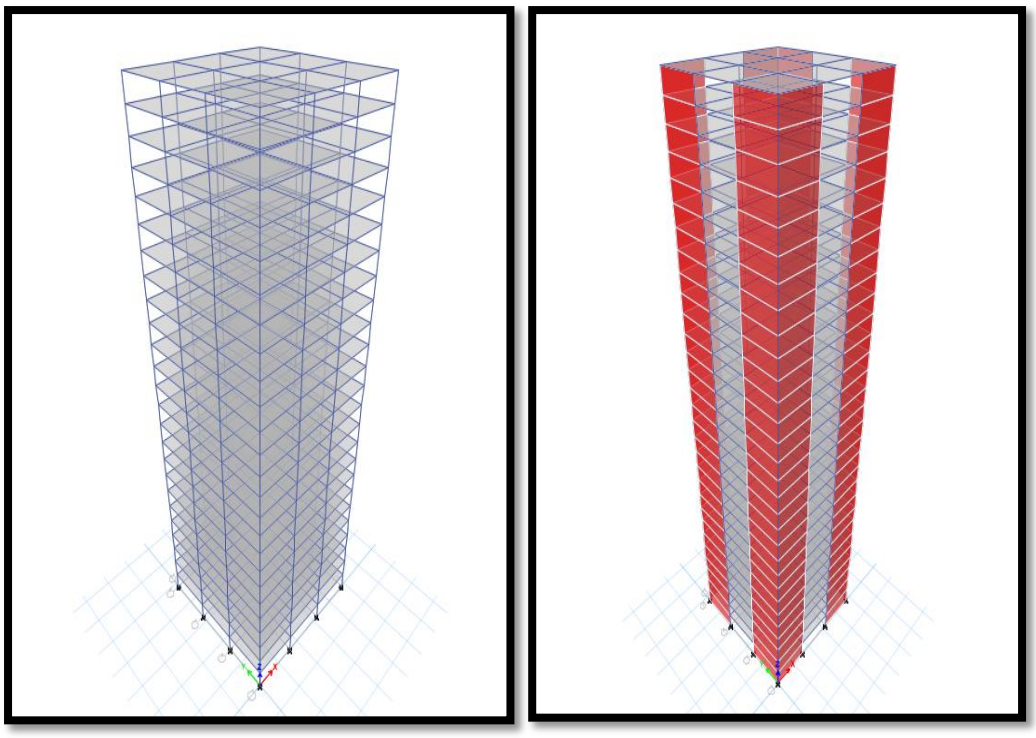

Figure 2: Elevation of rigid frame and shear wall structural systems

The modeling and analysis of various structural systems were carried out in software. The software was used to model and assess the effectiveness of various structural systems under lateral loadings. Seismic loading was applied to the structures. The structural systems that were modeled and analyzed are:

1. **Rigid frame system:** The word rigid means ability to resist the deformation. Rigid frame structures can be defined as the structures in which beams & columns are made monolithically and act collectively to resist the moments which are generating due to applied loads.
2. **Shear wall system:** In structural engineering, a shear wall is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on a structure. Shear wall is a structural member used to resist lateral forces.

Five models of varying stories were analyzed for rigid frame structural system. The numbers of stories analyzed for the system are 5 storeys, 10 storeys, 15 storeys, 20 storeys, 25 storeys.

Four models of varying stories were analyzed for Shear wall structural system. The numbers of stories analyzed for the system are 10 storeys, 20 storeys, 30 storeys, 40 storeys. For Shear wall structural system, the orientation of the shear wall is considered at the corners of the building with L-shaped.

Maximum permissible storeydisplacement and permissible storey drift are calculated from IS: 1893 – 2002 and IS: 456 – 2000.

Maximum permissible storey displacement is limited to H/500. Where, H – total height of building.

Maximum permissible storey drift is limited to 0.004 h. Where, h – storey height.

In this article all these different heights achieve compare all different parameters like maximum storey displacement, storey shear and storey drifts.

Results and Discussion

Rigid Frame Structure

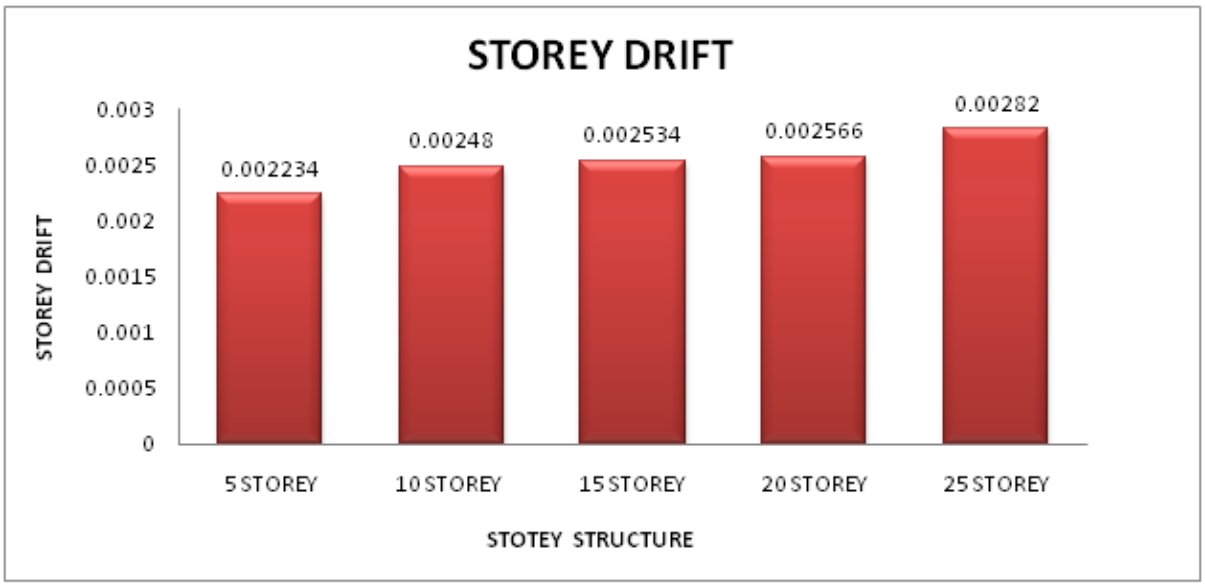

Figure 3: Storey Drift

STOREY STRUCTURE	STOREY DRIFT
5 STOREY	0.002234
10 STOREY	0.00248
15 STOREY	0.002534
20 STOREY	0.002566
25 STOREY	0.00282

Table 2: Storey Drift

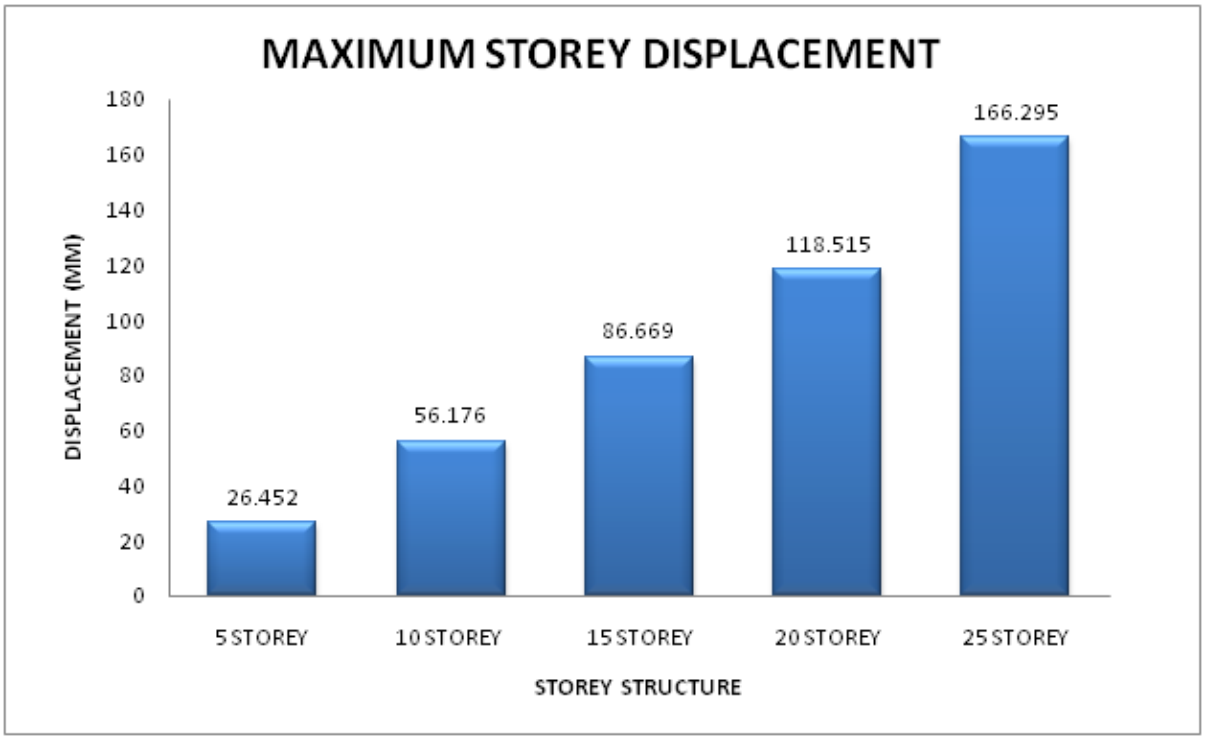

Figure 4: Maximum Storey Displacement

STOREY STRUCTURE	DISPLACEMENT (MM)
5 STOREY	26.452
10 STOREY	56.176
15 STOREY	86.669
20 STOREY	118.515
25 STOREY	166.295

Table 3: Maximum Storey displacement

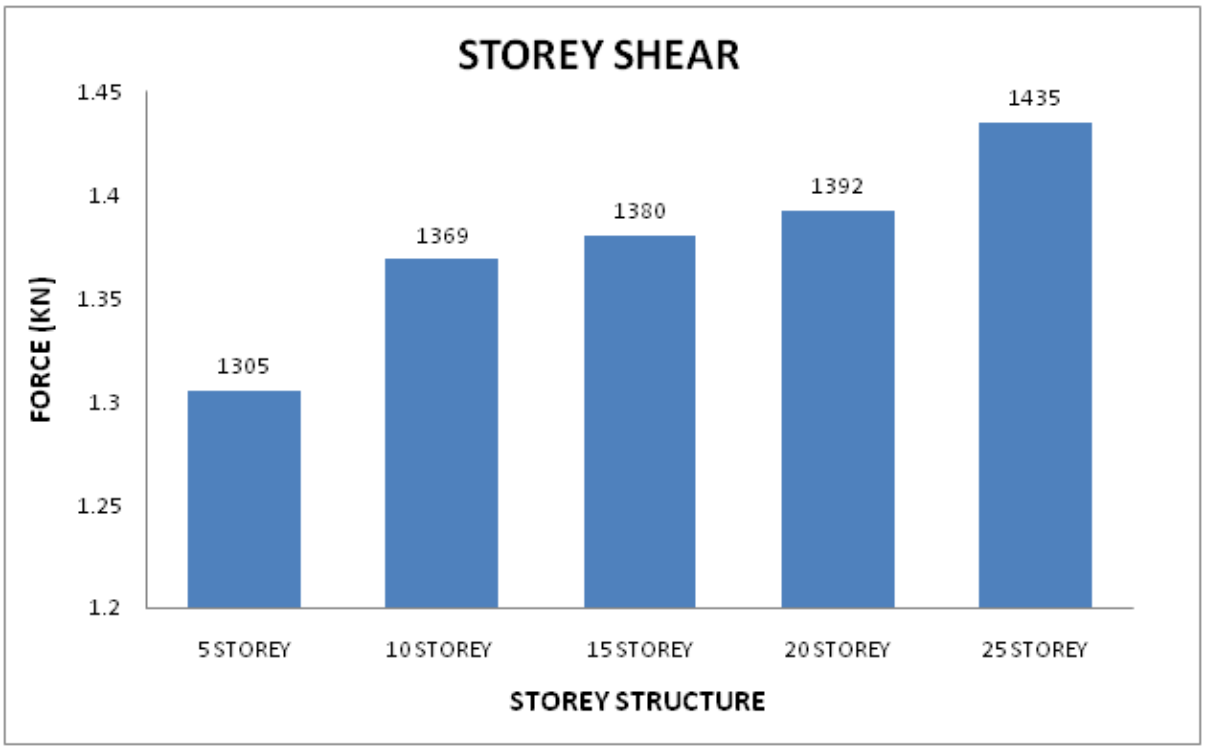

Figure 5: Storey Shear

STOREY STRUCTURE	FORCE (KN)
5 STOREY	1305
10 STOREY	1369
15 STOREY	1380
20 STOREY	1392
25 STOREY	1435

Table 4: Storey Shear

Shear Wall Structure

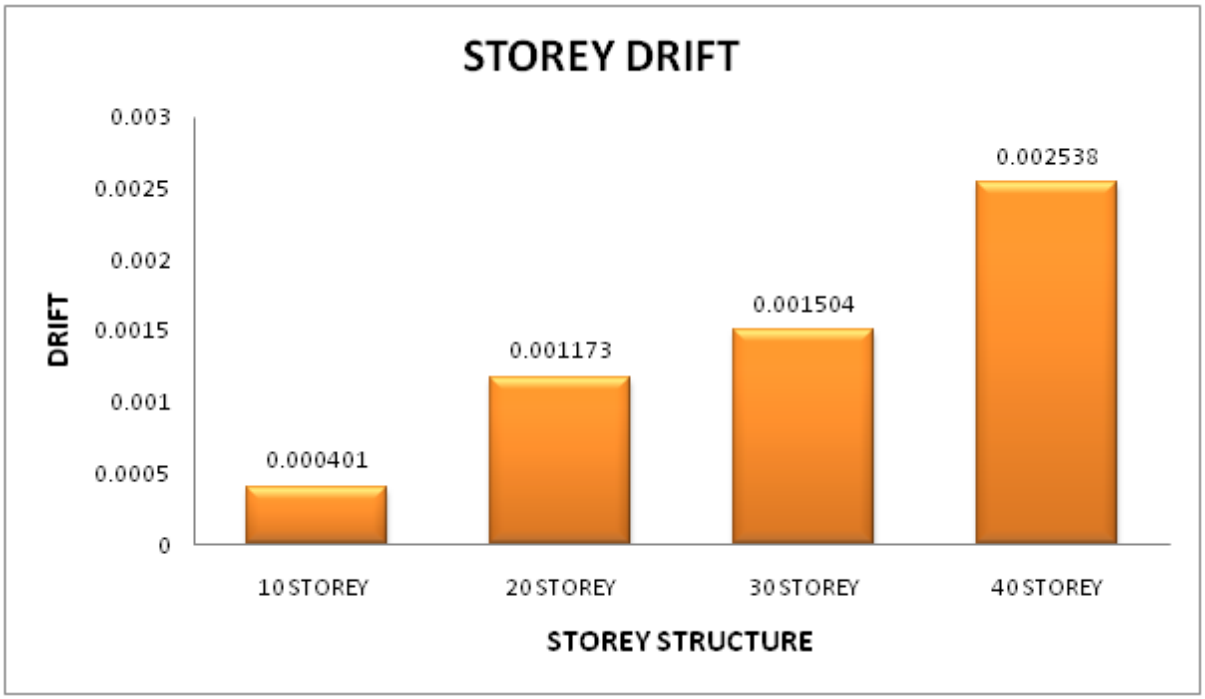

Figure 6: Storey Drift

STOREY STRUCTURE	DRIFT
10 STOREY	0.000401
20 STOREY	0.001173
30 STOREY	0.001504
40 STOREY	0.002538

Table 5: Storey Drift

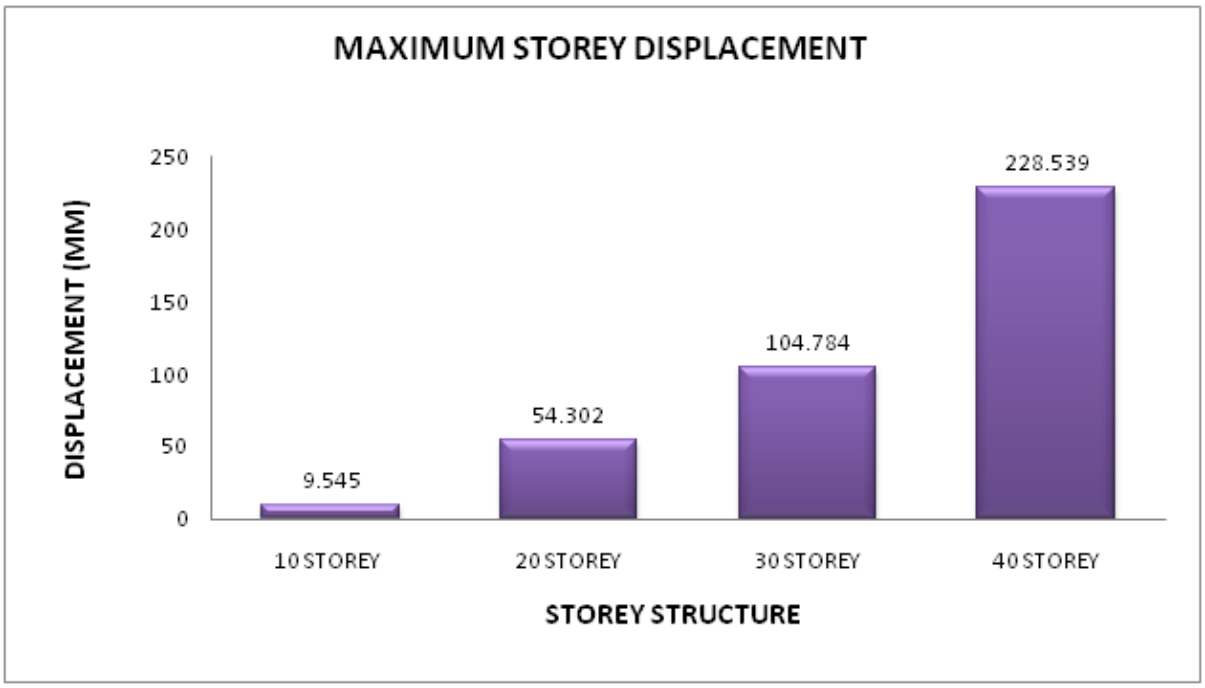

Figure 7: Maximum Storey Displacement

STOREY STRUCTURE	DISPLACEMENT (MM)
10 STOREY	9.545
20 STOREY	54.302
30 STOREY	104.784
40 STOREY	228.539

Table 6: Maximum Storey Displacement

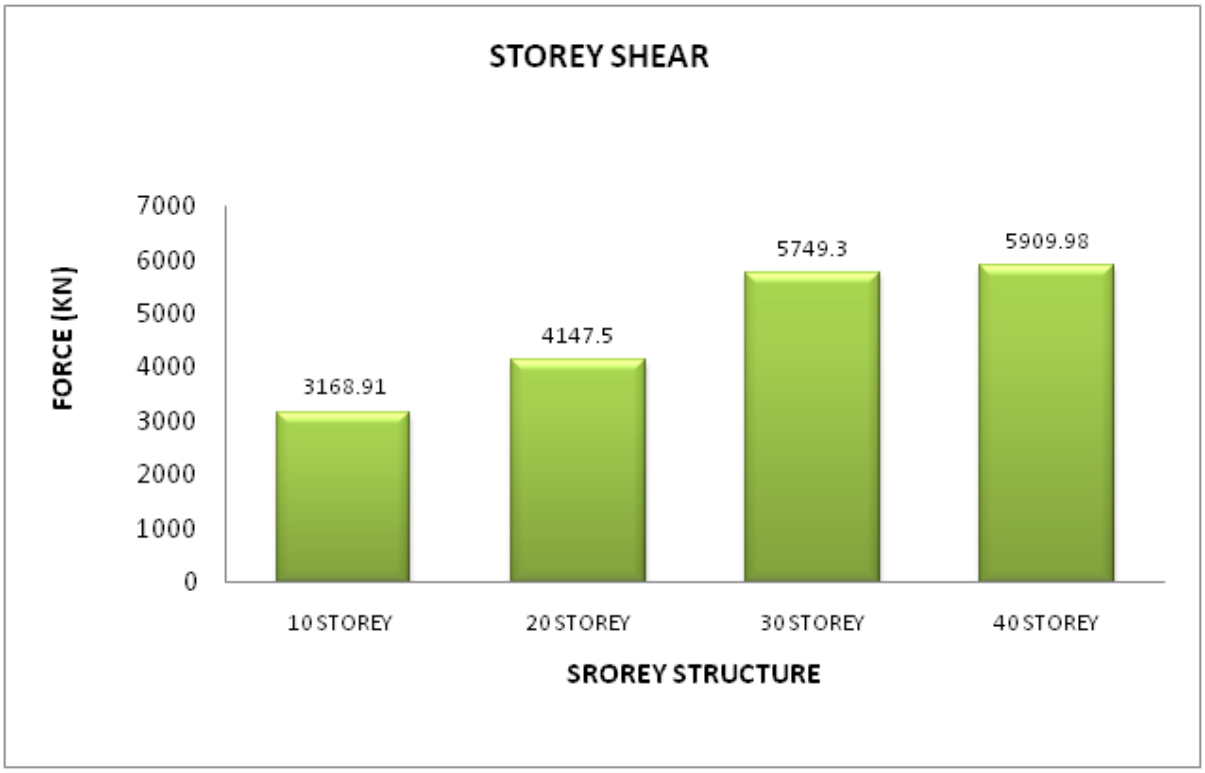

Figure 8: Storey Shear

STOREY STRUCTURE	FORCE (KN)
10 STOREY	3168.91
20 STOREY	4147.50
30 STOREY	5749.30
40 STOREY	5909.98

Table 7: Storey Shear

Discussion

Under the seismic loads as the height of the structure increase the Storey drift, Maximum storey displacement and Storey shear also increases. Rigid frame structure is recommended up to 25 stories. Storey drift, maximum storey displacement and storey shear for the models are within the limit specified by IS-1893:2002 (Part I).

Conclusions

1) In this study is carried out according to earthquake code IS-1893 (part 1):2002 and analysis is carried out by taking regular plan of building.

2) The key idea in limiting the seismic effect in a tall building is by changing the structural system of the building into something more rigid and stable to confine the deformation and increase stability.

3) The maximum storey displacement is reduced by the use of shear wall structure as compare to rigid frame structure.

4) From the selected structural system for analysis, shear wall structural system is most efficient.

5) Rigid frame structural system is more appropriate than shear wall structural system for low rise building considering economical aspect.

References

1. Prajapati,M.N.,Patel,V.V.,& Patel,B.R.(2016).Parameters comparison for different structural system.*International Research Journal of Engineering and Technology (IRJET), 03*(05),1963-1966.
2. Rana,N., & Rana,S.(2014).Structural Forms Systems for Tall Building Structures.*SSRG International Journal of Civil Engineering, 01*(04),33-35.
3. Smith,B.S., & Coull.A.(2006).*Tall Building Structures: Analysis and Design*,New York,United States of America: John Wiley & Sons.
4. Bureau of Indian Standards.(1987).*Code of practice for design loads for building and structures. Part-1: Dead load- Unit weights of Building Materials and Stored Materials* (IS : 875).
5. Bureau of Indian Standards.(1987).*Code of practice for design loads for building and structures. Part-2: Imposed load*. (IS : 875).
6. Bureau of Indian Standards.(2002).*Criteria for Earthquake Resistant Design of Structures. Part-1: General Provision and Buildings*.(IS : 1893).