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Structural Performance of RC Structural wall system over conventional Beam Column System in G+15 storey Building.

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Abstract— In the recent years there are vital changes in the construction process. In old days building are constructed with Concept of load bearing and then RCC frame construction invented. Now RC Structural wall construction in metropolitan cities is widely used. The latest technique is invented for the modern construction is called as Aluform technique or Mivan technique .In this technique whole building is design with RC structural wall i.e. shear wall .It is specially design to allow rapid construction on all types of architecture layout. This research work having scope of analysis and design of G+15 storey building with RC Structural wall and its advantages as a structural point of view. For this thesis design software ETABS is used for design and analysis. Analysis is carried out considering the various seismic and wind load condition for both system of framing. Column beam conventional system and RC structural wall compared on the basis of various structural parameters. From analysis result new structural parameter is represented which having the best performance in the worst loading. For validation of work we will go for part manual calculation to check correctness of analysis. Then design for the both system is carried out. For both the system design comparison is done on the basis of % steel and concrete quantity with cost consideration too. Concluding remark will be given with respective high structural performance.

Keywords— Aluform Technique, RC Structural wall system, Beam Column System, Analysis and Design, ETABS v9.6.0,Wind and Seismic loading, Comparison, Structural Performance.

INTRODUCTION

Construction of high rise building is highly complex and required advanced construction technology and equipment. Mivan technologies, climbing formwork, Aluform technologies are the new development in the formwork and latest one. Therefore counties are conceived to design and built more and higher building. Due to large population and small per capita area the need of ultra-high rise building becomes much more urgent You can put the page in this format as it is and do not change any of this properties.

Population of India is growing fastly in urban area or in metro cities. This is the basic reason for increasing land cost in cities. With increasing land cost, it is not surprising that the number of stories in building in urban areas across the country is increasing rapidly. Therefore the construction of tall structures such as high rise building, sky scrapers or sky towers is an important indicator of country or cities economic and technological strength with the continued development and progress of the economy, technology and material in recent years.

In Beam Column System of buildings reinforced concrete frames are provided in both principal directions to resist vertical loads and the vertical loads are transmitted to vertical framing system i.e. columns and foundations. This type of system is effective in resisting both vertical & horizontal loads. The brick walls are to be regarded as non-load bearing filler walls only. This system is suitable for multi-storied building which is also effective in resisting horizontal loads due to earthquake.

In RC Structural wall system the lateral and gravity load-resisting system consists of reinforced concrete walls and reinforced concrete slabs. RC structural walls are the main vertical structural elements with a dual role of resisting both the gravity and lateral loads. Wall thickness varies from 140 mm to 500 mm, depending on the number of stories, building age, and thermal insulation requirements. In general, these walls are continuous throughout the building height; however, some walls are discontinued at the street front or basement level to allow for commercial or parking spaces. Usually the wall layout is symmetrical with respect to at least one axis of symmetry in the plan.

Therefore counties are conceived to design and built more and higher building. Due to large population and small per capita area the need of ultra-high rise building becomes much more urgent. Now a day, many R.C. building of 12-60 stories are being planned and executed. The lateral load resisting provided in most multi storey building is moment resisting frame, with beams being eliminate in years in majority of the building to simplify and accommodate the use of more economical formwork. In recent years R.C. tube structure and R.C. structural wall have been introduced to provide the required stiffness.

LITERATURE REVIEW

Ramesh kannan M.et.al.[1] explore the various factors influencing the section and operation of the different types of the climbing formwork system adopted in the constructability survey This research paper conclude by bringing down the potential advantages of the climbing formwork system over the conventional formwork system on the basis of cost, time, quality, safety and sustainability factor using qualitative and quantitative indices by a technique called Constructability.

Patil D.S.et.al.[2] has discussed comparisons of conventional formwork and aluminum formwork on the basis of cost, time, and quality and quantity parameter. This technical paper covers advantages of Mivan formwork. Also covers advantages of Mivan formwork over the conventional formwork and limitation of the same.

O.Esmaili et.al.[3] have done study of the 56-storeyed tower constructed by using RC shear wall system. In this researchers had studied 56 storey building for various structural aspects which is located in the high seismic zone. In this tower shear wall system with irregular opening has utilized under both lateral and gravity loads and also study of structural behavior of shear walls. Also nonlinear structural analysis was performed to analysis of RC structural walls. The optimality of shear wall in tall storied building had studied.

Kaustubh Dasgupta[4] is explained the role of structural wall in tall structures and also the wall region is decided according end condition or joint i.e. D-region (disturbed region) and B- region (Bernoulli region).Due to the RC wall plastic hinges formation had been explained.

M.A.Hube et.al.[5] have done analysis of seismic behavior of RC slender structural wall. Researcher had mentioned effect of Chile Earthquake on RC structural walls and its damage analysis in year 2010.The objective of this research is to understand observed damaged in slender walls i.e. crushing of concrete, buckling and fracture of reinforcement. Recommendations had provided to avoid the lateral displacement and effective stiffness to slender walls.

David Spires et.al.[6] focused on Optimal Design of Tall RC framed Tube building. In this researcher had made analysis and design of concrete framed tube building using a general modern design optimization algorithms and software outcome. A tall building G+5 and G+40 design consideration and framed tube behavior had presented. Cost comparison had carried out on the basis of concrete quality, steel quantity and formwork cost for various conditions.

Ali Soltani et.al.[7] represents the investigation for numerical modeling of RC shear walls. The simulation of nonlinear behavior of reinforced concrete shear walls under the lateral loads had been studied and this is important problem for community. They had carried out analysis of RC shear walls at three level of refinement. Researcher had evaluated three different modeling techniques of RC shear walls in to the OpenSEES software (Open System for Earthquake Engineering Simulation). Comparison of simulated responses with experimental data on one rectangular shear wall had been carried out.

Chaitanya kumar[8] have carried out analysis of multi storey building with precast load bearing walls. Researcher had studied G+11 storey precast load bearing wall structure for analysis. For modeling and analysis researcher had used ETABS software.

P.P. Chndurkar[9] had presented study of G+9 building having three meters height for each storey. The whole building design had carried out according to IS code for seismic resistant design and the building had considered fixed at base. Structural element for design had assumed as square or rectangular in section. They had done modeling of building using ETAB software in that four different models were studied with different positioning of shear walls.

M.G.Rajendran.[10] presents the study and comparison of the difference between the wind behavior of building with and without shear wall using STAAD Pro. In this paper the STAAD model of 15 storey building considered to carry out study with and without shear wall and also 20 storey building will model same as it. Displacement of 15 storey building and 20 storey building with shear wall is 20.18% and 14.60% less than the building without shear wall. They concluded that building with shear wall will resist wind load effectively.

Francesca Ceroni et.al. [11] had demonstrated that building constructed with large lightly reinforced wall characterized by adequate area respect to the floor extension could suffer lower damage as compared to RC frame structure due to real earthquake. Researcher had focused that new construction technology of RC wall construction with new type of integrated formwork is helpful for insulation gives higher energetic efficiency and continuous construction speed. Researcher had pinpointed there is lack of research work carried out in this area and experimental information is less. Review of the Euro code regarding RC shear wall construction had carried out in this research paper. Static and Dynamic nonlinear analysis had been carried out for a whole RC building designed with both large lightly reinforced walls along the perimeter. Finite element model had being developed by SAP2000 and DIANA software. The total analysis had carried out to check seismic performance of building according to stiffness performance of building according to stiffness.

In this present study, G+15 storey typical building floor plan is selected for analysis and design of building. Modeling, analysis and design are planned to done by using ETABS. Analysis and design is done for both conventional and RC structural Wall system.

Comparison of both the system is done on the basis of analysis and design. ETABS database is used for comparison according to analysis and design. This paper covers the comparison of both structural systems on the structural performance.

METHODOLOGY

A typical residential building plan is selected having G+ 15 storey. For that typical plan both conventional beam column system and RC structural wall system framing is decided. Conventional beam column system is constructed by regular construction process with conventional formwork. RC structural wall system is constructed by using Aluform Technique. Modeling of both systems is carried in ETABS with certain assumptions. Analysis and design of both systems are carried in ETABS for various loading. Typical residential building plan have total floor area 3877.71 square feet. Figure 1.1 will show typical floor plan. Following assumptions are made during design and analysis.

1. The material is homogeneous, isotropic.
2. All columns supports are considered as fixed at the foundation.
3. All RC structural wall supports are considered as fixed at the foundation.

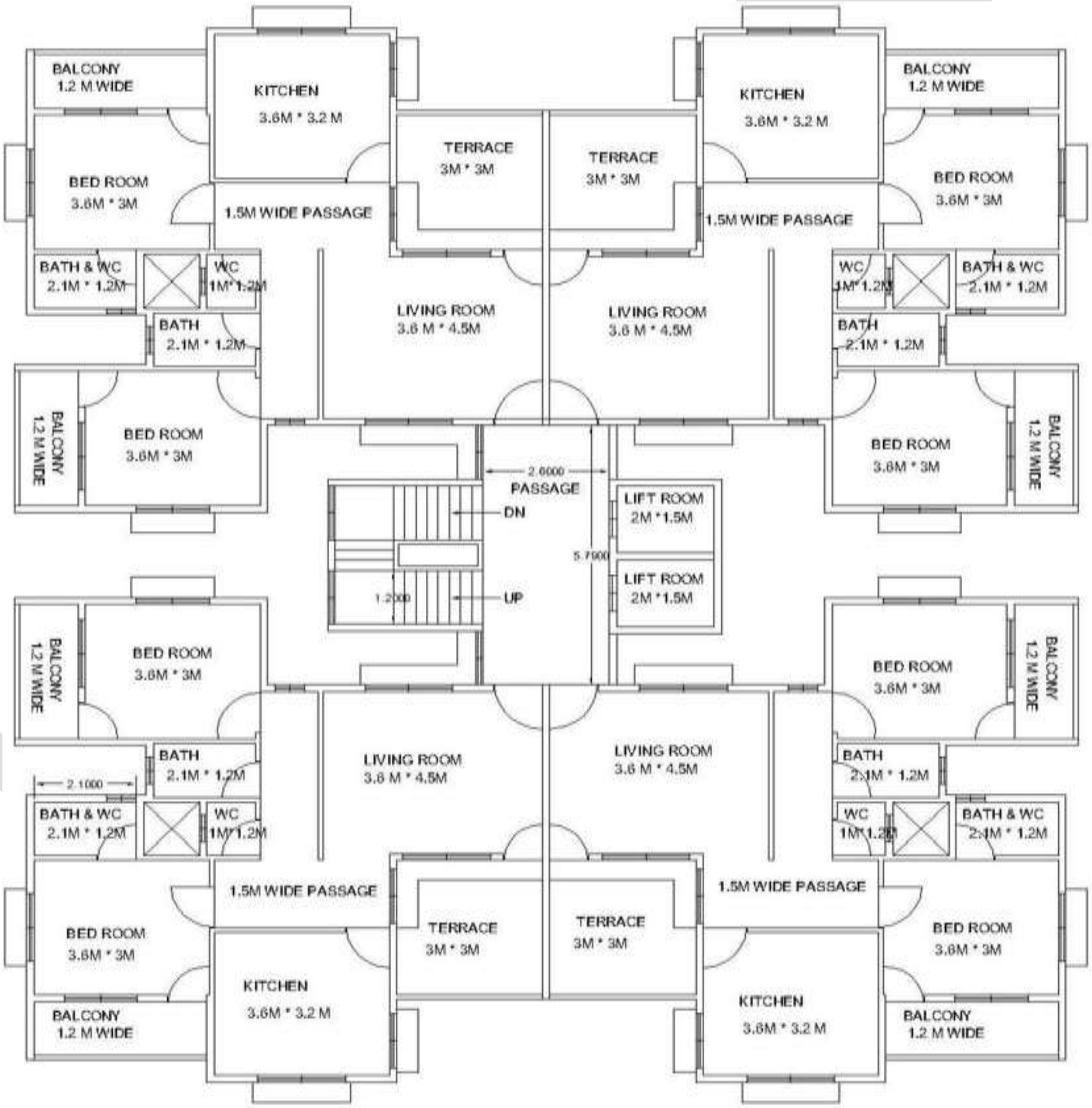


Figure 1.1 Typical Floor Plan

Details of sizes and geometry of various structural components for both framing are shown in Table No: 1.1. Basic wind and seismic loading condition for the both systems are shown in Table No: 1.2.

Table 1.1 Structural Data and Material Properties

Sr.No.	Structural Data	Property
1	Concrete Grade	M25
2	Type of material	Isotropic
3	Mass Per Unit Volume	2.5 KN/M^3
4	Modulus of Elasticity	25 $KN//mm^2$
5	Poisson's Ratio	0.2
6	Concrete Strength	25 MPa
7	Wall Size above door in RC structural wall system	160mm x 600mm
8	Wall Thickness	160mm
9	Slab Thickness	100mm
10	Sunk Slab Thickness	100mm
11	Waist Slab Thickness	100mm
12	Tensile Reinforcement	Fe 500
13	Shear Reinforcement	Fe 415
14	Number of Stories	G +15
15	Depth of Foundation	2m
16	Storey Height	3m
17	Beam size in conventional beam column system	230mm x 600mm
18	Column sizes- C1 on Ground Floor	230mm x 1400mm
19	Column size: C2 to C64 Ground floor	230mm x 1200mm
20	Column size: C1 to C64 1st to 2nd Floor	230mm x 1200mm
21	Column size: C1 to C64 3rd to 4th Floor	230mm x 1000mm
22	Column size: C1 to C64 5th to 15th Floor	230mm x 750mm

Table 1.2 Seismic, Wind, Dead, Live Loading Parameters

Sr.No.	Parameter	Value
1	**Seismic coefficient as per IS:1893-2000**	
	Seismic zone	III
	Seismic Zone Factor	0.16
	Soil Type	II(Medium)
	Importance Factor(I)	1
	Response Reduction Factor(R)	4.5
2	**Wind Coefficient as per IS:875**	
	Risk Coefficient(K_1)	1
	Terrain Category , Height, structure Size Factor (K_2)	1.02
	Topography Factor (K_3)	1
	Location	Ahmednagar
	Basic Wind Speed	39 m/s
3	**Dead load**	
	Sunk Slab	4 KN/m^2
	Floor finished load	1 KN/m^2
	Water proofing load	2 KN/m^2
4	**Live Load**	
	For Floors	2.75 KN/m^2
	For Staircase	3.75 KN/m^2

BUILDING MODELING

Modeling means nothing but formation of structural body in ETABS and assigning the loads to the members as per loading consideration. There is quite difference in modeling steps of conventional beam column system and RC structural wall system. After accurate modeling we can able to perform analysis of any structural member in ETABS. Modeling procedure for both the systems are summarized in this context. Before analysis we have to assign loads to each structural element and various loading combinations are considered for completion of analysis procedure. Afterword's from analysis data we will able to compete the design.

The modeling for Beam Column system is done in ETABS Nonlinear v9.6.0 as follows.

1. Centerline plan is drawn in auto cad and imported to ETABS.
2. The structure is divided in to distinct membrane element.
3. Gridlines are made for the x, y and z coordinates and the beam, column, slab, wall are drawn from scratch. Grid is shown in figure 1.2

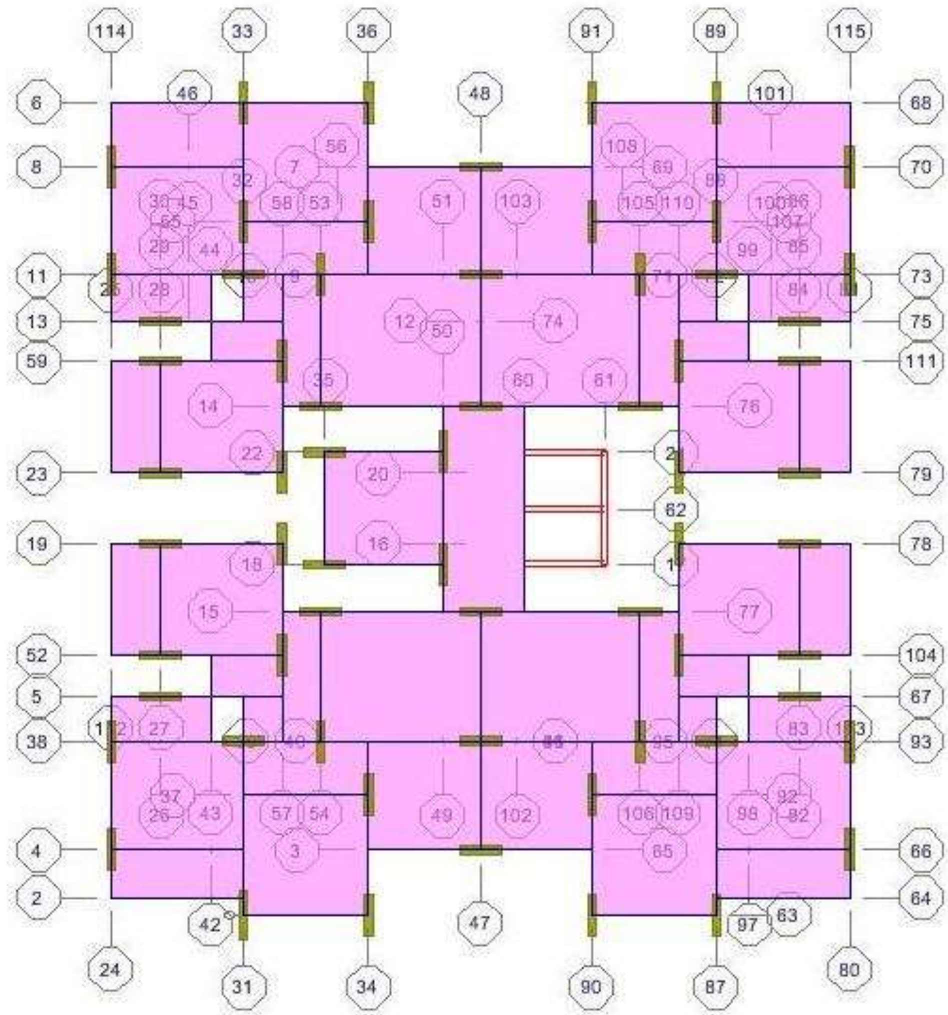


Figure 1.2 Typical floor plan showing Beam Column System

4. Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned to the bottom of the column i.e. at the ground level where restraints should be against all movement to imitate the behavior of column.

5. Define materials to be used, here we will define concrete, steel material using define section properties menu.

6. The geometric properties of the framed sections are dimensions for the beam and column are defined first and then assigned in the grid. Also slab and wall sections are defined first then assigned in the grid.

7. Wind loading and seismic parameters are defined for structure as per the preliminary data.

8. Response spectrum functions are defined as per the seismic consideration and also diaphragms.

9. Static load cases and load combinations are defined and loads are assigning to the joint as they will be applied in the real

structure.

10. The model is ready to analyzed forces, stresses and displacement shown in figure 1.3

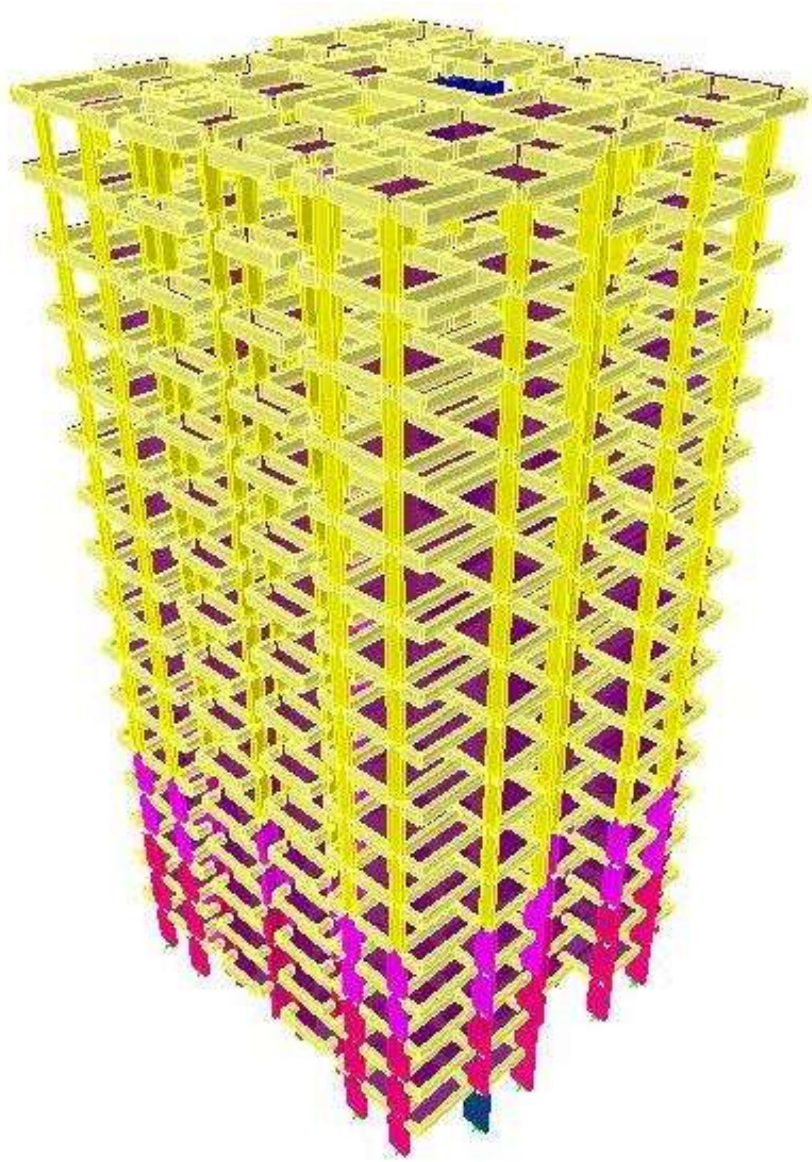


Figure 1.3 3D Model of G+15 Storied Conventional Beam Column System Building

The modeling for RC structural wall system is done in ETABS nonlinear v9.6.0 as follows.

1. Centerline plan is drawn in auto cad and imported to ETABS.
2. The structure is divided in to distinct membrane element.
3. Gridlines are made for the x, y and z coordinates and the wall is drawn from scratch. Grid is shown in figure 1.4.
4. Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned to the bottom of the wall i.e. at the ground level where restraints should be against all movement to imitate the behavior of structural wall.
5. Define materials to be used, here we will define concrete, steel material using define section properties menu.
6. The geometric properties of the elements are dimensions for the wall is defined first and then assigned in the grid. Wall is considered as pier and spandrel.

7. Wind loading and seismic parameters are defined for structure as per the preliminary data.

8. Response spectrum functions are defined as per the seismic consideration and also diaphragms.

9. Static load cases and load combinations are defined and loads are assigning to the joint as they will be applied in the real structure.

10. The model is ready to analyzed forces, stresses and displacement shown in figure 1.5

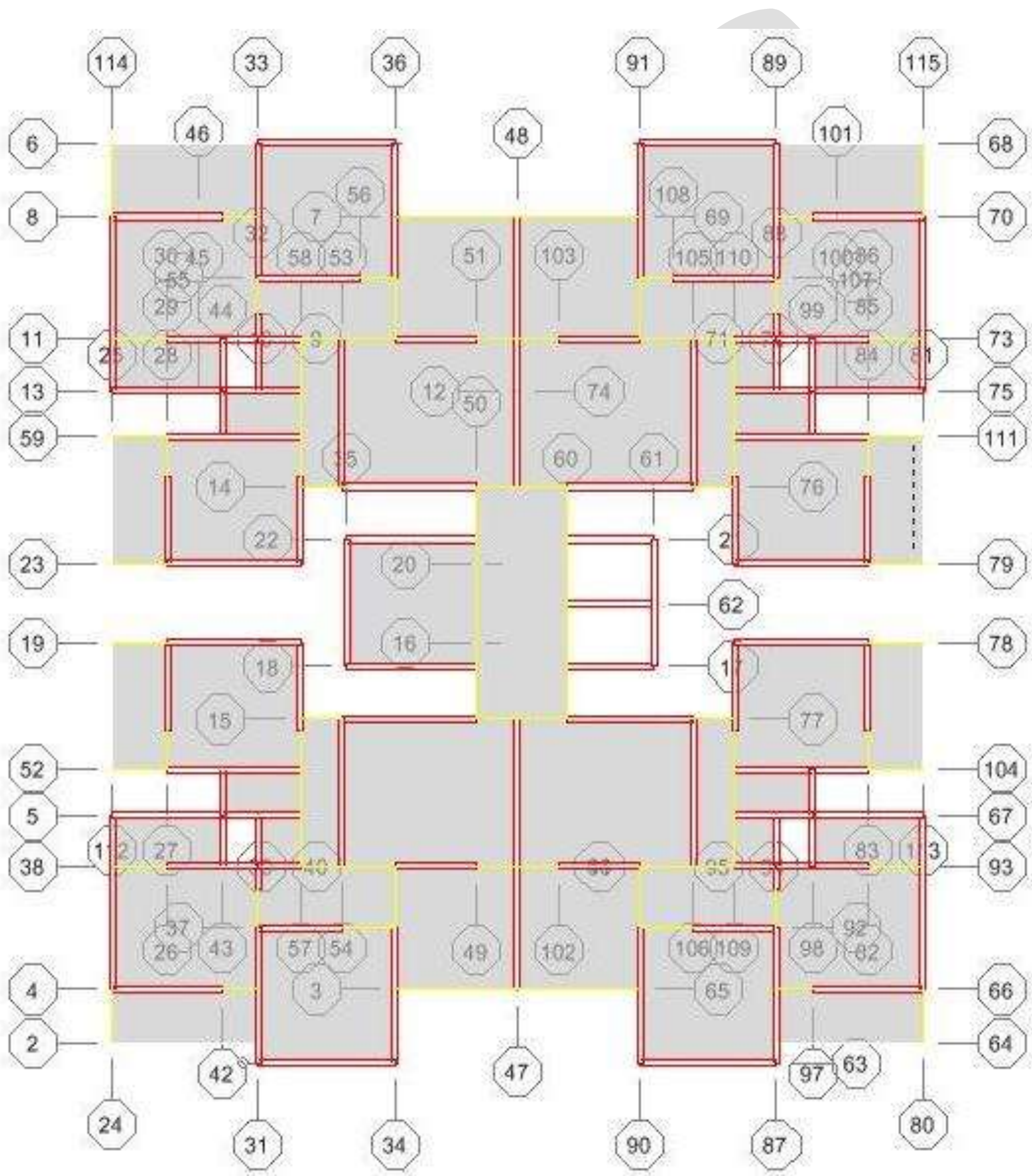


Figure 1.4 Typical floor plan showing RC Structural Wall System

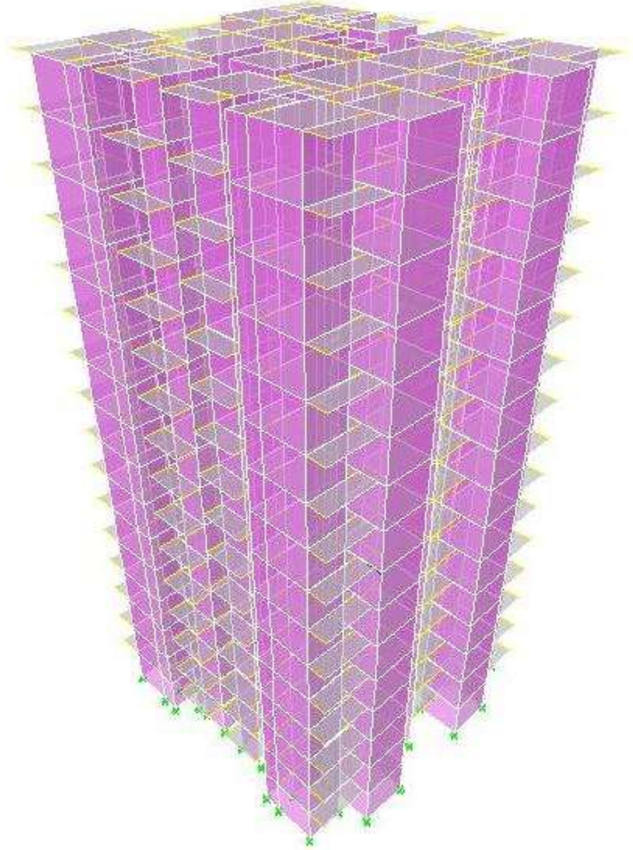


Figure 1.5 3D Model of G+15 Storied RC Structural Wall System Building

RESULTS AND DISCUSSION

In this context G+ 15 storey RC Structural wall system and Beam Column system analysis and design output is considered. In this section results obtained by analysis and design are represented in comparative forms. The effect of mode, time period, storey displacement, storey drift, storey shear are observed for different stories. The analysis is carried out using ETABS and database is prepared for different storey levels are as follows. Both system analysis results are represented in table

1. **Time period.**

Table 1.3 shows the various mode & natural period for both the systems. Figure 1.6 shows variation of the same.

Table 1.3 Modes and Natural Period

Mode	Beam Column System	RC Structural Wall System
	Natural period (Sec)	Natural period (Sec)
1	2.544124	0.689776
2	2.419788	0.616437
3	2.209361	0.502675
4	0.833029	0.422948
5	0.793966	0.16706
6	0.699386	0.162694
7	0.515711	0.138444
8	0.469032	0.115834
9	0.435964	0.079475
10	0.379516	0.074676
11	0.319348	0.067856
12	0.293051	0.054437

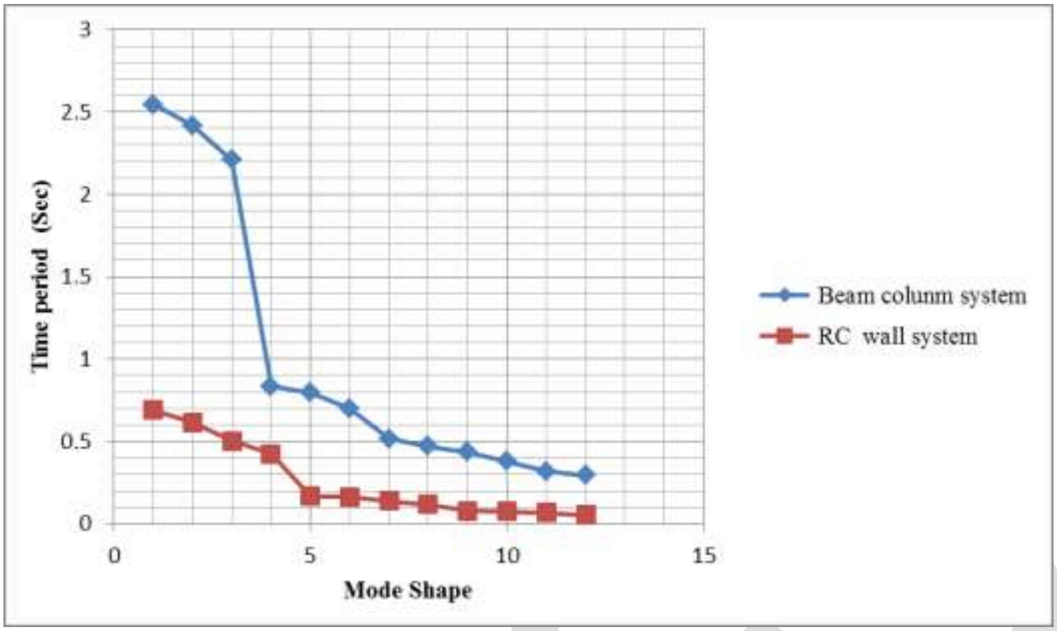


Figure 1.6 Mode shape and Natural Period

Time required to complete one oscillation is called as natural period in the case of SDOF system. Time required to complete one cycle of motion is called natural period in MDOF system. Mode of structure is nothing but in which all points of structure moves harmonically at the same frequency to reach their individual maximum response .The number of modes to be used in analysis should be such that the sum total of modal masses of all modes considered is at least 90% of total seismic mass and missing mass correction beyond 33 %. According to this requirement of IS 1893:2002 (part 1) we had considered 12 mode. Generally first three modes are considered for consideration and corresponding natural period.

2. **Natural Frequency:**

Table 1.4 shows various mode and natural frequency. Figure 1.7 shows variation of natural frequency for different modes.

Table 1.4 Modes and Natural Frequency

Mode	Beam Column System	RC Structural Wall System
	Natural Frequency (Hz)	Natural Frequency (Hz)
1	0.393063	1.449746
2	0.413259	1.622226
3	0.45262	1.989357
4	1.200438	2.364357
5	1.2595	5.985873
6	1.429826	6.146508
7	1.939071	7.223137
8	2.132051	8.633044
9	2.293767	12.58257
10	2.634935	13.39118
11	3.13138	14.73709
12	3.412375	18.36986

The frequencies at which normal mode vibrations are possible for a structure are called as natural frequencies of structure. The structure is said to be vibrating in k^{th} normal mode when frequency is equal to k^{th} natural frequency. The k^{th} natural period is the reciprocal of the k^{th} natural frequency expressed in Hz. Table 1.4 shows that maximum frequency will be there for minimum natural time period. Generally first three frequencies are considered as per the practice. Figure 1.7 will shows variation of natural frequencies according to the mode. Natural frequency is maximum for mode 12 and minimum for mode1.

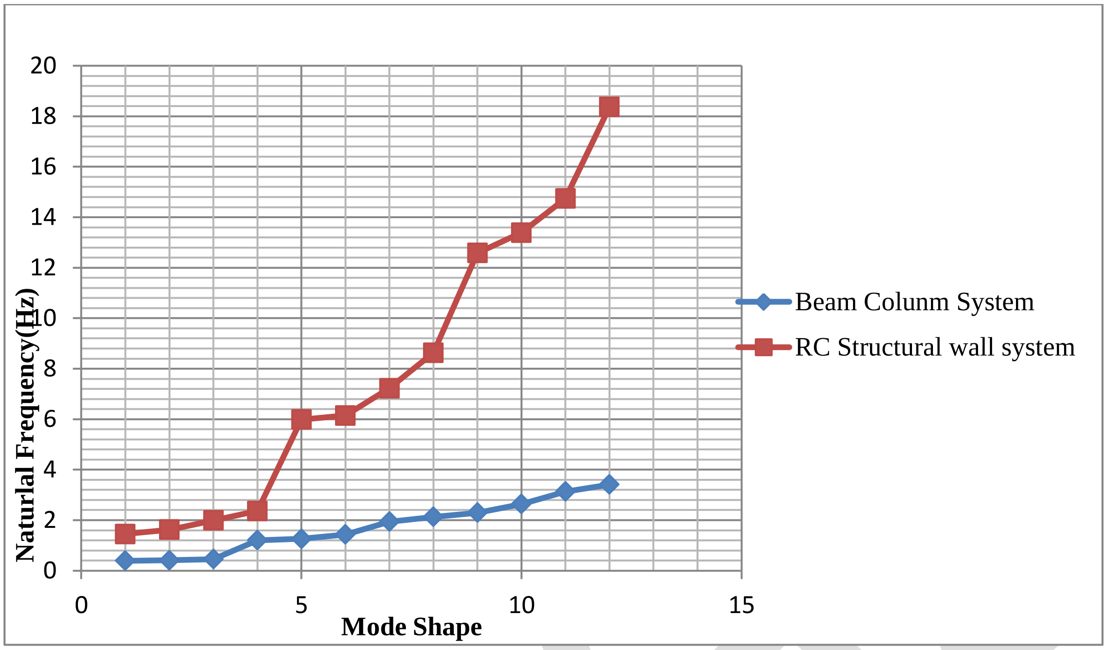


Figure 1.7 Mode shape and Natural Frequency.

3. Maximum Storey Displacement:

Table 1.5 shows the maximum storey displacement for various storey level and height.

Table 1.5 Storey Heights and Maximum Storey Displacement

Storey	Storey Height (m)	Maximum Storey Displacement (m)	
		Beam Column System	RC Structural Wall System
T	48	0.08	0.01
15	45	0.08	0.01
14	42	0.07	0.01
13	39	0.07	0.01
12	36	0.06	0.01
11	33	0.06	0
10	30	0.05	0
9	27	0.05	0
8	24	0.04	0
7	21	0.04	0
6	18	0.03	0
5	15	0.02	0
4	12	0.02	0

3	9	0.01	0
2	6	0.01	0
1	3	0	0

Storey displacement means the displacement which occurred at each storey level because of various loading pattern. Generally storey displacement maximum limit is nothing but maximum storey displacement. In multistoried building maximum storey displacement will observed at top stories. As the height is increasing the storey displacement will have maximum value. From output of both the system it is observed that maximum storey displacement is occur for beam column system. Figure 1.8 shows maximum at top storey then goes on reduction up to first storey for both systems.

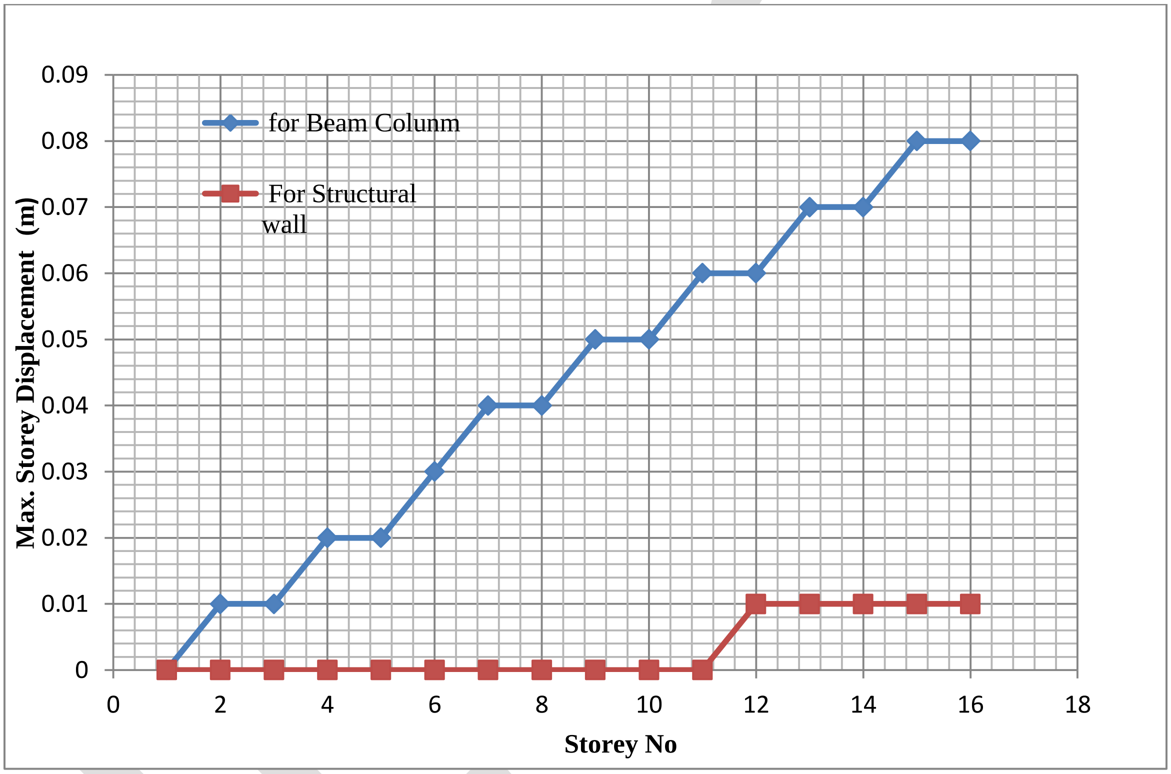


Figure 1.8 Storey No. and Maximum Storey Displacement.

4. Storey Drift:

Table 1.6 shows the storey drift for different storey. Figure1.9 shows variation according to the storey level.

Table 1.6 Storey No. and Storey Drift

Storey	**Storey Drift (mm)**	
	Beam Column System	**RC Structural Wall System**
T	1.172	0.337
15	1.381	0.344
14	1.643	0.353
13	1.906	0.364
12	2.135	0.373
11	2.33	0.38
10	2.485	0.383
9	2.596	0.383

8	2.662	0.377
7	2.666	0.364
6	2.613	0.343
5	2.345	0.314
4	2.179	0.274
3	1.856	0.222
2	1.543	0.161
1	1.726	0.088

Storey drift is relative displacement between any two levels of storey between the floor above and below the under consideration. For beam column system storey drift is greater than the RC structural wall system. As per the IS1893-2002 storey drift is 0.004 times the storey height. Therefore maximum storey drift is 12mm. All storey drift are within permissible limit.

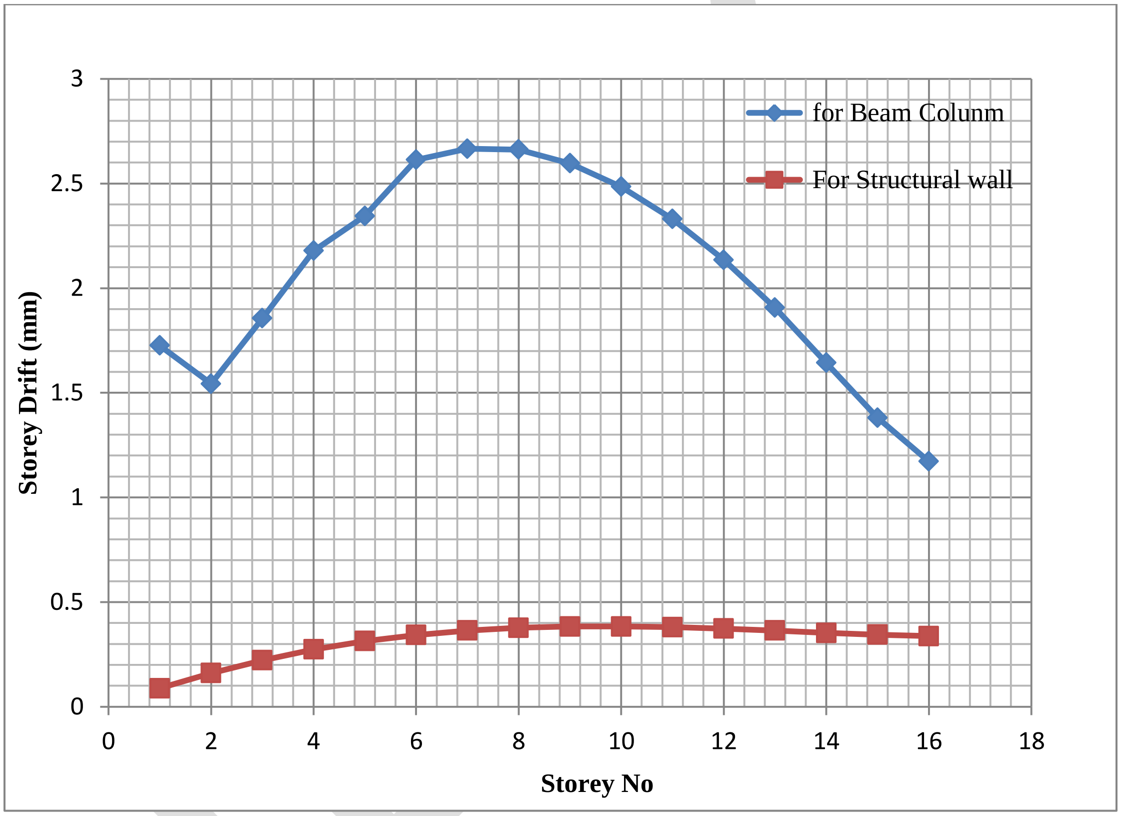


Figure 1.9 Storey No. and Storey Drift.

5. **Storey Shear:**

Table 1.7 shows variation of storey shear for both the type of system.

Table 1.7 Storey No. and Storey shear

Storey	**Storey Shear (KN)**	
	Beam Column System	**RC Structural Wall System**
T	-906.92	-520.78
15	-1749.02	-1127.76
14	-2482.59	-1656.51
13	-3115.1	-2112.42
12	-3654.04	-2500.88
11	-4106.9	-2827.3

10	-4481.17	-3097.07
9	-4784.33	-3315.59
8	-5023.86	-3488.28
7	-5207.25	-3620.43
6	-5341.98	-3717.54
5	-5436.5	-3784.98
4	-5497.93	-3828.15
3	-5532.75	-3852.43
2	-5548.42	-3863.22
1	-5552.34	-3805.12

In the case of any seismic analysis of any building response is majorly represented by using this storey shear parameter. Storey shear is sum total of all design lateral forces above the storey level under consideration. Storey shear is one of the very important parameter which represents total storey shear load carrying capacity. From that it is observed that storey shear at the base is maximum i.e. nothing but the base shear.

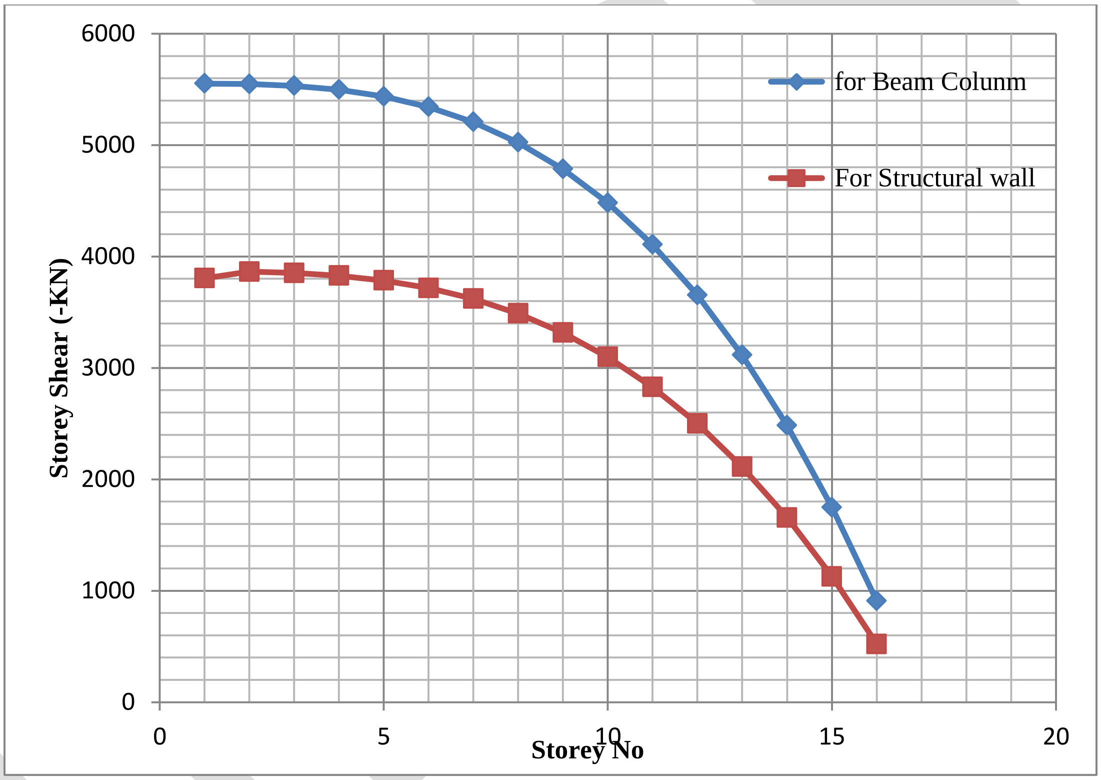


Figure 1.10 Storey No. and Storey shear

From the analysis values then complete design of both systems were carried out in ETABS. Basic difference between both the systems is load transfer mechanism. In the case of beam column system column will transfer the load and in the case of RC structural wall system RC wall will transfer the load.

1. **Steel and Concrete quantity:**
   Table 1.8 and table 1.9 shows steel quantity and concrete quantity required for both the systems according to each floor levels.
   In this section for both beam column system and RC structural wall system quantity of steel and concrete required per floor is calculated. From this steel quantity it is observed that beam column system will require more steel than RC structural wall system. Concrete quantity required for beam column system is less than the RC structural wall. Figure 1.11 the variation of steel quantity and concrete quantity according storey.

Table 1.8 Storey No. and Steel quantity

Storey	Steel Quantity (Kg)	
	Beam Column system	RC Structural Wall System
T	3194.36	2345.50
15	3194.36	2345.50
14	3194.36	2345.50
13	3194.36	2345.50
12	3194.36	2345.50
11	3194.36	2345.50
10	3194.36	2345.50
9	4234.32	2345.50
8	6160.27	2345.50
7	7771.81	2345.50
6	7771.81	2345.50
5	7183.98	2345.50
4	7183.98	2345.50
3	11669.42	2345.50
2	11705.89	2345.50
1	11908.58	2345.50

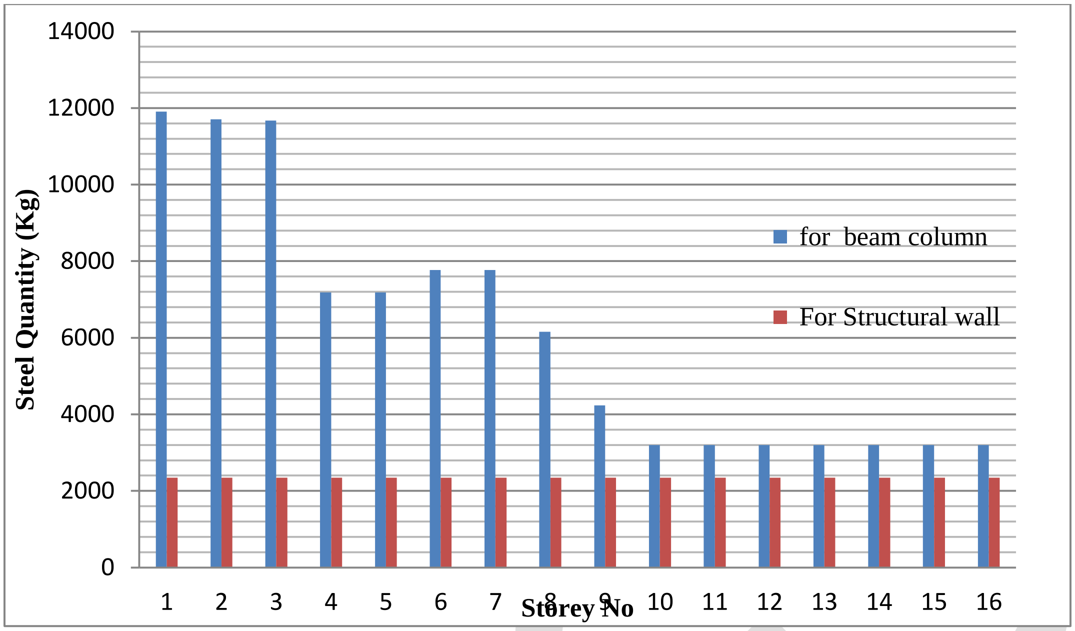
Table 1.9 Storey No. and Concrete quantity

Storey	Concrete Quantity (Cu.m.)	
	Beam column system	RC Structural Wall system
T	89.90	119.52
15	89.90	119.52
14	89.90	119.52
13	89.90	119.52
12	89.90	119.52
11	89.90	119.52
10	89.90	119.52
9	89.90	119.52
8	89.90	119.52
7	89.90	119.52
6	89.90	119.52
5	100.95	119.52
4	100.95	119.52
3	109.92	119.52
2	109.92	119.52
1	109.92	119.52

2. **Cost of steel and concrete:**

Table 1.9 shows the cost required for construction for both beam column system and RC structural wall system.

In the general consideration major cost of any construction project is mainly consist of the cost of reinforced concrete framework i.e. cost of concrete and cost of steel. From quantity of steel and concrete we can able to calculate framework costing. In this contexts cost of steel is greater in case of Beam column system and lesser in RC structural wall system. Cost of concrete in case of RC structural wall is greater than Beam column system. Total cost of framing system is greater for beam column system is greater than RC structural wall system



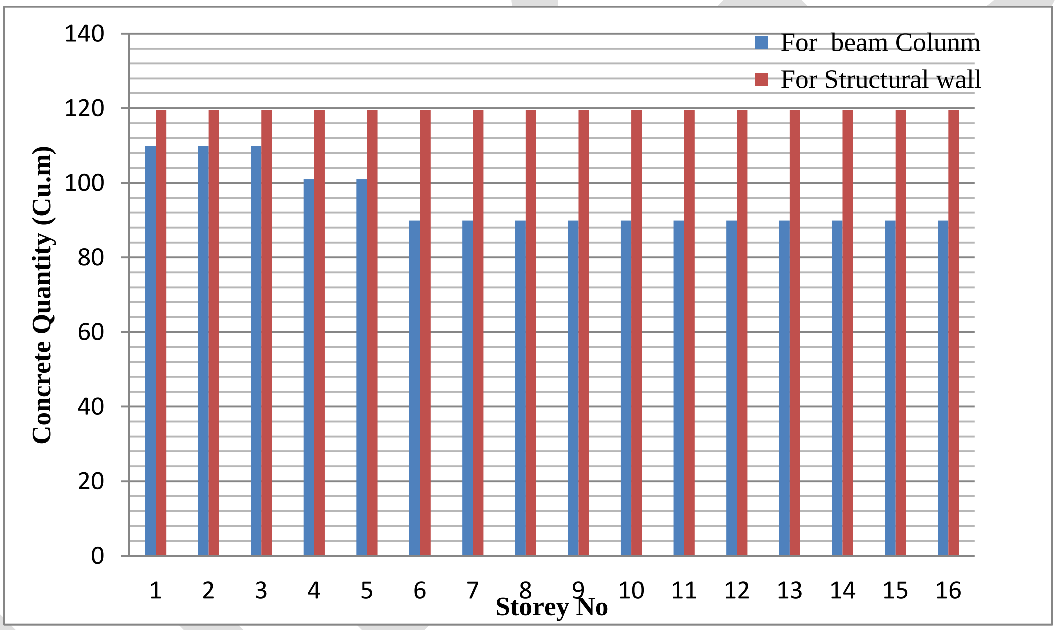


Figure 1.11 Storey No. and Steel quantity, Concrete Quantity.

Table 1.9 Cost of steel and concrete.

Sr.No	**Total Cost (Rs)**	
	Beam Column System	**RC Structural Wall System**
Total Steel Quantity(MT)	97.52	37.52
Rate Per MT	58908	58908
Steel Cost	**5744750.57**	**2210228.16**
Total concrete quantity (Cu.m)	1509.67	1912.24
Rate per Cum	16881	13869
Concrete cost	**25484739.27**	**26520856.56**
Total Cost (Rs)	**3,12,29,489.84**	**2,87,31,084.72**

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CONCLUSION

- From storey data it is observed that time period for beam column system is greater than RC structural wall system. Difference in the both system time period for different modes is in between 72.88 to 81.42 percent. Mode 1 gives maximum time period.
- It is seen that natural frequency for RC structural wall system is greater than the beam column system. Natural frequency for RC structural wall system for different mode is in the range 72.88 to 81.44 percent.
- At top storey maximum storey displacement in the case of beam column system is 87.5 percent greater than RC structural wall system.
- At top storey Beam column system is having 71.25 percent greater storey drift than RC structural wall system All storey drift are within limit i.e. 12mm as per the requirement of IS 1893: 2002(Part 1).
- Base Storey shear in RC structural wall system is 31.47 percent lesser than the Beam column system.
- RC structural wall System has high structural performance to worst loading than conventional beam column system
- Structural framing cost of RC structural wall system is 8 percent cheaper than the Beam column system

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