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ANALYSIS OF HIGH-RISE STRUCTURES WITH DIFFERENT STRUCTURAL SYSTEMS

JAHAGIRDAR SAYYEDAZARA SAYYEDJEELANIPASHA
P.G. Student of Structural Engineering, Department of Civil Engineering, N.K. Orchid College of Engg & Technology, Solapur, India

PRAKARSH SANGAVE
Associate. Professor, Department of Civil Engineering, N.K. Orchid College of Engg & Technology, Solapur, India

ABSTRACT:

Lateral load effects on high rise buildings are quite significant and increase rapidly with increase in height. In high rise structures, the behavior of the structure is greatly influenced by the type of lateral system provided and the selection of appropriate. The selection is dependent on many aspects such as structural behavior of the system economic feasibility and availability of materials. Few of the lateral structural systems are Shear wall system, Braced frame system, Framed tube system, Tube in tube system, Bundled tube system. The lateral structural systems give the structure the stiffness, which would considerably decrease the lateral displacements. In the present work Shearwall system and Framed tube system 21 and 41 story structures. The analysis has been carried out using software Etabs. Earthquake Load is given in form of Spectrum load referring to IS 1893-2002 and Wind load is given as per norms of IS 875-Part III 1987. The Storey displacements and Base-Shear are studied and compared. It is seen that the Shear wall system is very much effective in resisting lateral loads for the structures up to 20 stories and for structures beyond 20 stories the Framed tube system is very much effective than Shear wall system in resisting lateral loads.

KEYWORDS: Etabs, Shear wall system, Frame tube system Base-shear and Storey Displacement

1.1 INTRODUCTION:

Recent trend of growth in population and scarcity of land has evolved an era of modern urbanization which indeed has led to the vertical growth of buildings and gave us the new trend setting structures named as High Rise Structures or Multi-Storeyed Structures as shown in fig1.1. These structures are need of time due to Scarceness of Land, Greater demand for business and residential space, Economical emergence, Technical Advancements, Innovations in Structural Systems and Desire for aesthetics in urban Area.

Various types of structural system have been used to facilitate the demand of high rise structures. In the tall structure the lateral drift is the most critical factor to be considered while designing. To reduse the lateral deflection the stiffness of the building has to be increased considerably. Earthquakes and wind forces are unpredictable but we need to take them in consideration. Opting for the best structural system in these structures greatly helps in improving its resistance behaviour to load.

Figure 1.1: High Rise Building

1.2 DEVELOPMENT IN STRUCTURAL SYSTEMS FOR HIGH RISE BUILDINGS:

In the early era hardly few buildings rose upto 10-15 storeys but later it became of prime importance to enhance the vertical growth of building.

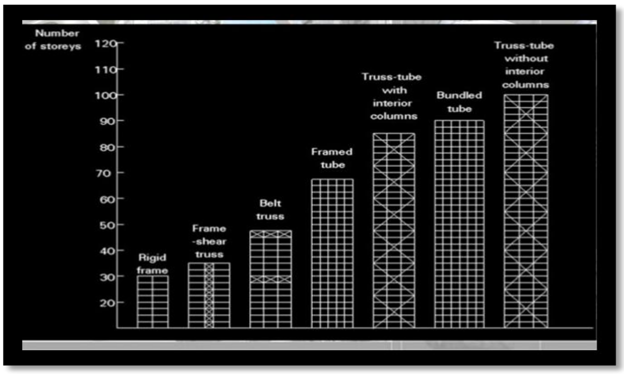


Figure No 1.2: Evolution of Structural Systems

Earlier common types of structural systems were as shown in figure 1.5 adopted in tall buildings such as Moment Resisting Frame System, Braced Frame System and Shear Wall System. Later evolved the new structural systems for high rise structures developed and invented by Dr. Fazlur R Khan the ‘Father of Tubular Systems’. He gave us new structural systems namely Braced Tube System, Framed Tube System, Bundled Tube System and Tube -In-Tube System.

2.1 METHODOLOGY:

To study this structural behavior the software ETABS 2015 program has been to used. The program offers general purpose structural analysis and design along with the extensive model generation and post processing facilities. Dynamic analysis shall be performed to obtain design seismic force and its distribution to different levels along the height of the building and lateral loads are assumed to be concentrated at the floor levels for the buildings. The dynamic analysis shall be done by using response spectrum method according to IS 1893:2002 and wind load is applied according to IS 875-Part III 1987.

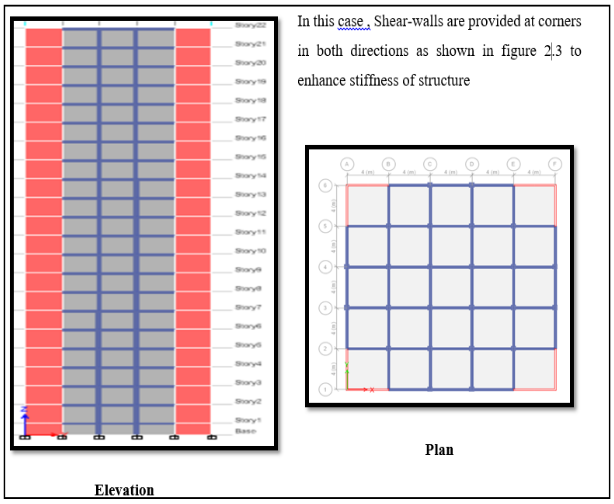
2.2 PROBLEM FORMULATION:

In the present study, the multistoried structures with different structural systems are modelled and analyzed using professional software ETABS 2015 in compliance with the codes IS 456:2000 and IS 1893(Part 1): 2002 and IS 875-Part III. Detailed Specifications of building configuration is given below in tabular form for different structures. Typical plan and elevations for different structures also the models for the Structures to be analyzed are shown in figures 2.1 and 2.2 respectively below:

2.3 DESCRIPTION OF MODELS WITH DIFFERENT STRUCTURAL SYSTEMS:

Model No	Name of Structural System
I	Shear-wall System
II	Framed Tube System

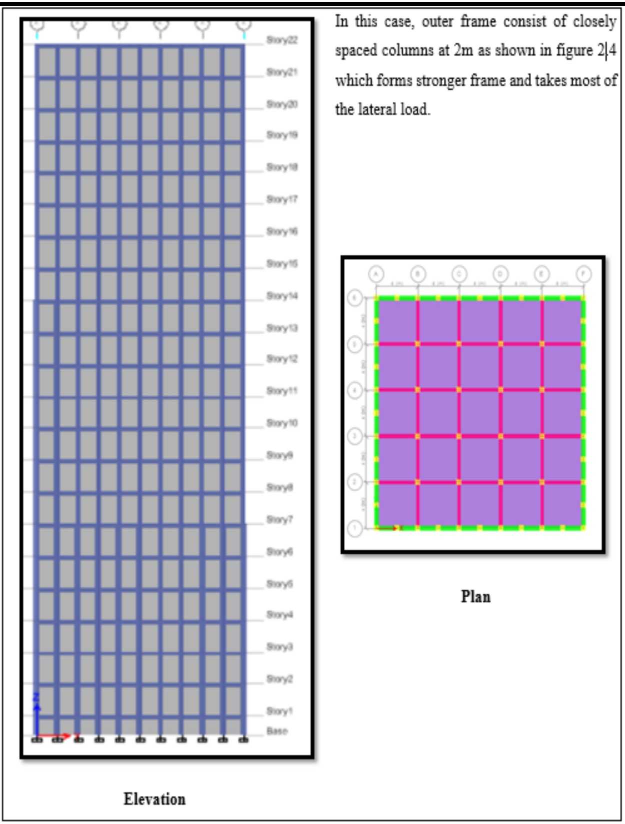
MODEL 1



In this case , Shear-walls are provided at corners in both directions as shown in figure 2.3 to enhance stiffness of structure

Figure No 2.3: Shear-wall System used as Structural System

MODEL 2



In this case, outer frame consist of closely spaced columns at 2m as shown in figure 2.4 which forms stronger frame and takes most of the lateral load.

Figure No 2.4: Framed Tube System used as Structural System

2.4 DETAILED DESCRIPTIONS OF MODELS:

Sr.No	Structural Element	Dimension
1	Plan Dimensions	20 X 20 m
2	Spacing in X-Direction	4 m
3	Spacing in Y-Direction	4 m
4	Typical Storey Height	3.2 m
5	Bottom Storey Height	2 m
6	Beam	0.23 X 0.5 m
7	Column	0.8 X 0.8
8	Thickness of Slab	0.2 m
9	Thickness of Shear-wall (for Shear-wall System)	0.15 m, 0.2m
10	Spacing of Columns (for Framed Tube Structure)	2 m
12	City	Bombay
13	Zone	III
14	Importance Factor **(I)**	1
15	Response Reduction Factor	5
16	Soil Type	II
17	Basic Wind Speed	44 m/s
18	Method of Analysis	Response Spectrum Analysis

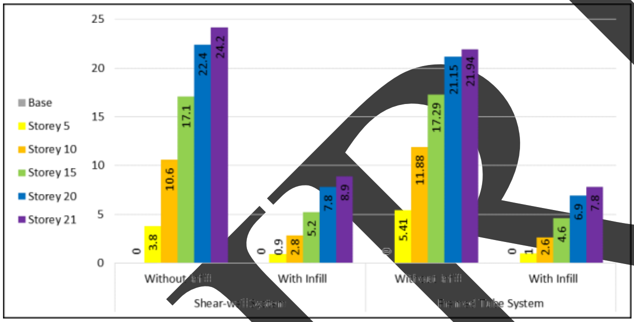
3. RESULTS AND DISCUSSIONS:

Linear analysis has been carried out in the entire study, seismic load is given in form of spectrum load referring to IS 1893-2002. The configuration of these Structural Systems differ from each other and therefore each model is represented to get the clear idea of using the Structural System All the analysis results are represented in tabular form in tables 3.1- 3.8 and graphs from 3.1 - 3.8 are obtained based on analysis result data for all cases, also the observations are made based on this data

FOR 21 STOREY

Table No 3.1: Storey Displacement developed due to Earthquake Forces.

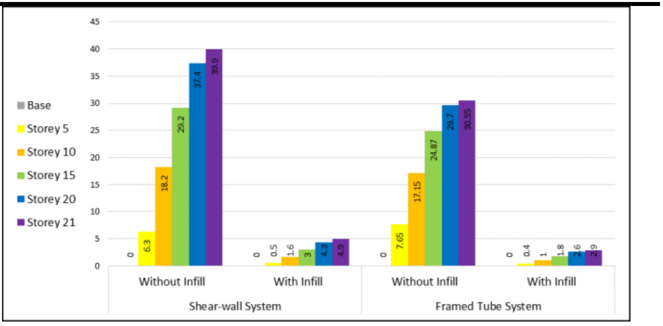
Storey Level	Model 1 Shear-wall System		Model 2 Framed Tube System	
	Without infill effect	With infill effect	Without infill effect	With infill effect
Base	0.00	0.00	0.00	0.00
Storey 5	3.80	0.90	5.41	1.00
Storey 10	10.60	2.80	11.88	2.60
Storey 15	17.10	5.20	17.29	4.60
Storey 20	22.40	7.80	21.15	6.90
Storey 21	24.20	8.90	21.94	7.80



Graph No 3.1: Storey Displacement developed due to Earthquake forces

Table No 3.2: Storey Displacement developed due to Wind Forces.

Storey Level	Model 1 Shear-wall System		Model 2 Framed Tube System	
	Without infill effect	With infill effect	Without infill effect	With infill effect
Base	0.00	0.00	0.00	0.00
Storey 5	6.30	0.50	7.65	0.40
Storey 10	18.20	1.60	17.15	1.00
Storey 15	29.20	3.00	24.87	1.80
Storey 20	37.40	4.30	29.70	2.60
Storey 21	39.90	4.90	30.55	2.90



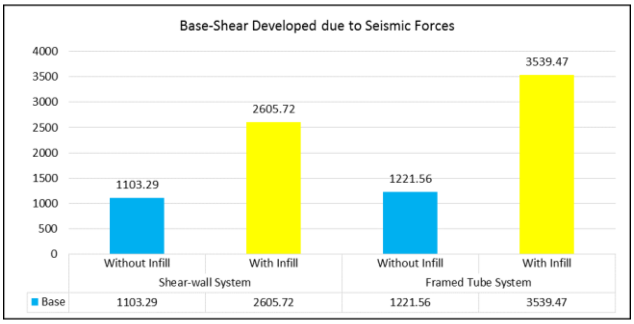
Graph No 3.2: Storey Displacement developed due to Wind Forces

OBSERVATIONS:

1. A small variation in storey displacement of 3 mm (9.33 %) is observed in Model I i.e. Shear-wall system and Model II i.e. Framed Tube System.
2. The presence of infill drastically reduces the storey displacement developed due to seismic forces nearly by 15-18mm in respective frames. This reduction in storey displacement occurs due to increase in the stiffness of the structure.
3. It can be observed from the above graph that, Model II i.e. Framed Tube System gives the minimum displacement (i.e. 30.55 mm) being the stiffest frame.

Table No 3.3: Base-Shear developed due to Earthquake Forces

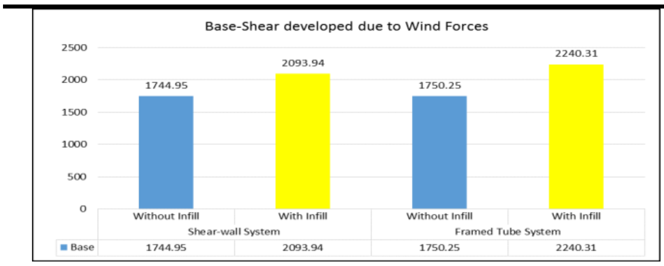
Storey Level	Model 1 Shear-wall System		Model 2 Framed Tube System	
	Without infill effect	With infill effect	Without infill effect	With infill effect
Base	1103.29	2605.72	1221.56	3539.47



Graph No 3.3: Base Shear Developed Due To Earthquake Forces (In kN)

Table No 3.4: Base-Shear developed due to Wind Forces

Storey Level	Model 1 Shear-wall System		Model 2 Framed Tube System	
	Without infill effect	With infill effect	Without infill effect	With infill effect
Base	1744.95	2093.94	1750.25	2240.31



Graph No 3.4: Base Shear developed due to Wind Forces (in kN)

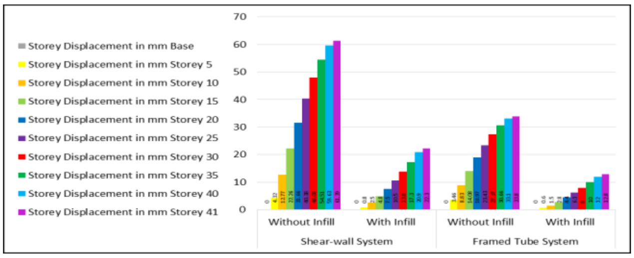
OBSERVATIONS:

1. It can be observed that Base-shear developed due to Seismic forces ranges from 1100-1300 kN which is merely adoptable.
2. A small variation of 120 kN is observed in base-shear for Model I i.e. Shear-wall system and Model II i.e. Framed Tube System.
3. The presence of infill increases the base-shear as displacement decreases. The base-shear ranges from 2600-3600 kN.
4. The presence of infill increases the base-shear as displacement decreases. The base-shear ranges from 1900-2300 kN.
5. Amongst Model I and Model II, Model I i.e. **Shearwall System** is more preferable and advisable as small variation of 5.05 kN i.e. 3.02 % difference in base-shear is observed as compared to that of Framed Tube System

FOR 41 STOREY

Table No 3.5: Storey Displacement developed due to Earthquake Forces.

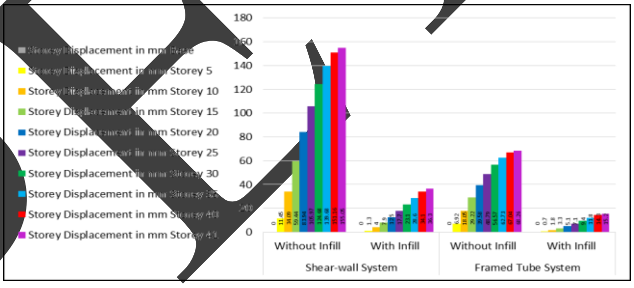
Storey Level	**Model 1 Shear-wall System**		**Model 2 Framed Tube System**	
	Without infill effect	**With infill effect**	**Without infill effect**	**With infill effect**
Base	0.00	0.00	0.00	0.00
Storey 5	4.32	0.80	3.46	0.60
Storey 10	12.77	2.50	8.83	1.50
Storey 15	22.26	4.80	14.08	2.80
Storey 20	31.66	7.50	18.97	4.40
Storey 25	40.38	10.50	23.43	6.10
Storey 30	48.08	13.80	27.37	8.00
Storey 35	54.51	17.30	30.66	10.00
Storey 40	59.63	20.90	33.10	12.00
Storey 41	61.39	22.30	33.80	12.80



Graph No 3.5: Storey Displacement developed due to Earthquake forces

Table No 3.6: Storey Displacement developed due to Wind Forces.

Storey Level	**Model 1 Shear-wall System**		**Model 2 Framed Tube System**	
	Without infill effect	**With infill effect**	**Without infill effect**	**With infill effect**
Base	0.00	0.00	0.00	0.00
Storey 5	11.45	1.30	6.92	0.70
Storey 10	34.09	4.00	18.05	1.80
Storey 15	59.44	7.90	29.22	3.30
Storey 20	83.94	12.50	39.58	5.10
Storey 25	105.97	17.70	48.79	7.10
Storey 30	124.68	23.10	56.57	9.40
Storey 35	139.68	28.60	62.73	11.80
Storey 40	151.16	34.10	67.04	14.30
Storey 41	155.05	36.30	68.26	15.20



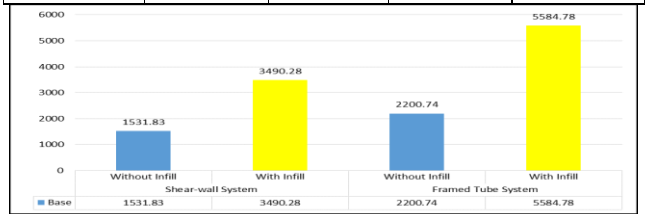
Graph No 3.6: Storey Displacement developed due to Wind Forces

OBSERVATIONS:

1. Considerable difference for storey displacement of 27.59 mm (44.94 %) and 10 mm is observed in Model I i.e. Shear-wall system and Model II i.e. Framed Tube System for frames without infill and frames with infill.
2. Amongst Model I and Model II, **Model II i.e. Framed Tube System** is most preferable and advisable as it reduces displacement nearly by 86.79 mm and 45mm respectively.

Table No 3.7: Base-Shear developed due to Earthquake Forces

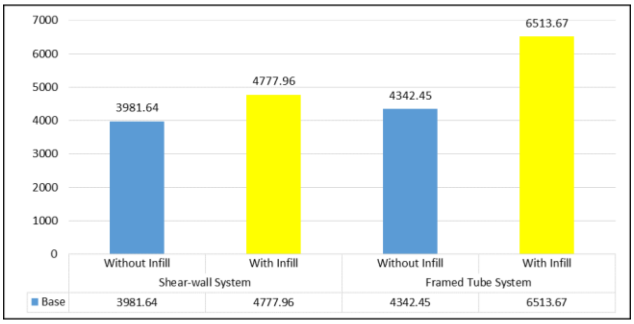
Storey Level	**Model 1 Shear-wall System**		**Model 2 Framed Tube System**	
	Without infill effect	**With infill effect**	**Without infill effect**	**With infill effect**
Base	1531.83	3490.28	2200.74	5584.78



Graph No 3.7: Base Shear developed due to Earthquake Forces (in kN)

Table No 3.8: Base-Shear developed due To Wind Forces

Storey Level	Model 1 Shear-wall System		Model 2 Framed Tube System	
	Without infill effect	With infill effect	Without infill effect	With infill effect
Base	3981.64	4777.96	4342.45	6513.67



Graph No 3.8: Base Shear developed due to Wind Forces (in kN)

OBSERVATIONS:

1. Base-shear increases by 2094.50 kN (37.50%) from Model I i.e. Shear-wall system to Model **II i.e. Framed Tube System** in presence of infill therefore it is preferred.

2. Base-shear increases by 1735.71 kN from Model I i.e. Shear-wall system to Model **II i.e. Framed Tube System** in presence of infill therefore it is preferred.

3. It can be observed from the above graph that, Model II i.e. Framed Tube System gives the maximum base-shear of 4342.45 kN for frames without infill and gives base-shear 6513.67 kN for frames with infill being the stiffest frame.

4. CONCLUSIONS:

From above observation final conclusions are drawn:

1. It is evident from the observing result that the storey displacements in the 21 story structures Shear Wall System and Framed Tube System are very close for E.Q. and for wind load.

2. As the Shear Wall System is more economical as compared to the framed tube system. Shear Wall System is more preferred.

3. For the structures above 20storeys the Framed Tube is very much effective in resisting lateral loads (both Wind and Earthquake loads) as compared to the Shear Wall system.

4. For the structure with Framed Tube System, the storey displacement is minimum from rest all other structural systems. Maximum Base Shear for 41 story structures is observed for structure with Framed Tube System.

So on overall point of view we can say that upto 20 Storeys (Low Rise Structures), Shear-wall System is the best adoptable structural system that can be adopted and for structures beyond 20 storeys (High Rise Structures) Framed Tube System is the best suitable and advisable system to prevent structures from lateral loads.

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