SEISMIC RESPONSE OF MULTISTOREY BUILDING WITH DUAL FUSED H-FRAME SYSTEM

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Abstract: -A dual fused H-frame (DFHF) is an efficient structural system that combines damped H-frame (DHF) modules welded wide flanges fuses (WWFFs) to create a structural solution that is efficient in construction and more seismically resilient. Each DHF module consists of two columns pin connected to a beam with two buckling restrained knee braces (BRKBs).Each DHF module can be prefabricated at the factory , shipped to the site , and connected vertically using simple bolt connections .The connections between the DHF module have relatively small moment demand , which makes the design ,fabrication , and construction of the DHF modules very efficient . Once the DHF modules are assembeled vertically , the bays of the DHF can be connected using WWFFs. WWFFs are simple shear connector that can be stably dissipate earthquake energy.

Keywords: Seismicanalysis ,Response spectrum method and Time history method.

1. INTRODUCTION

With the endless growth in population all around the world there has been a lot of increment in the land usage. This scenario is known as urban extension. It will have adverse effect on the environment such as air pollution and more energy consumption. Therefore, to counteract these problems of extensive population without any drawbacks the construction of high rise or tall buildings becomes absolute necessary. With the development of the elevator and a new structural system, the frame structure which looks like iron skeleton hidden behind masonry walls began the establishment of high-rise buildings. It also favours the social and environmental positives as the city becomes more compact. High rise buildings provide effective way for the residential and commercial use. Apart from these advantages, high rise buildings become landmarks of a city to signify the whole world. Different types of structural systems are to be used to resist the effect of lateral loads on the buildings. They are rigid frame structures, braced frame structures, shear wall frame structures, outrigger systems, and tubular structures. In structural engineering, the tube is the system where in order to resist lateral loads (wind, seismic, etc.) a building is designed to act like a hollow cylinder, cantilevered perpendicular to the ground.

Nowadays, the advancements in structural systems, increase in building height and slenderness, use of high strength materials, reduction of building weight etc., has necessitated the consideration of lateral loads such as wind and earthquake in the design process. Lateral forces resulting from wind and seismic activities are now dominant in design considerations. Lateral displacement of such buildings must be strictly controlled, not only for occupants’ comfort and safety, but also to control secondary structural effects.

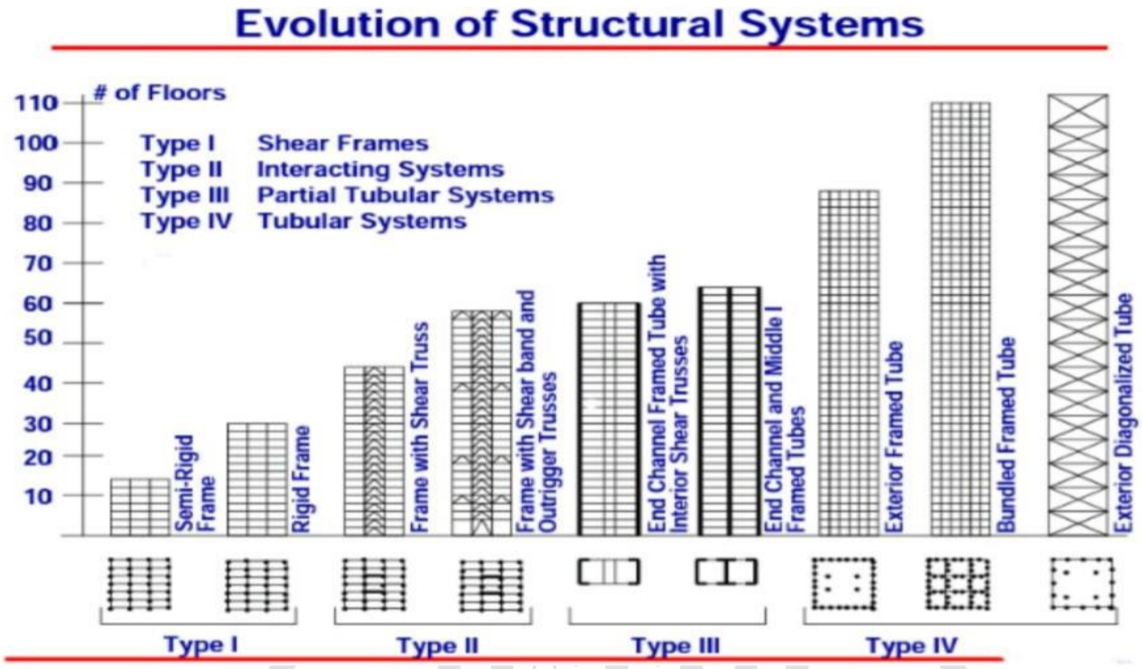


Figure 1.Evolution of structural system

1.1 Dual Fused H-Frame System

Most of the fused SFRSs mentioned in previous section, do not take construction efficiency into considerations. To address this issue, a novel resilient fused SFRS namely Dual-Fused H-Frame (DFHF) is proposed in this project. DFHF, as shown in Figure 1.9, combines H-Frames with two types of specially designed and replaceable structural fuses, Welded Wide Flange Fuses (WWFFs) (Yang et al. 2018a) and BRKBs, to create a dual energy dissipation mechanism. Each H-Frame consists of two columns pin connected to a beam. The combination of H-Frame and BRKBs defined as Damped H- Frame (Etebarian and Yang 2018) can be prefabricated to improve construction quality and reduce erection time. BRKBs provide stiffness to H-Frame. As H-Frame is displaced laterally, the damage free connection depicted in Figure 1.10(b) engages BRKBs axially to dissipate energy in tension or compression. Damped H-Frames are spliced on-site using simple bolt connection shown in in Figure 1.10(a) at the location where moment demand is relatively small. This simplify the design, construction, and cost of the connection. As shown in Figure 1.10(a), Damped H-Frames are connected via WWFFs at two different elevations: one at the BRKB and another below the column splice connection. WWFFs use the steel web plate to dissipate earthquake energy through shear yielding in the longitudinal direction, while the flanges are designed to remain elastic (Yang et al. 2018a). Figure 1.10(c) and Figure 1.10(d) present the close-up view of a WWFF.

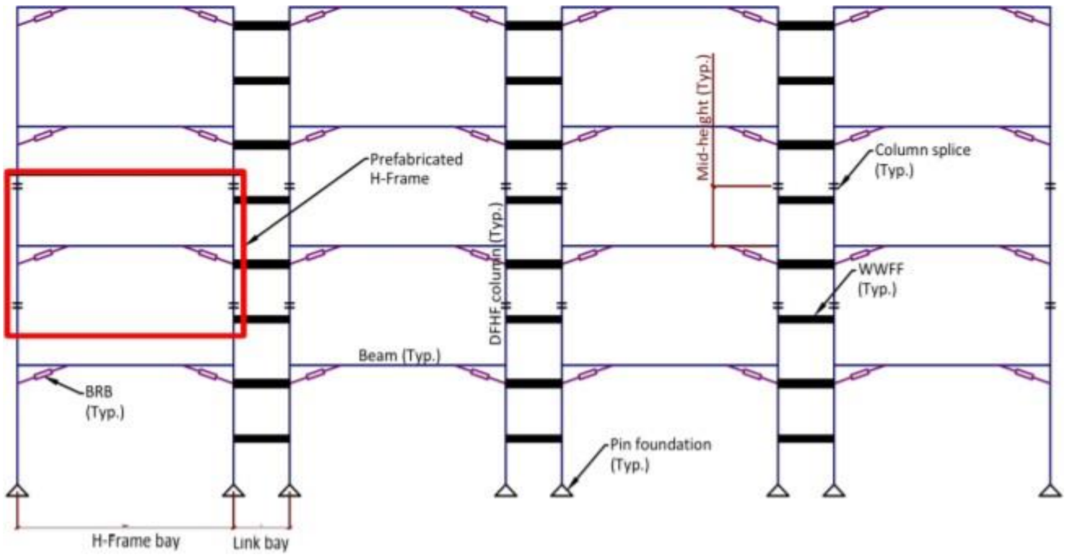


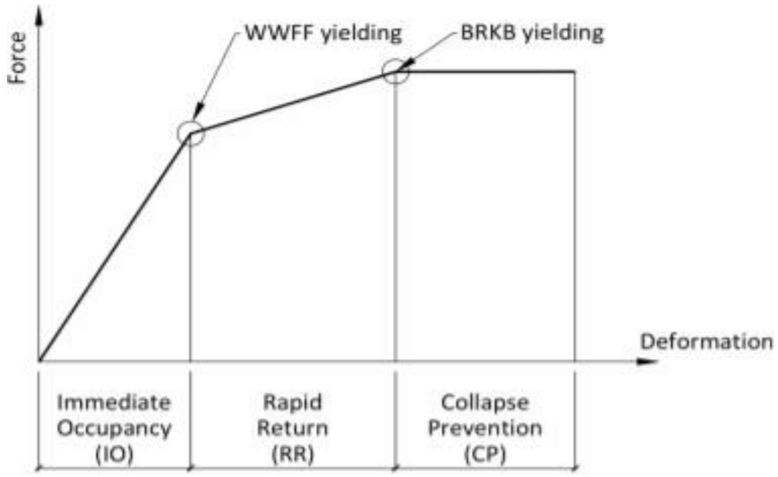
Figure1.1DFHF Configeration

1.2 Energy Dissipation Mechanism of DFHF System

As shown in Figure above and described previously, the proposed DFHF consists of prefabricated H- Frames and two types of structural fuses that work essentially in parallel to provide the desired seismic responses. WWFFs and BRKBs are designed to dissipate earthquake energy while protecting H-Frames from damages. WWFFs and BRKBs are decoupled from the gravity system. Hence, they can be quickly inspected, repaired, or replaced after a strong earthquake shaking. After the structural fuses are replaced, H-Frames can be re-centred to minimize residual deformation. This makes the proposed DFHF resilient and functional immediately or shortly after a strong earthquake shaking.

ith the combination of WWFFs (primary structural fuse) and BRKBs (secondary structural fuse), the proposed DFHF has a tri-linear force-deformation relationship as shown in Figure. After a service level earthquake (SLE) shaking, the system's performance is targeted to be immediate occupancy (IO), where the structure is expected to remain elastic without repairs. After a design-based earthquake (DBE) shaking, the system's performance is targeted to be rapid return (RR), where WWFFs are designed to yield and dissipate earthquake energy, while BRKBs are designed to remain elastic. WWFFs are designed to be repaired or replaced quickly so that the structure can be functional immediately or shortly after a DBE shaking. After a maximum credible earthquake (MCE) shaking, the systems performance

Figure1.2 Performance objectives and force-deformation relationship of DFHF



2 . AIMS AND OBJECTIVES

2.1 OBJECTIVES

- To study the effect of DFHF on seismic response of Structure
- To study the seismic force resisting capability with Dual fused H frame system buckling restrained Knee Braces (BRKB) and Ordinary Moment resisting Frame (OMRF).
- To investigate story displacement, maximum top storey displacement, storey drifts, base shear, base reaction, storey stiffness, bending moment and shear force at critical storey for above systems.
- To compare and draw conclusions for structure with and without the above system.

2.2 APPLICATIONS:

- Mainly employed in steel construction.
- Midrise buildings are more suitable to adopt this system.
- Enhancing the lateral stiffness and stability can be achieved.
- Regular slender members can be adopted.
- Economy can be achieved due to repetitive work for number of stories.
- The bracings can be concealed in doors and windows to avoid obstructions.

3. MODELLING

In the present study,15 storey structure is considered .Totally ix number of model are created and analysed . The model details are listed below :

1. MODEL 1 - Dual Fused H Frame System Steel- Storey Ht.3m.
2. MODEL 2- Dual Fused H Frame System Steel – Storey Ht 4m.
3. MODEL 3- Dual Fused H Frame System Steel – Storey Ht.5m.

4. MODEL 4- Dual Fused H Frame System RCC- Storey Ht.3m.
5. MODEL 5- Dual Fused H Frame System RCC- Storey Ht.4m.
6. MODEL 6- Dual Fused H Frame System RCC- Storey Ht.5m.

The modeling is carried out using FEM based software ETABS ,While tge steps included in modeling are listed below .

- Fixing Grid & and Storey pattern.
- Defining Material
- Defining Frame & area Sections.
- Defining Load Cases &Load combination .
- Defining Mass sources.
- Drawing Beam ,Columns ,and slabs.
- Assigning Support condition.
- Assigning loads.
- Analysis
- Result Extraction.

The same procedure is carried out for all other models and result are extracted .Few of images are presented in the below section, which are self-explanatory.

3.1 BUILDING DESCRIPTION

The proposed model is conventional RCC & Steel structure .Thee model is 15 Storey height with irregular in plan shaped structure .The below Table 3-1 Shows material properties and design parameters used in this project.

Table 3-1-Material Properties and Design Parameters

Sl. No.	Description	Data
1.	Seismic Zone	III
2.	Seismic Zone Factor (Z)	0.16
3.	Importance Factor (I)	1.5
4.	Response Reduction Factor (R)	4
5.	Damping Ratio	0.05
6.	Soil Type	Hard Soil (Type II)
7.	Height of the building	45m, 60m, 75m (15 Storey)
8.	Story to story Height	3.0, 4.0, 5.0m
9.	Span Length	Varies
10.	Column Size used	Steel – ISHB300 Concrete - 300x750mm
11.	Thickness of Slab	125mm
12.	Floor Finish	1.5KN/m^2
13.	Live Load	4.0KN/m^2
14.	Grade of Concrete (f_{ck})	M 25 for Beams, Slabs. M35 for Columns.

15.	Grade of Structural Steel (f_{ys})	Fe 350
16.	Grade of Reinforcing Steel (f_{yr})	Fe 500

3.3. Various Models

Model 1

Model one is a steel structure. It consist of steel beam steel column and RCC slab the first 3 models are similar. However the only difference is hey the story height hey for model one story height is 3 metres, for model 2 the story height is 4 metre and for model 3 the story height is 5 metres in the similar way it is presented as below

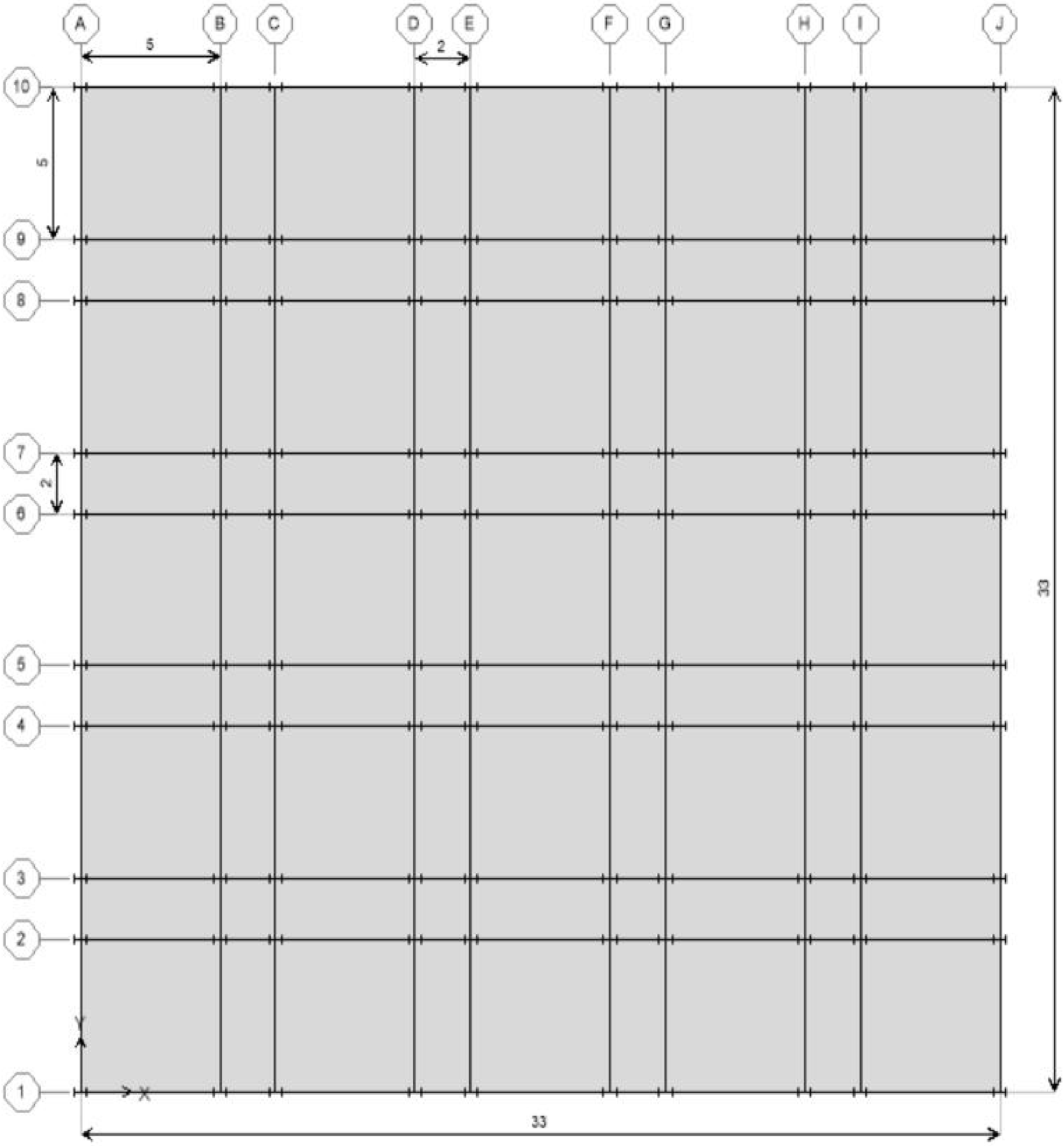
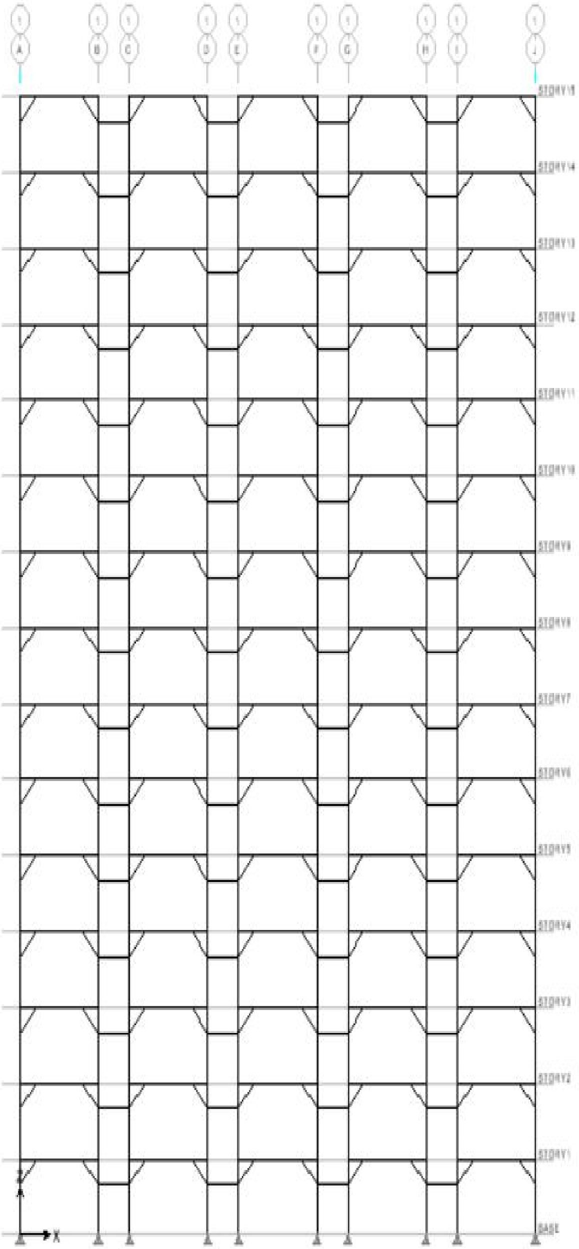


Figure 3.1 Grid Data



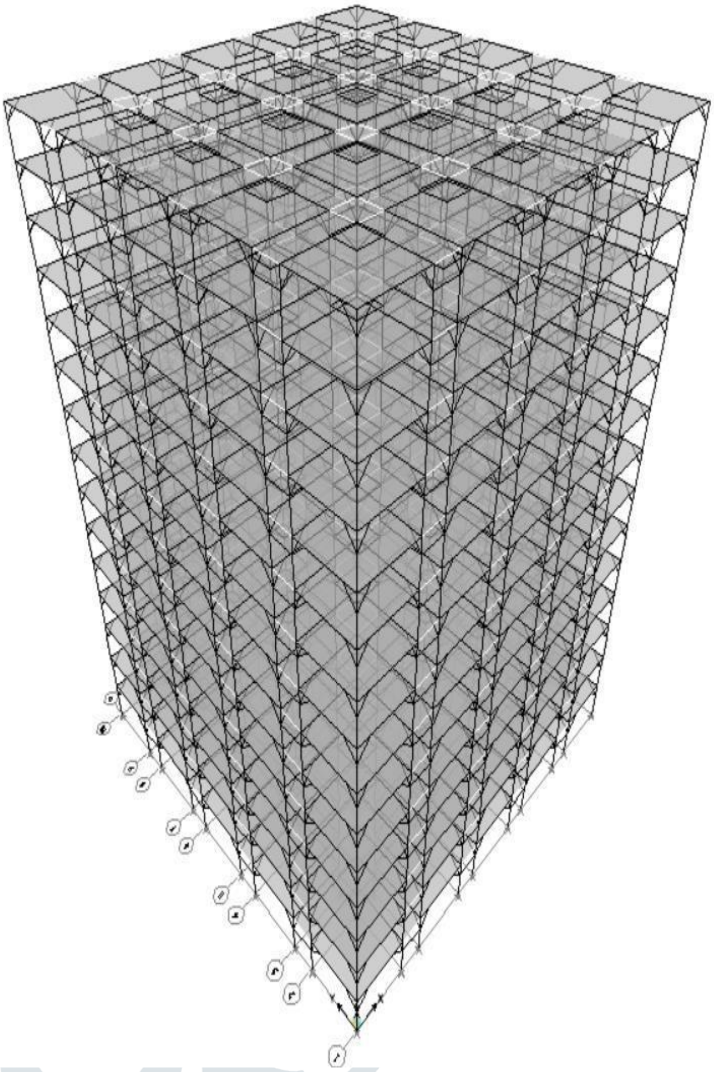
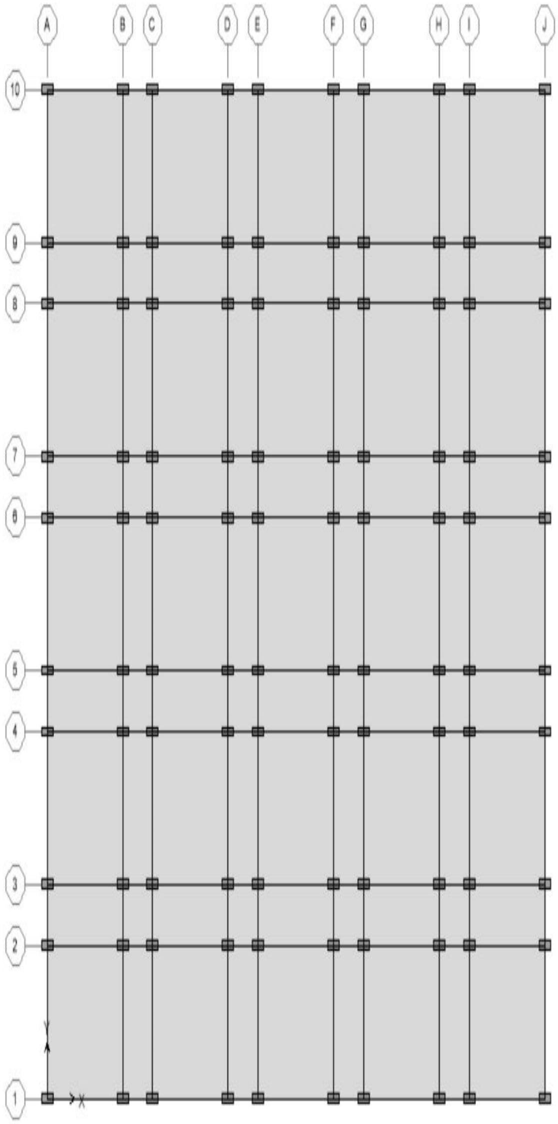


Figure 3.19 Model 1_3D View

Figure 3.18 Model 1_Elevation View

Model 4

The similar way the model 4 5 and 6 RCC structures the only difference is varied story height for the model 4 the story height is 3, for model 5 it is 4m and for model 6 it is 5mts.



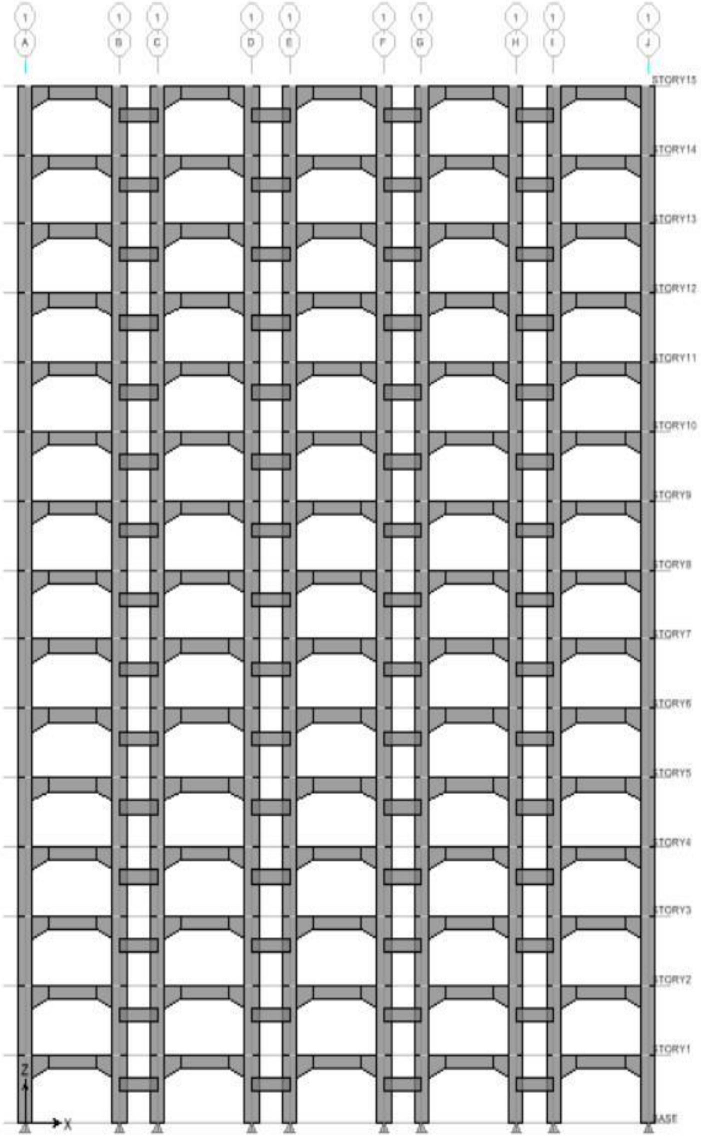


Figure 3.21 Model 4_Elevation View

Figure 3.20 Model 4_Plan View

4. RESULT AND DISCUSSION

The models are first loaded with gravity loads and then lateral loads are applied to check the behaviour of the models. Since, the models are symmetrical in both X and Y direction, the results are extracted for X direction only. The results obtained from various analysis are listed below:

4.1. Equivalent Static Analysis (ESA)

4.1.1. Displacement_ ESA

The displacement of Models in X direction is tabulated and presented below.

Table 4-1-Displacement in X Direction_ EQX

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
15	189	332	541	13	22	35
14	182	319	520	12	21	34
13	174	304	495	12	21	32
12	164	287	467	11	19	31
11	154	268	436	11	18	29
10	142	248	402	10	17	27
9	130	226	366	9	16	25
8	116	203	329	8	14	22
7	103	179	290	7	13	20
6	89	154	251	6	11	17
5	74	130	211	5	9	15
4	60	105	172	4	8	12
3	46	81	133	3	6	10
2	32	57	94	2	5	8
1	17	31	52	2	3	5
0	0	0	0	0	0	0

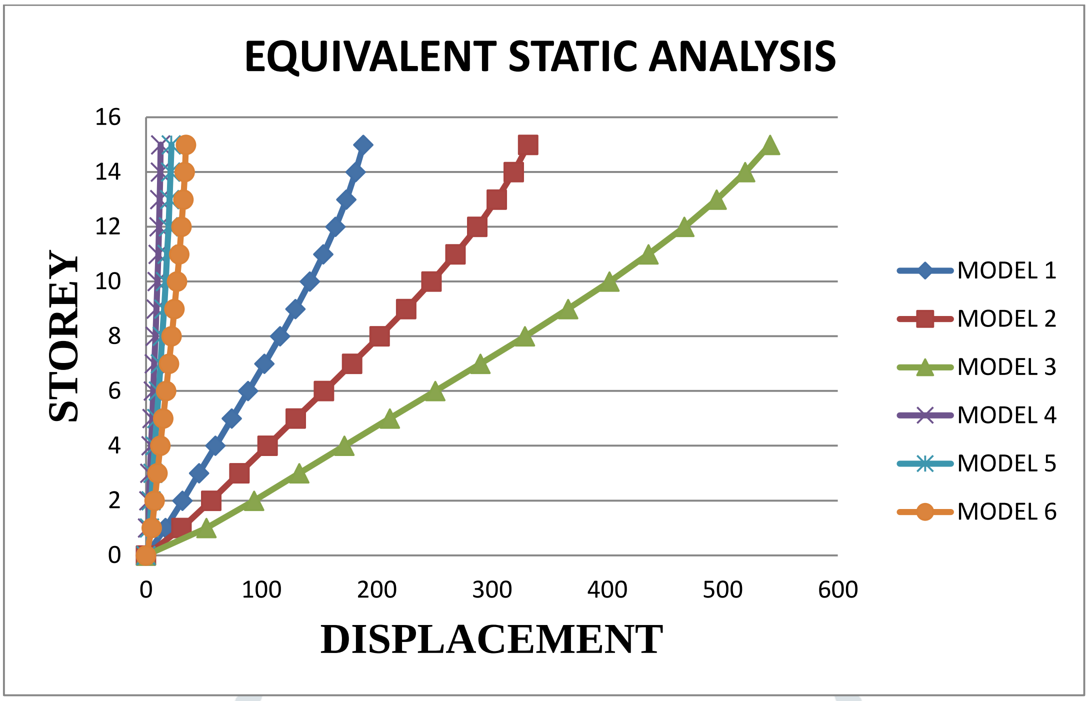


Figure 0.1 Displacement vs Storey in X Dir._EQX

In the above graph, displacement vs storey height is indicated for all 6 models. From the graphs it can be explain that, the models 1, 2 and 3 are showing highest displacement compared model 4,5 and 6. There is a huge difference. This difference is due to stiffness variation. It is clear from the results that, steel structure is having less stiffness than RCC structures.

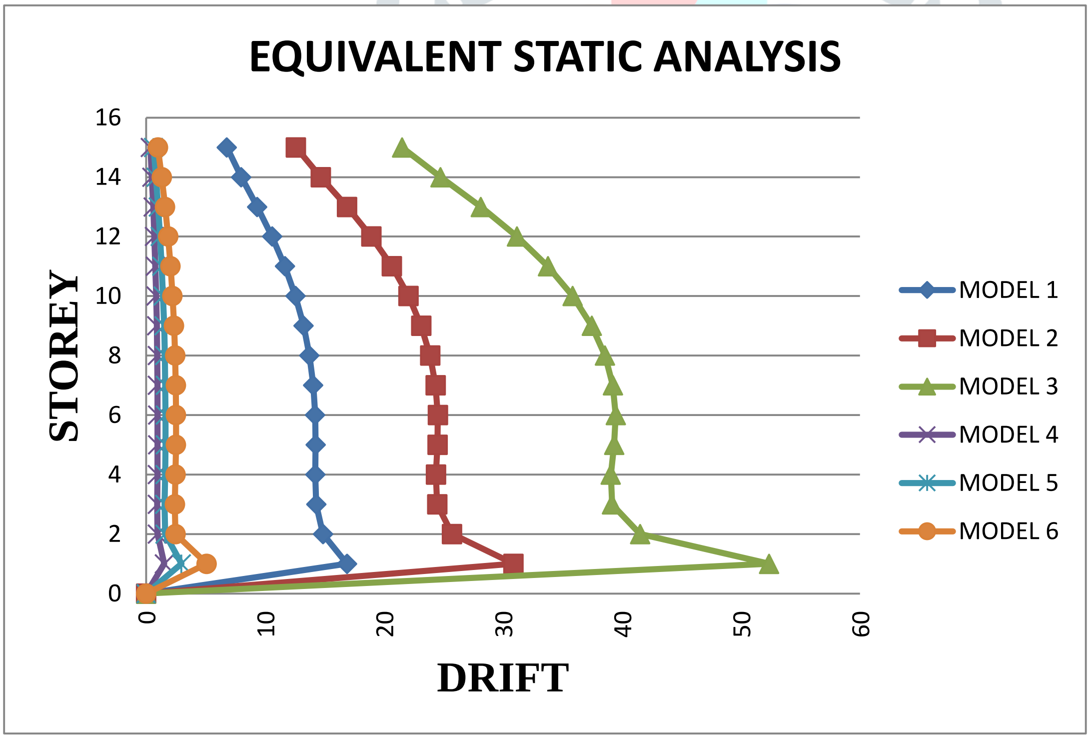


Figure 0.2 Storey Drift vs Storey in X Dir._ EQX

The drift values differ much in case of steel structure and it is noticed that, it is exceeding drift limitation. However, RCC structure showing consistent values in case of drift comparatively.

4.1.2 Base Shear_ESA

Base shear is the shear force at base or foundation level. The following table indicates the base shear value for different configurations.

Table 0-1-Base Shear_ EQX

15 STOREYS					
MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
3799	3464	3407	4913	4155	3691

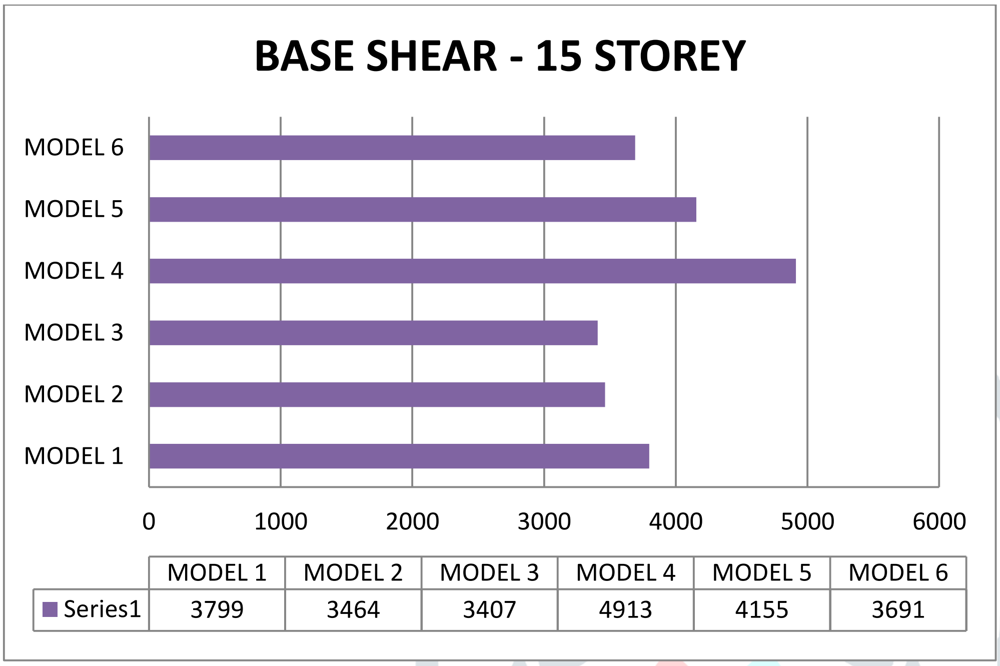
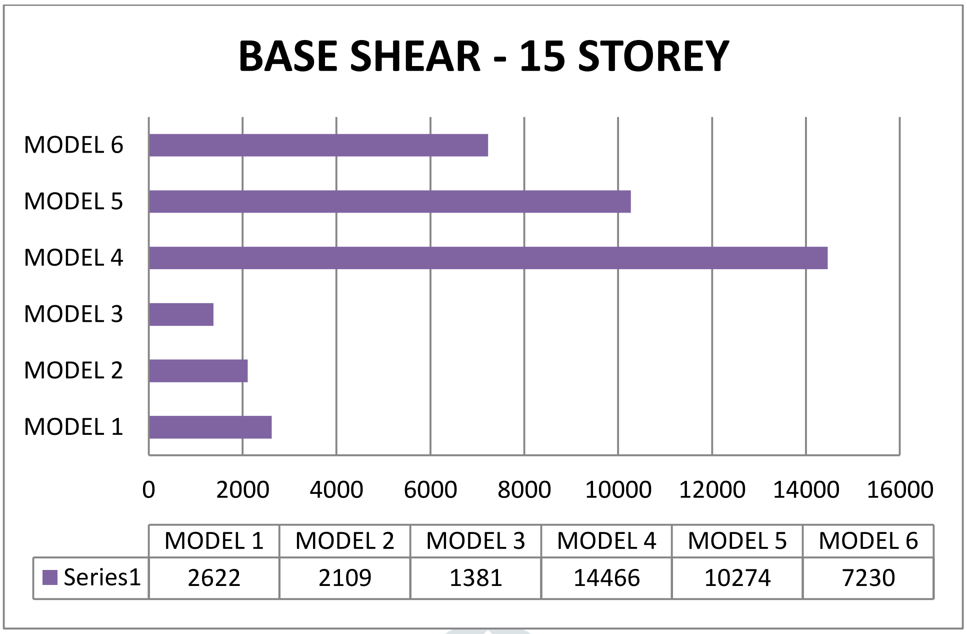


Figure 0.3 Base shear

The base shear values of RCC structure is found to be more in compared with steel structure. However, base shear values are decreasing with increasing storey height.

4.2.3 Base Shear_ THA

15 STOREYS					
MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
2622	2109	1381	14466	10274	7230



	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
🟪 Series1	2622	2109	1381	14466	10274	7230

Figure 0.4Base Shear

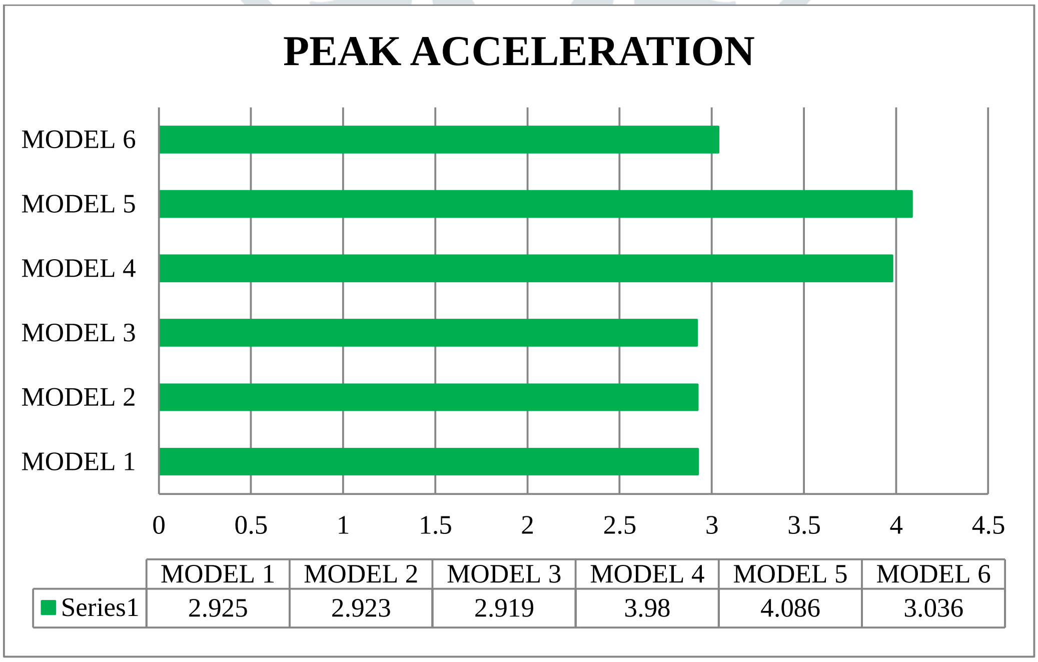
The base shear values are higher for RCC structure. The structure having lesser storey height is having highest base shear value. Base shear value is decreasing with increase in storey height.

4.2.4 Acceleration

The seismic acceleration for various models is presented below.

Table 0-2-Acceleration

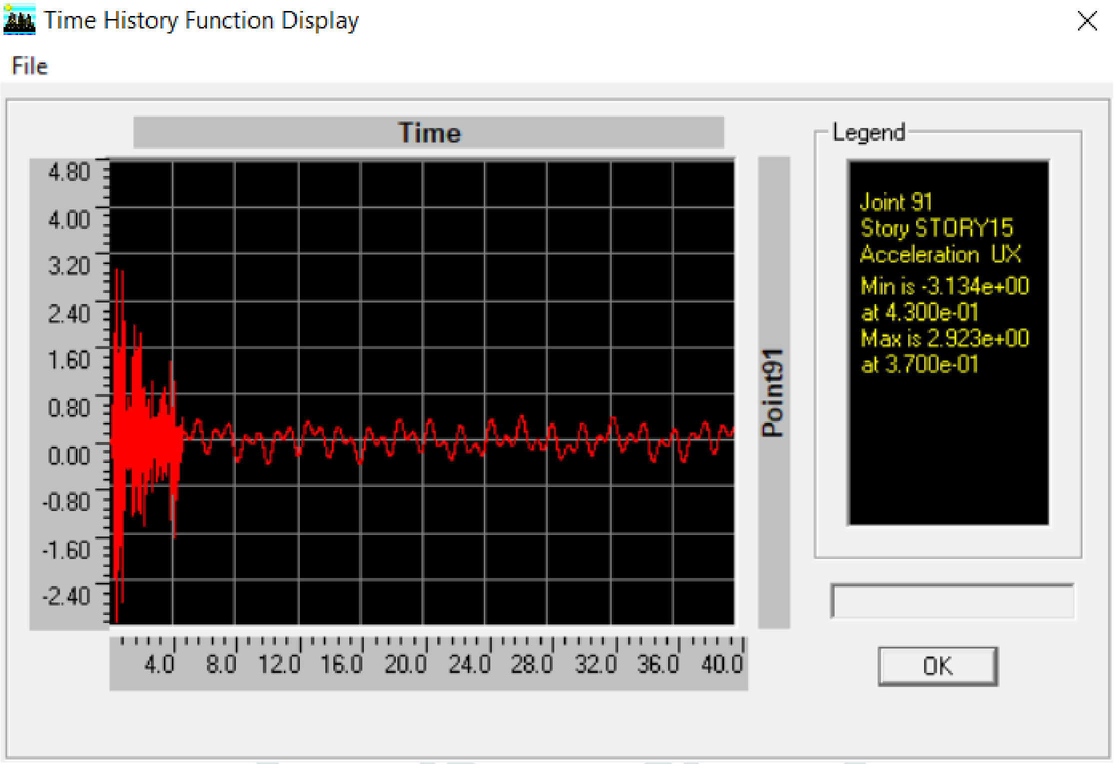
15 STOREYS					
MODEL 1	**MODEL 2**	**MODEL 3**	**MODEL 4**	**MODEL 5**	**MODEL 6**
2.925	2.923	2.919	3.98	4.086	3.036



	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
🟩 Series1	2.925	2.923	2.919	3.98	4.086	3.036

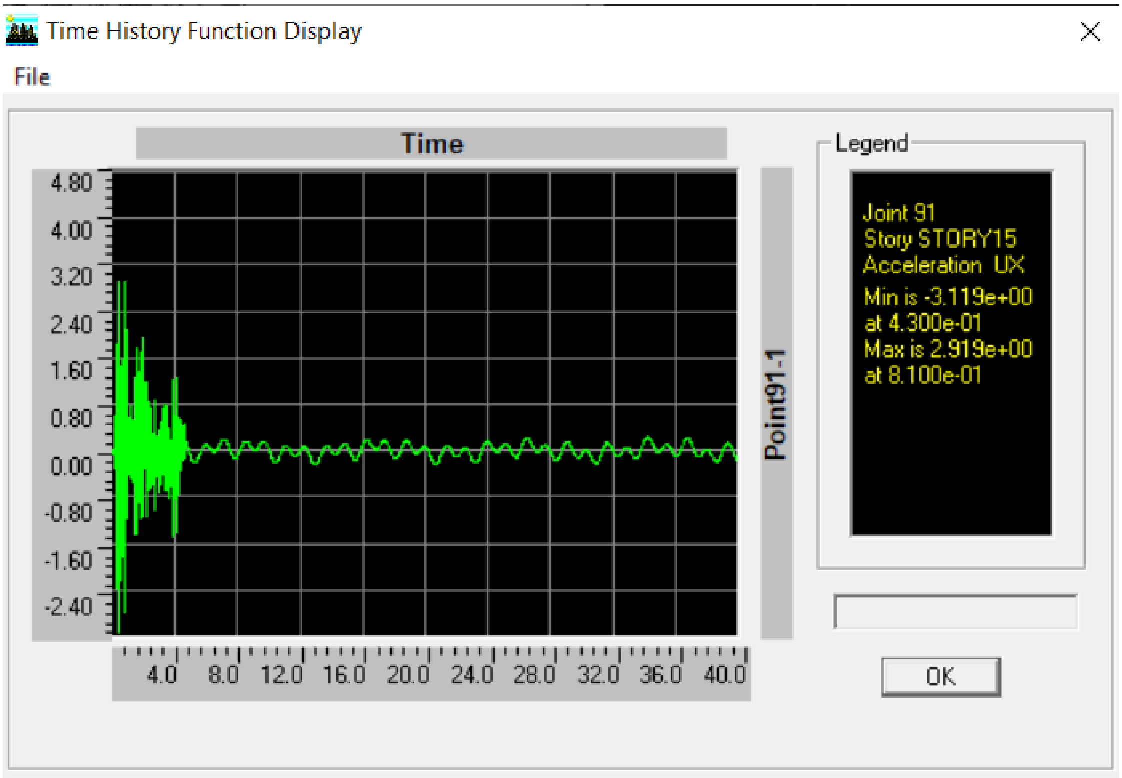
Figure 0.5 Acceleration for Various Models

It is observed from the graph that the model 5 is exhibiting highest acceleration compared to all other model. For steel structures all models are showing almost same values.



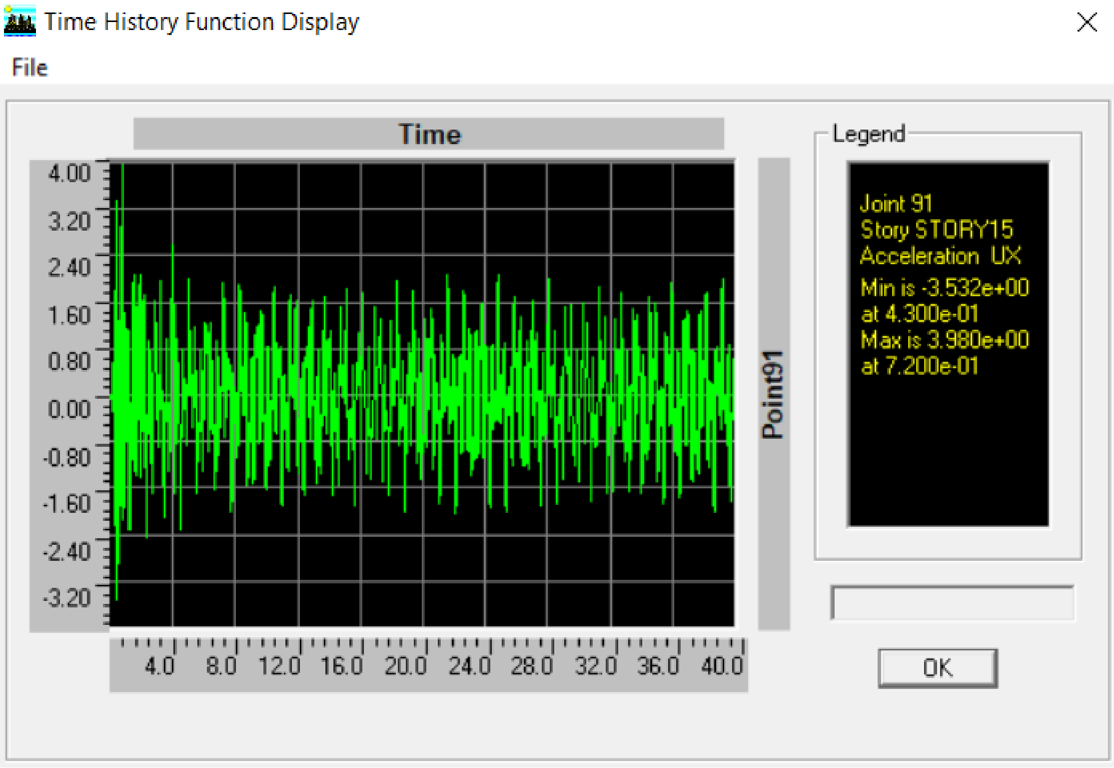
Joint 91
Story STORY15
Acceleration UX
Min is -3.134e+00
at 4.300e-01
Max is 2.923e+00
at 3.700e-01

Figure 0.8 Acceleration vs Time_ Model 2



Joint 91
Story STORY15
Acceleration UX
Min is -3.119e+00
at 4.300e-01
Max is 2.919e+00
at 8.100e-01

Figure 0.9 Acceleration vs Time_ Model 3



Joint 91
Story STORY15
Acceleration UX
Min is -3.532e+00
at 4.300e-01
Max is 3.980e+00
at 7.200e-01

Figure 0.10 Acceleration vs Time_ Model 4

5 CONCLUSIONS

- From the overall results it is observed that the time history analysis results look very realistic compared to static analysis.
- The displacement values in static analysis for various models shows huge differences when it is compared with RCC and steel structures. The displacement value increases with increase in storey height. The displacement is higher in model 3 for steel structure by 1.63 times and 2.86 times when compared with model 2 and model 1 respectively.
- Whereas in case of RCC structure model 6 is having highest displacement when compared with model 5 and 4 with 1.59 and 2.69 times respectively. However, from steel and RCC percentage of difference remains almost same. But the values vary considerably.
- The drift value for static analysis are huge in consideration with steel structure i.e., model 1,2 &3. The allowable limit for Drift value is h/250 = 12, 16, 20 for model 1, 2 & 3. However, these models are crossing allowable limits.
- The Static analysis results for Concrete structures are within the allowable limits because of high stiffness comparatively.
- The base shear value obtained from Static analysis shows higher for model having lesser storey height because it is having higher stiffness. However, RCC structure having higher base shear compared with steel structure due to self-weight is high in RCC.
- In case of time history analysis, the displacement values seem realistic and difference between RCC and Steel models are reducing compared with static analysis.
- There is huge reduction in displacement values compared between static and dynamic analysis. There is an average of 2.5 times reduction in displacement values for dynamic analysis. This is a significant conclusion drawn from this work.
- Time history analysis drift values are realistic, and all the values are within allowable limit. However, these values are not within the permissible limit in case of static analysis.
- Acceleration values obtained for various models show that model 5 has higher value compared to other models. However, it is also observed that it is greater for RCC structures.
- From the model analysis, it is concluded that the modal results such as frequency and time period will not depend on the type of analysis. However, it depends only on the model dynamics.
- The time period increases with increase in storey height and model become flexible. And also, Steel structure has greater flexibility compared with RCC and hence higher time period.
- The frequency values are inversely proportional to time period. However, if the model is having highest frequency nothing but having lowest time period.
- From the overall analysis, it is concluded that, the time history analysis (Dynamic analysis) gives better and reliable results compared to static analysis. Thus for high-rise structure static analysis is not advisable.
- RCC structures possess greater stiffness and stability compared to steel structures by decreasing displacement and storey drift. However, due to increase in self-weight, in case of RCC structures, the base shear also increases.
- It is also concluded that, increase in storey height for same number of storeys leads to increase indisplacement, storey drift which will reduce the overall economy of the structure.

6. REFERENCES

- T. Y. Yang, Yuanjie LiAnd Subhash C. Goel, M.Asce, "Seismic Perfo`rmance Evaluation Of Long-Span Conventional Moment Frames And Buckling-Restrained Knee-Braced Truss Moment Frames".
- HamidrezaEtebarian, T. Y. Yang and Dorian P. Tung, "Seismic Design and Performance Evaluation Of Dual-Fused H-Frame System".

- Hamidreza Etebarian1 And T.Y. Yang, “Development and Assessment of Innovative Modular Damped Hframe System”.
- S.H. Mohamed& M.A. Zaki, S.A. Mourad, “Numerical Study of The Seismic Performance of Knee Braced Frame”.
- Sara Raphael1, Soni Syed, “A Comparative Study of Knee Braced Steel Frame”.
- Maria Antonietta Conti, Luigi MastrandreaAnd Vincenzo Piluso, “Plastic Design and Seismic Response of Knee Braced Frames”.
- Arunroy N S, K Vasugi, “Seismic Performance of Different Bracing for Steel Frames”.
- Jiuk Shin, “Experimental Study on Buckling-Restrained Knee Brace with Steel Channel Sections”.
- Anitha M, Divya K.K, “Comparative Study on Seismic Behaviour of Steel Knee Braced Frame With Eccentric Braced Frame”.