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Comparative Pushover Analysis of Special Moment Resisting Frames of Steel Structure considering IS18168:2023 and Reinforced Concrete Structure

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ABSTRACT
In this paper, study about the seismic analysis of the special moment resisting frame for Steel structure and Reinforced concrete Structure by the pushover analysis with the help of the ETAB20 software, which is a product of the Computer and Structure & Inc. The code used for seismic analysis is Indian Standard CODE 1893 part1:2016. The method used in this analysis is Nonlinear static Analysis, in which static analysis represents the Response Spectrum method. The main aims of this paper are to study the Pushover curve comparison between Steel Structure & RC Structure of Special moment resisting frame and which one performs better in the pushover analysis. The main purpose to choose a special moment resisting frame is that frame that resists the strong ground motion during the earthquake. After analysis, we can say that which frame performs better when we consider IS 18168:2023 for steel structure. The designing criteria of the Special Moment Resisting Frame for steel structure and RC structure are given in the Indian Standard Code 1893 part1:2016.
Keywords: Seismic analysis of frames, ETAB20, Moment resisting frames, earthquake, recentering, pushover analysis, time history analysis.

1. INTRODUCTION
It could be a well-known truth that steel (both auxiliary and reinforcing) plays vital and broad parts within the display development industry. Within the building division, seismic tremors shape a major chunk of pulverization of structures due to drive majeure occasions. This comes about within the development of plan innovation to make building frameworks that can stand up to such occasions with negligible human casualty. Auxiliary steel, having a gigantic strength/weight proportion is as of now one of the finest and most utilized materials for such frameworks. But it isn't cheap. Repair / substitution of steel structures has persistently been considered to be taken a toll and work truly. This brought about in a move in inquire about interface from planning sidelong drive standing up to outlines to horizontal drive standing up to outlines with simple reparability.

Advantage Of Steel Structure
• Light structural weight
• Good seismic performance
• High degree of industrial production
• Fast construction speed
• Beautiful shape
• Green environmental protection
• Large space
• High strength per unit mass

Impediment Of Steel Structure
• High maintenance costs

• Fireproofing costs
• Buckling issues
• High expansion rate with changing temperatures
• Small resistance against fire
• Susceptibility to corrosion
• Higher transport costs due to weight limitation

The arrangement of Indian standard code 18168:2023 applies for enumerating of steel building having the taking after auxiliary framework.
a) Special moment resisting frame (SMRF)
b) Special concentrically braced frame (SCBF)
c) Eccentrically braced frame

Advantage of RC Structure
a) Reinforced concrete has a high compressive strength compared to other building materials.
b) As reinforced concrete can be moulded to any shape required, it is widely used in precast structural components.
c) Due to the provided reinforcement, reinforced concrete can also withstand a good amount of tensile stress.
d) Reinforced concrete has a high compressive strength compared to other building materials.
e) Compared to the use of steel in structure, reinforced concrete requires less skilled labour for the erection of the structure.

Impediment Of RC Structure
a) RCC column section for a multi-storey building is larger than the steel section because of its lower compressive strength.
b) Shrinkage causes development of cracks and strength loss.
c) The most stages of utilizing fortified concrete are blending, casting and curing.
d) The fetched of the shapes utilized for casting is generally tall

1. SPECIAL MOMENT RESISTANT FRAME

A lateral load resisting system composed of interconnected beams and columns, without structural walls and inclined member as braces, which function as a complete self-contained unit with or without the aid of horizontal diaphragms of floor bracing systems, in which the system resists gravity and lateral force effects primarily by axial and flexural actions.

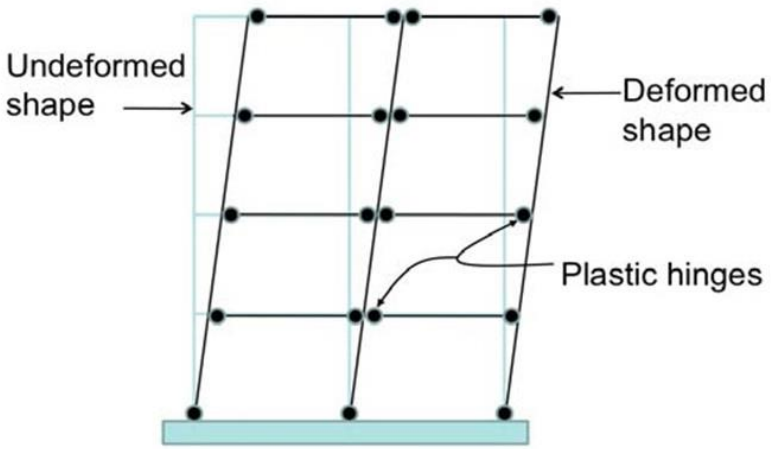


Figure 2: Special moment resisting Frame.

2. METHODOLOGY AND ANALYSIS

Pushover analysis is a static, nonlinear procedure to analyse the seismic performance of a building where the computer model of the structure is laterally pushed until a specified displacement is attained or a collapse mechanism has occurred. The loading is increased in increments with a specific predefined pattern such as uniform or inverted triangular pattern. The gravity load is kept as a constant during the analysis. The structure is pushed until sufficient hinges are formed such that a curve of base shear versus corresponding roof displacement can be developed and this curve known as pushover curve. The maximum base shear the structure can resist and its corresponding lateral drift can be found out from the Pushover curve.

In the modelling we write the details about the model which was analysed in ETAB20. Such as the material parameter, Section parameter, load parameter, and seismic parameter.

2.1 Building Structure Details

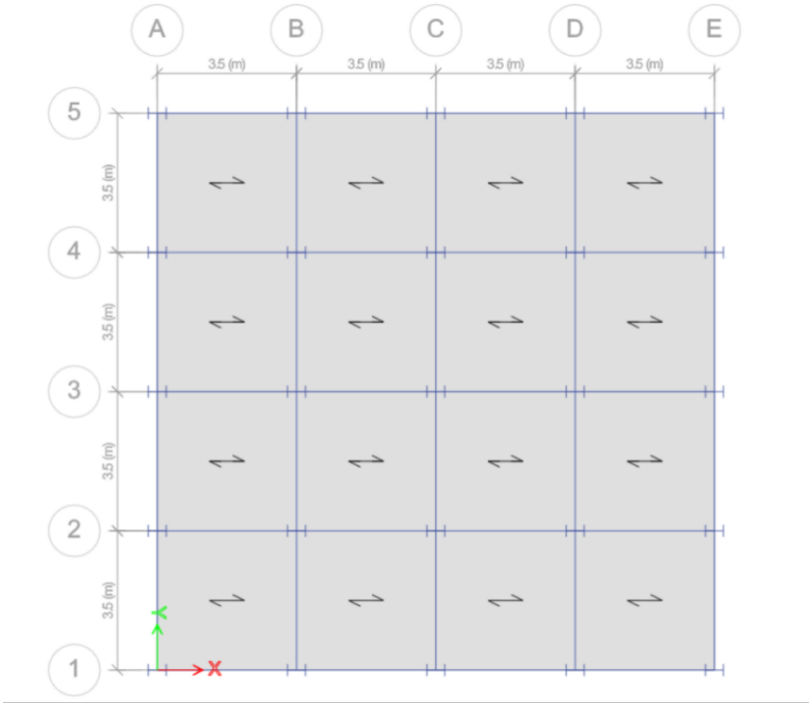


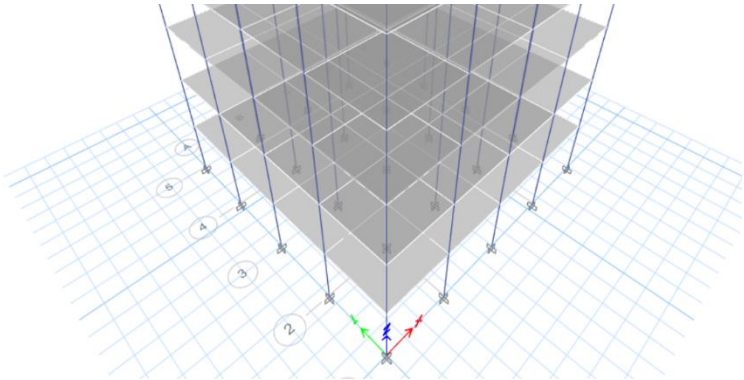
Figure 2.1: Plan of the Steel & RC Structure

Table-1: Material Parameter

Material Name	**Value**
Concrete	M30
Rebar	HYSD550 or Fe550
Steel	E350

Table-2: Section & Seismic Parameter

Figure 2.2: Modal of the Steel & RC Structure



Particulars	**Steel Structure**	**RC Structure**
Plan Dimension	14mX14m	14mX14m
Total Height of the building	15m	15m
Height of each storey	3m	3m
Size of Beams	WPB 300mmX300mm@117.03	300mmX300mm
Size of Columns	WPB 450mmX300mm@171.11	300mmX450mm
Thickness of Slab/Deck		150mm
Seismic Zone Zone Factor Importance Factor	V 0.36 1.2	V 0.36 1.2

Site Type Damping Ratio Reduction Factor	II 0.05 5	II 0.05 5
Time Period	0.29 Sec	0.29 Sec
Live Loads at all floors Density of concrete Density of steel	3.5 kN/m2 25 kN/m2 7850 kg/m3	3.5 kN/m2 25 kN/m2 7850 m3

3. Result and Discussion

The result for both RC Structure & Steel Structure the pushover analysis was done and also find out the storey drift, Max storey displacement, Max storey shear and pushover curve by apply acceleration in the X Direction in the form of Push-X.

3.1 Storey Displacement

We control the displacement max upto 300mm when analysing the both structure and found that the maximum displacement is occur in RC structure but it's just approx. 1% high displacement at 4th floor of the building. Its mean we can say that if we control the displacement upto 300mm so both of the structure behave as similar.

3.2 Storey Drift

Upto Storey 2 the RC structure have more drift and after the 2nd floor the storey drift increase in steel structure and which is also higher upto the 5th floor of the building but the different between steel structure and RC structure is almost nearby so we can say that drift is equal on both SMRF frame of the structure.

3.3 Storey Shear

From the analysis, it fount that the storey shear is almost double in steel structure compare to the RC structure when we apply the push-X acceleration on X direction of the both structure.

3.4 Pushover analysis

The maximum shear force developed in Steel structure and minimum shear force developed in RC structure; pushover curve represents the shear force to displacement graph or displacement developed due to shear force. According to the pushover analysis result, the pushover curve is higher in steel structure. It means that during the earthquake the steel structure is pushing more than the RC structure. It means after some time RC structure develop cracks and failed and in steel structure, its deformed shape during the earthquake and after earthquake steel structure regains its shape, but with some minor losses like change in shape and loss of strength.

Table-3: Maximum storey displacement

TABLE: Maximum storey displacement				
Story	**Elevation**	**Location**	**RC STRUCTURE**	**STEEL STRUCTURE**
	m		mm	mm
Story5	15	Top	30	30
Story4	12	Top	27.266	27.022
Story3	9	Top	22.341	21.922
Story2	6	Top	15.17	14.681
Story1	3	Top	6.419	6.11
Base	0	Top	0	0

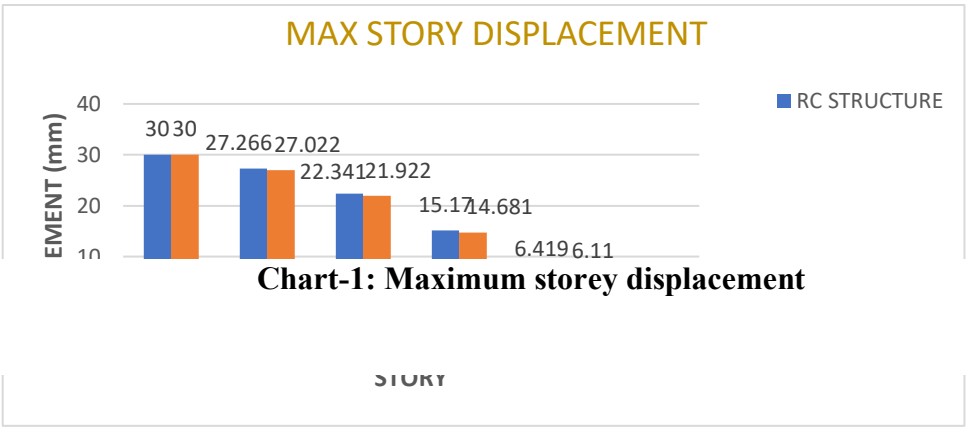


Chart-1: Maximum storey displacement

Table-4: Maximum storey drift

TABLE: Maximum storey drift				
Story	**Elevation**	**Location**	**RC STRUCTURE**	**STEEL STRUCTURE**
	m			
Story5	15	Top	0.000911	0.000993
Story4	12	Top	0.001642	0.0017
Story3	9	Top	0.00239	0.002414
Story2	6	Top	0.002917	0.002857
Story1	3	Top	0.00214	0.002037
Base	0	Top	0	0

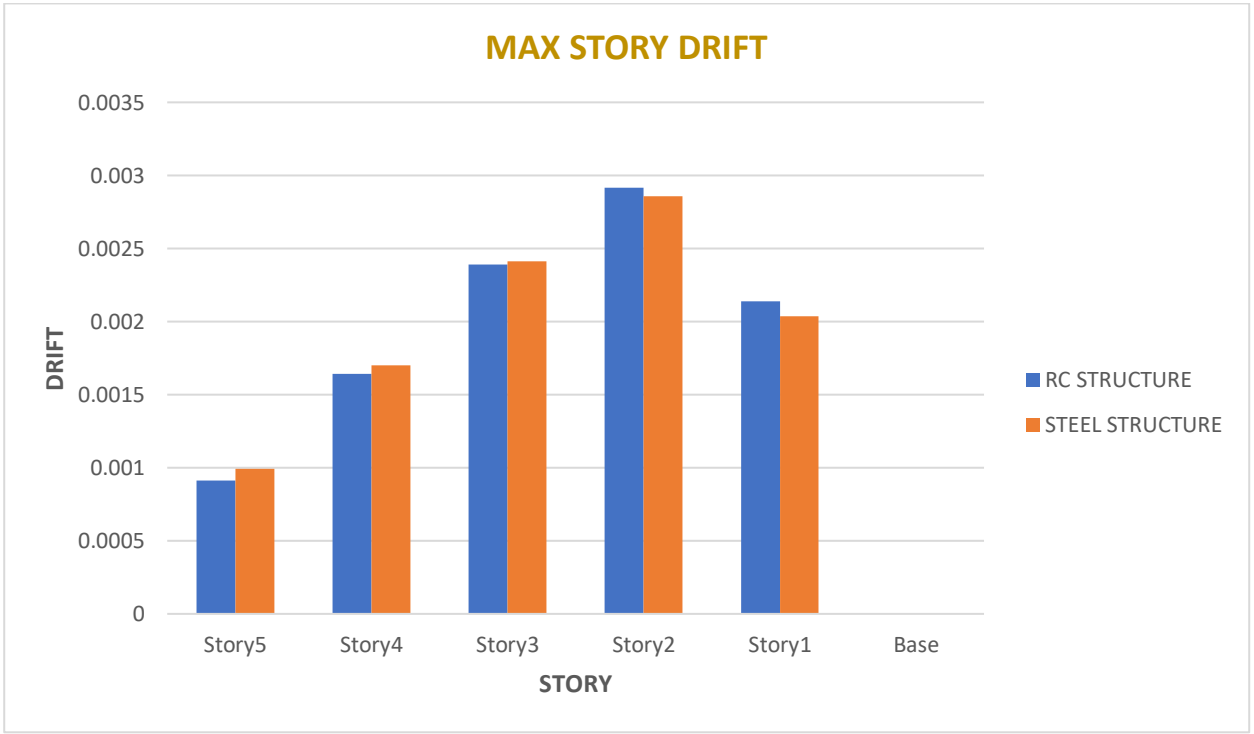


Chart-2: Maximum storey drift

Table-5: Maximum Storey Shear

TABLE: Story Response				
Story	**Elevation**	**Location**	**RC STRUCTURE**	**STEEL STRUCTURE**
	m		kN	kN
Story5	15	Top	378.4444	610.9876
		Bottom	378.5973	611.1119
Story4	12	Top	782.6852	1242.9482
		Bottom	782.8382	1243.0725
Story3	9	Top	1186.9261	1874.9089
		Bottom	1187.079	1875.033
Story2	6	Top	1591.1673	2506.87
		Bottom	1591.3198	2506.9936
Story1	3	Top	1995.4068	3138.8277
		Bottom	1995.5706	3138.9652
Base	0		0	0

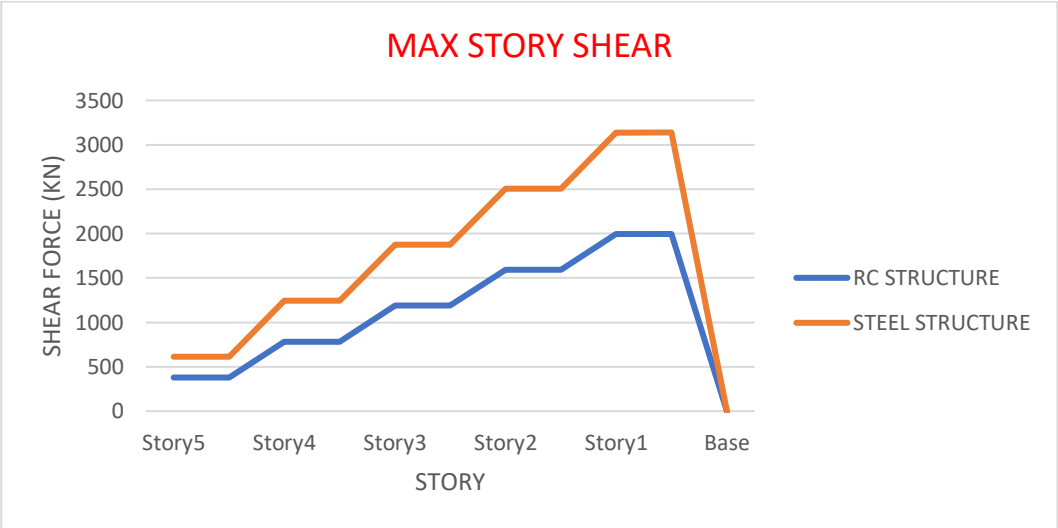


Table-5: Maximum Storey Shear

Chart-3: Maximum Storey Shear

TABLE: Base Shear vs Monitored Displacement				
	RC STRUCTURE		**STEEL STRUCTURE**	
Step	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**
	mm	kN	mm	kN
0	0	0	0	0
1	-30	2021.0604	-30	3159.686
2	-55.351	3728.9284	-60	6319.3714
3	-57.886	3896.9186	-90	9479.0558
4	-57.889	3897.0928	-120	12638.7386
5	-64.482	4234.9981	-134.753	14192.5904
6	-64.485	4235.0727	-134.753	14192.5907

7	-65.295	4270.303	-133.418	13820.2167

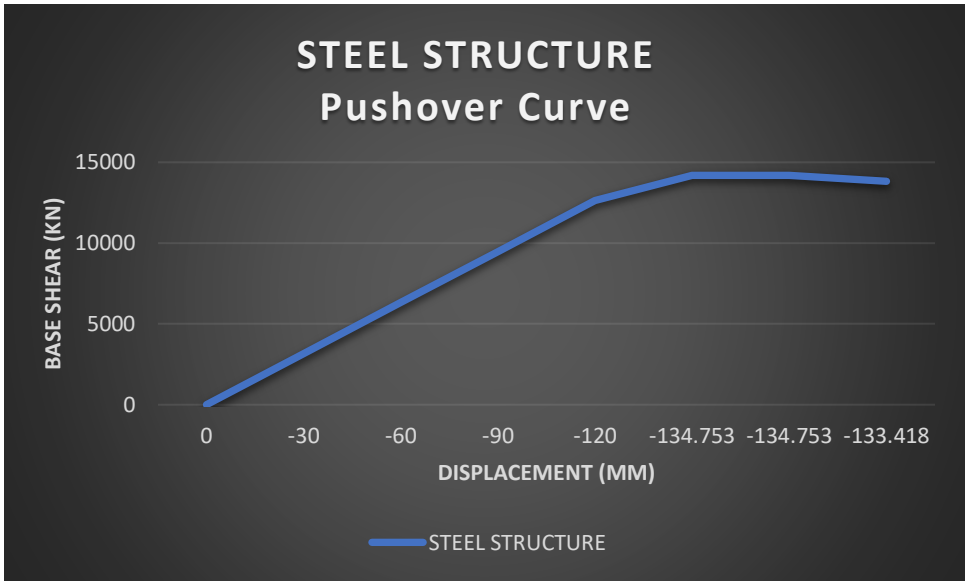


Chart-2: Pushover curve For Steel Structure

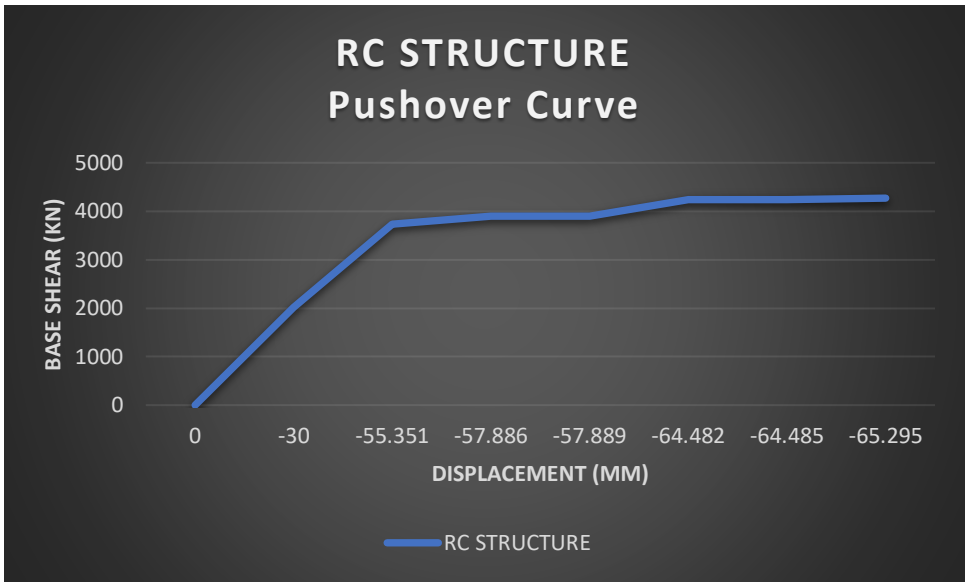


Chart-2: Pushover curve For RC Structure

4. CONCLUSION

1. This analysis results of 5th storey Steel Structure and RC Structure has been studied and represented here. The comparison results of theses building models are as follows and including the IS:18168:2023 for detailing and Earthquake analysing the steel structure.
2. Displacement in RC structure is more than the steel structure when we control the displacement limit upto 300mm so higher value for the both structures are same on the top storey of the building. But below the top storey the RC structure has more displacement compare to the Steel structure. But this difference is minor difference upto 1% to 2%.
3. The Drift in RC structure is more upto 2nd storey and after 2nd storey drift in RC structure is decrese and drift in steel structure is increase upto 5th storey of the building and the difference in 5th storey is minor. It means drift in both structure is approximate same.
4. The Shear force in steel structure is much higher than steel structure while we take the size of the element is almost similler. The storey shear in steel structure is two times of the shear force of RC structure.
5. As per our analysis the puchover curve show that the steel structure is more stable when the earthquake will occur due to its ductility and RC structure will develop cracks some time after experiencing earthquake tremors. Steel structure will also suffer some damage during the earthquake.

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