Study on Performance of Cantilever Space Frame for Lateral Load and Buckling

[1]Bharath U R,[2]B Sharath,[3]C Rakesh
[1]M.Tech.Student,[2]Assistant Professor,[3]Assistant Professor
[1]Department of Civil Engineering,
[1]Dr.Ambedkar Institute of Technology, Bengaluru,India

Abstract - To study the behaviour & performance of Cantilever Space frame Structure subjected to lateral load. Modelling of Cantilever Space Frame in SAP2000 software, defining of load cases, selection of program defined load combination and the analysis is carried out for static (Equivalent Static Analysis). After rigorous analysis and results, the cantilever space frame response to lateral forces can be identified this information aids in designing a robust structure that can with stand various loading conditions with minimizing the risk of buckling failures.

Key Words - Space frame, Cantilever, Double Layer Grid, Equivalent static method

I. INTRODUCTION

The increase in the space frame over the last few decades has been mostly due to its good structural possibilities and visual elegance. New and innovative applications of space frames are being created across a wide range of building types, including sports stadiums, exhibition pavilions, assembly halls, transit terminals, aeroplane hangars, workshops and warehouses. They must be utilised not only on long-span roofs, but also on mid- and short-span enclosures such as roofs, exterior walls, and canopies to provide a nice aesthetic perspective. Several intriguing projects have been created and built all around the world using a variety of space frame layouts. Space frames are a very statically indeterminate structure. If performed by hand, their analysis results in very time-consuming computing. The issue of comprehensive analysis of such systems contributed to their limited application. The introduction of electronic computers revolutionised the entire approach to space frame analysis. It is possible to analyse extremely sophisticated space structures with precision and in less time by using computer programmes.

Space Frame Components:

In general, members are axial elements with circular or rectangular sections, all members can only resist tension or compression. The space grid is assembly of relatively long tension members and short compression members.

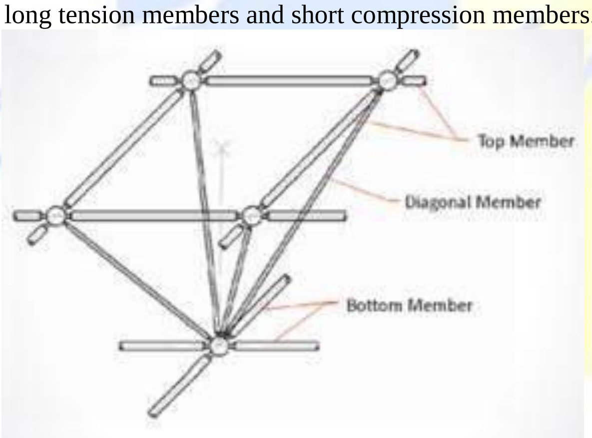

Fig 1. Typical detail of one unit of double layer grid Space Frame element

Different types of space frame connection consist of welded, bolted and threaded. Chief issue within the structural joint design is that the thought of a truly rigid connection that may support a load.

II. METHODOLOGY

1. The basic modelling is carried out using SAP2000 software
2. Modelling of Cantilever Space Frame in SAP2000 software
3. Defining of load cases.
4. Selection of program defined Load combination
5. The analysis is carried out for static (Equivalent Static Analysis).
6. Tabulation of results subjected for cantilever Space Frame.

Design of Structural members:

Here structure is designed for 5m Height, Width of 10m at each column interval is 2m & length of 13.05m with including extra projection structural models are considered for the hollow pipe section space framed structure considered for the analysis. The [Figure 2] shows dimension of cantilever space frame structure modelled in AutoCAD. Double layered Grid design is considered for the analysis. The structural models are modelled using SAP2000 software. The proposed models are cantilever space frame structure. The [Table 1] shows material properties used in this project.

Table 1. Structural details of Model

Sl. No.	Description	Data
1.	Structure Height	5m
2.	Structure Width	10m
3.	Overall span Length	13m
4.	Column Size used	ISNB 350H
5.	Beam Size used	ISNB 50H (TOP CHORD) ISNB 100H (BOTTOM CHORD)
6.	Brace Size used	ISNB 300H, ISNB 32H
7.	Thickness of Roof	20mm
8.	Grade of Steel (f_y)	Fe 345

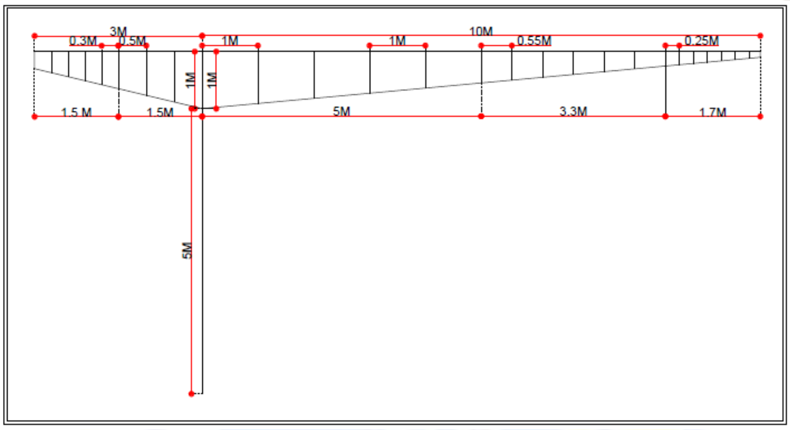

Fig 2. Plan View

III. RESULTS AND DISCUSSIONS

The models are first loaded with Dead loads and then Lateral loads are applied to check the behaviour of the models. Models are then analyzed with a combination of loads automatically calculated from the program. The results are taken from bottom members with starting three members at fixed end support and last three members at free end support. The results obtained from analysis based on shear force and bending moment are discussed in terms of Equivalent Static Analysis.

1. Equivalent Static Analysis (ESA):

Equivalent static analysis of both Cantilever Space Frame Structure is analysed based on the seismic load. The results of the ESA are tabulated as shown below.

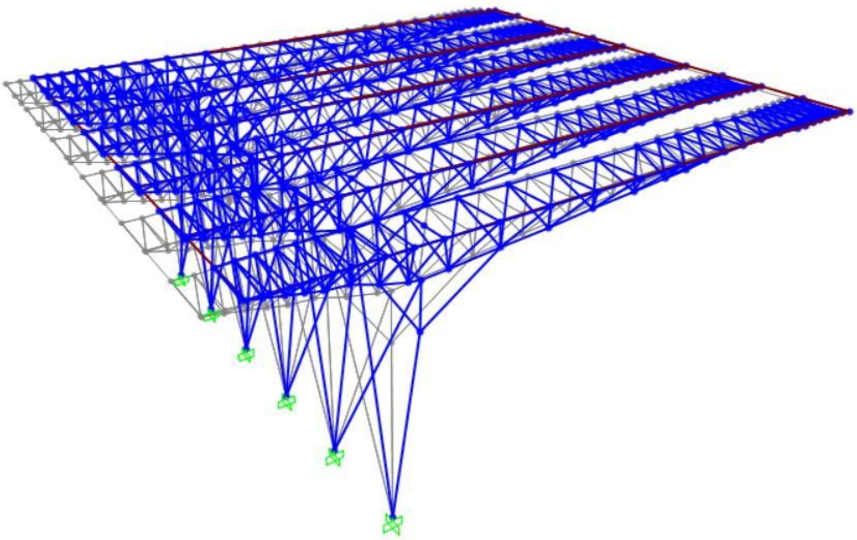

Fig 3. Deformed Shape of Space Frame_ Seismic Force

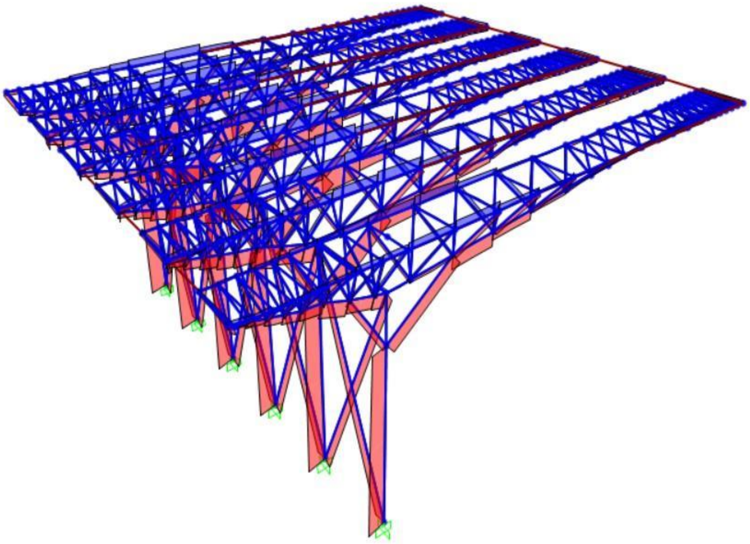

Fig 4. Bending Moment Diagram of space frame

Table 2. Model analysis of Shear Force for cantilever Space Frame

Shear Force (kN)			
Frame no's	**End Type**	**Member no's**	**Model**
			Space Frame
CANTILEVER FRAME -1	**Fixed End**	199	-2.824
		200	0.873
		201	0.0695
	Free End	214	-0.3267
		215	-0.4895
		216	-0.3781
CANTILEVER FRAME -3	**Fixed End**	619	-3.2363
		620	0.9791
		621	0.0494
	Free End	634	-0.421
		635	-0.6352
		636	-0.483
CANTILEVER FRAME -6	**Fixed End**	1249	-2.8265
		1250	0.871
		1251	0.0692
	Free End	1264	-0.3268
		1265	-0.4891
		1266	-0.3786

Here,

- The Model analysis of shear force at fixed end support of each cantilever space frame value shows more. In cantilever space frame-3 in fixed end at member (620), shear force value is less when when compared to cantilever space frame-1 structure.
- The Model analysis of shear force at free end of each cantilever space frame value shows satisfactory results. But each cantilever space frame (1, 3, 6) at the member of (216, 636, 1266) value decreases at free end.

Table 3. Model analysis of Bending moment for Cantilever Space Frame Structure

Bending Moment (kN-m)			
Frame no's	**End Type**	**Member no's**	**Model** Space Frame
CANTILEVER FRAME -1	**Fixed End**	199	0.503
		200	0.384
		201	-0.072
	Free End	214	0.020
		215	0.206
		216	0.353
CANTILEVER FRAME -3	**Fixed End**	619	0.541
		620	0.435
		621	-0.093
	Free End	634	0.017
		635	0.258
		636	0.443
CANTILEVER FRAME -6	**Fixed End**	1249	0.503
		1250	0.384
		1251	-0.072
	Free End	1264	0.02012
		1265	0.20678
		1266	0.35311

Here,

- The Model analysis of bending moment at fixed end support of each cantilever space frame value shows satisfactory results. But starting two member (619, 620) of fixed end support of middle cantilever frame-3 value shows lesser value. After starting with two member of fixed end support of middle cantilever frame-3 value shows satisfactory results.
- The Model analysis of bending moment at free end of middle cantilever space frame-3 shows lesser value in cantilever space frame structure. But free end of cantilever frame-1 and cantilever frame-3 end of member value shows more satisfactory results.

Table 4. Earthquake in X-direction of Bending Moment for Cantilever Space Frame Structure

Bending Moment (kN-m)			
Frame no's	**End Type**	**Member no's**	**EQ-X** Space Frame
CANTILEVER FRAME - 1	**Fixed End**	199	0.1444
		200	0.0324
		201	0.0063
	Free End	214	0.0045
		215	0.0047
		216	0.0065
CANTILEVER FRAME - 3	**Fixed End**	619	0.1546
		620	0.0343
		621	0.0071
	Free End	634	0.0053
		635	0.0072
		636	0.0101
CANTILEVER FRAME - 6	**Fixed End**	1249	0.1443
		1250	0.0324
		1251	0.0063
	Free End	1264	0.0045
		1265	0.0047
		1266	0.0065

Here,

- The Earthquake analysis in X-direction of bending moment both at fixed end support and free end of each cantilever space frame value shows satisfactory results.
- The Earthquake analysis in Y-direction of bending moment at both fixed end support and free end of cantilever space frame-1 and cantilever space frame-6 value shows lesser value.
- But in middle cantilever space frame-3 at fixed end support initial two members (619, 620) shows lesser value. After the value of member (619, 620) increases gradually up to the free end of the structure.

IV. CONCLUSIONS

In the previous chapter results are extracted and tabulated. The results are compared and final conclusions are drawn in this chapter.

- The analysis of a Cantilever Space frame for Lateral Loads and Buckling is crucial to ensure the structural stability and safety of the structure.
- After rigorous analysis and results, the cantilever space frame response to lateral forces can be identified and potential buckling modes can be identified.
- This information aids in designing a robust structure that can with stand various loading conditions with minimizing the risk of buckling failures.
- Its important to consider factors like material properties, support conditions, and load distribution for design process.
- In conducting the Static analysis on cantilever space frame EQ in X direction shows more values for bending moment and shear force when compared to the values in Y direction.
- Cantilever space frame (1,3 and 6) of earthquake analysis in X- direction of bending moment and shear force at both fixed end and free end, the values for frame-1 and frame 6 shows less values when compared to the middle cantilever space frame-3

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