DESIGNING FRAMED STRUCTURE IN ETABS AND STAAD PRO

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Abstract - *As the use of steel building increases daily, it is crucial to create aesthetically pleasing structures that are also cost-effective. Since no software is perfect, designers must rely on a variety of tools to create unique architectures, specific components, or connections. In this study, we'll create a PEB structure and assess its viability and simplicity using two distinct pieces of software, then compare the outcome.*

Key Words: Software, designing, structure, BIM, steel, construction.

1. INTRODUCTION

Steel construction is growing day by day and it's important to design the structure elegantly and economically. Software is used to design the structure and hand calculation is carried out to check the accuracy of the design. In many countries, it's important to check the integrity of design using hand calculation. There is various software in the market with each having certain capabilities to design certain structures more efficiently. There is various type of structure and some general structure such as concrete, steel, aluminum, and wood structure used more often and countries have different codes and regulation to design these structures. No software is complete and thus designers have to depend upon various software to design different structures or certain parts or connections. In this study, we going to design a PEB structure and check the feasibility and ease with which we design the same structure in two different software and compare the result. We will use the same loads and members size to design the structure. We will check the quality of the final results of the two software.

1.1 OBJECTIVE AND RESEARCH PROPOSAL – The objective of this research is to check the design capability of two software by comparing the result. The structure design is a steel connection and the members used in designing is approximately the same.

2. MATERIAL AND METHODS – Before designing the structure we assumed various data regarding the structure, its use, its location and the forces it can count upon. We assumed LSM methodology using Indian standard codes to design the members, the structure falls in earthquake zone IV and the structure is framed PEB structure and the structure is partially opened.

2.1 LIMIT STATE METHOD - The likelihood of a structure failing is lowest when it is thoughtfully planned and developed. In order to account for variations in material properties and the load to be supported, the structure is designed using characteristic values of its material strengths and applied loads. Applying partial safety factors results in design value.

The design action Qd is expressed as

$$Q_d = \sum_k \gamma_f Q_{ck}$$

And, the design strength Sd is obtained as

$$S_U = Su/\gamma_m$$

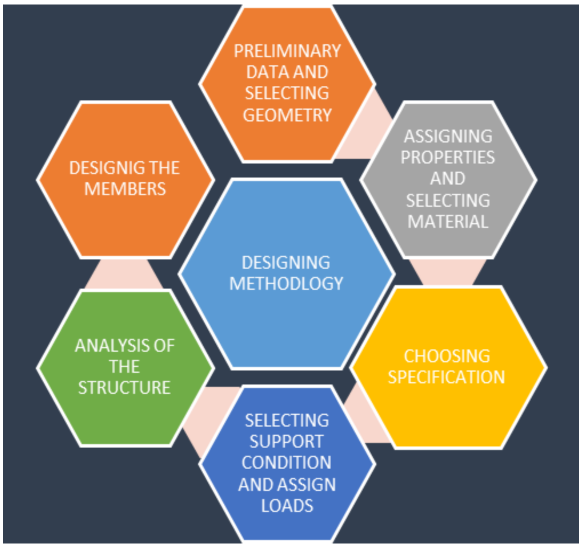

Fig – Design process in the software

2.2 SPECIFICATION –

Table 1 - Structure specification

01	The span of the PEB	40 m
02	Spacing of the PEB frame	7.6 m
03	Height of column	5 m
04	Length of building	91 m
05	Rise of the PEB	7 m
06	Slope of the roof (ϴ)	10 degree
07	Length along the sloping roof	20. m
08	Length of each panel (c/c spacing of purlin)	7.6 m
09	Spacing of gable from PEB frame	7.4 m

2.3 MATERIAL REQUIRED

Table 2 -Material List by frame Section Property

TABLE: Frame Section Property Definitions - Steel I/Wide Flange								
Name	**File Name**	**Section in File**	**Total Depth**	**Top Flange Width**	**Top Flange Thickness**	**Web Thickness**	**Bottom Flange Width**	**Bottom Flange Thickness**
			mm	mm	mm	mm	mm	mm
col_400			400	300	16	8	300	16
col_750_depth			750	350	16	8	350	16
ISLB600	Indian	ISLB600	600	210	15.5	10.5	210	15.5
ISWB550	Indian	ISWB550	550	250	17.6	10.5	250	17.6
mem_1_high_depth_800			800	350	16	8	350	16
mem_1_low_depth_700			700	300	16	8	300	16
mem_2_high_depth-900			900	300	30	12	300	20
SteelBm			500	166.7	12.5	6.3	166.7	12.5
SteelCol			500	500	25	12.5	500	25

Table -

Section	Object Type	No of Pieces	Length	Weight
			m	kN
member_700mm	Beam	34	154.098	166.0928
mem_1_prismatic_800mm_to_700mm	Beam	22	147.3982	173.1145
member_2_prismat_700mm_to_900mm	Beam	22	147.3981	227.7299
Column 400mm	Column	21	138.6	133.8249
Column middle	Column	26	130	124.8399
member_3_900_to_700	Beam	22	73.6992	113.8653
ISMC	Beam	104	791.54	273.43
ROD50	Beam	36	366.54	16.72
ROD50	Brace	12	109.83	5.08

2.4 LOADS CALCULATION –

Dead load – Dead load is calculated using Indian code 875 part 1

Member's Dead load-

There are two frames in the section -

1) Gabble end frame
2) main frame or center span frame

- Dead Load - the members in the main frame consist of members of various sizes from rod section to non-prismatic members consisting = 3.1 KN/m
- Dead Load in the End frame- Gabble Ends = 1.4 KN/m
- Loads from different parts such as sheets, purlin, HVAC fitting,

Solar panel etc. = 40.0 Kg/m^2

These loads are either calculated using IS 875 part 1 then assign to the members or codes can be selected when designing the structure and weight can be assigned using self-weight option.

Live load - Live loads can be calculated using Indian code 875 part 2

Live Loads on members – area on which live load acts is 2600 sqm2

Live load/unit area = 75.00 Kg/m^2

Dead Load center span = 5.5 KN/m

Dead Load Gable End Span = 3 KN/m

Wind load – For calculating the wind load we used IS 875 part 3

Vb = 33 m/s
V_z Is given by $V_z = V_b \times K_1 \times K_2 \times K_3 \times K_4$
$(P_z) = 0.6 \times V_z^2$
$P_d = P_z \times K_d \times K_a \times K_c$
K_d = 0.9 Clause 7.2.1
K_a =0.80 Clause 7.2.2
K_c = 0.90 Clause 7.3.3.13

$K_d \times K_a \times K_c$ = 0.648 > 0.7
P_d = 0.457 KN/m2

Pressure Coefficients is taken from IS 875 part 3 using the following values
Percentage Area of the Opening = 9.65% (Between 5% to 20%)
Enclosure condition = **Partially Enclosed**

External Pressure Coefficient – Use table 4 from IS: 875 part 3

Earthquake load – Earthquake load can be calculated using Indian standard code 1893 –

To calculate earthquake load according to Indian standard follow IS 1893 part 1.

a) Find zone for the structure
b) The structure is steel building with ordinary moment resisting frame and response reduction factor for the structure is 3
c) Importance factor - 1
d) Soil type – medium soil
e) Structure type – Steel MRF Buildings
f) Damping ratio -5%
g) Periodic acceleration in time period – 0.32 sec
h) First calculate seismic weight – follow clause 7.3.1 table 8 IS: 1893 part 1
i) Calculate fundamental – clause 7.6.2 of IS: 1893 part 1

$$T = 0.09h/\sqrt{d}$$

$$A_h = \frac{ZI}{2R}\frac{S_a}{g}$$

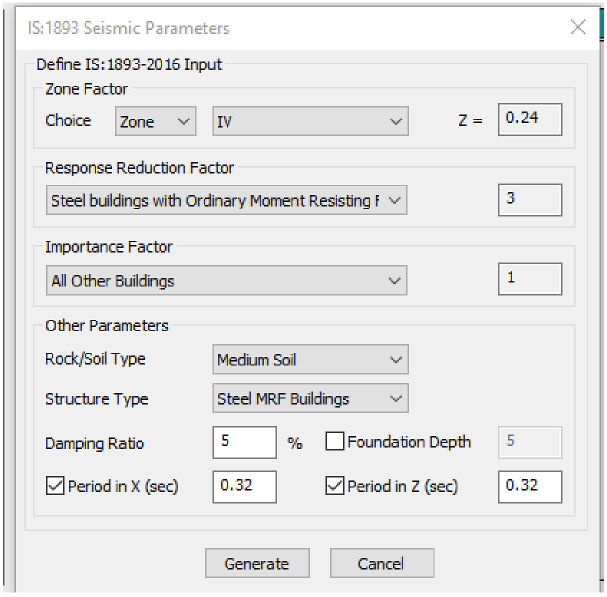

Fig- Defining seismic load for the structure in Staad pro

Design base shear – follow clause 7.5.3 of IS: 1893 part 1

$$V_B = A_h W$$

3. RESULT –

Following result are compaired with each other-

3.1 SUPPORT REACTION

Table – Support reaction result from Staad Pro

	Horizontal		Vertical
	Fx kN	Fz kN	Fy kN
Max Fx	88.44	0.084	130.07
Min Fx	-88.43	0.083	130.10
Max Fy	0	0.001	313.436
Min Fy	-0.04	-4.61	-6.452
Max Fz	-0.015	14.723	21.973
Min Fz	-0.024	-14.73	36.62
Max Mx	20.784	0.056	48.817
Min Mx	20.784	0.056	48.817
Max My	20.784	0.056	48.817
Min My	20.784	0.056	48.817
Max Mz	20.784	0.056	48.817
Min Mz	20.784	0.056	48.817

Table- Support reaction by Etabs

TABLE: Base Reactions			
Output Case	**FX**	**FY**	**FZ**
	kN	kN	kN
Dead	0.0	0.0	181.3
Live	0.0	0.0	27.6
1.5(DL+LL)	0.0	0.0	82.4
1.2(DL+LL+WL1)	-36.6	0.0	59.9
1.2(DL+LL+WL2)	13.9	0.0	39.6
1.2(DL+LL+WL3)	0.0	5.0	41.6
1.2(DL+LL+WL4)	0.0	-0.2	61.9
1.5(DL+LL+WL1)	-45.7	0.0	33.4
1.5(DL+LL+WL2)	17.6	0.0	8.0
1.5(DL+LL+WL3)	0.0	0.0	105.6
1.5(DL+LL+WL4)	0.0	0.0	36.0
0.9(DL)+1.5WL1	-45.7	0.0	170.2
0.9(DL)+1.5WL2	17.4	0.0	-83.3
0.9(DL)+1.5WL3	0.0	0.0	-58.5
0.9(DL)+1.5WL4	0.0	0.0	19.5

3.2 Beam End Forces

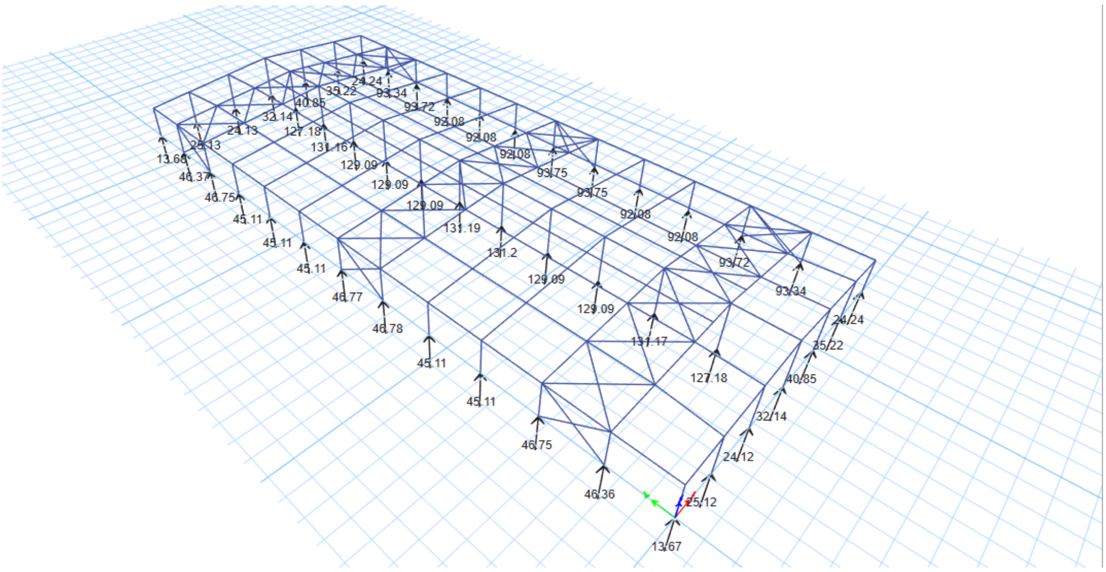

Fig -1: support reaction using etabs

TABLE – Beam End forces by staad Pro

	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	313.436	0	0.001	0	0	0
Min Fx	-14.427	-0.017	0.149	-1.2	1.498	-0.215
Max Fy	57.543	158.13	0	-0.001	-0.004	523.103
Min Fy	57.543	-158.13	0	0.001	-0.004	523.105
Max Fz	0.839	4.892	5.04	0.038	-7.611	3.625
Min Fz	2.139	8.111	-5.04	-0.038	9.273	9.017
Max Mx	0.697	6.392	2.116	1.923	8.024	3.288
Min Mx	0.957	-3.791	-2.116	-1.923	9.442	-0.124
Max My	0.418	3.837	-0.406	1.409	14.448	1.97
Min My	0.699	6.372	0.408	-1.409	-14.64	3.28
Max Mz	57.543	-158.13	0	0.001	-0.004	523.105
Min Mz	150.85	72.991	0	0	0	-364.957

Table – Beam End forces by ETABS

TABLE - BEAM END FORCES						
Type	**P**	**V2**	**V3**	**T**	**M2**	**M3**
MAX P	67.4950	-145.7338	-0.0008	-0.0070	-0.0035	-343.5496
MIN P	-83.1259	1.5565	0.0000	0.0000	0.0000	0.8301
MAX V2	2.5212	165.1478	-0.0089	-0.0059	0.0172	-497.4287
MIN V2	5.2157	-146.0349	-0.0009	-0.0070	-0.0035	-344.7351
MAX V3	21.9101	116.2113	0.0156	0.0059	0.0222	-52.3802
MIN V3	14.5278	116.2113	-0.0156	-0.0059	-0.0222	-52.3802
MAX T	5.9496	-146.0348	0.0008	0.0070	0.0035	-344.7346
MIN T	13.0919	-146.0349	-0.0010	-0.0070	-0.0034	-344.7351
MAX M2	-28.3501	0.4330	0.0082	-0.0034	0.0313	5.5319
MIN M2	-2.1094	-0.4330	0.0082	0.0000	-0.0313	5.5319
MAX M3	5.1489	4.6209	0.0013	0.0050	-0.0024	348.2012
MIN M3	4.6765	165.1477	0.0112	0.0059	-0.0198	-497.4299

3.3 JOINT DISPLACEMENT RESULT

TABLE – Joint displacement by Staad Pro

	X mm	Y mm	Z mm	Resultant mm	rX rad	rY rad	rZ rad
Max X	9.627	-14.42	-0.127	17.339	0	0	-0.001
Min X	-9.62	-14.42	-0.128	17.34	0	0	0.001
Max Y	-5.568	25.13	0.012	6.109	0	0	0
Min Y	2.65	-24.5	-0.03	24.657	0	0	-0.01
Max Z	0.003	-0.037	29.561	29.561	0.004	0.002	0
Min Z	0.004	-0.061	-29.836	29.836	-0	-0	0
Max rX	1.2	-10.487	5.231	11.781	0.046	0.005	-0.001
Min rX	1.202	-10.502	-5.268	11.81	-0.05	-0.01	-0.001
Max rY	0	0	0	0	0.001	0.051	-0.001
Min rY	0	0	0	0	0.001	-0.05	0.001
Max rZ	0.907	-9.266	-0.036	9.311	0	0	0.004
Min rZ	-0.91	-9.264	-0.036	9.309	0	0	-0.004
Max Rst	0.004	-0.061	-29.836	29.836	-0	-0	0

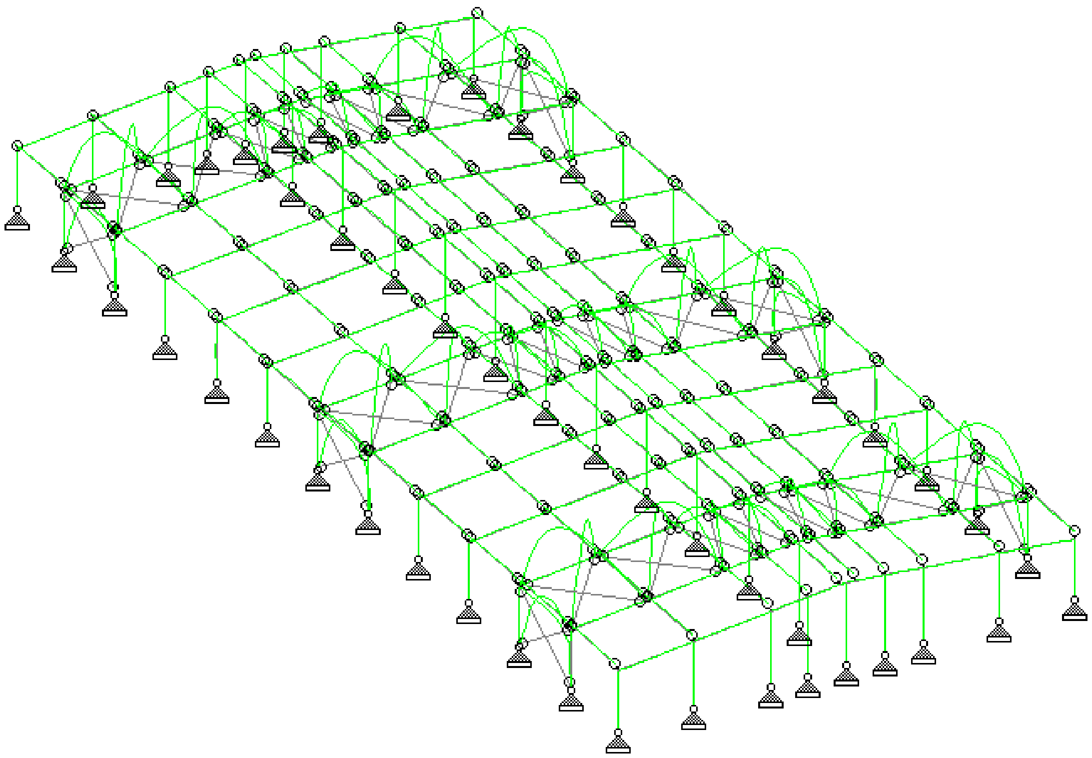

Fig – Displacement diagram result using Staad Pro

Table – Joint displacement by ETABS

TABLE: Joint Displacements						
Type	**Ux**	**Uy**	**Uz**	**Rx**	**Ry**	**Rz**
	mm	mm	mm	rad	rad	rad
MAX X	9.107	-0.001	-15.18	-0.000556	0.001083	-0.000056
MIN X	-9.107	-0.001	-15.18	-0.000556	-0.001083	0.000056
MAX Y	-2.909E-07	27.712	-0.417	-0.003843	8.196E-11	-4.003E-12
MIN Y	-2.909E-07	-27.712	-0.417	0.003843	8.196E-11	3.867E-12
MAX Z	-5.999	-0.371	24.28	0.000072	-0.000955	-0.000037
MIN Z	-2.611	0.003	-24.4	0.000576	-0.002134	-0.000058
MAX Rx	0	0	0	0.005997	-0.000007	-0.000007
MIN Rx	0	0	0	-0.005992	-0.000007	0.000007
MAX Ry	-0.891	-0.0002275	-9.083	-0.000265	0.003336	0.000027
MIN RY	0.891	-0.0002275	-9.083	-0.000265	-0.003336	-0.000027
MAX Rz	0	0	0	-0.001606	-0.000022	0.001883
MIN Rz	-0.002	7.968	-0.026	-0.001572	-0.000039	-0.001883

3.4 RENDERING –

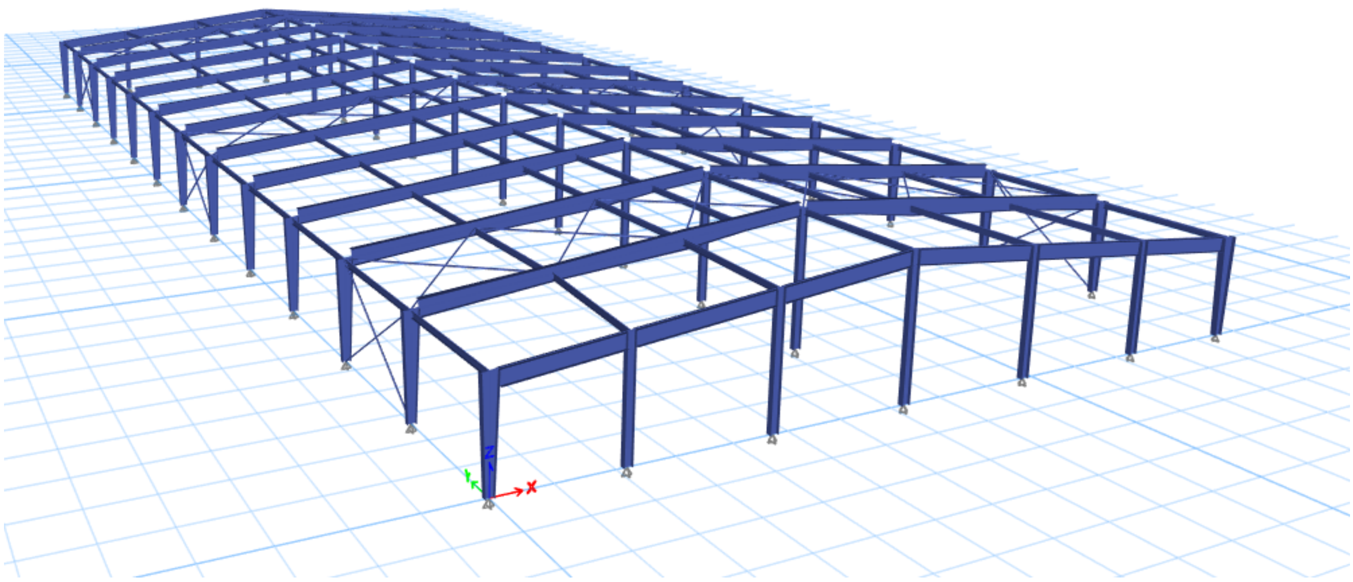

Fig –Render result of PEB structure using ETABS

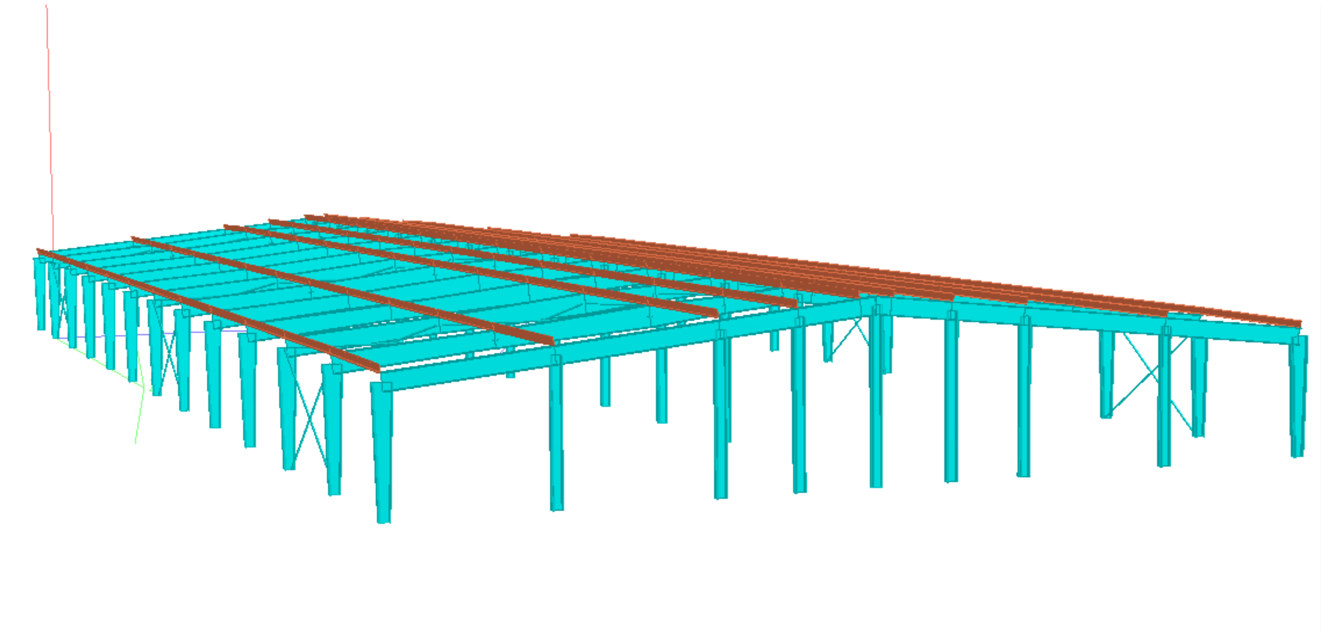

Fig - Render result of PEB structure using Staad Pro

3.5 Moment diagram –

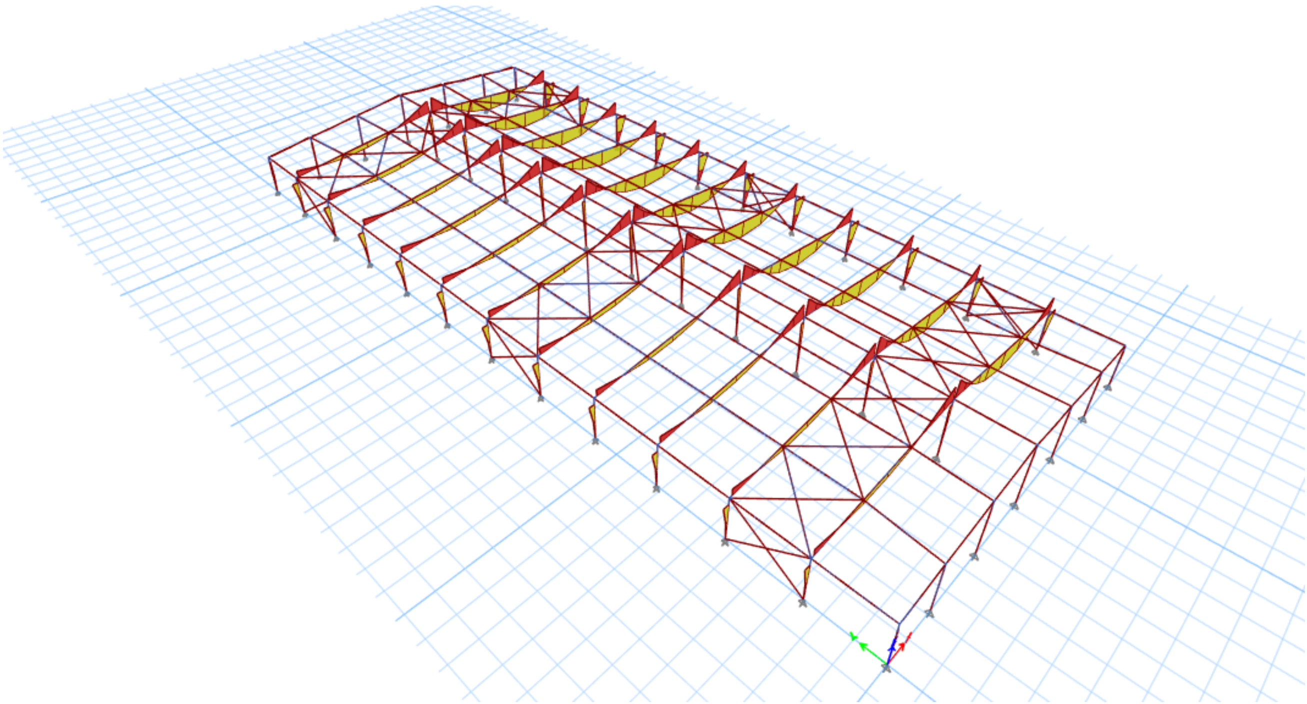

Fig – Bending Moment diagram using Etabs

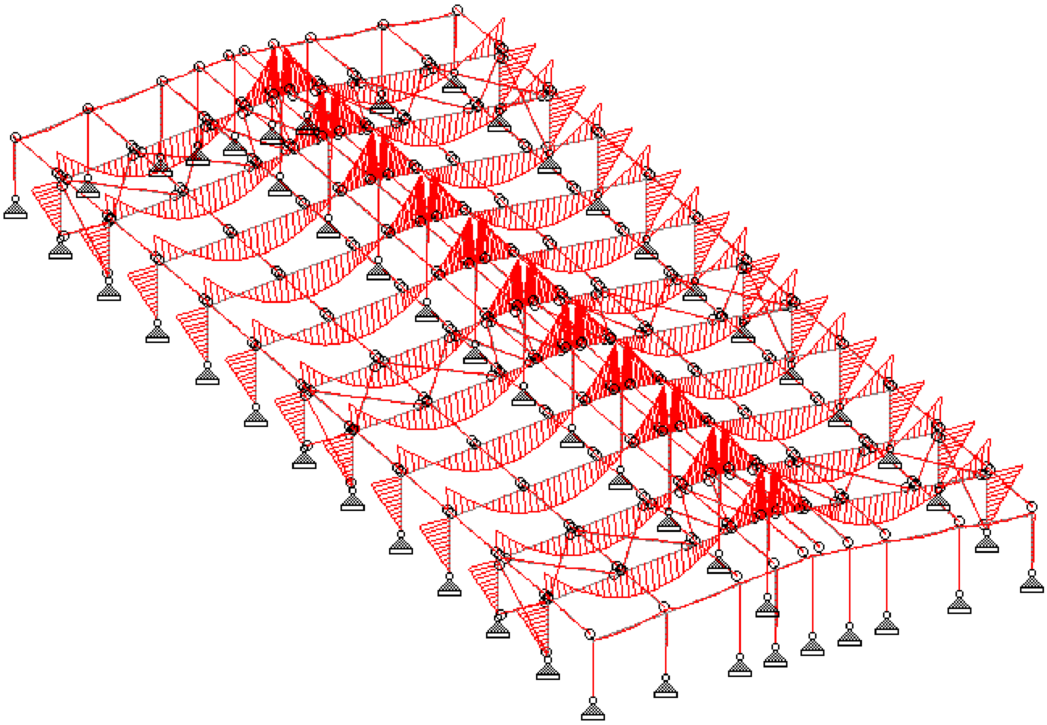

Fig – Bending Moment diagram using Staad pro

3. CONCLUSIONS

- The result given by both the software is not identical but somewhat similar in ± 5 % range.
- The GUI of ETABS software is better but ETABS software doesn't have connection designing capabilities and depend upon other software to do so.
- The Staad Pro have connection designing capabilities and can design Generic connection inside the software using RAM Connection link.
- Both software can transfers data from one software to other.

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