International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Study & Analysis of Pre-Engineering Building with Varying Span

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Abstract - *Today, very need of pre-engineering building in construction field, generally pre- engineering building is construction by steel material so, fabrication work is in factory and erection is very easy and time efficient than conventional steel building and concrete material building. This PEB concept is very useful in the world. Hence in this project we study and analysis of pre-engineering building behavior of bending moment, shear force, dead weight variation of span of pre-engineering building. In this project We have five spans include (23m,25m,27m,29m & 31m), clear height 6m and length 92m constant using STAAD PRO. V8I software. In this project, we have primary member like column and rafter and secondary member cross bracing is design and analysis by STAAD PRO. V8I software and secondary member z purlin, girt (side purlin) and sag rod is manually design. dead load & live load as per (IS-875 part-1&2) and wind load as per is (IS875-2015 part-3).*

***Key Words*:** structure and analysis, wind load, bending moment, shear force, cross section size, dead weight and STAAD pro. v8i

1.INTRODUCTION Pre- engineering building is defined as pre-fabricated and manufacturing by raw material of metal. Today pre-engineering building is most use in our India and other country, now generally use in industry sector. This building is designed by helping of structure engineer because this building can be most use by purpose of economical and cost efficient so, pre-engineering building is analysis of building by structure engineer. this building is design by different element member and are joint or connected by bolt so, it can be easy and low time erection. within geographic industry sector these building also called pre -engineered metal building. pre -engineering building can be used in different accessories like mezzanine floor, canopies, interior, canopies and etc.

pre-engineering building are different as conventional building and cost efficient because pre-engineering building are design and analysis by structure engineer & are most use of calculation of dead load, live load, self-weight live load, wind load and are applied in pre-engineering building member than after analysis of bending moment, shear force, deflections and all member internal stress than after safe of building by optimization of section of member of building. pre-engineering building is generally design by I section so in this analysis of building and mostly condition designed by bending moment so, where bending moment is low so, we can optimization of section of member of building and pre-engineering building economically is generally depends on primary member like column and rafter.

1.1 COMPONENT OF PRE-ENGINEERING BUILDING

1.1.1 PRIMARY MEMBER: vertical member column and vertical member rafter, column & rafter is constructed in rigid main frame and hot rolled steel material used.

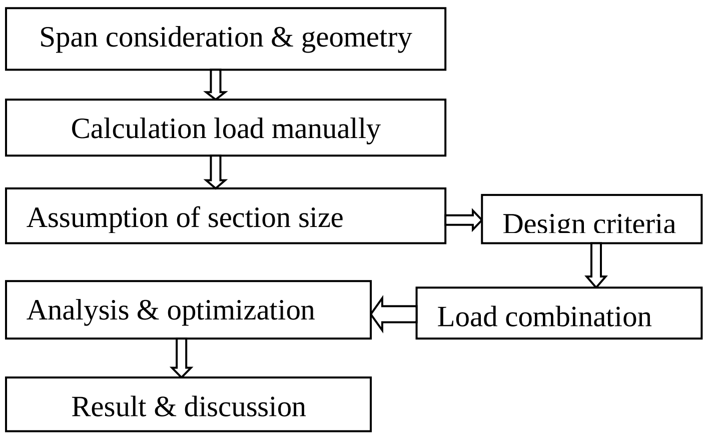
1.1.2 SECONDARY MEMBER: Purlin, girt and cross bracing, purlin & girt cold formed z-section and cross bracing is generally circular hollow or steel rod used.

1.1.3 STRUCTURAL SUNDRY ITEM: anchor bolt, connection bolt, expansion bolt, sheeting fasteners and sag rods.

1.1.4 GALVALUME SHEET: Which are used in roof covering and side wall. 0.47mm thickness for roof covering and 0.50mm thickness for side wall.

METHODOLOGY: In this project, analysis and design of PEB building member are given below

- Column, rafter and cross bracing by STAAD pro. v8i software design
- Purlin & sag rod by manually design by IS800-2007



2.1 GEOMETRY MODEL

TABLE NO. 01 DETAILS OF GEOMETRY MODEL

S. NO.	MODEL NAME	LENGTH	SPAN	HEIGHT	BAY SPACING	WIND COLUMN SPACING	ROOF ANGLE	PURLIN SPACING	AREA
1	23MX92M	92M	23M	6M	7.08M	5.75M	5.71°	1.28M	2116M^2
2	25MX92M	92M	25M	6M	7.08M	6.25M	5.71°	1.25M	2300M^2
3	27MX92M	92M	27M	6M	7.08M	6.75M	5.71°	1.23M	2484M^2
4	29MX92M	92M	29M	6M	7.08M	5.8M	5.71°	1.21M	2300M^2
5	31MX92M	92M	31M	6M	7.08M	6.20M	5.71°	1.29M	2300M^2

2.2 LOAD CALCULATION

2.2.1 DEAD AND LIVE LOAD

Total dead load = 15kg/m^2 =0.15KN/m^2 as per IS CODE 875(PART-1)

Live load= 0.57 KN/m^2 as per IS CODE-875 (part-2)

TABLE NO. 02 DEAD & LIVE LOAD

S.NO.	NAME	FRAME	LOAD (KN/M)
1.	DL	MIDDLE	1.06
2.	LL	MIDDLE	4.03
3.	DL	GABLE	0.53
4.	LL	GABLE	2.01

2.2.2 WIND LOAD

Wind load is greatly affecting the design of steel structure so consideration of wind load is most important during load calculation. Design of wind load done as per IS Code 875 (2015) PART-3.

In this study we consider, in project gable frame wind load is apply half of the middle fame.

Basic Wind speed =39m/s (as per clause ANNEX-A clause no. 6.2 of IS CODE 875 (2015) PART-3)

Design wind pressure = 0.67 KN/M^2 AS PER IS CODE 875 (2015) PART-3

TABLE NO. 03 WIND LOAD

S.NO.	MODEL	FRAME	LOAD IN FACE (KN/M) A	B	C	D	EF	GH
1.WIND LOAD LEFT INTERNAL PRESSURE (WLLIP) 0 DEGREE								
1.	23MX92M	MIDDLE	2.37	2.13	-3.08	3.08	4.39	2.31
2.	25MX92M	MIDDLE	2.37	2.13	-3.36	3.36	4.77	2.51
3.	27MX92M	MIDDLE	2.37	2.13	-3.6	3.6	5.15	2.52
4.	29MX92M	MIDDLE	2.37	2.13	-3.1	3.1	4.43	2.33
5.	31MX92M	MIDDLE	2.37	2.13	-3.3	3.3	4.73	2.49
2.WIND LOAD RIGHT INTERNAL PRESSURE (WLRIP) 180DEGREE								
1.	23MX92M	MIDDLE	-2.13	-2.37	-3.08	3.08	2.31	4.39
2.	25MX92M	MIDDLE	-2.13	-2.37	-3.36	3.36	2.51	4.77
3.	27MX92M	MIDDLE	-2.13	-2.37	-3.6	3.6	2.52	5.15
4.	29MX92M	MIDDLE	-2.13	-2.37	-3.1	3.1	2.33	4.43
5.	31MX92M	MIDDLE	-2.13	-2.37	-3.3	3.3	2.49	4.73
3. WIND LOAD LEFT INTERNAL SUCTION (WLLIS) 0 DEGREE								
1.	23MX92M	MIDDLE	4.26	0.23	-1.54	1.54	2.85	0.77
2.	25MX92M	MIDDLE	4.26	0.23	-1.67	1.67	3.09	0.83
3.	27MX92M	MIDDLE	4.26	0.23	-1.8	1.8	3.34	0.9
4.	29MX92M	MIDDLE	4.26	0.23	-1.55	1.55	2.87	0.77
5.	31MX92M	MIDDLE	4.26	0.23	-1.66	1.66	3.07	0.83
4. WIND LOAD RIGHT INTERNAL SUCTION (WLRIS) 180 DEGREE								
1.	23MX92M	MIDDLE	-0.23	-4.26	-1.54	1.54	0.77	2.85
2.	25MX92M	MIDDLE	-0.23	-4.26	-1.67	1.67	0.83	3.09
3.	27MX92M	MIDDLE	-0.23	-4.26	-1.8	1.8	0.9	3.34
4.	29MX92M	MIDDLE	-0.23	-4.26	-1.55	1.55	0.77	2.87
5.	31MX92M	MIDDLE	-0.23	-4.26	-1.66	1.66	0.83	3.07

5.WIND LOAD GABLET INTERNAL PRESSURE (WLGIP) 90 DEGREE								
S.NO.	MODEL	FRAME	LOAD IN FACE (KN/M)					
			A	B	C	D	EG	FH
1.	23MX92M	MIDDLE	-3.3	3.3	1.92	1.15	3.85	2.83
2.	25MX92M	MIDDLE	-3.3	3.3	2.09	1.25	4.18	2.59
3.	27MX92M	MIDDLE	-3.3	3.3	2.26	1.42	4.52	2.8
4.	29MX92M	MIDDLE	-3.3	3.3	1.94	1.16	3.88	2.4
5.	31MX92M	MIDDLE	-3.3	3.3	2.07	1.24	4.15	2.57
6.WIND LOAD GABLET INTERNAL PRESSURE (WLGIP(-VE)) 270 DEGREE								
1.	23MX92M	MIDDLE	-3.3	3.3	-1.15	-1.92	2.38	3.85
2.	25MX92M	MIDDLE	-3.3	3.3	-1.25	-2.09	2.59	4.18
3.	27MX92M	MIDDLE	-3.3	3.3	-1.42	-2.26	2.8	4.52
4.	29MX92M	MIDDLE	-3.3	3.3	-1.16	-1.94	2.4	3.88
5.	31MX92M	MIDDLE	-3.3	3.3	2.07	1.24	4.15	2.57
7.WIND LOAD GABLE INTERNAL SUCTION (WLGIS) 90 DEGREE								
1.	23MX92M	MIDDLE	-1.41	1.41	3.44	0.38	2.31	0.84
2.	25MX92M	MIDDLE	-1.41	1.41	3.78	0.41	2.51	0.92
3.	27MX92M	MIDDLE	-1.41	1.41	4.07	0.45	2.84	0.94
4.	29MX92M	MIDDLE	-1.41	1.41	3.49	0.38	2.33	0.77
5.	31MX92M	MIDDLE	-1.41	1.41	3.73	0.41	2.49	0.83
8.0WIND LOAD GABLE INTERNAL SUCTION (WLGIS(-VE)) 180 DEGREE								
1.	23MX92M	MIDDLE	-1.41	1.41	-0.38	-3.44	0.84	2.31
2.	25MX92M	MIDDLE	-1.41	1.41	-0.41	-3.78	0.92	2.51
3.	27MX92M	MIDDLE	-1.41	1.41	-0.45	-4.07	0.94	2.84
4.	29MX92M	MIDDLE	-1.41	1.41	-0.38	-3.49	0.77	2.33
5.	31MX92M	MIDDLE	-1.41	1.41	-0.41	-3.73	0.83	2.49

2.3 ASSUMPTION OF CROSS SECTION

For STAAD Pro. analysis firstly we assume the section size of members, this assumed section size given to STAAD Pro. to cross checked that section pass or fail for given loads. If section size is small than requirement, STAAD Pro. warn by show in red color for the particular member. If the section size is sufficient for the given loads than, software shows all members in green color. For purlin, girt & sag rod are design manually & taken same for all models.

2.4 DESIGN CRITERIAS

In STAAD pro. analysis and design of PEB building as per AISC-ASD CODE so, we used of some design parameter.

a. F_Y=350000 KN/M^2 yield strength of steel
b. L_Z=23.12,25.12,27.14,29.14 & 31.16 span of 23m,25m,27m,29m,& 31m respectively rafter length
c. L_Y=1.4 length in local y axis for slenderness value KL/R
d. UNT=1.4 unsupported length of bottom flange for calculate bending capacity
e. UNB=1.4 unsupported length of bottom flange for calculate bending capacity
f. Beam (1) connected to column and rafter in rigid frame
g. Commands: steel takeoff & check code

2.5 LOAD COMBINATION

TABLE NO. 04 LOAD COMBINATION

S.NO.	LOAD - COMBINATION	S.NO.	LOAD - COMBINATION
1.	DL+LL	10.	DL+LL+WLL(IP)
2.	DL+WLL(IP)	11.	DL+LL+WLR(IP)
3.	DL+WLR(IP)	12.	DL+LL+WLL(IS)
4.	DL+WLL(IS)	13.	DL+LL+WLR(IS)
5.	DL+WLR(IS)	14.	DL+LL+WLG(IP)
6.	DL+WLG(IP)	15.	DL+LL+WLG(IP) -VE
7.	DL+WLG(IP) -VE	16.	DL+LL+WLG(IS)
8.	DL+WLG(IS)	17.	DL+LL+WLL(IP)
9.	DL+WLG(IS) -VE		

2.5 ANALYSIS AND OPTIMIZATION

Provide all parameters to design and analysis of PEB building like consideration of all support provides pin support and loads, assume section size, load combination design criteria as per AISC-ASD code and release of moment in wind column and after analysis of bending moment, shear force and utility ratio. Utility ratio is defined design result of section size of member when utility ratio is greater than one member may be overstress and when utility ratio is less than one member is under stress. We know PEB building is design by bending moment. Where bending moment is minimum, section size will be optimized and bending moment is maximum, section size will increase. Hence in PEB building pin support and point of inflection bending moment is zero so, where optimize of section size and in PEB building ridge & rigid joint bending moment is maximum so, increase of section size. In PEB building gable frame is connected to the wind column which reduces the bending moment, due to which the gable frame not optimized and section size is less than middle frame of PEB building.

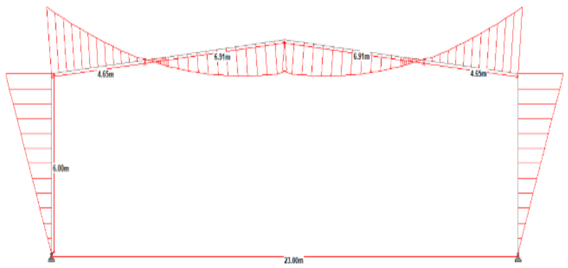


Fig.no.01 B.M. diagram

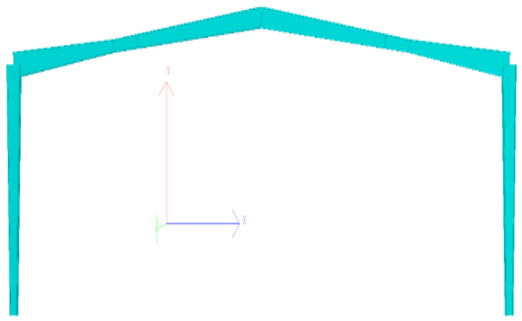
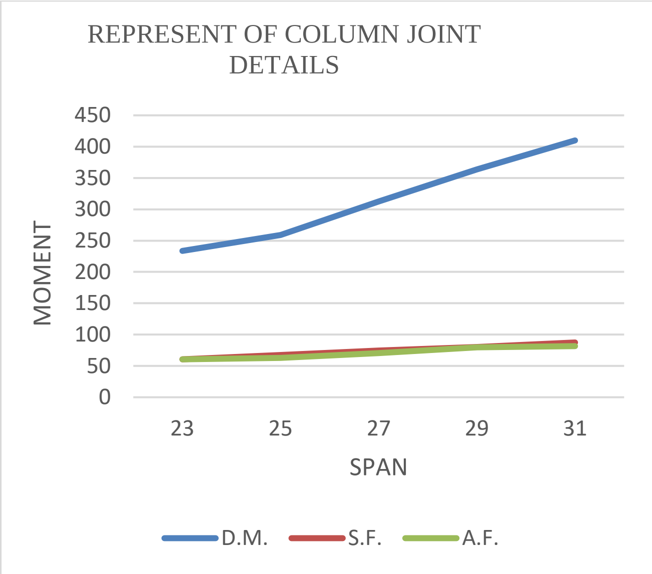


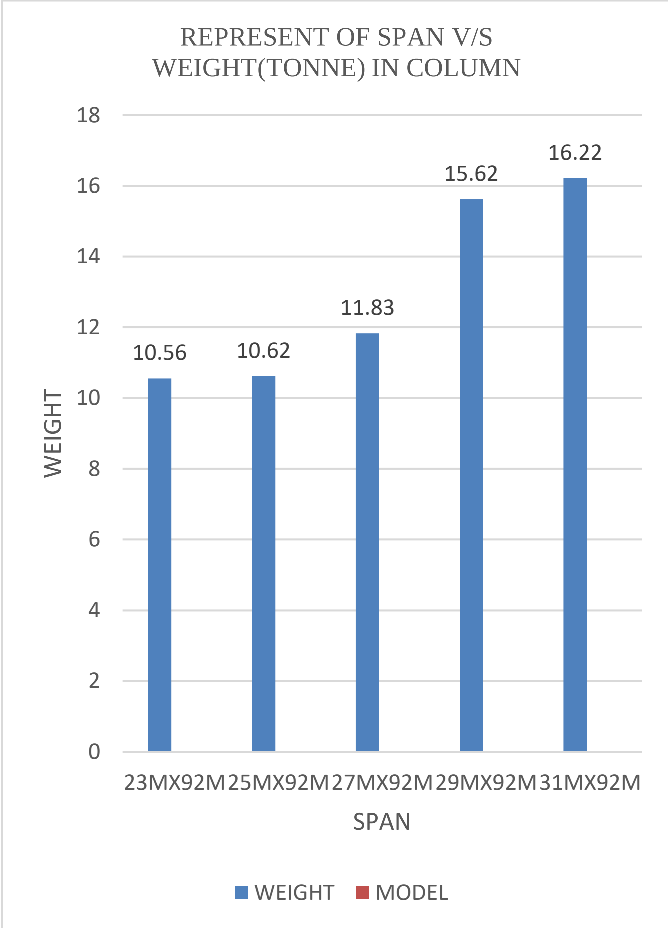
Fig.no.02 optimization diagram

2.6 RESULT AND DISCUSSION

TABLE NO. 05 REPRESENTATION OF COLUMN RESULT

S.NO.	PARTICULAR		MODEL NAME				
			23MX92M	25MX92M	27MX92M	29MX92M	31MX92M
1.	SPAN(M)		23	25	27	29	31
2.	HEIGHT(M)		6	6	6	6	6
3.	MAX. B.M. KN-M	SUPPORT	0	0	0	0	0
		JOINT	233.616	258.994	312.462	363.704	409.945
4.	MAX. S.F. KN	SUPPORT	37.506	43.157	52.060	60.609	68.306
		JOINT	60.589	67.243	74.449	80.136	87.449
5.	AXIAL FORCE(KN)	SUPPORT	63.754	65.992	74.203	84.639	86.636
		JOINT	60.540	62.622	70.405	79.883	81.625
6.	STEEL WEIGHT (TONNE)		10.56	10.62	11.83	15.62	16.22





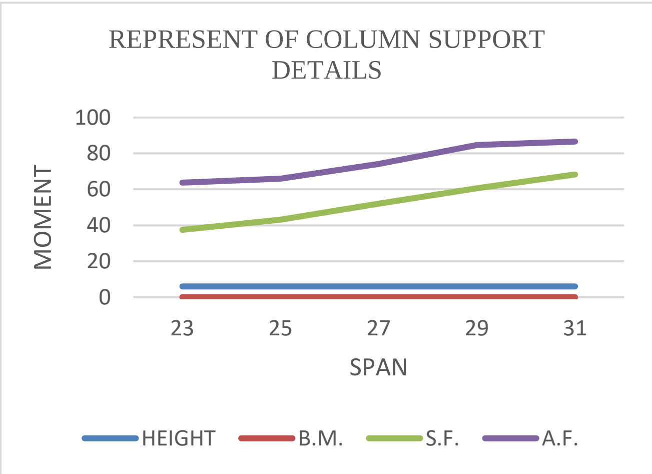
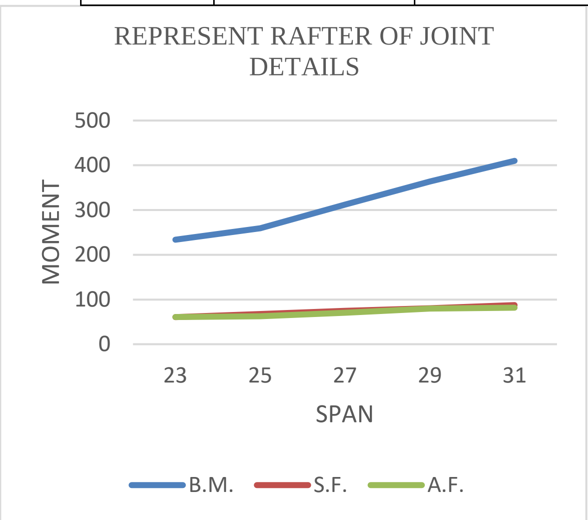


TABLE NO. 06 REPRESENTATION OF RAFTER RESULT

S.NO.	PARTICULAR		MODEL NAME				
			23MX92M	25MX92M	27MX92M	29MX92M	31MX92M
1.	SPAN(M)		23	25	27	29	31
2.	OPTIMIZATION POINT (O.P.) M		4.65	4.78	5.15	5.56	6.22
3.	MAX. B.M. KN-M	JOINT	233.616	258.994	312.462	363.704	409.945
		O.P.	5.058	1.109	4.730	8.008	9.050
		RIDGE	114.749	151.069	175.411	192.102	240.272
4.	MAX. S.F. KN	JOINT	60.589	67.243	74.449	80.136	87.449
		O.P.	34.769	40.705	45.059	47.883	50.819
		RIDGE	3.555	1.793	2.431	3.492	3.698
5.	AXIAL FORCE(KN)	JOINT	60.754	62.622	70.405	79.883	81.625
		O.P.	35.341	39.093	48.826	60.556	70.594
		RIDGE	8.657	7.507	14.397	34.403	23.768
6.	STEEL WEIGHT (TONNE)		14.56	16.86	22.90	29.18	37.59

S.NO.	MODEL NAME	PARTICULAR		DEPTH OF SECTION	WEB THICK	FLANGE SIZE	FLANGE THICK
1.	23MX92M	MAIN COLUMN	SUPPORT	300MM	8MM	240MM	8MM
			JOINT	600MM	8MM	240MM	8MM
		WIND COLUMN		180MM	6MM	180MM	6MM
2.	25MX92M	MAIN COLUMN	SUPPORT	300MM	8MM	240MM	8MM
			JOINT	600MM	8MM	240MM	8MM
		WIND COLUMN		280MM	6MM	180MM	6MM
3.	27MX92M	MAIN COLUMN	SUPPORT	280MM	8MM	240MM	10MM
			JOINT	620MM	8MM	240MM	10MM
		WIND COLUMN		280MM	6MM	180MM	6MM
4.	29MX92M	MAIN COLUMN	SUPPORT	300MM	12MM	240MM	10MM
			JOINT	660MM	12MM	240MM	10MM
		WIND COLUMN		300MM	8MM	200MM	8MM
5.	31MX92M	MAIN COLUMN	SUPPORT	300MM	12MM	240MM	12MM
			JOINT	600MM	12MM	240MM	12MM
		WIND COLUMN		260MM	8MM	200MM	8MM



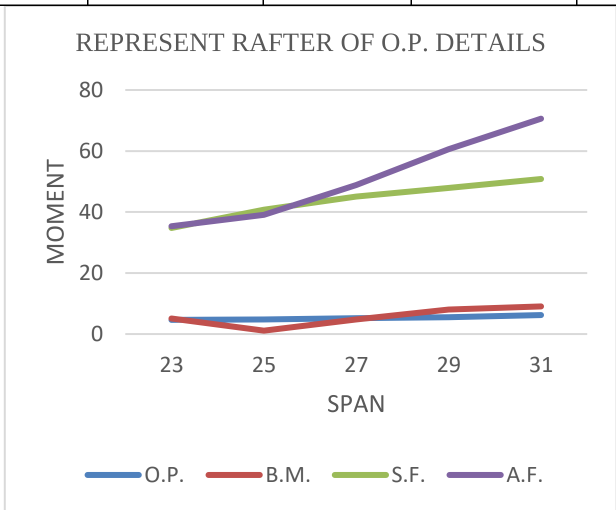
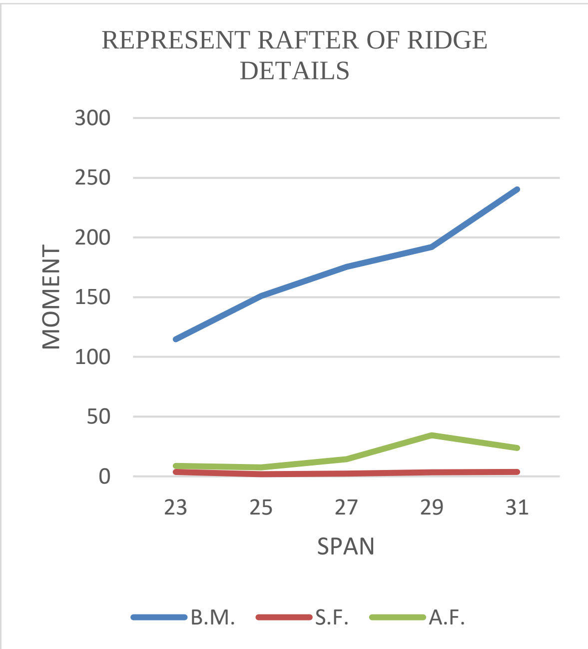
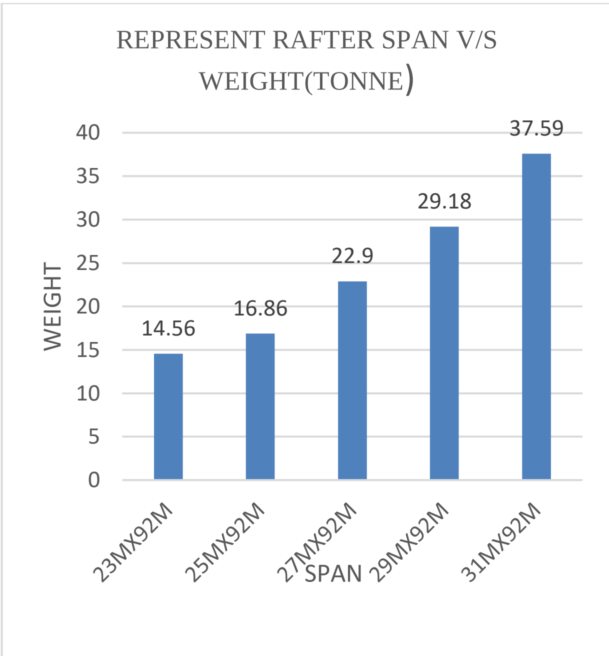


TABLE NO. 07 REPRESENTATION OF COLUMN SECTION SIZE





International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

TABLE NO. 08 REPRESENTATION OF RAFTER SECTION SIZE

S.NO.	MODEL NAME	PARTICULAR		DEPTH OF SECTION	WEB THICK	FLANGE SIZE	FLANGE THICK
1.	23MX92M	MIDDLE RAFTER	JOINT	600MM	6MM	240MM	8MM
			O.P.	280MM	6MM	240MM	8MM
			RIDGE	480MM	6MM	240MM	8MM
		GABLE RAFTER		280MM	6MM	200MM	6MM
2.	25MX92M	MIDDLE RAFTER	JOINT	620MM	6MM	240MM	8MM
			O.P.	300MM	6MM	240MM	8MM
			RIDGE	600MM	6MM	240MM	8MM
		GABLE RAFTER		300MM	6MM	200MM	8MM
3.	27MX92M	MIDDLE RAFTER	JOINT	640MM	8MM	240MM	10MM
			O.P.	300MM	8MM	240MM	10MM
			RIDGE	600MM	8MM	240MM	10MM
		GABLE RAFTER		340MM	6MM	240MM	8MM
4.	29MX92M	MIDDLE RAFTER	JOINT	640MM	10MM	240MM	10MM
			O.P.	400MM	10MM	240MM	10MM
			RIDGE	580MM	10MM	240MM	10MM
		GABLE RAFTER		360MM	8MM	240MM	10MM
5.	31MX92M	MIDDLE RAFTER	JOINT	670MM	12MM	240MM	12MM
			O.P.	409MM	12MM	240MM	12MM
			RIDGE	600MM	12MM	240MM	12MM
		GABLE RAFTER		420MM	12MM	240MM	10MM

TABLE NO. 09 REPRESENTATION OF SECONDARY MEMBER SECTION SIZE

S. NO.	MODEL	SECONDARY MEMBER			
		PURLIN MM	GIRT MM	BRACING MM	SAG ROD
1.	23MX92M	Z200X61X 2.5MM MANULLY	Z200X61X 2.5MM MANULLY	CHS139.7X4.5	12
2.	25MX92M			CHS165.1X4.5	12
3.	27MX92M			CHS165.1X4.5	12
4.	29MX92M			CHS165.1X4.5	12
5.	31MX92M			CHS165.1X6	12

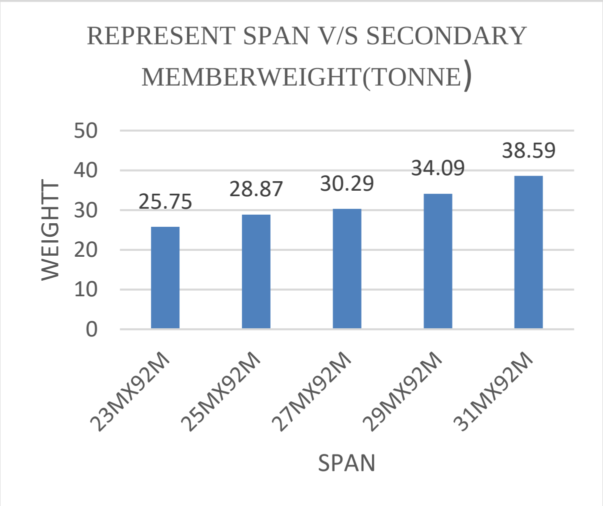
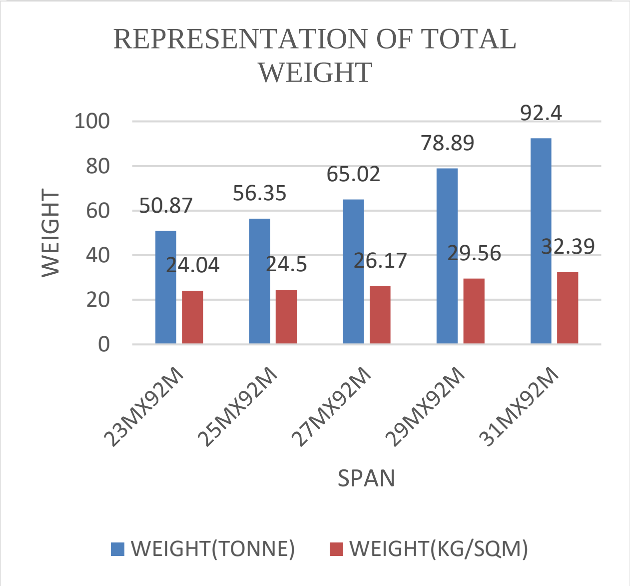


TABLE NO. 10 REPRESENTATION OF SECONDARY MEMBER STEEL WEIGHT (TONNE)

S. NO.	MODEL	WEIGHT(TONNE)				
		PURLIN	GIRT	BRACING	SAG ROD	TOTAL
1.	23MX92M	12.27	4.60	8.08	0.8	25.75
2.	25MX92M	13.50	4.68	9.83	0.86	28.87
3.	27MX92M	14.72	4.76	10.07	0.94	30.29
4.	29MX92M	15.95	4.84	12.30	1.0	34.09
5.	31MX92M	15.95	4.92	16.52	1.20	38.5

TABLE NO. 11 REPRESENTATION WEIGHT OF PEB BUILDING

S.NO.	MODEL NAME	TOTAL WEIGHT(TONNE)	WEIGHT(KG/M^2)
1.	23MX92M	50.87	24.04
2.	25MX92M	56.35	24.5
3.	27MX92M	65.02	26.17
4.	29MX92M	78.89	29.56
5.	31MX92M	92.4	32.39



2.7 CONCLUSION

The general objective of study and analysis was to evaluate varying of load act moment parameter, optimize cross section size and weight to increase the span of PEB building.

- The increase span of PEB structure because of which increase of wind column spacing. We study and analysis in project not provide wind column spacing greater than seven. In project 27m span model wind load in gable and roof panel maximum because wind column spacing in 27mx92m model maximum. Hence design of PEB structure, we should be minimum of wind column spacing.
- Bending moment is direct proportion to span, obviously varying in span because of which increase in stress in the member of PEB building. We analysis in the project varying in span so, point of inflection or optimization point far away from joint of column and rafter.
- Cross section size is Optimize in support and point of inflection because bending moment is zero so, decrease section size and maintain weight of project. secondary member section size like purlin and girt same cross section size use in PEB building Z section mainly used and approximate same size used and section size of bracing is analysis by STAAD software. So variable size used of cross bracing.
- Varying span so increase in total weight of PEB building. weight is mainly dependent on primary member optimization quality and secondary member design is based on suitable spacing of purlin and girt.

2.8 REFERENCE

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