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Effect of Bracing under Different Loading for Conventional and Pre Engineering Industrial Structure

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Abstract*: Industrial building is used to store any manufacturing products. Mostly these buildings are constructed with steel material. Ordinary steel structure are made up of truss as a roofing system with roof top covering, it is called as conventional steel building (CSB). Pre engineering building (PEB) is new type of building framing system adopted in the industrial building, the concepts is steel framing system, supporting members and roof covering are connected each other. Pre Engineering Building (PEB) systems being an alternative to conventional steel building in cost wise. Due to its less in dead weight, industrial building designed for lateral loads. To with stand the lateral load bracing are provided in the industrial structure. The aim of this research work is optimize the bracings for both conventional steel building structure (CSB) and Pre Engineering Building (PEB), analyze the behavior of structure under different loads by using Etabs software. Cost comparison of steel used for CSB and PEB are also studied.

***Index Terms*: Industrial building, bracings, optimization, lateral loads, steel cost.**

I. INTRODUCTION

India is the second fastest growing steel manufacturing industries. In modern construction industries usage of steel quantity is increased in India. Steel is highly ecofriendly and globally used in the world. And steel manufactured products are 100% of recyclable after usable in structure and the advantage of high tensile strength and ductility of the steel material. Steel is mostly used in construction of steel structures or industrial structures with large span. The construction of industrial building has discovered, invented and developed a number of technologies, one of the concepts of pre-engineering buildings. The pre-engineering building is designed by tapered section with different plate sizes and often has with the flanges and web with variable thickness plate or sections based on the internal and external stresses over the section. Pre engineering building are delivered as complete or proper finished products to the site of construction period of structure and supplied by one week of structural framed materials as compared to conventional steel building structure. Pre engineering building has large openings of industrial structures as well as low dead weight of structure. The conventional steel buildings are made by hot rolled sections by heavyweight of material.

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II. LITERATURE REVIEW

Y.M Manjunath [1], he analyzed the industrial buildings with two categories namely normal and simple industrial buildings. Normal industrial buildings consist of simple single-storeyed industrial sheds with or without gantry girders to house workshop. The pre engineering building has lightest possible structure under heavy load without any compromise. Comparison between trapezoidal trusses decreases the axial force in the chord members adjacent at support.

Darshana. P. Zoad [2], brought the suggestion that the PEB is the most economical, low cost and also benefits from faster construction cycle. In PEB system has been speedy, valuable and also save percentage of steel.

A Kailasa Rao [3], the study of steel has the ductile and flexible material. The pre-engineered building (PEB) is fabricated in the steel factory by pre-fabricated the PEB design economically as per the requirements. PEB can be made in many applications like mezzanine floors, canopies, fasciae, interior partition walls, etc. The PEB structure matches the shape of the internal stress (bending moment) diagram and reducing the total weight of the PEB structure.

Swapnil N. Dhandel [4], he analyzed the different types of bracings namely Inverted V Bracing (IVB), Vertical V bracing (VVB) and Cross Diagonal Bracing (CDB), he found that bracing configuration reduce the natural time period of vibration.

T.D. Mythili [5], Pre-Engineered Building involves predesigned and prefabricated. PEB is new technique preferred when the demand for large span needed and good appearance in aesthetic view. Based on the BMD the sections can be varied throughout its length.

B. Meena Sai Lakshmi1 [6], this paper effectively conveys that Pre-Engineered Steel can be easily designed as per IS800-2007 with simple procedure due to its low in weight. Flexible frames and Pre-Engineered Building offer higher resistance to earthquake load. Pre-Engineered steel Building (PEB) concept involves predesigned and prefabricated.

Kavya.Rao [7], The Pre-Engineered Building (PEB) includes the technique of providing the most effective attainable section in line with the optimum demand.

The study is achieved by coming up with associate industrial building exploitation each the ideas and analyzing them exploitation the structural analysis.

Kavita.K.Ghogare1 et al. [8], she is suggest that various types of industrial shed, variety of industrial sheds, hot rolled steel shed. Howe truss is economical other than trusses. This paper suggest suitable configuration of the industrial shed.

B K Raghu Prasad [9], the analysis pre engineering building includes the technique provides the most effective potential section in keeping with the optimum demand. This concept has several benefits over the traditional steel building (CSB). According to that PEB structures square measure a lot of merits compared to CSB structures in terms of value effectiveness, speedy in construction and ease in erection.

Raveesh.R.M [10] he analyzed by PEB structure and studied the effect of bracings in the PEB structure, under wind loads and dampers for earthquake loads. The determine the change in dynamic for those condition in terms of different mass ratio and height by breath ratio. Compare to dampers model with bracing provides more effectiveness in reducing the structural parameters.

Vrushali Bahadure [11], this paper gives a comparison between numerous configurations of a commercial shed. This paper can provide the U.S.A. the appropriate configuration of the commercial shed by creating and scrutiny style and analysis of varied configurations of commercial sheds.

Aditya Dubey [12], he is suggested for pre-engineered building has tapering sections to reduce the excessive steel as per the bending moment's demand. In PEB suggest decrease or increase the depth so strength also varies and at the same time leading to economic structures. The PEB structure provides a clear span; it weighs 10% lesser than conventional steel buildings.

Anitha M [13], she analyzed a double knee braced frames with eccentric bracings and it's without bracings and comparison are made. The total load for double knee bracings is more compared to without bracings with eccentric bracings. For seismic analysis double knee bracing provides better performance. Bearing of ultimate load by double knee bracing is grater compared to without bracing with eccentricity.

. III. OBJECTIVE

1. To model the Conventional Steel Building (CSB) and Pre Engineering Building (PEB) for different bracing by using Etabs software.
2.To analyze the Conventional Steel Building (CSB) and Pre Engineering Building (PEB) for different loads with different bracing by using Etabs software.
3.To optimize the bracing for lateral loads.
4.Result comparison of PEB with CSB structure.

IV. STRUCTURAL MODELLING

As per IS code SP38 for the span 25 m Pratt truss pattern is adopted and used for analyzing Conventional Steel Building (CSB), and for PEB Tapered I section varied in depth is used which is shown in figure 1 & 2. The 3D cross sectional view using different bracing like X-bracing, K-bracing, Diagonal bracing, alternate diagonal bracing, V-type& Inverted V-type bracing for both CSB and PEB shown in figure 3**.** To develop the model the input parameters are taken in account which is shown in Tabel 1.

Tabel 1 Input Parameter for Modeling CSB & PEB

S. No.	Description	Values
1	Building Dimensions	25 m x 48 m
2	Type Of Roofing	G.I Sheet
3	Location Of Building	Pune
4	Bay Spacing	6 m
5	Number of bays	8 No.
5	Wind Speed	39 m/s
6	Roof Slope	1in3
7	Riser Height	3 m
8	Height Of The Column	8 m
9	Purlin Spacing	1.42 m c/c
10	Type Of Truss	Pratt Truss
11	Column Section(CSB)	UC/ISMB
13	Truss Chord Section	RHS
14	Column Section(PEB)	Tapered
15	Rafter Section(PEB)	Tapered
16	No. of Bays	8
17.	Width of the building	25 m

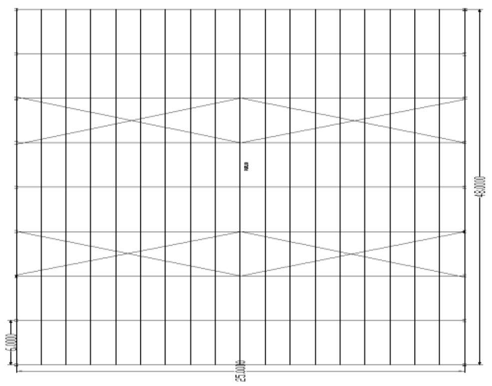


Fig.1 Plan for CSB and PEB Structure

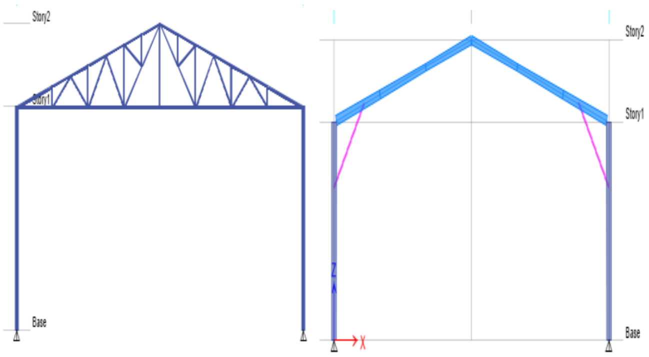
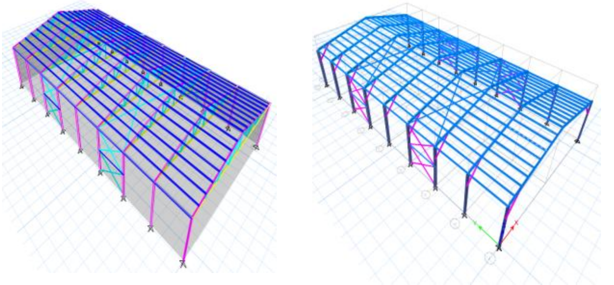
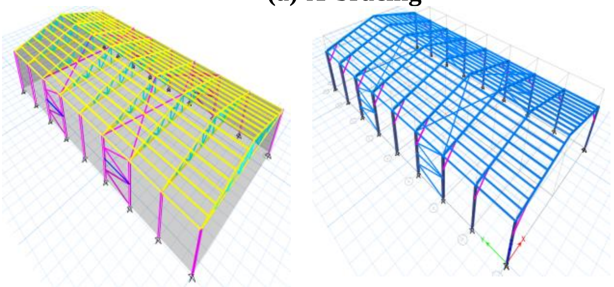


Fig 2 & 3 Model showing Cross sectional view of CSB & PEB structure in Etabs software

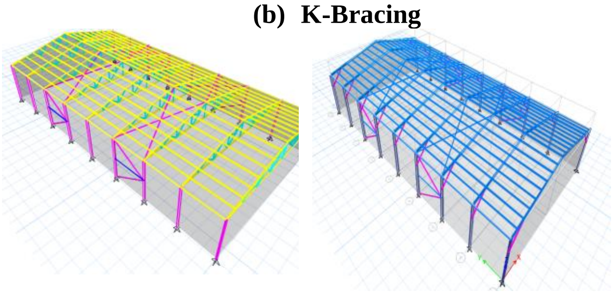
Conventional Steel Building (CSB)	Pre-Engineered Building



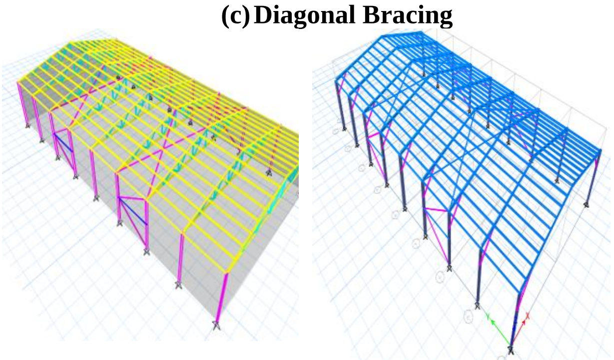
(a) X-bracing



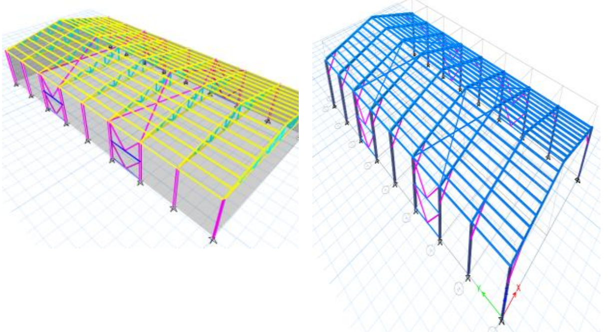
(b) K-Bracing



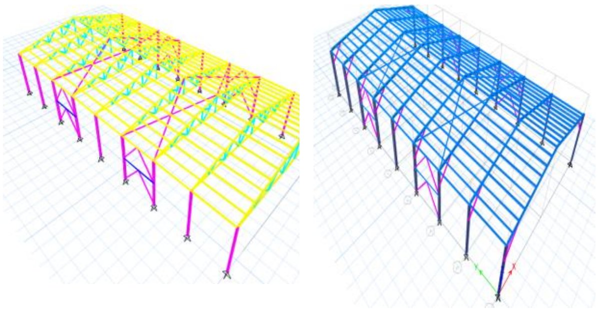
(c) Diagonal Bracing



(d) Alternate diagonal bracing



(e) V bracing



(f) Inverted V bracing

Fig4 (a) to (f) 3D Models showing cross sectional view with different bracings for both CSB and PEB structure

A. *Section Properties of Tapered Section*

The frame of a Pre-Engineering Building modeled by assigning the Tapered sections for rafter is an equal length tapered 2, tapered 3 tapered 4 and tapered 1 for the column shown in fig 4 and section properties shown in table 2.

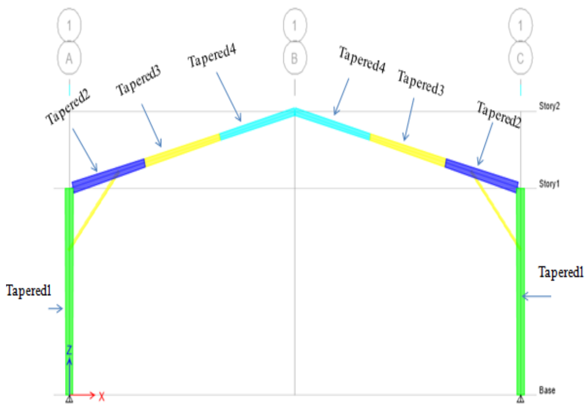


Fig 5 Cross sectional view showing various Tapered Sections assigned for PEB

Table 2 Section Properties of Tapered sections for PEB

Description	Taper1	Taper2	Taper3	Taper4
Depth of section at start node (m)	0.4	0.40	0.35	0.25
Thickness of web (m)	0.0089	0.0081	0.0069	0.0075
Depth of section at end node (m)	0.45	0.35	0.25	0.3
Width of top flange (m)	0.14	0.14	0.125	0.14
Thickness of top flange (m)	0.016	0.0142	0.0125	0.0124
Width of bottom flange (m)	0.14	0.14	0.125	0.14
Thickness of bottom flange (m)	0.016	0.0142	0.0125	0.0124

V.ANALYSIS

The design of CSB and PEB as per IS 800-2007. The Pratt truss is being used as the truss for CSB as from literature reviews it was found that the most economical in analysis of conventional steel building. The Pratt truss chord was designed and analyzed with different sections such as ISA, ISMB, and RHS. The most economized section is then used for CSB's truss chord member. The CSB is then modeled and design for six (6) different bracing such as cross bracing, K bracing, diagonal bracing, alternate diagonal bracing, V is bracing, Inverted V bracing. The PEB is modeled and analysis for the same bracing as above CSB. Both the CSB and PEB will be analyzed for under different loads.

1. *Loads*

Dead; live and wind loads used for analysis as per IS875 I, II, and III respectively shown in table 3. Internal pressure coefficient (Cpi) = ± 0.5 (assuming 20% wall area opening) and external pressure coefficient taken for the wind analysis shown in table 4. Earthquake Load, taken for analysis as per the Zone – III, R = 5 (Steel structure), I = 1 Z=0.16 T_a= 0.2 sec. Soil Type- Medium $\frac{Sa}{g}$=2.5 damping=5% A_h=0.05

Table 3 Loads used for analysis

Type of Loads	Load Intensity	IS code
DL	0.48 kN/m	IS875-I
LL	2.76 kN/m	IS875-II
WL	39 m/s	IS875-III
EL	As per IS1893	

Design wind speed= V_z = 34.32 m/s

Design wind pressure (P_z) = 0.707 kN/m^2

Internal pressure coefficient (Cpi) = ± 0.5 (assuming 20% wall area opening)

Wind load = (Cpe ± Cpi) x P_z x bay spacing along length

Table 4 External pressure coefficient (Cpe)

Angle	Roof		Wall	
0°	-0.72	-0.4	0.7	-0.25
90°	-0.8	-0.6	-0.5	-0.5

2. *Load Combinations*

1. 1.5(DL+LL)
2. 1.2(DL+LL)+0.6(WLP)
3. 1.2(DL+LL)-0.6(WLN)
4. 1.2(DL+LL+WLP)
5. 1.2(DL+LL-WLN)
6. 1.5(DL+WL)
7. 1.5(DL-LL)
8. 1.2(DL+LL+EQLP)
9. 1.2(DL+LL-EQLN)
10. 1.5(DL+EQL)
11. 1.5(DL-EQL)

VI. RESULT ANALYSIS AND COMPARISON

A. *Comparison of Weight*

Whole structural weight of conventional steel and pr-engineering building showing that graphically and also get the comparison between two buildings is a minimum weight of X-Type bracing for conventional building and the minimum weight of V-Type bracing. If two comparisons conclude that PEB reducing steel quantity given table 5 and graphical representation shown in fig 6.

Table 5 Weight comparison for the sections used for CSB and PEB structure

Type of bracing	CSB (Tons)	PEB (Tons)
X-Bracing	39.35	35.77
K-Bracing	38	35.2
Diagonal	38.25	33.34
Alternate Diagonal	37.95	33.54
V-Type	37.08	30
Inverted V-Type	37.68	32.12

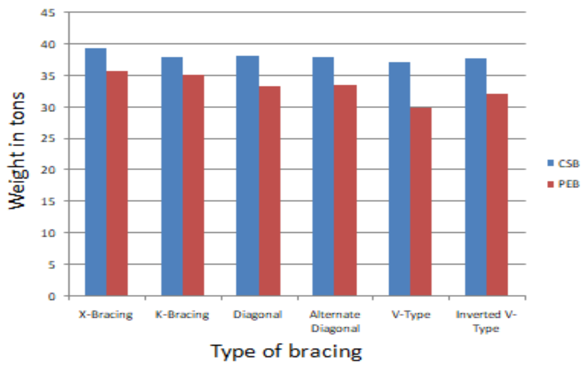


Fig 6 Weight vs. Type of bracings for both CSB and PEB

B. *Natural Time Period*

The natural time period of a building is the time taken by it, to undergo one complete cycle of oscillations. It is an inherent property of building controlled by its mass (m) and stiffness (k) so that pre-engineering building reducing steel quantity as well as the whole weight of building as compared to conventional steel building, therefore, the time period of CSB is 0.5 sec and PEB is 0.32 sec. In this result PEB building reducing vibration as well as oscillations to gives great resistance capacity than CSB. Details shown in table 7 and graphically representation shown in fig 6

Table 7 Time period taken for CSB and PEB structure

Type of bracing	CSB (Sec)	PEB (Sec)
X-Bracing	0.56	0.432
K-Bracing	0.538	0.408
Diagonal bracing	0.623	0.568
Alternate Diagonal bracing	0.613	0.44
V-Type bracing	0.50	0.32
Inverted V-Type bracing	0.52	0.38

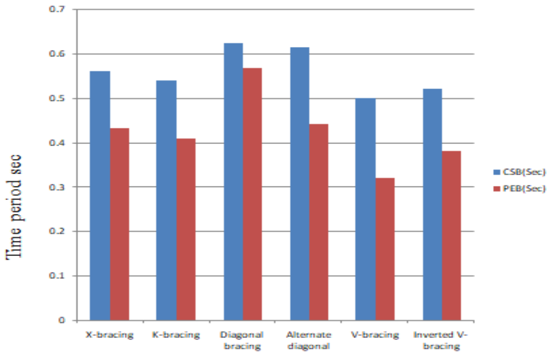


Fig 7 Time period vs. Type of bracings for both CSB and PEB

C. Base Shear

Base shear is the maximum lateral force that will occur due to seismic acceleration at the base of the structure. The base shear depend input seismic acceleration and weight of structure. Base shear obtained for different bracing shown in table 8 and Fig 7 shows the variation of base shear for different bracings

Table 8 Base shear for both CSB and PEB structure

Type	CSB(kN)	PEB(kN)
Cross bracing	15.72	8.78
K bracing	14	8.8
Diagonal bracing	15.63	8.74
Alternate diagonal	15.63	8.74
V bracing	13.2	7.5
Inverted V bracing	14.2	8.32

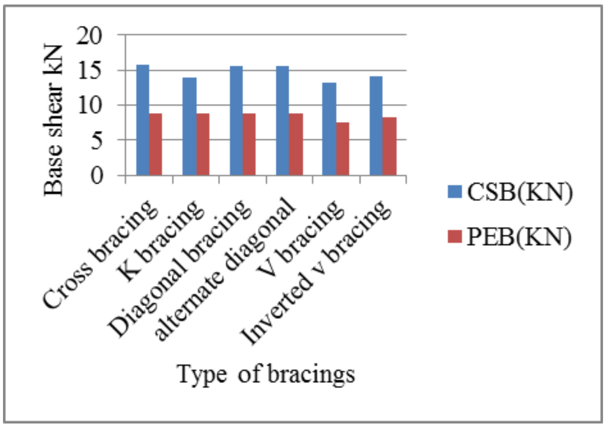


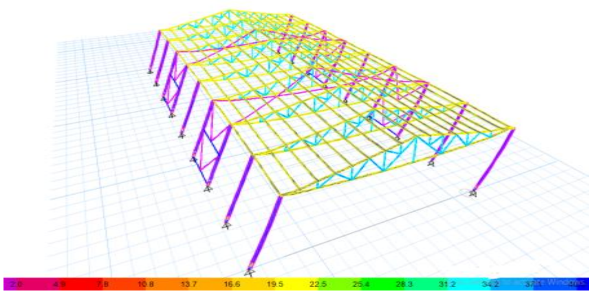
Fig 7Base shear vs. Type of bracings

D. Displacement

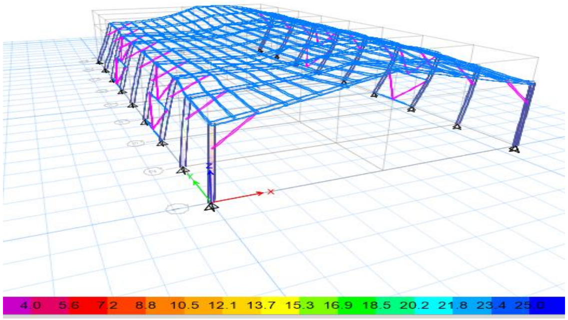
The models are analyzed with cross bracing, K- bracing, diagonal bracing, alternate diagonal bracing, V-type bracing, inverted V-type bracing to avoid high displacement. First the structures were to be analyzed with none bracing than the displacement of the structure once the wind load hits at 90° are going to be on the far side and result in the failure of the structure. Therefore it is suggested to go with bracing since the roof and the ridge cannot alone provide rigidity to the structure especially for Knee bracing of PEB the ridge of the tapered frame can fail simply for any slight lateral force. The structures were analyzed for wind loads at 0° and wind loads at 90°. When the wind acts at 0° the significant displacement is prevented by the columns and truss chords of CSB or by tapered structures in case of PEB, however the Knee bracings and wind bracings of PEB also helped in the functioning of the structure effectively and also due to reducing wind effects and lateral earthquake force means that reduces displacement of structure. When wind load acts at 90° the bracing plays a significant role in preventing displacement of the members. Displacement obtained for different bracing shown in table 9 and Fig 8 shows the variation of displacement for different bracings.

Table 9 Displacement both CSB and PEB structure

Type Of Bracing	CSB (mm)	PEB (mm)
X-Bracing	52.6	50.4
K-Bracing	45.06	40.2
Diagonal bracing	43	34
Alternate Diagonal bracing	43.36	35.33
V-Type bracing	**36.36**	**30.2**
Inverted V-Type bracing	48.45	46.2



(a)



(b)

Fig 9 (a) & (b) Displacement for both CSB and PEB using V-Bracing

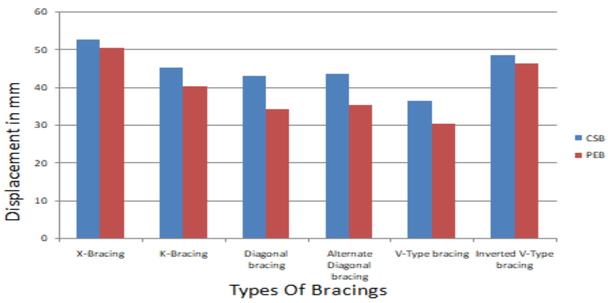


Fig 10 Displacement vs. Type of bracings

VII. DISCUSSION

For the usage of the section for the most economical members for the truss chord member, it's found that RHS and ISA for the inner and outer chord.

It is found that ISLC/ISA, UC (Universal Column), and RHS (Rectangular Hollow Section) and ISLC. Sectional property RHS is found to be economical with section weight of 9.82kg. Knee bracing property ISLB is a lightweight good resistance property for the deflection of a structure.

An economic analysis is found that in the percentage of steel,

1. Percentage of weight increased in CSB as compared to PEB in cross bracing is 9.1%.
2. Percentage of weight increased in CSB as compared to PEB in K bracing is 9.2%.
3. Percentage of weight increased in CSB as compared to PEB in Diagonal bracing is 8.7%.
4. Percentage of weight increased in CSB as compared to PEB in alternate diagonal bracing is 8.8%.
5. Percentage of weight increased in CSB as compared to PEB in V bracing is 7.1%.
6. Percentage of weight increased in CSB as compared to PEB in inverted V bracing is 8.5%.
7. The maximum displacement among PEB is obtained when cross bracing and minimum displacement is observed by V bracing.
8. The maximum displacement among CSB is obtained when cross bracing and minimum displacement is observed by also V bracing.

The maximum deflection located in the structure of ridge and rafter that is wind load is obtained by a front of the structure by the angle of 90° and earthquake load considerable at maximum displacement at whole structure**.**

Technical analysis is found that,

1. Percentage of base shear increased in CSB as compared to PEB in V bracing is 5.68%.
2. Percentage of time period increased in CSB as compared to PEB in V bracing is 6.4%.
3. Percentage of displacement in CSB as compared to PEB in V bracing is 8.3%.

VIII. CONCULSION

1. The analysis of pre-engineering building is the most economical than a conventional steel building.
2. The pre-engineering building gives an aesthetic and good appearance view of the structure.
3. The used knee bracing in pre-engineering building its gives more resistance of deflection of a structure.
4. The pre-engineering building reduces steel quantity, always the reduction of dead load of the structure.
5. The reduction of weight of structure for pre-engineering building also reduces the size of the foundation.
6. The pre-engineering building most effective and economical to arresting different load on structure than a conventional steel building.
7. It is found that pre-engineering building with V bracing comes out to be best suited when economical (reduction of weight) and deflection of the structure.
8. Above the results reduction of the time period of the pre-engineering building than a conventional steel building.

Therefore minimum time period for K bracing of pre-engineering building and maximum time period for K bracing of conventional steel building comparative results.

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