IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 20, Issue 3 Ser. I (May. – June. 2023), PP 12-17
www.iosrjournals.org

Design And Analysis Of Pre-Engineered Aircraft Hanger Using Staad.Pro

Pranay M. Makde[1], Priyanka P. Mengade[2], Dr. K. N. Kadam[3]
B.E (Civil) Student,[1,2] Associate Professor[3] (Dean Applied Mechanics),
Department of Civil Engineering,
Government College of Engineering Nagpur, India

ABSTRACT
Steel structures in India are predominantly conventional type using prismatic hot rolled sections yielding to higher tonnage. Cost of steel is increasing day by day and use of steel has increase in the construction industry. Hence to achieve economic sustainability it is necessary to use steel to its optimum quantity. In steel structure design the Pre-engineering building (PEB) system is a modern technology that provides economical, eco-friendly, and sustainable structures. Pre-Engineered for frames and cold formed sections for purlins and girt which greatly reduces the tonnage resulting in lighter and economical structure. This paper mainly focuses on the present relative study of conventional and PEB steel Aircraft Hanger with the help of finite element-based software STAAD.Pro. Analysis is done using STAAD.Pro software and members are designed manually as per the relevant code requirements and detailing diagrams are executed in AutoCAD.

Keywords: *Pre-Engineered Building (PEB), Conventional steel building (CSB), Structure analysis and Design, STAAD.Pro V8i*

Date of Submission: 28-04-2023 Date of Acceptance: 09-05-2023

I. INTRODUCTION

Steel is one of the most multipurpose commonly used structural materials. The structures that are constructed with structural steel are called steel structures. Pre-engineered building system were introduced in the early 1960's because of high consumption of steel in old structures for instance C.S.B who consumed more quantity of steel as all the members of C.S.B are hot rolled and cost of construction was becoming more and seen to be a heavy structure In P.E.B. all the structural components such as tapered columns and rafters are manufactured in the steel plant itself and directly transported to the proposed site where steel building is to be erected and later roofing, wall sheeting, anchor bolts etc are used coverings and connecting the members with each other. The P.E.B. system takes less time for its erection when compared to C.S.B. and required less skilled labours. In the P.E.B. system tapered columns of I-shape and rafter as an incline beam and flat plates at their ends are used for making bolted connections by providing holes in their ends.

A steel building is a metal structure fabricated with steel for the internal support and for exterior cladding, as opposed to steel framed buildings which generally use other materials for floors, walls, and external envelope. The main objective of this paper is to optimise steel usage for an Aircraft Hangar and to prepare a report of Pre-Engineered steel building for Aircraft Hangar using STAAD.PRO V8i Software. The objective of this project is also to compare and study the difference in bending moment, reactions and steel take off in PEB.

II. LITERATURE REVIEW

An industrial structure is analysed and designed according to Indian standards. A comparative study between PEB & CSB frames is done and it is observed that PEB structures are more economical. The researches show that PEB structures are easy to design. These structures are more reliable than CSB. The provision of a tapered section in PEB makes it economical and tapering of the section is done as per the bending moment diagram. From all the analyses made it can be concluded that steel consumption in PEB is on average 30% lesser than a conventional steel structure. [1, 2]

Cost comparative study of industrial shed by considering only primary members using C.S.B. and P.E.B. concept and design results have been carried out in detail and given statement that the conventional steel building concept is an old concept and will take lots of time for its construction and erection. To improve the quality and different types of erection methods the concept of pre-engineered building has been used in this research as this P.E.B. concept was introduced in the design industries in the 1990's. Also, it is observed in this design that how much time will the erection process takes for its execution. [3]

The authors explain the utility of the steel is increasing day by day particularly in industrial buildings in the construction industries. Every owner of the industrial buildings wants their structure to be ready for use in less time and want estimated cost very less. [4]

The advantage of P.E.B. as a speedy erection and control over quality and quantity of steel material by using two different code system and a building is designed as a single storey and suggested the P.E.B. is efficient and best alternative to conventional steel structure. In this study a warehouse steel structure is designed and comparison done by using two designed codes by keeping loading parameters similar. [5]

III. METHODOLOGY

History of PEB

Since then, the use of pre-engineered buildings has spread across Asia and Africa, where the PEB architecture concept has been widely accepted and praised. The principle of pre-engineered steel buildings is known as the most flexible and economical building. In civil construction, the economy and speed of delivery and installation of these buildings are incomparable. No other building system can match the pre-engineered building system in terms of speed and cost from excavation to occupation.

Components Of PEB

I. Primary Members: The primary members in a PEB are the primary load-bearing membranes and usually consist of the rigid main structure. Vertical members are called columns and horizontal members are called columns. These are generally members constructed from hot rolled plate.

II. Secondary Members: Cold formed members such as roof purlins, wall beams, eaves struts, etc. are the secondary members in the PEB process. These are called cold formed members as there is no involvement of processes such as cutting, welding, and grinding.

Load Application

I. Dead Load: According to IS: 875 (part 1) - Dead load comprises of self-weight of the structure, weights of roofing, bracings, and other accessories [6].

II. Live Load: According to IS: 875 (Part 2) - for roof with no access provided, the live load can be taken as 0.75 kN/m^2 with a reduction of 0.02 kN/m^2 for every one degree above 10 degrees of roof slope [7].

III. Wind Load: According to IS: 875 (part 3) - The force exerted by the horizontal component of wind is to be considered in the design of buildings, towers etc. The wind force depends upon the velocity of wind, shape, size & location of buildings [8]. Brief idea is given below;

(a) Using colour code, the basic wind velocity 'V_b' is shown in a map of India. Designer can pick up the value of V_b depending upon the location of the structure.

(b) To get the design wind velocity V_z, the following eq.1 shall be used;

$$V_z=k_1\ k_2\ k_3\ k_4\ V_b \qquad \textbf{Eq. (1)}$$

where, k_1 = Risk coefficient factor
k_2 = Coefficient based on terrain, height and structure size
k_3 = Topography factor
k_4 = Importance factor for cyclonic regions

The design wind pressure is given by eq.2,

$$p_d = K_d\ K_a\ K_c\ p_z \qquad \textbf{Eq. (2)}$$

where, $p_z = 0.6\ V_z^2$

p_d = design wind pressure
p_z = wind pressure at height z
K_d = wind directionality factor
K_a = area averaging factor
K_c = combination factor

Wind loading on individual structural members such as roofs, walls, and individual cladding units and their fittings as per IS875 (part 3):2015 as per eq.3,

$$F = (C_{pe} - C_{pi}) * A\ p_d \qquad \textbf{Eq. (3)}$$

where, F = Wind Force,
C_{pe} = external pressure coefficient,
C_{pi} = internal pressure coefficient,
A = surface area of structural element or cladding unit

Analysis using STAAD PRO V8i

Staad ProV8i software was used to analyse and design pre-engineered building structures and conventional structures in this project. For the first structure, a pre-designed 3D construction model of a

WAREHOUSE building was designed and compared to the conventional structure using conventional steel. In the second example, an 88m wide 2D flat structure was designed with conical sections for PEB, this structure cannot be built by the conventional method as it is not feasible and not economical for the project. Different spacings between stalls were considered to verify the most adequate.

Pre-engineered building by STAAD PRO

STAAD proV8i comes with several tools and modes to benefit from a user-friendly interface. Design and analysis can be done side by side to check designs for errors. For PEB design, different dimensions of Conical I sections can be verified for a stable and optimized structure and the same is for conventional steel design, where pre-rolled sections with commercially available dimensions are accessible for design and analysis purposes. STAAD pro software can be used to analyse and design pre-engineered buildings. It can analyse the bending moment, axial forces, shear forces, torsion, beam stresses of a steel structure so that the design can be done using conical sections and check safety. For the current design, the common stiffness matrix method was used for the structure analysis. Used pre-engineered building members are funnelled using the Software's built-in option. The software offers a choice of support options for our requirements. Here in this project, fixed supports are assigned. For the loads, we manually calculated and assigned them to our structure using the correct steps.

IV. DESIGN AND ANALYSIS

Building Parameters

The present study is included in the design of an Aircraft Hanger structure located at Mumbai. The structure is proposed as a Pre-Engineered Building of 79.3 meters width, 10 bays each of 7.93 meters length and an eave height of 27meters as shown in figure 1. In this study, a PEB frame of 79.3-meter width is taken into account and the design is carried out by considering wind load as the critical load for the structure. The designs are carried out in accordance with the Indian Standards and by the help of the structural Analysis and design by software Staad ProV8i.

Table 1: Building Parameters for the structure

Type of building	Aircraft Hanger
Location	Mumbai
Length	84.8m
Width	79.3m
Eave Height	27m
Bay Spacing	7.93m
Number of bays	10
Roof Slop	1 in 10
Basic wind speed	44m/s

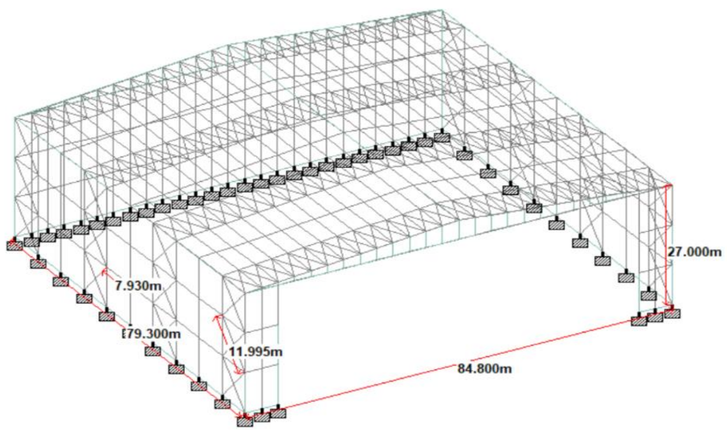


Fig.1: 3D Model of Aircraft Hanger

Load Calculation

1) Dead load Weight of sheeting = 5 kg/m^2
   Weight of purlin = 4.12 kg/m^2

Weight of sag rod, bracing, clips etc = 5.75 kg/m^2
Total = 15 kg/m^2
So, dead load = 0.15 KN/m^2
Dead load on frame = 0.15 * 7.93 = 1.1895 KN/m
Dead load on end frame = 0.59475 KN/m

Collateral Load
Load = 25 kg/m^2
Collateral load on frame = 0.25 * 7.93 = 1.9825 KN/m
Collateral load on end frame = 0.99125 KN/m

Live Load
Live load for non-accessible roof = 0.75KN/m2
Live load on frame = 0.75 * 7.93 = 5.9475 KN/m
Live load on end frame = 2.9375 KN/m

Wind Load
$\mathbf{V_z = k_1\ k_2\ k_3\ k_4\ V_b}$
$k_{1\ =\ 1,}$ k_2 =1.105, k_3 = 1, k_4 = 1.15, V_b= 44 m/s
So, V_z = 55.913 m/s
$\mathbf{p_z = 0.6\ V_z^2}$
So, p_z = 1.88 KN/m^2
K_d = 1, K_a = 0.8, K_c = 0.9
$\mathbf{p_d = K_d\ K_a\ K_c\ p_z}$
So, p_d = 1.35 KN/m^2
NOTE: The Value of pd, however shall not be taken as less than 0.70 p_z.

V. RESULT AND DISCUSSIONS

From the above analysis the following result is obtained, The optimise steel usage for an Aircraft Hangar is obtained which is given in table 2. And Max shear force and max bm on a particular frame in x-y-z direction are given in table 3. According to AISC code unity check diagram is obtained and considered to be pass as shown in figure 3. Final rendering view of aircraft hanger structure is shown in figure 5.

Table 2: Steel Takeoff of Aircraft Hanger

PROFILE	LENGTH (METER)	WEIGHT (kN)
Tapered Member No.1:	1323.47	159110.643
Tapered Member No.2:	938.11	35203.637
ST I125012B55025	158.60	726.141
ST I100012A40016	1982.49	6868.491
LD ISA100X100X15	55.12	23.627
ST I125012B50020	108.00	432.248
ST ISMC400	512.89	251.373
ST I160016C55040	169.60	1218.173
LD ISA200X200X24	2360.56	3285.830
	TOTAL=	207120.162

Table 3: Max shear force and max bm on a particular frame in x-y-z direction

BEAM	NODE	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
472	270	42719.094	-433.966	36.983	-16.058	62.664	359.636
1005	5	-554.253	58.548	0.173	0.070	-0.484	101.247
74	54	4864.544	5554.618	-12.096	0.000	161.292	39635.730
694	445	7320.856	-6583.241	15.798	0.000	41.459	-12224.858
594	369	895.304	2240.864	1857.169	0.304	-110.322	81.828
617	318	621.524	-56.755	-1592.607	0.028	1000.058	-35.914
73	55	1818.403	13.874	-9.236	1516.203	137.892	-956.205
86	67	1471.813	193.391	34.200	-1513.497	70.432	-663.998
604	198	834.967	-13.624	-961.816	0.013	2978.840	-41.068
606	5	1301.552	-10.051	767.598	0.000	-2765.015	-34.935
739	2	-0.000	-3600.104	-0.000	-0.000	-0.000	60356.594

694	445	7320.856	-6583.241	15.798	0.000	41.459	-12224.858

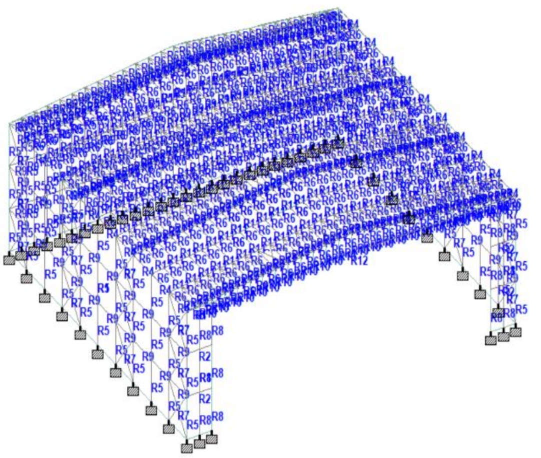


Fig. 4 Unity Check Diagram

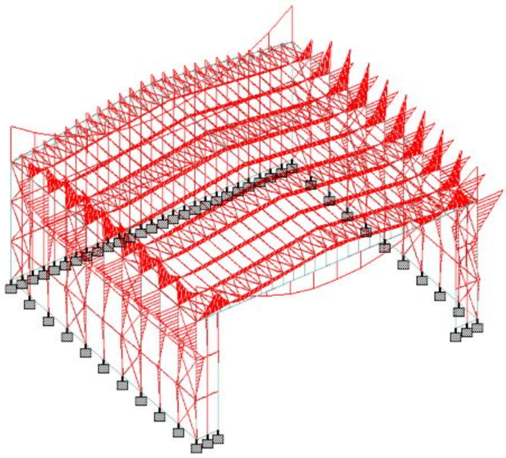
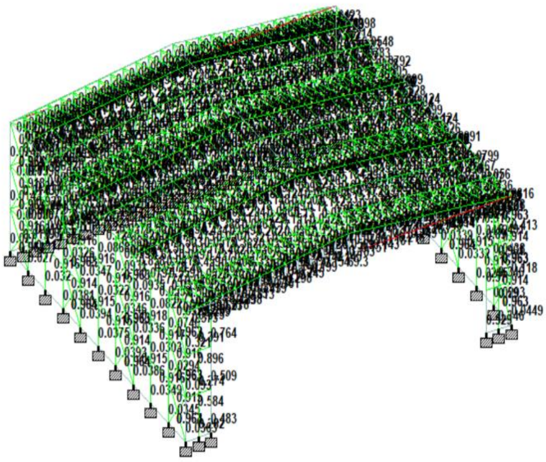
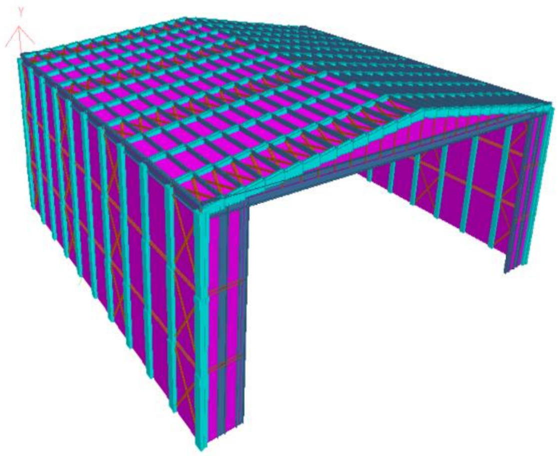


Fig.5 Rendering View





VI. CONCLUSION

- PEB structures are more advantageous than CSB structures in terms of cost-effectiveness, quality control speed in construction, and simplicity in an erection.
- PEB building cost is 30% lesser than the cost of CSB structure.
- Deformation is maximum at column and minimum at ridge level.
- Pre-engineered steel structures building offers low cost, strength, durability, design flexibility, adaptability and recyclability.
- The material used here is not only eco-friendly but also reusable. Steel is the basic material that is used in pre-engineered steel building materials. Infinitely recyclable, steel is the material that reflects the sustainability imperatives.
- The above design concludes that the obtained amount of steel mainly depends on primary members and type of purlins of the structure.

REFERENCES

[1]. "A Review on Comparative Study on the Structural Analysis and Design of Pre-Engineered Building [PEB] with Conventional Steel Building [CSB]", Mitaali Jayant Gilbile and S. S. Mane, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 9 Issue 09, September-2020.

[2]. "COMPARATIVE STUDY OF PRE-ENGINEERED BUILDING AND CONVENTIONAL STEEL STRUCTURES" Nikita D Radake and R V R K Prasad International Journal for Research in Applied Science & Engineering Technology (IJRASET). ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 10 Issue IV Apr 2022.

[3]. "Cost Comparative Study of PEB with Conventional Method for Industrial Building," Shalaka Patil, Dr.M.B. Kumthekar, International Journal of Advance Research and Innovative Ideas in Education (IJARIIE), volume-7, issue – 1, page no:207-218. 2021.

[4]. "Load analysis on an aircraft hangar", Asswani M. Kadam, prashanth.G. chavan, vinod. L.patil. pravin.S. chavanke, Azim.S. shaikhi, international journal of research and analytical Reviews (IJRAR), volume 7, issue2, page no:881 – 884. 2020.

[5]. “Parametric study on design of pre-engineered building using IS:800-2007 and AISC 360 13th edition”. Animesh Tripathi, Rituraj, Shezad Memon, Nishant Patil, August 2020, “parametric study on design of pre-engineered building using IS:800- 2007 and AISC 360 13th edition”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 17, Issue 4, page no: 07-14.
[6]. IS 875 (part 1)1987 Code of practice for Dead load.
[7]. IS 875 (part 2)1987 Code of practice for Live load.
[8]. IS 875 (part 3)1987 Code of practice for Wind load. IS: 800-2007: Code of practice for general construction in steel