MAIN FRAME DESIGN OF PRE-ENGINEERED BUILDING

ADITYA DUBEY
Student, Department of Project & Construction Management,
Swami Vivekananda Subharti University, Uttar Pradesh India

AKSHATA SAHARE
Student, Department of Project & Construction Management,
Swami Vivekananda Subharti University, Uttar Pradesh India

ABSTRACT
Pre-Engineered building (PEB) is a new concept for the construction of single storey industrial building. The concept is versatile not only due to its quality pre-designing and prefabrication but also due to its time efficiency and light weight. The concept of Pre-Engineered Building includes the technique of providing the best possible section according to the optimum requirements. This concept has many advantages over Conventional Steel Structure (CSB). And Pre-Engineered Building is efficient alternative to Conventional Steel Building. In this paper main frame of Pre-Engineered Structure of 12 m, 14m, 16m, 18m, 20m width & 6m Eave height have been analysed and designed by Staad pro to understand behaviour of PEB. The design is done by IS 800:2007, "Code of practice for General Construction in Steel Structures" as well as IS 875:1987(Part 1,2&3), "Indian Standard code of practice for loads on buildings and structures". Load case considered in modelling are Dead load, imposed load & Wind load with the various combinations as specified in IS.

KEY WORDS: Pre-Engineered Building, Tapered Sections, Staad pro

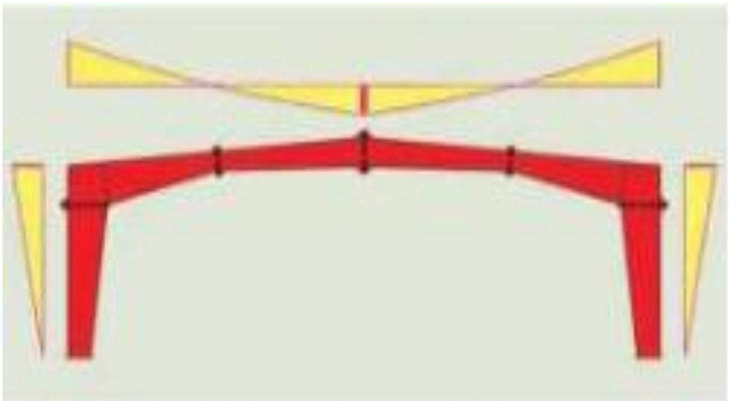
INTRODUCTION
Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment's requirement. To decrease or increase the strength by mere change of depth is quite a logical approach in P.E.B industry and at the same time leading to economic structures. One may think about its possibility, but it's a fact many people are not aware about Pre-Engineered Buildings.

Pre-engineered building is steel building wherein the framing members and other components are fully fabricated in the factory after designing and brought to the site for assembly, mainly by nut-bolts, thereby resulting into a steel structure of high quality and precision. If we go for regular steel structures, time frame will be more, and also cost will be more, and both together i.e. time and cost, makes it uneconomical.

Presently, large column free area is the utmost requirement for any type of industry and with the advent of computer software's it is now easily possible. With the improvement in technology, computer software's have contributed immensely to the enhancement of quality of life through new researches. Pre-engineered building (PEB) is one of such revolution.

The majority of steel structures being built are only low-rise buildings, which are generally of one storey only. Industrial buildings, a sub- set of low-rise buildings are normally used for steel plants, automobile industries, light, utility and process industries, thermal power stations, warehouses, assembly plants, storage, garages, small scale industries, etc. These buildings require large column free areas. Hence interior columns, walls and partitions are often eliminated or kept to a minimum.

This is a very versatile building system and can be furnished internally to serve any functions, and accessorized externally to achieve unique and aesthetically pleasing architecture designs



Pre-engineered Steel Frame

COMPONENT OF PEB

The component of a PEB may be broadly divided into following four parts namely-;

1) Main Frame
2) Secondary Frame
3) Wind Bracing
4) Exterior cladding

These structures use hot rolled tapered sections for primary framing and cold rolled sections (generally "Z" and "C" sections) for secondary framing as per the internal stress requirements, thus reducing wastage of steel and the self- weight of the structure and hence lighter foundations. Basically, a PEB is a rigid jointed plane frame from hot-rolled or cold – rolled sections, supporting the roofing and side cladding via hot-rolled or cold- formed purlins and sheeting rails. PEB frames have a roof slope of from 6 to 12 degree, mainly chosen because of the smaller volume of air involved in heating and cooling the building.

Furthermore, Pre-engineered Building system focuses on using pre-designed connections and pre-determined material stock to design and fabricate the building structures, thus significantly reduces the time for design, fabrication and installation.

The use of steel structures is not only economical but also eco-friendly at the time when there is a threat of global warming. Here, "economical" word is stated considering time and cost. Time being the most important aspect, steel structures (Pre-fabricated) is built in very short period and one such example is Pre-Engineered Buildings (PEB).

ADVANTAGES OF PRE-ENGINEERED BUILDING

1. Ability to span long distances
2. Faster occupancy
3. Cost efficient
4. Low-cost maintenance
5. Unique and aesthetically pleasing architecture designs

6. Time efficient
7. Light weight
8. Greater durability
9. Higher tensile strength

DIS-ADVANTAGES OF PRE-ENGINEERED BUILDING

1. Variable construction quality
2. Lack of reserve strength
3. Possible manufacture's unfamiliarity with local codes.

DESIGN AND ANALYSIS OF MAIN FRAME OF PEB PARAMETERS

Location: Nagpur
Building width: 12 m, 14 m, 16 m, 18 m, 20 m
Eave Height: 6 m
c/c of mainframes: 6.00 m
Slope of Roof: 1:10

LOAD CALCULATIONS

A) DEAD LOAD

As per IS: 875 (Part 1)
UDL on roof measured on plan area = 0.25 KN/m^2

B) IMPOSED LOAD

As per IS: 875 (Part 2), pg. no. 14
UDL on roof measured on plan area for slope less than 10° = 0.75 KN/m^2

C) WIND LOAD

According to clause 5.3 of IS 875 (Part 3), pg. no. 8
$V_z = V_b*K_1*K_2*K_3$
where,
V_b= basic wind speed = 44 m/s
K_1= Risk coefficient = 1 (IS 875 part 3, Table no. 1, Assuming average life span of structure = 50 years)
K_2= terrain roughness and height factor = 0.88
(IS 875 part 3 Table no. 2)
K_3= topographical factor = 1
(IS 8750 Part 3)

Therefore,
Designed Wind Speed, V_z= 44*1*0.97*1
= 42.68 m/s

Design wind pressure,
$P_z= 0.6*V_z^2$

$=0.6*42.68^2 = 1.092\ KN/m^2$
$= 1\ KN/m^2$

Calculation of External Pressure Coefficient "Cpe"
Referring to IS: 875 (Part 3)
Here, h = 6 m
Roof angle = 5^o71

CPE + CPI (WIND LEFT)

SURFACE	1	2	3	4
COEFFICIENT	0.9	0.45	1.1	0.6
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	5.4	2.7	6.6	3.6

CPE - CPI (WIND LEFT)

SURFACE	1	2	3	4
COEFFICIENT	0.5	0.05	0.7	0.2
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	3.0	0.3	4.2	1.2

CPE + CPI (WIND RIGHT)

SURFACE	1	2	3	4
COEFFICIENT	0.45	0.9	0.6	1.1
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	2.7	5.4	3.6	6.6

CPE - CPI (WIND RIGHT)

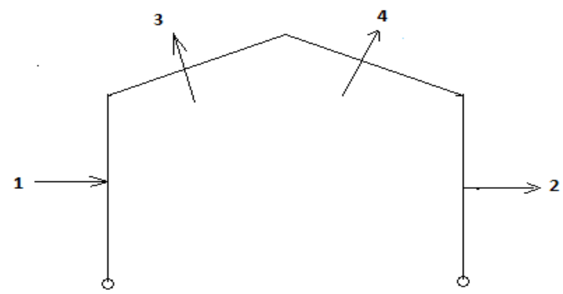
SURFACE	1	2	3	4
COEFFICIENT	0.05	0.5	0.2	0.7
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	0.3	3.0	1.2	4.2

CPE + CPI (WIND LONGITUDINAL)

SURFACE	1	2	3	4
COEFFICIENT	0.7	0.7	1.1	0.6
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	4.2	4.2	6.6	3.6

CPE - CPI (WIND LONGITUDINAL)

SURFACE	1	2	3	4
COEFFICIENT	0.3	0.3	0.7	0.2
SPEED	1	1	1	1
SPACING	6	6	6	6
PRESSURE	1.8	1.8	4.2	1.2



LOAD COMBINATION

1. DL + LL
2. DL + WL Left (Cpe + Cpi)
3. DL + WL Left (Cpe - Cpi)
4. DL + WL Right (Cpe + Cpi)
5. DL + WL Right (Cpe - Cpi)
6. DL + WL Longitudinal (Cpe + Cpi)
7. DL + WL Longitudinal (Cpe - Cpi)

CONCLUSION

1. It is seen that weight of pre-engineered building depends on bay spacing, with increasing bay spacing up to certain spacing, the weight reduces and further increase makes the weight heavier.
2. Comparison shows that even though PEB structure provides clear span, it weighs 10% lesser than conventional steel buildings.
3. It can be seen that PEB's reduce the steel used by 36% than that required for the CSB. Reduction in the steel quantity definitely reducing the dead load.
4. It is seen that due to reduction in dead load in PEB, size of foundation also reduces. And this is the main factor for the cost reduction of structure.
5. Support reaction for PEB is lesser compared to CSB. Hence heavier foundation can be avoided.
6. The bending and shear forces of PEB are lesser than the CSB which in turn reduces the material required for the structure.
7. The lighter tapered sections offer better resistance to earthquake forces than the heavy frames of CSB in earthquake zones.
8. The PEB components are manufactured before bringing it to the site and therefore easily erected using nut and bolts at the site. No field work is required.

9. Up to 30% cost reduction can be achieved using PEB which can be done in many ways such as saving material, providing lighter foundation, etc.
10. PEB components are manufactured from cold formed sheet steel, which is the most recycled material. Hence it can be recycled again and again without losing its engineering properties.
11. PEB can be easily expanded in length by adding additional bays.
12. Pre-engineered steel structures building offers low cost, strength, durability, design flexibility, adaptability and recyclability.
13. To conclude “Pre-Engineered Building Construction gives the end users a much more economical and bettersolution for long span structures where large column free areas are needed”.

REFERENCES

1) Charkha S.D. and Sanklecha L.S. *“Economizing Steel Building using Pre-engineered Steel Sections.”International Journal of Research in Civil Engineering, Architecture & Design, volume: 2, Issue: 2, pp:01-10.*

2) Firoz Syed, Kumar B. Sarath Chandra, Rao S.K. (2012). *“Design concept of pre- engineered building.” International Journal of Engineering Research and Applications (IJERA), volume: 2, Issue: 2, pp:267-272.*

3) IS 875:1987(Part 1), "*Indian Standard code of practice for Dead loads on buildings and structures" Edition 3.1, Bureau of Indian Standard(BIS), New Delhi, Second Revision*

4) IS 875:1987(Part 2), *"Indian Standard code of practice for Imposed loads on buildings and structures" Edition 3.1, Bureau of Indian Standard(BIS), New Delhi, Second Revision*

5) IS 875:1987(Part 3), *“Indian Standard code of practice for Wind loads on buildings and structures " Edition 3.1, Bureau of Indian Standard (BIS), New Delhi, Second Revision.*

6) IS 800:2007, “Code of practice for General Construction in Steel Structures", Bureau of Indian Standards (BIS), New Delhi, Third Revision.

7) Kiran G.S., Rao A.K. and Kumar R.P. (2014). “*Comparison of Design Procedures for Pre-Engineering Buildings (PEB): A Case Study.” World Academy of Science, Engineering and Technology International Journal of Civil, Architectural, Structural and Construction Engineering, volume: 8, Issue: 4, pp:480-484.*

8) Meera C.M. (2013). “*Pre-Engineered Building Design of an Industrial Warehouse.” International Journal of Engineering Sciences & Emerging Technologies, volume:5,Issue: 2, pp:75-82.*

9) Pradeep V, Papa Rao G (2014). *“Comparative Study of Pre Engineered andConventional Industrial Building.” International Journal of Engineering Trends and Technology (IJETT), volume: 9, Issue: 1, pp:01-06.*

10) Thakar J.D. and Prof. Patel P.G. (2013). *"Comparative Study of Pre-Engineered Steel Structure by Varying Width of Structure." International Journal of Advanced Engineering Technology, pp:56-62.*

11) Wankhade S., Prof. Dr. Pajgade P.S. (2014). "*Review Paper on Comparison of Conventional Steel Building and Pre-Engineering Building." International Journal of Research in Advent Technology, volume-2, Issue: 5, pp:215-220.*

12) Zende A.A., Prof. Kulkarni A.V. and Hutagi A. (2013). "*Comparative Study of Analysis and Design of Pre-Engineered-Buildings and Conventional Frames." IOSR Journal of Mechanical and Civil Engineering, volume-5, Issue: 1, pp:32-43*