# ANALYSIS AND DESIGN OF PRE-ENGINEERED BUILDING WAREHOUSE IN DIFFERENT SEISMIC ZONES

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## ABSTRACT

Construction of pre-engineered steel buildings is increasing very rapidly nowadays. The methodology used in PEB is not just because of high quality in pre-designing and pre-fabrication but also due to light weight and economical construction. From past studies it has been found that PEB has good strength, flexibility, recyclable nature, longer span, no limitation in size of components and has more seismic resistance capacity as compare with conventional buildings. PEB are environmentally friendly and long lasting. In CSB hot rolled section is used where as in PEB cold formed purlins is used. Usage of tapered I-section and cold formed sections of columns and rafters which reduces wastage of steel and decrease the budget considerably. Minimum weight of structure is proportional to the minimum cost and hence lowers seismic and gravitational forces. In this study, review paper on analysis and design of PEB warehouse in different seismic zones. Study of existing PEB warehouse subjected to wind load analysis has also been investigated. In this study an industrial structure (Warehouse) is analysed and designed for different seismic zones according to the Indian standard design codes of steel IS 800-2007 and Earthquake IS 1893 part1. Present work involves dead load of 30KN/M$^2$, live load of 250KN/M$^2$, wind load of 39KM/hr, UDL bearing 250KN/M$^2$ and air changes 10 Nos. /Hr.

**Keywords: -** PEB, Warehouse, STAAD-Pro, Analysis, Seismic Zones

# INTRODUCTION

Pre-engineered building suppliers, also known as PEB manufacturers, are companies that offer a single design that can be produced using a variety of materials and fabrication techniques to meet a variety of structural and aesthetically pleasing design requirements.Standardized architectural designs for buildings were first identified as PEBs in the 1960s. Historically, an assembly of I-shaped members—often referred to as I beams—has served as the main supporting framework of a pre-engineered building.Sami Kteily is the executive chairman and co-founder of the 1994-founded PEB Steel Building Co. The fastest adopter of pre-engineered buildings in India has been the industry of inter-arch building metal production.The best application for the pre-engineered metal building system is typically built using this kind of structural idea. Industrial uses covered by PEB include sophisticated industrial facilities, logistic parks, repackaging facilities, warehouse and distribution centers, etc.Due to its high strength-to-weight ratio, flexibility, recyclable nature, longer span, no height restrictions on components, and greater seismic resistance capability when compared to reinforced concrete buildings, steel is becoming more and more popular.

Steel is an environmentally friendly substance that has no adverse effects on the environment, making steel structures more sustainable than other types of construction.PEB is used more because of its advantage.The primary disadvantage is that there are restrictions on PEB construction due to the use of the international standard IS 800-2007, which makes no allowance for the use of web-tapered members. Regardless of what the PEB group is, they use the American Code AISC-ASD9 (LOW RISE metal building design) AISC2010, which USE the allowable stress design.PEBs are pre-planned structures in which only connections need to be made on location. Each and every connection is accurately made and described. Zero percent material loss is the goal of PEB groups.Various bracing system are also implemented in PEB.

The effectiveness of PEB is further increased by the benefits of cold formed members, which include their durability, simplicity of installation, non-combustibility, resilience, and strength.American Iron and Steel Institute's 1996 code was followed in the construction of this cold-formed component. The Indian code which is used to designing of cold formed members is IS 301-1975.

**Warehouse:**

“Ancient Romans” built the first warehouse around the 2nd century BCE. A warehouse is a structure where products are kept. Manufacturers, importers, exhibitors, distributors, transportation businesses, communities, and other businesses use warehouses.Regarding the term "warehouse," its first recorded use as "a structure or room for the storage of merchandise or commodities" was in Britain in the 1300s. Or, to put it another way, a place to keep your possessions, with "wares" increasingly referring to made items like glassware and ceramics.

There are generally 6 different type of warehouses

1. Cold storage
2. Pick, pack and ship warehouses
3. Smart warehouses
4. On demand storage warehouses
5. Bonded warehouse

6. Distribution centre

Three main types of warehouse layout flows that companies use to organize the way their warehouse operate:

1. U-shaped.
2. I-shaped.
3. L-shaped.

**STAAD.PRO:**

Its full term is structural analysis and design, Staad Pro offers a flexible data cooperation method, advanced features, and a customizable modelling environment. Due to its support for both Indian and international codes, the software is the best available for structural analysis and design. Structural engineers can virtually design and assess any type of structure using Staad Pro. Staad Pro offers trustworthy results for the quantity of horizontally used reinforcement and shear reinforcement. Staad makes it simple to integrate structural analysis into a BIM workflow and share synchronised models for cross-discipline cooperation. Its capabilities allow you to conduct analyses on any structure that is susceptible to loads such as thermal, seismic, wind, static, or dynamic movement.

## LITERATURE REVIEW

**M D Gawade et al [1]**in their **"STUDY OF PRE-ENGINEERED BUILDING CONCEPT"**has carried out the study of PRE-ENGINEERED BUILDING CONCEPT with the use of tapered members for columns and rafters and also using web tapered members depending on design limitations mentioned in the Indian code. They concluded that PEB is more effective than CSB when it's about steel structure. From this research work it is seen that weight of PEB is very less as compare to CSB with same loading. Whereas PEB requires accurate design and detailing unlike CSB.

**A. Sravan Kumaret al [2]**in their **"Design and Analysis of Pre Engineered Industrial Buildings (PEB)"**performing analysis of PEB using IS code 800-2007 in STAAD PRO software. Explaining every parameters and detailing procedure. They concluded that if this construction had been conventional rather than a PEB, the weights would have increased by 30%. The base of an external column is a permanent support. Sway doesn't use pinned connections to manage. Base of an internal column is regarded as a permanent support. The building's exterior walls are fully sheeted. Roof and wall rod bracing is taken into consideration for horizontal restraint.

**Muhammad Umair Saleemet al [3]**in their **"Minimum Weight Design of Pre Engineered Steel Structures using Built-up Sections and Cold Formed Sections"**they analyse to Reduce seismic and gravitational pressures result from a structure's minimum weight being inversely proportional to its lowest cost. Pre-engineered tapered and cold formed sections are used after conventional steel hot rolled sections have been analysed and developed to achieve the aforementioned goals and to confirm the suitability and applicability of the PEB concept.It has been determined that cold formed section secondary framing for PEB structures weighs about 60% less than traditional hot rolled secondary framing used in the late 20th century. Built-up section primary framing is also 32% less expensive than traditional hot rolled section primary

framing. Less distortions and sway have been seen in both main and secondary framing when using hot rolled sections. Buildings are now more affordable, lightweight, and aesthetically pleasing thanks to PEB technology.

**C. M. Meera et al [4]** in their **"PRE-ENGINEERED BUILDING DESIGN OF AN INDUSTRIAL WAREHOUSE"** The research is completed by designing an example frame for a hypothetical industrial warehouse structure using both concepts and the structural analysis and design software Staad.Pro. This paper successfully illustrates how PEB structures can be created using straightforward design processes that adhere to national standards. According to the research, it can be said that PEB structures are superior to CSB structures in terms of cost efficiency, speed of construction for quality control, and ease of erection. The article also provides straightforward and cost-effective ideas for PEBs' preliminary design concepts. Understanding the design process of the PEB concept is made easier with the assistance of the concept shown.

**Subhash Kumar Sah et al [5]** in their **"Performance and Protection of Pre-Engineered Buildings Subjected to Blast and Earthquake Excitations"** The research demonstrates the value of using fluid viscous dampers to improve the performance of PEB structures that have been exposed to blast and earthquake vibration control techniques in the form of passive dampers. The effect of various damper placements and properties on the structural performance of PEB structures subjected to blast and earthquake is also covered in the study. The most efficient damper for the chosen PEB system at reducing the effects of blast and earthquake is class B-3 technique in mitigating the blast and earthquake responses of a PEB system designed for wind effects. Damper class B-3 is the most effective damper in mitigating the blast and earthquake responses of the selected PEB system.

**Sandeep Sathe et al [6]** in their **"A state of art review on analysis and design of pre-engineered buildings"** A review of the analysis and design of PEB structures is provided in the current work. The study gives a step-by-step description of how to model PEB structures and examines the various elements of the PEB system. This review article concludes research on PEB's various aspects, including characteristics, configuration, and performance in comparison to conventional steel buildings. The design guidelines of different international codes of practise are also compared in the study.

**Shashank Pattanshetti et al [7]** in their **"Comparative Study on the Economy between Pre-Engineered and Conventional Steel Buildings"** The research, which compares conventional steel structures and pre-engineered structures, discusses the economics of the structures in terms of reducing structural weight and maximising material use. A 3D model of a traditional steel structure and pre-engineered building is designed and analysed for the research using the structural designing software STAAD Pro. When compared to a conventional steel construction, the weight of structural steel for pre-engineered buildings is 33.00% less. The weight of the structure has been decreased by 10.10% thanks to the replacement of ISMC with tube (hollow) sections and the alteration of structural component sizes in response to the size of approaching pressures demonstrating that an economical steel design can be achieved by optimising structural components based on weight magnitude.

**Akshay Sharma et al [8]**in their **"Comparative Study of Conventional Steel Building and PreEngineered Building to be used as an Industrial Shed"** This case study for Industrial Shed is based on a summary and a number of other case studies that demonstrate the

experimental and analytical research they have done in this area. The outcome demonstrates how these buildings are cost-effective, energy-efficient, and flexible in their design. The findings indicate that compared to other types of industrial structures, steel structures are significantly more cost-effective, energy-efficient, and flexible in their construction.

**Seena Somasekharan et al [9]**in their **"WIND LOAD ANALYSIS FOR INDUSTRIAL BUILDING WITH DIFFERENT BRACING PATTERNS AND ITS COMPARISON WITH PRE ENGINEERED BUILDING"**The truss chord members for various sections, including ISLC/ISA, UB/UC, and SHS, are designed in this research using SAP 2000-18. The industrial building's design makes use of the most cost-effective truss chord sections, and various bracing techniques, including X-bracing, diagonal bracing, and k-bracing, are used to perform wind analysis on the structures. The overall economic study reveals that PEB is less profit than CSB. Less steel is used when PEB is used instead of CSB. Therefore, based on the research presented above, we can say that CSB or PEB are the best types of industrial buildings to use when the span is near to 42 metres and the distance between bays is 6 metres.

**Mr. Hitesh Jibhkate et al [10]** in their **"COMPARATIVE ANALYSIS OF PRE-ENGINEERED BUILDING AND CONVENTIONAL STEEL BUILDING BY STAAD PRO"** This study's goal is to examine the most economical tonnage frame and potential causes of inconsistent results. Additionally, a comparative study is done between the cold-formed purlins used in PEB and the hot-rolled section used in CSB. In comparison to the CSB structure, the PEB structure type created by IS 800:2007 has less axial force, shear force, and bending moment. Compared to CSB structure, the PEB structure type created by IS 800:2007 is lighter. In comparison to the CSB Structure, the PEB Structure is 64% lighter.

**Nauman Khurram et al [11]**in their **"Optimisation of flange and web slenderness for pre-engineered built-up steel sections"** The impact of unbraced length ratios on flange and web slenderness ratios is elaborated in this paper, which also presents a design-based optimisation for pre-engineered steel frames made up of built-up sections. A Mat lab-based tool was created to address the issue of built-up non-compact and slender sections based on the planning process. Different unbraced length ratios' section capacities were assessed. The parameters of interest for the entire research were the local slenderness of the web and the flange.

**Swati Wakchaure et al [12]**in their **"Design and Comparative Study of Pre-Engineered Building"** This research analyses and designs a PEB Frame and CSB Frame industrial structure in accordance with Indian standards (IS 800-1984 and IS 800-2007).

In terms of weight comparisons between Indian codes (IS800-1984, IS800-2007), as well as between PEB and CSB building structures, the economy of the structure is addressed. The portion is categorised as Plastic, Compact and Semi-Compact, Slender Cross portion in IS Code 800-2007 Table 2. The narrow portion is not designed in accordance with IS 800-2007.Therefore, in PEB design, the slender sections are not designed in accordance with IS 800-2007 code and IS 800-1984 code, which reduces the weight of the framework. When compared to IS 800-2007, the deflection limits in IS 800-1984 are greater. PEB structures reduce dead loads, which in turn decrease foundation size.

## Summary of Literature Review:

| S. No. | Ref No. | Name of Researcher | Title | Aspect Study | Findings and Conclusions | Source |
|---|---|---|---|---|---|---|
| i | 1 | M D Gawade and U. P. Waghe | STUDY OF PRE-ENGINEERED BUILDING CONCEPT | Comparison Based on design. | PEB is more effective than CSB when it's about steel structure. From this research work it is seen that weight of PEB is very less as compare to CSB with same loading. | JREAS, Vol. 3, Issue 03, July 2018 |
| ii | 2 | A. SRAVAN KUMAR , SANJEEV RAO, MADAN MOHAN, DR. SREENATHA REDDY | Design and Analysis of Pre Engineered Industrial Buildings (PEB) | Comparison based on design and analysis. | construction had been conventional rather than a PEB, the weights would have increased by 30%. | ISSN 2320 – 3439, Vol. 03, No. 06, |
| iii | 3 | Muhammad Umair Saleem, Zahid Ahmad Siddiqi, Hisham Qureshi, | Minimum Weight Design of Pre Engineered Steel Structures using Built-up Sections and Cold Formed Sections | Study of minimum weight design using cold formed sections. | Reduce seismic and gravitational pressures result from a structure's minimum weight being inversely proportional to its lowest cost. Less distortions and sway have been seen in both main and secondary | Advanced Materials Research Vol. 684 (2013) pp 125-129 |

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| | | | | | framing when using hot rolled sections. | |
| iv | 4 | C. M. Meera | PRE-ENGINEERED BUILDING DESIGN OF AN INDUSTRIAL WAREHOUSE | Study of Understanding the design process of the PEB concept | PEB structures are superior to CSB structures in terms of cost efficiency, speed of construction for quality control, and ease of erection. | Volume 5, Issue 2, pp: 75-82 ©IJESET |
| v | 5 | Muhammed Zain, Subhash Kumar Sah, Sachin Bakre | Performance and Protection of Pre-Engineered Buildings Subjected to Blast and Earthquake Excitations | Check performance and protection in earthquake. | using fluid viscous dampers to improve the performance of PEB structures that have been exposed to blast and earthquake vibration control techniques in the form of passive dampers. | Research Square, October 26th, 2022 |
| vi | 6 | Subhash Kumar Sah, Muhammed Zain Kangda ,Sandeep Sathe, Nilesh Mate | A state of art review on analysis and design of pre-engineered buildings | study gives a step-by-step description of model PEB structures | PEB's various aspects, including characteristics, configuration, and performance in comparison to conventional steel buildings. The design guidelines of different | Elsevier, · December 2022 |

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| | | | | | international codes of practise are also compared in the study. | |
| vii | 7 | Shashank Pattanshetti1, Prof. Sachin M. Kulkarni | Comparative Study on the Economy between Pre-Engineered and Conventional Steel Buildings | Comparsion between CSB and PEB. | the economics of the structures in terms of reducing structural weight and maximising material use. conventional steel construction, the weight of structural steel for pre-engineered buildings is 33.00% less. | (IRJET) Volume: 04 Issue: 07 \| July -2017 |
| viii | 8 | AbhyudayTitiksh , AbhinavDewangan , AnkurKhandelwal , Akshay Sharma | Comparative Study of Conventional Steel Building and PreEngineered Building to be used as an Industrial Shed | Case Study | Buildings are cost-effective, energy-efficient, and flexible in their design. Steel structures are significantly more cost-effective, energy-efficient, and flexible in their construction. | ISSN: 2248-9622, Vol. 5, Issue 11, (Part - 2) November 2015, |
| ix | 9 | Seena Somasekharan , Vasugi K | WIND LOAD ANALYSIS FOR INDUSTRIAL BUILDING WITH DIFFERENT BRACING PATTERNS AND ITS COMPARISON | Study of wind load. | The overall economic study reveals that PEB is less profit than CSB. Less steel is used when PEB is used | (IJCIET) Volume 8, Issue 4, April 2017 |

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| | | | WITH PRE ENGINEERED BUILDING | | instead of CSB. | |
| x | 10 | Mr. Hitesh Jibhkate,Prof.Dilip L. Budhlani | COMPARATIVE ANALYSIS OF PRE-ENGINEERED BUILDING AND CONVENTIONAL STEEL BUILDING BY STAAD PRO | Comparetive analysis of CSB and PEB. | Examine the most economical tonnage frame and potential causes of inconsistent results. The cold-formed purlins used in PEB and the hot-rolled section used in CSB. | irjmets Volume:03/Issue:07/July-2021 |
| xi | 11 | Muhammad Umair Saleem, Nauman Khurram, Hisham Jahangir Qureshi, Zaheer Abbas Kazmi, Zahid Ahmad Siddiqui | Optimisation of flange and web slenderness for pre-engineered built-up steel sections | The impact of unbraced length ratios on flange and web slenderness ratios | The impact of unbraced length ratios on flange and web slenderness ratios is elaborated. Different unbraced length ratios' section capacities were assessed. | ICE ,July 2018 |
| xii | 12 | Swati Wakchaure, N.C.Dubey | Design and Comparative Study of Pre-Engineered Building | analyses and designs a PEB Frame and CSB Frame | PEB structures reduce dead loads, which in turn decrease foundation size. | 2016 IJEDR \| Volume 4, Issue 2 |

## EXPECTED METHODOLOGY

1. The research methodology involves analysing and designing of warehouse in different zones in India. Having super built up area of 1,25,500 Sq. FT.
2. The model is generated using STAAD-PRO V8i software.

3. Design code is for design of warehouse in earthquake IS 1893:1962(recommendation for earthquake resistant design of structure).
4. The load definitions for specific load group like:

- Dead load -**30KN/SQ.MTR** ,
- Wind load -**39KN/SQ.MTR**,
- Live load -**250KN/SQ.MTR**,
- Seismic load.

5. Zone factor for zone 3 = 0.16 and zone 4 = 0.24

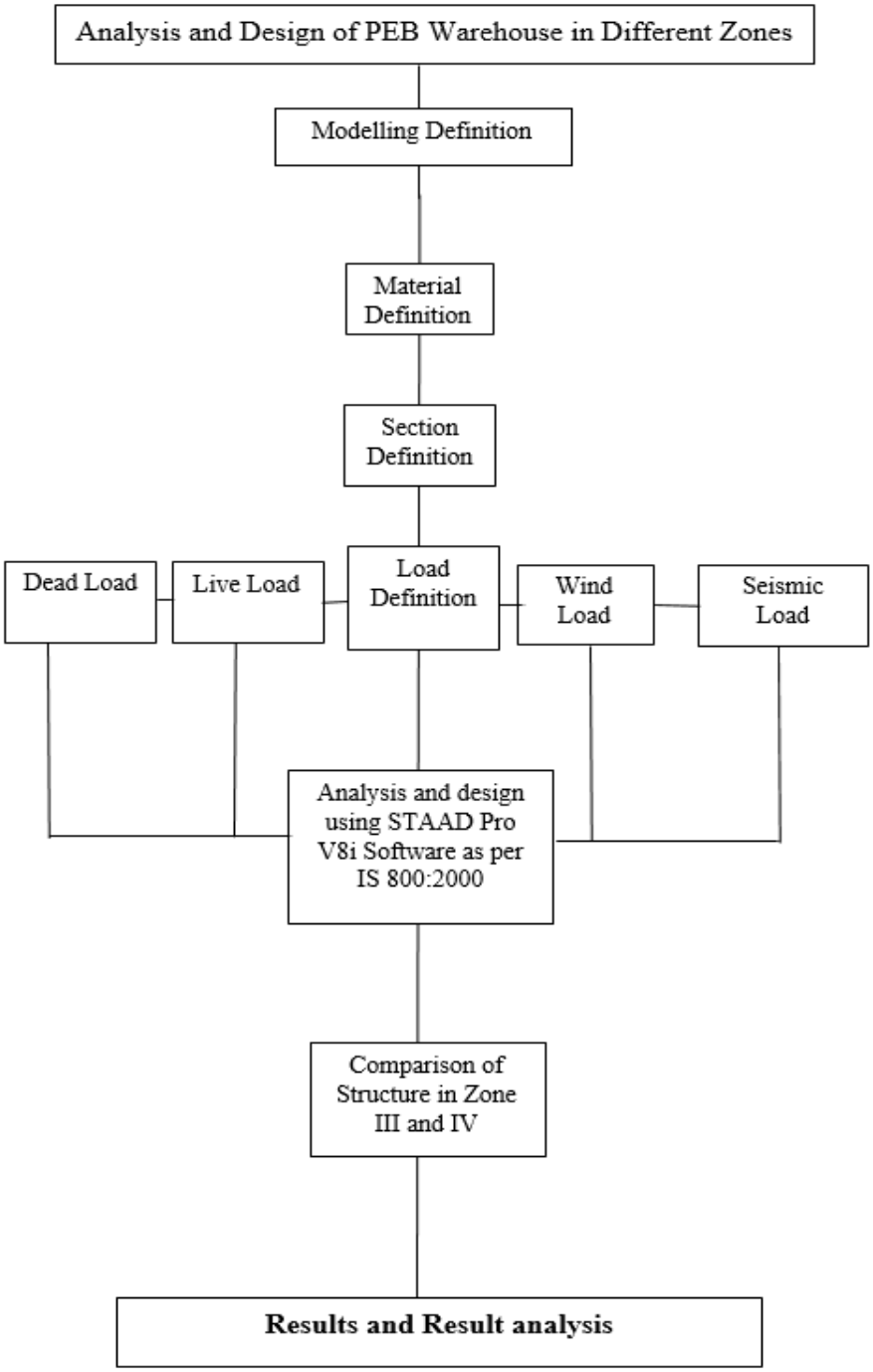


**Fig 1. Flow Chart of Methodology**

## CONCLUSION

1. Cold formed sections are taken which produced having low cross section area which leads to low unit weight of components and hence contributes less dead load to structure.
2. Pre-engineered structure components having cross section based on their concentration of frorces and stresses developed.
3. Load definitions that is used here are dead load which involves self weight also, live load, seismic load and wind load.
4. Load combinations are also be taken for analysis of the structure stability.
5. In the analysis, total weight of steel is also be analysed.
6. For modelling and analysis purpose, STAAD-PRO V8i is used.
7. As it is a review paper, the final results that will be obtained due to same loading in different seismic zones in India and various stresses occuring due to load combinations will be discussed in final paper.

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