

Pre-Engineered Buildings with Crane: Designed by Indian and American Code

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Abstract: *Over the past few decades, technological advances have significantly improved the quality of human life. Pre-engineered buildings (PEBs) represent one such advancement within the construction industry. Although the concept originated in the 1960s, its widespread application has increased only in recent years. PEBs introduce a modern approach to constructing single-story industrial structures, emphasizing the selection of optimal structural components based on functional requirements. These buildings are primarily developed through pre-design and prefabrication techniques. The growth of PEB technology is driven by advantages such as reduced construction time, cost efficiency, enhanced structural performance, and improved architectural flexibility. In this study, a pre-engineered building is designed with multiple parameters using the STAAD-Pro software and analyzed under various loads, including dead load, live load, collateral load, wind load, and their appropriate combinations. The main objective is to understand the fundamental principles of PEBs and to determine the minimum structural weight while ensuring acceptable displacements and force distributions that contribute to safety and stability. This work also presents a detailed design of a PEB incorporating crane movement, evaluated using both Indian and American standard codes.*

Keywords: Pre-engineered buildings, Industrial warehouse structure, STAAD-Pro

1. Introduction

This study aims to address the key challenges associated with Pre-Engineered Building (PEB) design by evaluating the underlying design philosophies, fabrication practices, and erection techniques prescribed in both Indian and American code systems. Through this comparative approach, the study seeks to ensure that the resulting structural solution is not only safe and cost-effective but also well-suited to industrial applications where integrated crane operations play a critical role in day-to-day functionality.

Pre-Engineered Buildings (PEBs) are an efficient structural system widely used for non-residential and industrial applications. Developed initially in the United States, PEBs are fabricated using standardized steel components and assembled on-site, enabling rapid construction and reliable quality control. Their design optimizes material usage by aligning structural geometry with bending moments, resulting in lighter and more economical structures. Capable of achieving large column-free spans and considerable heights, PEBs are suitable for warehouses, factories, power plants, and commercial facilities. In addition to structural efficiency, PEBs offer reduced construction time, lower lifecycle costs, minimal maintenance requirements, and improved durability, making them a sustainable alternative to conventional construction methods.

Pre-Engineered Buildings (PEBs) have become an alternative to conventional steel structures due to their cost efficiency and rapid construction timelines. However, when these buildings are intended for industrial use, particularly those incorporating crane operations, the design process demands careful attention to multiple factors, including load combinations, structural optimization, and adherence to international standards.

One of the key challenges is comparing Indian Standards (IS 800:2007, IS 875) with American codes such as ASCE, AISC,

and IBC to identify the most effective design approach in terms of structural weight, cost, and safety. Achieving this requires optimizing member sizes based on bending moment distribution and validating structural performance through advanced analysis tools like STAAD-Pro. The goal is to design the structure with minimum steel usage with ensuring strength, stability, and compliance with safety norms.

2. Literature Review

Lovneesh Sharma, Nileshwar Taak, and Pankaj Kumar Mishra (2021) [1], This study compares PEBs and CSBs across multiple performance parameters. Using Bentley STAAD-Pro, two structurally identical buildings were designed—one as a PEB and the other as a CSB. The analysis revealed that PEBs offer significant advantages in construction speed, cost efficiency, and material optimization. Reduced Dead load and better material utilization make PEBs a sustainable and economical alternative to conventional steel systems.

Shaik Kalesha, B.S.S. Ratnamala Reddy, Durga Chaitanya Kumar Jagarapu [2], the authors emphasize that PEB systems employ prefabricated steel components manufactured in controlled environments, ensuring uniform quality and reducing on-site labor. PEB construction can be completed in 6–8 weeks, much faster than CSBs. Steel, being infinitely recyclable, aligns with sustainability goals. The study found that PEB structures weigh about 50% less than CSBs, resulting in approximately 35% cost savings.

G. Sai Kiran, A. Kailasa Rao, R. Pradeep Kumar [3], this research highlights that PEBs designed under modern codes such as IS 800:2007 or MBMA are lighter and more economical than those designed under older standards like IS 800:1984. The study also examined seismic and wind load considerations for structures in Zone IV with wind speeds of 47 m/s. It concluded that international codes like

AISC/MBMA are often preferred due to their provisions for slender sections, which IS 800:2007 does not address.

Aakash Varma and Dr. Rajeev Chandak [4], the authors analyzed PEB behavior under various loads using STAAD-Pro V8i. They highlighted the efficiency of tapered I-sections, which align better with bending moment diagrams, improving material utilization. PEB systems allow modular design and mass production, reducing construction time and costs while promoting sustainability.

Shubham Dashore and Shraddha Kanojiya [5], this study designed a PEB warehouse considering dead, live, wind, and seismic loads using STAAD-Pro and Indian codes IS 800:2007 and IS 1893. Findings indicate that reduced structural mass and effective bracing systems enhance seismic performance. Cold-formed sections designed by IS 801 and AISI standards further improve resilience.

M. Varshitha and B D V Chandra Mohan Rao [6], the authors compared two steel buildings—one PEB and one CSB—and found that PEB required 24.9% less steel. Wind load combinations were more critical than seismic loads. PEBs demonstrated advantages such as reduced cost, faster construction, and better aesthetics, making them preferable for industrial applications.

Moiz Mohammed and Ahmed Hussain Mohammed [7], this research focused on designing an Airbus A-380 hangar using STAAD-Pro. The study revealed that bay spacing significantly influences steel quantity, with larger spacing reducing primary member weight but increasing secondary member weight. Lightweight members improve wind resistance and reduce foundation costs.

Animesh Tripathi, Rituraj, Shezad Meman, Nishant Patil [8], the authors compared PEB designs under IS 800:2007 and AISC 360-10. AISC-based designs yielded lighter sections due to lower imposed loads and serviceability criteria. Steel weight reductions of up to 27% were observed under AISC compared to IS codes, making AISC more economical for long-span structures.

Pradeep V and Papa Rao G [9], this study demonstrated that PEB frames are lighter and more flexible, offering better seismic resistance. Roof structures in PEBs were 26% lighter than CSBs, and foundations were simpler and less costly. Overall, PEBs were found to be 30% more economical than CSBs.

Pratik R. Atwal, Vinaysingh Chandrakar, and Pravinsingh Tomar [10], this work compares designs prepared under IS 800:2007 with those based on international standards for a school building, with loading parameters consistently taken from Indian codes. Analysis and design were conducted using STAAD-Pro and manual checks. The results show notable reductions in steel tonnage when international standards are applied: Euro-03 reduces weight by 27.2%, and BS 5950-2000 reduces weight by 9.04%, relative to IS 800:2007. The study discusses code-level differences including bracing slenderness limits (≤ 120), limit state design alignment with Eurocodes, and the continued presence of ASD provisions

within IS 800:2007 highlighting IS 800's hybrid nature and Indian practice-oriented safety factors.

Kavya Rao M. N and K.N. Vishwanath [11], an industrial building was designed and evaluated under both PEB and CSB concepts using STAAD-Pro, including resistance to dynamic actions such as wind. The authors report that PEBs use ~36% less steel than CSBs, leading directly to material and cost savings without compromising performance.

V Vishnu Sai, P Poluraju, and B Venkat Rao [12], this comparative study assesses a multiple-bay PEB system across different wind zones specifically Vijayawada and Hyderabad using STAAD-Pro. Performance was evaluated via shear force (SF) and bending moment (BM) outputs, from which section properties were selected. The building in Vijayawada was found to be 11.04% heavier than the one in Hyderabad, reflecting wind-zone sensitivities in member selection and overall tonnage.

Md Mehre Alam and Rashmi Sakalle [13], A 3D industrial warehouse framework was designed and analyzed using IS 800:2007 with reference to AISC LRFD. The study considered dead, live, wind, seismic, and snow load per IS provisions to compare PEB versus CSB outcomes. The authors examine differences in shear forces, support reactions, weight correlations, and costs, illustrating how codal choices and load combinations affect structural demand and economy.

Quazi Syed Shujat and Ravindra Desai [14], this paper provides a comparison among CSB, PEB, and Tubular Structures designed to IS 800:2007 with loads per IS 875 (Parts I-III), using STAAD-Pro V8i. The authors conclude that PEBs are generally more cost-effective than CSBs due to faster erection (often < 6 weeks), lighter members, and improved aesthetics. Tubular trusses were found to be even more economical than PEBs in many cases, though market limitations in available tubular sizes constrain their broader adoption; increased standardization may improve usage.

Nihar Shah, M.G. Vanza, and Prasham Vora [15], PEBs were designed and analyzed under Indian (IS) and American (AISC) codes to compare frame weights. AISC-based designs produced sections 3–10% lighter than IS designs, and when ASD load combinations are used under AISC 360, sections can be 15–30% lighter than IS outcomes. The authors caution against applying American safety factors to Indian construction without adaptation, emphasizing that code adherence must match the construction locale to ensure safety

3. Conclusion

The analysis of existing research demonstrates that Pre-Engineered Buildings (PEBs) offer considerable advantages over Conventional Steel Buildings (CSBs) in terms of efficiency, economy, and construction practices. Studies consistently indicate that the use of optimized tapered sections and prefabricated components in PEBs leads to a substantial reduction in material usage, typically in the range of 25–50%. This decrease in structural weight not only lowers the overall cost of construction but also reduces foundation loads and associated expenses.

In addition, PEB systems are characterized by significantly shorter construction durations, often completed within 6–8 weeks. This is largely attributed to off-site fabrication and streamlined on-site assembly, which minimizes labor requirements while ensuring improved quality control. Structural evaluations further reveal that PEBs perform effectively under wind and seismic forces due to their reduced mass and efficient bracing mechanisms, making them adaptable to diverse environmental conditions.

Moreover, the selection of design standards influences the overall efficiency of the structure. International codes such as AISC and MBMA generally yield lighter and more economical designs compared to IS 800:2007, although appropriate consideration of local conditions remains essential for ensuring safety and reliability.

Overall, the findings establish PEBs as a technologically advanced, cost-effective, and sustainable alternative to conventional steel structures, particularly suitable for industrial and long-span building applications.

4. Expected Result

The anticipated outcomes suggest that the application of AISC (LRFD) provisions in the design of pre-engineered buildings will lead to a reduction in structural steel weight of approximately 10–15% when compared to IS 800:2007 under identical loading conditions. This reduction can be attributed to the relatively flexible design approach adopted in AISC standards.

In contrast, designs based on IS 800:2007 are expected to exhibit higher steel consumption due to stringent serviceability requirements, particularly tighter deflection limits. Additionally, the higher live load values prescribed by Indian standards are likely to generate greater internal forces, leading to increased member sizes and overall structural weight.

The conservative nature of IS provisions is further influenced by stricter section classification criteria, which are less accommodating to slender and optimized PEB members. Moreover, seismic evaluation based on IBC provisions is expected to produce larger base shear values compared to IS 1893, reflecting a more rigorous safety-oriented design philosophy.

Overall, AISC-based designs are expected to provide improved material efficiency and economic benefits, especially for industrial PEB applications, owing to their adaptability in designing slender and cold-formed sections. However, IS 800:2007 is anticipated to ensure higher safety margins and serviceability control, albeit with increased material usage and associated costs.

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