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Study of Pre-Engineered Industrial Building - A Review

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Abstract: The rapid growth of industrial infrastructure has significantly increased the demand for economical, sustainable, and structurally efficient building systems. Pre-Engineered Buildings (PEBs) have emerged as a modern alternative to Conventional Steel Buildings (CSBs) and Reinforced Cement Concrete (RCC) structures due to their optimized design, prefabrication advantages, reduced material consumption, and faster construction timelines. This review paper presents a comprehensive synthesis of previous research studies conducted between 2014 and 2025 on the analysis, design, optimization, and performance evaluation of pre-engineered industrial buildings. The literature highlights comparative assessments based on structural weight, displacement behavior, bending moment distribution, steel consumption, seismic performance, wind response, construction time, and cost efficiency. The review identifies that most studies rely on STAAD.Pro or ETABS-based static analysis and emphasize material optimization through tapered built-up sections. Although PEB systems consistently demonstrate superior economic and structural performance over conventional systems, significant research gaps remain in areas such as integrated performance optimization, life-cycle cost analysis, hybrid structural systems, advanced dynamic analysis, sustainability quantification, and AI-based structural optimization. This paper consolidates past findings and identifies potential directions for future research to enhance structural efficiency, safety, and sustainability of pre-engineered industrial buildings.

Keywords: Pre-Engineered Building (PEB), Conventional Steel Building (CSB), Industrial Warehouse, Structural Optimization, Tapered Sections, Steel Consumption, Seismic Performance, Sustainability.

I. INTRODUCTION

Industrial buildings form the backbone of economic development, accommodating manufacturing plants, warehouses, distribution centers, and logistics facilities. Traditionally, such structures were constructed using Conventional Steel Buildings (CSB) or RCC framed systems. However, these systems often involve excessive material usage, longer construction periods, and limited structural optimization. With advancements in computational design tools and prefabrication technologies, Pre-Engineered Buildings (PEB) have revolutionized industrial construction. PEB systems involve:

- Factory-fabricated built-up tapered primary members
- Cold-formed secondary members (Z & C sections)
- Optimized section design based on bending moment distribution
- Bolted site assembly
- Reduced construction time

The concept originated in the United States in the 1960s and gained prominence in India in the late 1990s. Over the last decade, extensive research has been conducted comparing PEB with CSB and RCC systems in terms of structural performance, cost efficiency, seismic resistance, and sustainability. This paper reviews major studies conducted from 2014 to 2025 and critically evaluates their findings to identify research gaps.

II. LITERATURE REVIEW

Structural Analysis and Design of Industrial Building Using PEB and Tube Section (2025) by Shrikant Anil Gattani and Sharif Shaikh – This study presents a comparative structural analysis of industrial buildings using Pre-Engineered Building (PEB) and Conventional Steel Building (CSB) systems, with special emphasis on the incorporation of tubular steel sections. The research highlights that modern industrial structures require lightweight, economical, and high-performance structural systems capable of providing large column-free spans. The methodology involved developing six analytical models with different bay configurations and structural systems using STAAD.Pro software. The structures were analyzed under various load combinations including dead load, live load, wind load, and accidental loads in accordance with IS 875 (1987) and IS 800 (2007). Structural parameters such as axial force, bending moment, shear force, and deflection were evaluated to assess performance. The findings revealed that PEB structures, particularly those utilizing tube sections, exhibited reduced deflection, higher stiffness, improved load distribution, and better overall structural efficiency compared to conventional truss-based systems. Additionally, the study identified considerable material and cost savings in PEB configurations without compromising safety and stability. The authors concluded that the integration of tubular sections within PEB frameworks offers an optimal solution for industrial building design by enhancing structural performance, economic efficiency, and sustainability.

Critical Review of Study of Conventional and Pre-Engineered Building (2025) by Narendra M. Shete, C. P. Pise, and Amol Kamble – This paper presents a comprehensive critical review of previous research comparing Conventional Steel Buildings (CSB) and Pre-Engineered Buildings (PEB), highlighting the evolution of construction technology and its impact on modern infrastructure development. The study emphasizes that advancements in engineering practices, structural optimization, and prefabrication techniques have significantly transformed the construction industry, particularly in industrial building applications. The methodology adopted in the paper is primarily literature-based, reviewing and synthesizing findings from earlier research studies on PEB and CSB systems. The authors examine key comparative parameters such as deflection behavior, steel quantity consumption, seismic performance, cost efficiency, and construction time. The review also discusses the fundamental structural concepts common to both systems, noting that while CSB and PEB share similar core framing principles, PEB components are prefabricated in factories based on optimized structural design and then assembled on-site, whereas CSB structures are constructed using standard market-available hot-rolled sections. The paper further categorizes industrial buildings based on span configurations and framing systems and highlights the widespread use of STAAD Pro software in most comparative studies for structural analysis and design. The findings from the reviewed literature indicate that PEB systems generally offer reduced material consumption, better structural optimization through tapered sections, improved seismic performance, and faster construction compared to conventional systems. Many researchers reported that PEB structures achieve lower deflection and improved efficiency due to variable cross-sections designed according to stress distribution. The authors conclude that PEB is a modern, economical, and performance-oriented solution for industrial construction, while also acknowledging that both systems have similar structural foundations. The review underscores the importance of continued research and technological innovation to further enhance structural safety, economy, and sustainability in building construction.

Study of Pre-Engineered Building (PEB) in Industrial Sector (2024) by Shubham Khandagale and Priyanka Patil – This study presents a comprehensive review of the role and advancements of Pre-Engineered Buildings (PEBs) in the industrial sector, emphasizing their growing importance in modern construction practices. The research highlights that with rapid industrialization and infrastructure growth, especially in developing economies like India, the demand for efficient, economical, and sustainable building solutions has significantly increased. PEBs have emerged as a practical alternative to conventional construction methods due to their prefabrication-based approach and improved structural performance. The methodology adopted in the study is primarily literature-based, supported by case studies and comparative assessments of PEB systems with conventional RCC structures. The review examines key components of PEBs, including primary and secondary structural members, fabrication techniques, and design methodologies. It further explores advancements in manufacturing technologies, material innovations, modular construction practices, and integration of renewable energy systems. The study also discusses differences between

PEB and RCC conventional structures in terms of fabrication process, construction time, flexibility, customization, and structural efficiency. The findings indicate that PEBs offer significant advantages such as reduced construction time due to factory-controlled fabrication, lower material wastage, enhanced quality control, and improved cost-effectiveness over the project lifecycle. The modular and customizable nature of PEBs makes them highly suitable for industrial facilities such as warehouses, manufacturing plants, and distribution centers. Additionally, the study identifies emerging trends including sustainable construction practices, adaptive reuse strategies, and integration of green technologies. However, it also notes challenges related to regulatory approvals, quality assurance, and environmental considerations.

Analysis & Design of Pre-Engineered & Conventional Industrial Building (2024) by Omkareshwar Prabhakar Tekale and Swati Ambadkar – This study presents a comparative structural analysis of Conventional Steel Buildings (CSB) and Pre-Engineered Buildings (PEB) using STAAD-Pro software to evaluate their performance under various loading conditions. The research emphasizes the growing importance of selecting efficient structural systems for industrial buildings based on stiffness, displacement control, and load response. The methodology involved developing analytical models of both CSB and PEB configurations and subjecting them to standard load combinations to assess parameters such as displacement, support reactions, and internal beam forces. The findings revealed that PEB models generally exhibited reduced displacement compared to CSB models, indicating higher stiffness and better resistance to deformation. However, the PEB configuration with 7 m bay spacing showed maximum support reactions and beam forces, suggesting that certain geometric arrangements may lead to increased force concentration. This highlights the importance of proper bay spacing and configuration optimization in PEB design. The study concludes that while PEB systems demonstrate superior stiffness and structural efficiency in most cases, careful evaluation of design parameters such as bay spacing and load distribution is essential to achieve optimal performance. Overall, the research supports the adoption of PEB systems for industrial structures, provided that detailed structural analysis is conducted to ensure safety and economy.

Analysis and Design of Pre-Engineered Industrial Warehouse Building with Different Standard (2024) by Shubham Tomar and Rakesh Grover – This study focuses on the structural analysis and optimization of a Pre-Engineered Building (PEB) industrial warehouse designed under different international codal provisions. The research highlights the growing preference for PEB systems over conventional concrete and steel construction due to their sustainability, speed of construction, and material efficiency. With increasing infrastructure demand driven by industrial expansion and initiatives such as smart city development, the need for optimized and economical structural systems has become essential. The methodology involved modeling and designing a pre-engineered industrial warehouse using STAAD.Pro software, considering various loading conditions including dead load, live load, collateral load, wind load, and their respective load combinations. The building was analyzed according to different country code provisions to evaluate variations in structural response and steel consumption. The primary objective was to determine the optimum steel quantity required while satisfying strength and serviceability criteria over the design life of the structure. The findings revealed that codal variations significantly influence member sizing, stress distribution, and overall steel weight. The study demonstrated that optimized PEB design under appropriate codal provisions results in reduced structural weight while maintaining safety and performance standards. The authors concluded that Pre-Engineered Buildings provide an efficient and economical solution for industrial warehouse construction, and careful comparison of international standards can further enhance material optimization and structural efficiency.

A Comparative Analysis of Conventional Steel Building and Pre-Engineered Building Systems: A Case Study Approach (2024) by Pratik M. Londhe, Rohan Vilas Ambekar, Priyanka R. Dhumal, Amar M. Chipade, Akshay D. Barkale, and Neha B. Sasane – This study presents a case-based comparative evaluation of Conventional Steel Buildings (CSB) and Pre-Engineered Buildings (PEB) with a focus on steel consumption and overall project cost. The research highlights the rapid urbanization in India and the growing demand for efficient construction systems, noting that traditional masonry and conventional steel construction methods are often unable to keep pace with increasing infrastructure needs. The study also emphasizes India's surplus steel production capacity, particularly in hot and cold rolled sheets, which can be effectively utilized in PEB construction. The methodology involved detailed estimation and cost analysis of both PEB and CSB structures for a building with specified dimensions. The quantity take-off, steel consumption, and project cost calculations were performed using Excel-based estimation sheets. The conventional steel building model used hot-rolled sections with constant cross-sections as per IS codes, whereas the PEB system incorporated optimized, prefabricated components designed to match stress variations along

the member length. The findings revealed that PEB systems resulted in reduced steel consumption due to tapered and optimized sections, leading to lower overall structural weight compared to conventional steel buildings where members often remain heavier than required. The cost analysis demonstrated that PEB structures were more economical in terms of material usage and construction efficiency. The authors concluded that Pre-Engineered Building systems provide a cost-effective and resource-efficient alternative to conventional steel construction, especially in the Indian context where surplus steel capacity can be strategically utilized to meet rising infrastructure demands.

Comparative Study on Pre-Engineered Buildings and Conventional Buildings Using Indian and International Standards for Industrial Warehouse (2024) by Yash P. Dongare, Pradeep P. Tapkire, and Atul S. Chandanshive – This study presents a comprehensive comparative evaluation of Pre-Engineered Buildings (PEBs) and Conventional Buildings (CBs) for industrial warehouse applications using both Indian and International design standards. The research highlights the growing transformation in the construction industry due to innovative prefabrication techniques and computerized design advancements, which have significantly improved the precision and efficiency of PEB systems. The methodology involved analytical modeling and design comparison of warehouse structures based on performance criteria, cost-efficiency, and environmental impact. Structural performance was assessed in terms of load-bearing capacity, durability, and overall structural integrity. Cost-efficiency evaluation included initial construction cost, erection time, maintenance requirements, and long-term economic benefits. Environmental impact analysis considered material consumption, energy efficiency, and sustainability aspects. The comparative study was carried out in accordance with relevant Indian codes and international standards to ensure globally applicable conclusions. The findings indicated that PEB systems provide superior time efficiency due to factory fabrication and rapid on-site assembly, resulting in reduced project duration and labor costs. Structurally, PEBs demonstrated adequate load-bearing capacity and reliability for industrial warehouse use, while also offering customization flexibility. Although initial costs may sometimes be slightly higher, long-term savings in maintenance and operational efficiency make PEBs economically advantageous. The study also observed that controlled manufacturing processes enhance quality consistency and reduce material wastage, contributing to improved sustainability. The authors concluded that PEB systems are generally more suitable for modern industrial warehouses compared to conventional buildings, particularly when evaluated on performance, economy, and environmental considerations under both Indian and international standards.

Study of Pre-Engineered Building (PEB) with Respect to Conventional Steel Building: Review Paper (2023) by Chetan Tagade, A.D. Shende, B.S. Ruprai, and Jigar Shah – This review paper presents a comparative evaluation of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB), focusing on their structural behavior, design methodology, and economic performance for single-storey industrial buildings. The study highlights that PEB systems represent a modern and sustainable alternative to traditional steel truss systems due to their lightweight construction, optimized design, and environmental advantages. The methodology involved analytical modeling and design of both PEB and CSB structures using STAAD Pro V8i software. The PEB system was designed based on the American code AISC 360:10, while the conventional steel building was designed in accordance with IS 800:2007. Loading conditions considered in the analysis included dead load (as per IS 875 Part 1:1987), live load (IS 875 Part 2:1987), and wind load (IS 875 Part 3:2015), along with appropriate load combinations as specified by both Indian and American standards. The comparison focused on structural performance, material utilization, and overall efficiency, particularly emphasizing tapered built-up sections used in PEB systems. The findings revealed that PEB structures demonstrated better material optimization, reduced structural weight, and improved structural efficiency compared to conventional steel truss systems using standard hot-rolled sections. The study also indicated that PEB systems provide enhanced sustainability due to lower material consumption and faster construction processes. The authors concluded that Pre-Engineered Buildings are a more economical, environmentally friendly, and technologically advanced solution for industrial construction when compared to Conventional Steel Buildings, especially under optimized design approaches using modern structural analysis tools.

A State-of-the-Art Review on Analysis and Design of Pre-Engineered Buildings (2023) by Subhash Kumar Sah, Muhammed Zain Kangda, Sandeep Sathe, and Nilesh Mate – This paper presents a comprehensive review of the analysis and design methodologies of Pre-Engineered Buildings (PEB), emphasizing their growing adoption in steel construction due to superior strength, flexibility, recyclability, and seismic performance compared to conventional concrete and steel structures. The study highlights that PEB systems are engineered and fabricated in factory-controlled environments based on specified loads and design codes, thereby ensuring quality control and reducing

project completion time. The methodology of the review involved examining previous research studies related to structural analysis, design optimization, and modeling of PEB systems. The paper discusses key structural components such as primary frames (tapered built-up sections), secondary members (cold-formed "Z" and "C" sections), bracing systems, and cladding elements. It also outlines systematic modeling procedures for PEB structures and compares them with Conventional Steel Buildings (CSB) in terms of weight, cost, displacement behavior, and construction time. The findings from the reviewed literature indicate that PEB structures are up to 50% lighter due to optimized tapered I-sections and cold-formed members, approximately 35% more economical than conventional steel structures, and exhibit reduced lateral and vertical displacements under seismic loading. Additionally, PEB systems can be constructed in nearly half the time required for conventional steel buildings. The study further emphasizes the architectural advantages of PEB, including large clear spans and ease of future expansion. The authors conclude that Pre-Engineered Buildings are more sustainable, environmentally friendly, and economically efficient than Conventional Steel Buildings, making them a preferred choice for modern industrial and commercial construction.

Structural Performance of Pre-Engineered Industrial Warehouse Building (2023) by Hariom Suresh Jaiswal and Vishal Sapate – This study focuses on the modeling and structural analysis of Pre-Engineered Building (PEB) industrial warehouse structures in the Nagpur and Nashik regions using STAAD Pro software. The research emphasizes the importance of evaluating PEB performance under region-specific loading and environmental conditions to ensure safe and economical design. The methodology involved finite element modeling and structural analysis of PEB warehouse systems for the selected locations. The study examined structural response parameters such as member forces, displacements, and overall performance under relevant load combinations as per Indian Standard provisions. The objective was to assess the suitability and efficiency of PEB structures in the climatic and geographical conditions of Nagpur and Nashik. The findings indicated that PEB systems provide efficient load distribution, optimized member design, and satisfactory structural performance for industrial warehouse applications in both regions. The study highlighted that regional factors such as wind and environmental conditions influence section selection and overall structural behavior. The authors emphasized that the results offer practical guidance for architects, structural engineers, and project decision-makers in designing cost-effective and reliable PEB systems.

Comparative Study and Analysis of Steel Structure Using Pre-Engineered Technology Over Conventional Construction Methodology (2023) by Dinanath Singh Priyadarshi and Rajesh Joshi – This study presents a comparative structural analysis between Pre-Engineered Metal Buildings (PEMB/PEB) and Conventional Steel Buildings (CSB), emphasizing cost efficiency, construction speed, and structural stability for large-span applications. The research highlights the growing preference for PEB systems in modern construction due to their ability to provide vast, column-free spaces while minimizing material wastage. The methodology involved analyzing a 40-meter span pre-engineered metal building using finite element analysis software ETABS (2013). For comparison, a conventional steel building with the same 40-meter span was also modeled and analyzed using the same software platform. Both systems were evaluated in terms of structural performance, economic efficiency, and overall stability. The findings indicated that the pre-engineered metal building system demonstrated superior economic benefits due to optimized member sizing and efficient prefabrication techniques. The rigid frame system, consisting of bolted roof beams and columns, allowed for large clear spans without intermediate supports. The analysis results showed improved structural stability and performance in the PEB model compared to the conventional steel building. Additionally, PEB systems enabled faster construction timelines, often completing projects in less than half the time required by conventional methods.

Comparative Study & Analysis of Pre-Engineering Building with Respect to Normal Construction (2022) by Samiksha Diware and A. B. Ranit – This study examines the performance of Pre-Engineered Buildings (PEB) in comparison with Conventional Steel Buildings (CSB) for single-storey industrial structures. The research emphasizes that PEB technology offers advantages such as pre-design optimization, prefabrication, reduced self-weight, and faster construction time compared to conventional construction methods. The methodology involved modelling and analyzing main frames of PEB structures with varying spans of 12 m, 14 m, 16 m, 18 m, and 20 m, each with an eave height of 6 m, using STAAD.Pro software. The design and analysis were carried out in accordance with IS 800:2007 and IS 875:1987 (Part 1, 2, and 3). The structures were evaluated under dead load, imposed load, and wind load combinations as specified by Indian Standard codes. The findings indicate that PEB systems provide optimized sectional properties, better structural efficiency, and reduced material consumption compared to conventional steel structures. The study concludes that Pre-Engineered Buildings are an efficient and economical alternative to normal

construction methods for industrial buildings, particularly for moderate span structures, due to their improved structural behavior and time-saving advantages.

Analysis of Warehouse Structure in Pre-Engineered Building with Conventional Steel Building (2022) by Sourabh Pardhi, Deepak Bandewar, and Sachin Jat – This study presents a comparative structural analysis of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for an industrial warehouse application. The research emphasizes that the PEB concept contributes significantly to design optimization, reduced construction time, and improved sustainability, especially in the context of increasing global steel usage and environmental concerns. The methodology involved planning and modeling a 3D frame of an industrial warehouse structure and analyzing it using structural analysis and design software. The design was carried out in accordance with Indian Standard IS 800:2007 and also referenced with American Standard AISC (LRFD). Various loading conditions including dead load, live load, wind load, seismic load, and snow load were considered as per relevant IS codes. A parametric comparison was conducted to evaluate variations in shear force, support reactions, structural weight, and overall cost between PEB and CSB systems. The findings revealed that PEB structures, due to the use of prefabricated tapered sections and optimized member design, resulted in reduced structural weight and improved material efficiency compared to conventional steel buildings that use standard hot-rolled sections. The study also highlighted that PEB systems provide large column-free spans suitable for warehouse structures, along with faster construction and cost benefits. The authors concluded that Pre-Engineered Buildings offer a more economical and structurally efficient solution than Conventional Steel Buildings for industrial warehouse construction, particularly when evaluated under multiple loading scenarios and international design standards.

Comparative Study on PEB Structure and Conventional Industrial Building (2022) by Somasundhara Naathan M. G and Ramadevi K – This study presents a comparative analysis of Pre-Engineered Building (PEB) systems and Conventional Industrial Steel Buildings, focusing on material optimization and economic sustainability in industrial construction. The research emphasizes the rising cost of steel and the necessity of optimizing steel usage to achieve cost-effective and sustainable structural solutions. The methodology involved designing and analyzing a 30 m span industrial truss structure subjected to crane loads of 10 tonnes, 15 tonnes, and 20 tonnes. Both conventional steel truss systems and pre-engineered steel configurations were evaluated to compare structural performance and material consumption. The analysis aimed to assess how optimized PEB design techniques influence steel quantity and overall structural efficiency under varying crane load conditions. The findings demonstrated a considerable reduction in the quantity of steel required in PEB systems compared to conventional structures. The study highlighted that PEB systems effectively provide long-span, column-free spaces essential for industrial buildings while maintaining structural safety. Additionally, due to prefabrication and optimized member sizing, PEB structures achieved improved economy and reduced construction time. The authors concluded that Pre-Engineered Buildings offer a more material-efficient and economically sustainable alternative to conventional industrial steel buildings, particularly for long-span structures subjected to heavy crane loads.

Structural Performance of Pre-Engineered Building: A Comparative Study (2021) by V. Vishnu Sai, P. Poluraju, and B. Venkat Rao – This study investigates the structural performance of Pre-Engineered Buildings (PEB) by conducting a comparative analysis under different wind zones in India. The research emphasizes the role of technological advancements in structural engineering and highlights PEB as an optimized, flexible, and fast-construction solution suitable for diverse applications. The methodology involved modeling and analyzing a multiple-bay PEB system using STAAD.Pro software. Two different geographical locations—Vijayawada and Hyderabad—were considered to evaluate the influence of varying wind zones on structural performance. The analysis focused on key structural response parameters such as shear force (SF) and bending moment (BM). Based on the computed SF and BM values, the geometrical properties of pre-engineered sections were optimized to achieve structural efficiency and safety. The findings revealed that wind intensity significantly affects structural weight and design requirements. The structure located in Vijayawada exhibited 11.04% higher structural weight compared to the structure in Hyderabad due to higher wind loading effects. The study concluded that wind zone variations play a critical role in determining section properties and overall material consumption in PEB systems. The authors emphasized that PEB structures, when optimized through analytical tools like STAAD.Pro, provide efficient and adaptable solutions for industrial and commercial construction across different climatic conditions.

Comparative Study of Industrial Steel Structure (Pre-Engineered Building) and Residential RCC Structure (2021) by Mahesh Nivrutti Ghumare and S. N. Daule – This study presents a comparative structural and economic evaluation between an industrial steel structure (Pre-Engineered Building – PEB) and a residential G+2 RCC structure under identical loading conditions. The research emphasizes the growing preference for steel-based prefabricated systems due to advantages such as speed of construction, cost efficiency, quality control, and seismic performance. The methodology involved modeling and analyzing both structures using STAAD Pro software. A G+2 public building (hospital plan) located in Pune, Maharashtra, with plan dimensions of 60 m × 52 m and total height of 11.25 m, was selected for the study. Both RCC and PEB frame systems were designed considering dead loads, live loads, wind loads, and earthquake effects. Structural elements such as beams and columns were modeled using RCC sections for the concrete structure and steel (PEB) sections for the industrial steel structure. Key parameters such as base shear, deflection behavior, and overall material cost were compared. The findings indicated that RCC structures possess higher seismic weight due to their bulkier sections, whereas steel (PEB) structures exhibit greater ductility and flexibility, which are advantageous under earthquake loading. Although steel structures may show comparatively higher deflections, their ductile behavior improves energy absorption capacity during seismic events. The cost comparison based on material quantities showed that industrial steel structures (PEB) were more economical than RCC structures for the same building configuration.

A Review of Pre-Engineered Steel Building (2021) by Sourav Uppal and Dheeraj Kumar – This review paper discusses the concept, advantages, and applications of Pre-Engineered Buildings (PEB) in comparison with Conventional Steel Buildings (CSB) and Reinforced Cement Concrete (RCC) structures. The study emphasizes the increasing adoption of PEB technology in India due to the growing demand for rapid, economical, and efficient construction methods. The methodology of the paper is primarily literature-based, reviewing the design philosophy, manufacturing process, and structural characteristics of prefabricated steel buildings. The authors discuss how PEB systems are manufactured in factory-controlled environments using standardized raw materials and then transported to the construction site in ready-to-assemble form. The study also explains the classification of buildings into RCC, steel, and timber structures, highlighting the comparative benefits of steel-based prefabricated systems. The findings indicate that PEB structures can be up to 30% lighter than conventional steel buildings due to optimized section design and efficient fabrication techniques. The reduction in weight results in lower steel consumption and cost savings of approximately 20–30% in overall project expenses. The construction time for PEB is significantly shorter (around 5–8 weeks), nearly half the time required for traditional steel construction. Additionally, PEB systems offer advantages such as earthquake resistance, water resistance, ease of expansion, relocation capability, and minimal on-site welding.

An Analytical Study on Pre-Engineered Buildings Using STAAD Pro (2020) by Shaik Kalesha, B.S.S. Ratnamala Reddy, and Durga Chaitanya Kumar Jagarapu – This study presents an analytical evaluation of Pre-Engineered Buildings (PEB) as a modern alternative to conventional steel construction, emphasizing optimization, sustainability, and construction efficiency. The research highlights the growing demand in the construction industry for cost-effective, high-quality, and rapidly executable structural systems with improved architectural appeal. The methodology involved modeling and analyzing pre-engineered steel building systems using STAAD Pro software to understand their structural behavior and optimize design parameters. The study focused on minimizing construction cost and time while maintaining structural integrity and safety. Comparative observations were made between PEB systems and conventional steel structures in terms of construction duration, material utilization, and overall project economy. The findings indicated that PEB systems significantly reduce construction time due to prefabrication and streamlined on-site assembly. The optimized design approach ensures better material utilization, leading to cost savings and structural efficiency. Additionally, the materials used in PEB construction are reusable, recyclable, and environmentally friendly, contributing to sustainability in modern infrastructure development. The authors concluded that Pre-Engineered Buildings outperform conventional steel construction in terms of economy, speed, and sustainability, making them a superior solution for contemporary building requirements.

Advantages of Pre-Engineered Building over Conventional Building (2020) by Rajnandan Verma and Raghvendra Singh – This study presents a comparative evaluation of Pre-Engineered Metal Buildings (PEB) and Conventional Steel Buildings (CSB), focusing on economy, structural stability, and construction efficiency for large-span applications. The research emphasizes that modern construction demands cost-effective solutions, reduced project duration, and large column-free working spaces, which PEB systems effectively provide. The methodology involved analyzing a 40-meter span pre-engineered metal building using finite element–based software ETABS (2013). For comparative purposes, a conventional steel building of the same 40-meter span was modeled and analyzed

using the same software. Both structural systems were evaluated under identical loading conditions to assess stability, structural behavior, and cost implications. The findings indicated that PEB systems offer significant material savings due to optimized member design and prefabrication techniques. The rigid frame system—comprising beams, columns, purlins, and rafters—allows wide column-free spans ranging from 15 m to 60 m, with the potential to extend even further in specialized cases. The study observed that PEB structures are approximately 30–40% lighter than conventional steel buildings, leading to reduced foundation loads and overall cost savings. Additionally, factory fabrication and bolted assembly reduce construction time by nearly half compared to conventional steel construction.

Comparative Study of Warehouse Structure in Pre-Engineered Building with Conventional Steel Building for Bhopal City (2020) by Raghvendra Bajpai and Rakesh Patel – This study presents a comparative structural analysis of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for an industrial warehouse located in Bhopal, Madhya Pradesh. The research highlights the increasing adoption of PEB technology in India due to its sustainability, rapid construction capability, and suitability for long-span, column-free industrial structures. The study also emphasizes the environmental advantages of steel as a recyclable material and its growing market share in the construction sector. The methodology involved planning and modeling a 3D frame of an industrial warehouse using structural analysis software (STAAD Pro V8i). The structure was analyzed and designed according to Indian Standard IS 800:2007 and also referenced with American Standard AISC (LRFD). Various load combinations including dead load, live load, wind load, seismic load, and snow load were considered as per relevant IS codes. A parametric comparison was performed to evaluate shear force, support reactions, structural weight, and cost implications for both PEB and CSB systems. The findings revealed that PEB systems demonstrated reduced structural weight due to the use of tapered sections and optimized member design. The prefabricated nature of PEB contributed to faster construction and lower overall cost compared to conventional truss-based steel buildings. The study also observed that PEB structures are particularly suitable for tropical regions like India and for remote or hilly areas where rapid construction is advantageous. The authors concluded that Pre-Engineered Buildings provide a more economical, sustainable, and structurally efficient alternative to Conventional Steel Buildings for warehouse applications, especially when evaluated under Indian and American design standards.

A Review on Comparative Study on the Structural Analysis and Design of Pre-Engineered Building (PEB) with Conventional Steel Building (CSB) (2020) by Mitaali Jayant Gilbile and S. S. Mane – This paper presents a comprehensive review and parametric comparison of Pre-Engineered Building (PEB) frames and Conventional Steel Building (CSB) frames for industrial structures designed as per Indian Standards. The study emphasizes the growing preference for optimized steel structures due to steel's high strength-to-weight ratio, ductility, and long-term durability. The introduction of PEB systems has enabled more efficient structural design by tailoring member sections according to bending moment distribution, thereby minimizing unnecessary material usage. The methodology involved analyzing and designing three different models each for PEB and CSB with varying building widths. The structural analysis was carried out considering load combinations as per IS 800:1984 and IS 800:2007, along with relevant provisions of IS codes for dead load, live load, wind load, seismic load, and snow load. A detailed parametric study was conducted to evaluate structural performance in terms of shear force, support reactions, structural weight, cost comparison, and construction time. The findings revealed that PEB systems demonstrated reduced structural weight and improved material optimization compared to CSB models. The study also indicated that cost and construction time were significantly lower for PEB structures due to prefabrication and efficient design practices. Variations in shear forces and support reactions were observed based on span width and structural configuration; however, PEB models consistently showed better economy. The authors concluded that Pre-Engineered Buildings offer a more optimized, economical, and time-efficient solution for industrial construction when compared to Conventional Steel Buildings, especially when evaluated through parametric performance analysis under Indian Standard loading conditions.

Study and Analysis of Pre-Engineering Building Structure (2019) by Sunil Kumar and G.B. Bhaskar – This study presents the analysis and design evaluation of Pre-Engineered Buildings (PEB) in comparison with Conventional Steel Buildings (CSB), focusing on industrial warehouse applications. The research emphasizes that the PEB concept significantly optimizes structural design by utilizing steel efficiently and adopting the Limit State Method as per IS 800:2007. The methodology involved analyzing and designing an industrial warehouse structure using STAAD Pro software in accordance with Indian Standard IS 800:2007. The study considered relevant loading conditions, including dynamic loads, and compared structural behavior between PEB and conventional steel systems. The investigation focused on parameters such as material utilization, fabrication efficiency, and overall structural

performance. The findings indicated that PEB systems offer improved economy due to optimized section design and reduced structural weight compared to conventional steel buildings. The prefabricated nature of PEB components ensures easier fabrication, better quality control, and faster construction. The study concluded that adopting PEB methodology in place of conventional steel construction provides advantages in terms of cost-effectiveness, lightweight construction, and structural efficiency. The authors noted that the observations from this comparative analysis are beneficial for practicing structural engineers in selecting appropriate building systems for industrial projects.

Optimization of Industrial Building using Pre-Engineering Building and Conventional Steel Building by Fully Stressed Design (2018) by Nitin Vishwakarma and Hardik Tayal – This study presents an optimization-based comparative analysis of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for an industrial structure with an 18 m span located at Palwal near New Delhi, India. The research emphasizes the need for economical and structurally efficient steel systems for long-span industrial buildings. The methodology involved designing and analyzing five different structural cases, including a PEB with built-up tapered members of varying thickness, a CSB with conventional hot-rolled sections, an optimized CSB configuration, and alternative roof systems such as Warren trusses with hollow and compound sections available in the Indian market. The concept of Fully Stressed Design (FSD) was adopted to achieve optimal utilization of material by maintaining the stress ratio of members close to but less than unity, in accordance with Indian Standards. The study incorporated optimization techniques such as size optimization (variation in cross-sectional properties), shape optimization (modification of structural geometry), and topology considerations. The findings revealed that PEB structures with tapered built-up members provided better material efficiency and reduced overall weight compared to conventional steel systems with constant-depth hot-rolled sections, which often resulted in overdesign in low-stress regions. The optimized PEB configuration achieved the most economical solution while maintaining structural safety and functionality. The authors concluded that the Fully Stressed Design approach significantly enhances structural performance and cost-effectiveness, and that PEB systems are generally more suitable for low-rise, long-span industrial buildings when compared to conventional steel construction.

A Case Study of Low Span Pre-Engineered Industrial Building (2018) by R. D. Shambharkar, P. A. Deotale, Vivek Naik, and D. K. Parbat – This study presents a detailed case analysis of a low-span Pre-Engineered Industrial Building (PEIB) constructed for a cement godown at Vijayawada. The research emphasizes that the design of industrial buildings is primarily governed by functional requirements, economy of construction, and optimization of structural dimensions such as bay spacing and span length. The methodology involved analyzing and optimizing a PEB structure with dimensions 15 m width, 50 m length, and 5 m height. The study examined the influence of bay spacing on structural weight and overall cost, comparing the optimized PEB configuration with a conventional steel building alternative. Particular attention was given to balancing the number of columns, trusses, purlins, and crane beams against foundation costs, as fewer columns directly reduce foundation expenses. The findings revealed that the optimized PEB system, with a bay spacing of 7.14 m, resulted in a minimum total structural weight of 22.51 tonnes and an estimated cost of ₹12.54 lakhs. In comparison, the conventional steel building with 6.25 m bay spacing had a total weight of 34.4 tonnes and a cost of ₹14.448 lakhs. The PEB system achieved a material saving of 11.73 tonnes (approximately 32.85%) and a net cost saving of ₹1.91 lakhs.

Pre-Engineered Building Design of an Industrial Warehouse (2018) by Anisha Goswami and Tushar Shende – This study presents the design and comparative evaluation of a Pre-Engineered Building (PEB) and a Conventional Steel Building (CSB) for an industrial warehouse located in Nagpur, Maharashtra. The research highlights the evolution of PEB technology in India since the 1990s as a solution to overcome the limitations of conventional steel construction, particularly in terms of construction time, erection complexity, and material efficiency. The methodology involved designing a typical industrial warehouse frame with a span of 30 meters, consisting of 8 bays each of 7.5 meters and an eave height of 6 meters. The PEB frame was analyzed considering wind load as the critical loading condition, while a conventional steel truss system was designed for the same span using an economical truss configuration. Structural elements such as principal rafters, columns, column bases, purlins, sag rods, tie rods, gantry girders, and bracings were designed and analyzed using STAAD Pro V8i in accordance with Indian Standard codes. The findings indicated that the PEB system provided improved structural efficiency through optimized section design and reduced self-weight compared to the conventional steel building. The bolted connections in PEB structures allow easy dismantling, relocation, and future expansion, making them more flexible and adaptable. The study concluded that Pre-Engineered Buildings are more economical and time-efficient for industrial warehouse construction, offering

better strength-to-weight ratio, faster execution, and long-term functional advantages over Conventional Steel Buildings.

A Study of Performance of Pre-Engineered Building of an Industrial Warehouse for Dynamic Load (2017) by Apurv Rajendra Thorat and Santosh K. Patil – This study investigates the structural performance of Pre-Engineered Buildings (PEB) subjected to dynamic loading conditions, with specific focus on an industrial warehouse structure. The research emphasizes the importance of evaluating seismic and time-dependent responses in PEB systems to ensure structural safety and stability. The methodology involved designing PEB structures in accordance with Kirby Technical Specifications based on ASCE-07 provisions. Two structural cases were considered: (1) PEB with bracing system and (2) PEB without bracing system. Both models were analyzed using STAAD.Pro software. For dynamic evaluation, Time History Analysis was performed using the El-Centro ground motion record to simulate earthquake effects. The study compared the dynamic response of both configurations under seismic excitation. The findings indicated that PEB structures with proper bracing systems demonstrated improved dynamic performance, reduced lateral displacements, and enhanced overall stability compared to unbraced PEB systems. The study highlighted that tapered sections in PEB frames effectively reduce excess steel usage while maintaining structural strength. The results also confirmed that PEB systems, when properly designed and braced, exhibit satisfactory performance under dynamic loading conditions.

A Comparative Study on Analysis & Design of Pre-Engineered & Conventional Industrial Building (2017) by Hemant Sharma – This study presents a detailed comparative analysis of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for industrial applications, focusing primarily on bending moment distribution and structural efficiency. The research emphasizes the concept of providing optimized structural sections in PEB systems according to the bending moment diagram, resulting in non-prismatic rigid frames with tapered built-up sections. The methodology involved modeling and analyzing both PEB and CSB structures using STAAD Pro V8 software in accordance with relevant Indian Standard codes. The analysis considered Dead Load, Live Load, and Wind Load for the geographical location of Vadodara, Gujarat. Various structural components of PEB such as purlins, girts, eave struts, and bracing systems were designed and evaluated. Additionally, different truss systems were examined for roofing and cladding in the conventional building model. The comparative evaluation was mainly based on bending moments at critical sections, overall economy, and construction time. The findings revealed that PEB systems, due to their tapered I-section configuration and optimized material distribution, achieved better structural efficiency and reduced material consumption compared to conventional truss-based systems using standard hot-rolled sections. The study also highlighted significant time savings in construction due to prefabrication in PEB systems. The author concluded that Pre-Engineered Buildings provide a more economical and time-efficient alternative to conventional industrial buildings, particularly where optimized design and rapid construction are essential.

Design and Analysis of Conventional and Pre-Engineered Building (R.C.C and Steel) (2016) by D. Rakesh, V. Sanjay Gokul, and G. Amar – This study presents a comparative evaluation of Conventional Steel Buildings (CSB) and Pre-Engineered Buildings (PEB), including considerations of RCC and steel structural systems for industrial applications. The research highlights the growing adoption of steel structures in industrial construction due to their high tensile strength, durability, weather resistance, and rapid installation. The methodology involved the design and structural analysis of both CSB and PEB models, focusing on parameters such as displacement behavior and load-carrying capacity. Standard hot-rolled "I" and "C" sections were used in conventional systems, whereas optimized prefabricated sections were adopted in PEB configurations. The analysis was carried out considering relevant loading conditions to assess structural performance. The findings indicated that PEB systems offer reduced structural weight, improved sectional optimization, and faster construction compared to conventional steel buildings. Additionally, PEB structures demonstrated better control over displacement and efficient load distribution due to optimized member sizing. The study also emphasized that both systems can be effectively used for industrial and even multi-storey (4–6 floors) buildings; however, PEB systems provide enhanced economy in terms of time and cost. The authors concluded that while conventional steel buildings remain structurally reliable, Pre-Engineered Buildings present a more efficient and economical alternative for modern construction needs, especially where speed, optimization, and aesthetic quality are key considerations.

Comparative Study of Pre-Engineered and Conventional Industrial Building (2015) by L. Maria Subashini and Shamini Valentina – This study presents a comparative structural analysis of Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for industrial applications requiring long-span, column-free spaces. The research

emphasizes that industrial buildings demand lightweight, economical, and time-efficient construction systems, and PEB technology effectively satisfies these requirements through prefabrication and optimized design. The methodology involved modeling and designing an industrial building with dimensions 44 m length and 20 m width using STAAD.Pro V8i software. The study compared conventional steel frames with concrete columns and steel columns against pre-engineered steel frames incorporating tapered sections. Both structural systems were analyzed under relevant loading conditions to evaluate their structural behavior and efficiency. The findings revealed that PEB structures, due to their tapered built-up sections and optimized member design, resulted in reduced structural weight, improved material efficiency, and faster construction compared to conventional systems. The study also highlighted that PEB systems provide better economy and structural performance while maintaining safety standards. The authors concluded that Pre-Engineered Buildings are a superior alternative to conventional industrial buildings, particularly where speed of construction, cost-effectiveness, and large unobstructed spaces are primary design requirements.

A Study on Pre-Engineered Building – A Construction Technique (2015) by Shrunkhal V. Bhagatkar, Farman Iqbal Shaikh, Bhanu Prakash Gupta, and Deepak Kharta – This study reviews the concept and development of Pre-Engineered Buildings (PEB) as an advanced construction technique for steel structures. The research highlights that the rapid growth of the steel industry and the need for economical, eco-friendly, and time-efficient construction methods have significantly increased the adoption of PEB systems. The methodology primarily involved a review of past experimental and analytical studies on PEB structures, along with an evaluation of their structural components such as rigid frames, purlins, girts, and cold-formed secondary members. The study discusses the evolution of rigid frame buildings from small spans in the 1940s to large-span industrial structures made possible through computer-aided design in the 1960s. The findings indicate that PEB structures reduce construction time (typically completed within 6–8 weeks), lower overall cost, enhance energy efficiency, and provide flexibility for future expansion. The authors observed that steel, being recyclable and durable, supports sustainable development goals, making PEB systems environmentally favorable. Furthermore, the study emphasizes that secondary members such as purlins and girts contribute significantly to load transfer and lateral stability in industrial buildings requiring large column-free spaces. The authors concluded that Pre-Engineered Buildings offer a practical, economical, and sustainable alternative to conventional steel construction, especially for low-rise industrial applications.

Comparative Study of Pre-Engineered and Conventional Industrial Building (2014) by Pradeep V and Papa Rao G – This study presents a detailed comparative analysis between Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) for industrial applications requiring long-span, column-free spaces. The research emphasizes that industrial structures demand economical, lightweight, and time-efficient construction systems, and PEB technology effectively fulfills these requirements. The methodology involved modeling and designing an industrial building of 44 m length and 20 m width using STAAD.Pro V8i software. Two structural configurations were analyzed: a conventional steel frame system with concrete and steel columns using traditional steel trusses, and a pre-engineered steel frame system incorporating tapered sections. Both systems were evaluated under relevant loading conditions to assess their structural behavior and efficiency. The findings revealed that PEB structures, due to their optimized tapered sections and prefabricated components, resulted in reduced structural weight, lower material consumption, and faster construction compared to conventional systems. The study also highlighted that PEB systems provide better economy and efficiency for long-span industrial buildings, while maintaining structural safety and performance standards. The authors concluded that Pre-Engineered Buildings are a superior alternative to conventional industrial construction, particularly where speed, cost-effectiveness, and large unobstructed spaces are primary design considerations.

III. RESEARCH GAP

Although extensive research has been conducted on Pre-Engineered Buildings (PEB) over the last decade, several significant gaps still exist in the current body of knowledge. Most of the reviewed studies primarily focus on comparative static analysis between PEB and Conventional Steel Buildings (CSB), emphasizing parameters such as structural weight, bending moment, displacement, and initial construction cost. However, these studies largely limit their scope to linear elastic analysis using software such as STAAD.Pro or ETABS, without incorporating advanced nonlinear or performance-based design approaches. There is a noticeable lack of comprehensive dynamic studies involving nonlinear time history analysis, performance-based seismic design, fragility assessment, and progressive collapse evaluation for industrial PEB structures.

Furthermore, while many researchers highlight cost savings associated with PEB systems, the majority of economic evaluations are restricted to initial material and construction costs. Detailed life-cycle cost analysis (LCCA), including maintenance cost, operational efficiency, durability assessment, recyclability benefits, and end-of-life value, remains largely unexplored. Sustainability is frequently mentioned as an advantage of PEB systems; however, very few studies provide quantitative analysis of embodied energy, carbon footprint, or environmental impact assessment through standardized green building metrics.

Another major research gap lies in integrated multi-objective optimization. Most optimization-based studies focus solely on minimizing structural weight or stress ratio through tapered sections, without simultaneously optimizing parameters such as cost, displacement control, energy efficiency, and sustainability. Advanced optimization techniques such as genetic algorithms, artificial intelligence (AI), machine learning, and parametric modeling tools have not been widely applied to PEB industrial building design. Additionally, limited research has been conducted on hybrid structural systems, such as PEB combined with composite floors, tubular–tapered hybrid members, or PEB-RCC integrated systems.

Moreover, there is insufficient investigation into region-specific design optimization under varying wind zones, seismic zones, and industrial loading conditions such as heavy crane loads. Although international and Indian codes are compared in some studies, there is still a lack of standardized, comprehensive design guidelines specifically tailored for pre-engineered industrial buildings in the Indian context. Therefore, future research should focus on advanced nonlinear analysis, life-cycle performance evaluation, sustainability quantification, AI-based structural optimization, hybrid structural configurations, and development of unified design frameworks to enhance the safety, economy, and long-term performance of pre-engineered industrial buildings.

CONCLUSION

Based on the comprehensive review of previous studies conducted between 2014 and 2025, it can be concluded that Pre-Engineered Buildings (PEB) have emerged as a structurally efficient, economical, and technologically advanced alternative to Conventional Steel Buildings (CSB) and RCC systems for industrial applications. The majority of the reviewed research demonstrates that PEB systems provide significant advantages in terms of reduced structural weight, optimized material utilization through tapered built-up sections, improved bending moment distribution, faster construction timelines due to prefabrication, and lower overall project costs. Studies consistently indicate that PEB structures achieve better performance in long-span, column-free industrial spaces, making them highly suitable for warehouses, manufacturing plants, and distribution centers. Additionally, PEB systems exhibit improved seismic ductility and adaptability under varying wind and environmental conditions when designed using appropriate codal provisions and bracing systems. However, while existing research strongly supports the structural and economic benefits of PEB systems, further advancements are required in areas such as nonlinear seismic analysis, life-cycle cost assessment, sustainability quantification, and integrated multi-objective optimization. Overall, the literature clearly establishes that Pre-Engineered Buildings represent a modern, efficient, and sustainable construction approach for industrial infrastructure, with substantial potential for further improvement through advanced analytical techniques and innovative design methodologies.

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