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COMPARATIVE STUDY ON PRE-ENGINEERED BUILDINGS AND CONVENTIONAL BUILDINGS USING INDIAN AND INTERNATIONAL STANDARDS FOR INDUSTRIAL WAREHOUSE

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Abstract - *In this study, the construction industry is undergoing significant transformations with the advent of innovative building techniques, among which Pre-Engineered Buildings (PEBs) have emerged as a noteworthy alternative to traditional Conventional Buildings (CBs). This project aims to conduct a detailed comparative analysis of PEBs and CBs, specifically in the context of industrial warehouses. PEBs, which are designed and manufactured in a factory setting before being assembled on-site, offer greater precision and faster construction times compared to CBs, which are built from scratch on-site using traditional methods. The analysis will focus on three key factors: performance, cost-efficiency, and environmental impact. Performance will be evaluated in terms of structural integrity, durability, and suitability for industrial warehouse use, while cost-efficiency will consider initial construction costs, long-term maintenance expenses, and potential savings. Environmental impact will be assessed by examining energy consumption, material usage, and sustainability. Both Indian and International standards will be used to ensure a comprehensive and globally relevant evaluation, providing a clear understanding of the advantages and disadvantages of each building type for industrial warehouses.*

Key Words: Pre-engineered buildings (PEB), Conventional buildings, Industrial warehouses, Load-bearing capacity, Prefabrication techniques.

1. INTRODUCTION

Technological advancements have revolutionized pre-engineered buildings (PEBs), significantly enhancing their design and efficiency. Originally developed in the 1960s, PEBs have recently seen a surge in popularity due to the capabilities of computerized design, which allow for precise engineering and efficient construction processes. In the USA, PEBs dominate the market for non-residential low-rise buildings, accounting for approximately 60% of such structures. Introduced to India in the late 1990s, PEBs have rapidly gained traction, with the market now boasting an annual potential of 1.2 million tons. While India excels in the fabrication of PEBs and follows strict building codes to ensure quality and safety, it is still advancing in areas such as design and aesthetics. Prefabricated buildings, including PEBs, offer numerous advantages over traditional construction methods. Despite sometimes being more expensive initially, they save a considerable amount of time because of their quick assembly process. This time efficiency can result in cost savings over the long term, as projects are completed faster, reducing labor and operational costs. Moreover, PEBs offer a high level of customization, allowing for designs tailored to specific client needs. The quality of PEBs is also high, thanks to the controlled manufacturing environment, which ensures consistent standards and minimizes on-site errors.

1.1 Aim & Objective

To identify most suitable provision for industrial warehouse.

The following are the objective of research work:

1. Analysis and design of industrial warehouse for different span and height by using Indian code provision by conventional design.
2. Analysis and design of industrial warehouse for different span and height by using Indian code provision by Pre-engineered design.
3. Comparing pre-engineered & conventional design of industrial warehouse using Indian and international code.
4. To develop non-dimensional chart to find most suitable frame design for warehouse.

2. Literature Review

Buildings & houses are the basic requirements of any human being. There are several changes in construction technology since the beginning. The basic requirements of construction nowadays are best aesthetic look, fast, economical & high quality. Pre- engineered building is best option for these all requirements. Pre-engineered buildings are cost effective, time consuming as compared to other conventional buildings. So as to study the design and effect of PEB over CSB various research papers and journal papers were reviewed among which some of the concern related papers are there central idea for their research are presented below.

Contributions of researchers are presented as follows,

Syed Firoz et.al (April-2012) [1] "International journal of engineering research & applications, volume 2, issue 2, pp:267-272" summarized the design concept of pre-engineered steel buildings offer several benefits for single-story constructions compared to traditional buildings. These structures are efficient, cost-effective, and adaptable, utilizing a central model that integrates various design disciplines. The Staad-Pro software helps in creating detailed, real-time data views of the project. Choosing steel for these buildings is advantageous due to its low cost, strength, durability, design flexibility, adaptability, and recyclability.

Aijaz Ahmad Zende et.al (Feb 2013), [2] "IOSR Journal of Mechanical and Civil Engineering, Volume 5, Issue 1 page 32-43" a study comparing Pre-Engineered Buildings (PEB) and conventional steel frames. PEBs are highlighted for their efficiency in creating long-span, column-free spaces, which are essential in industrial structures. The study involves analyzing and designing these two types of structures using Staad Pro software, focusing on weight and cost differences. Three examples are analyzed: two compare PEBs with conventional frames, and the third examines a longer span PEB. The study includes dynamic forces like wind and seismic forces, with wind analysis done manually according to IS 875 (Part III) – 1987 and seismic analysis as per IS 1893 (2002).

C. M. Meera (June 2013), [3] "International journal of engineering sciences & emerging technologies. Volume 5 Issue 2, pp:75-82" a study on Pre-Engineered Buildings (PEB) for industrial warehouses. PEBs are a modern approach to single-story industrial building construction that offers benefits such as quality pre-designing, prefabrication, lightweight structure, and cost-effectiveness. The study compared PEBs with Conventional Steel Buildings (CSB) using structural analysis software Staad-Pro. It concluded that PEBs are more advantageous than CSBs, being approximately 30% lighter, more cost-effective, and offering better quality control and faster construction.

Sai Kiran Gone et.al (2014), [4] "International Journal of Civil, Architectural, Structural & Contraction Engineering, Volume 8, No. 4" summarized a case study on the comparison of design procedures for Pre-Engineered Buildings (PEB) versus Conventional Steel Buildings (CSB). PEBs have gained popularity due to their cost-effectiveness and ease of fabrication. The study examines an industrial warehouse structure using different standards: Indian standards (IS 800-1984, IS 800-2007), MBMA-96, and AISC-89. The analysis focuses on a structure with specific dimensions and includes different 2D frame configurations. The study compares the weight and economy of the structure according to Indian and American codes.

Kavya Rao M. N, K.N. Vishwanath (Sept 2014), [5] "International Journal of Research in Advent Technology, Vol.2, No.9" transition from traditional steel frame structures to Pre-Engineered Buildings (PEBs) in industrial construction. PEBs, a modern construction method that has gained popularity in recent years, offer an optimized design by using the best possible sections based on specific requirements. The paper compares PEBs and Conventional Steel Buildings (CSBs) by designing an industrial building using both methods and analyzing them with structural analysis software, Staad-pro. The study concludes that PEBs have advantages over CSBs, particularly in handling dynamic forces like wind.

Sravan kumar et.al (2014 Nov) , [6] "International Journal of Applied Sciences, Engineering and Management ,ISSN 2320 – 3439, Vol. 03, No. 06, November 2014, pp. 26 – 29" Design and analysis of Pre-Engineered Buildings (PEBs), a concept introduced in the 1960s. These steel structures are manufactured off-site using I-sections, with no on-site welding required. The design is efficient, using only the necessary amount of steel based on the moments at specific locations, making it economical. The author worked on designing a 69m wide and 173m long textile building using the IS 800-2007 Design code and STAAD Pro software, detailing the design process and parameters.

Shrunkhal V. Bhagatkar et.al (March 2015) et.al [7] "Int. Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 3, (Part -2) March 2015, pp.05- 09" Summarized A Study on Pre-Engineered Buildings (PEBs) are a construction technique involving steel structures, which are both economical and eco-friendly. The steel industry is expanding worldwide, and PEBs can be built quickly, making them a popular choice. Studies have shown that PEBs are cost-effective, energy-efficient, and allow for flexible expansion, making them a favorable option in the face of global warming and time constraints.

Mr. Aditya P. Mehendale1 et.al (June 2016) [8] "Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-6, 2016ISSN: 2454-1362" Reviewed the Overview of Pre-engineered buildings (PEBs) are an efficient and cost-effective construction option. They offer a good aesthetic look, are faster to build, and are lighter compared to traditional buildings. PEBs are pre-designed and pre-manufactured in a factory, then assembled on-site, saving time and costs. Although PEBs are advantageous in terms of economy, speed, and simplicity, they are not yet widely preferred in India.

Swati Wakchaure (2016), [9] "International Journal of Engineering Development and Research Volume 4, Issue 2" Studied on Pre-Engineered Buildings (PEB) compared to Conventional Steel Buildings (CSB). It highlights how PEB designs optimize construction by designing members according to bending moment diagrams, which reduces steel use. The study analyzes and designs an industrial structure using both PEB and CSB frameworks according to Indian standards (IS 800-1984 and IS 800-2007). It examines a

structure with specific dimensions and roof slopes for both types. The study also compares the economic aspects, particularly the weight differences between PEB and CSB structures, based on the specified Indian codes.

Apurva R. Thorat et.al (2017), [10] "International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 06 | June -2017"A study that compares the Pre-Engineered Building (PEB) design concept with the Conventional Steel Building (CSB) approach for industrial warehouses. The PEB concept involves pre-designing and prefabricating sections, making it lighter, more economical, and versatile compared to the traditional CSB method. The study uses structural analysis software, Staad-Pro, to design and analyze a typical frame for a warehouse using both concepts, highlighting the advantages of PEB over CSB..

Hemant Sharma (March 2017), [11] "IJIRST –International Journal for Innovative Research in Science & Technology| Volume 3 | Issue 10" Presented the Comparative Study on designs pre-engineered buildings (PEB) and conventional steel buildings (CSB), focusing on comparing bending moments at different sections. It uses Staad Pro v.8 and Indian standard codes, particularly looking at components like purlins, girts, eave struts, and bracings. The comparison includes evaluating the economic and time-saving aspects of construction. The study also considers various loads, including dead, live, and wind loads, specifically for Vadodara, Gujarat.

T.D. Mythili et.al (April 2017), [12] "International Journal of Scientific & Engineering Research, Volume 8, Issue 4, April-2017" Reviewed the study by overview of Pre-engineered buildings are an efficient construction option that meets modern needs for aesthetics, speed, cost, and quality. They are typically quicker to build (25% faster) and lighter (30% lighter) than conventional buildings. The process involves designing and calculating load requirements beforehand, manufacturing components in a factory, and then assembling them on-site.

Dr. S. A. Halkude, Mr. M. G. Kalyanshetti, Mr. S. H. Kalyani [13] "2nd International Conference on Current Research Trends in Engineering and Technology 2018 IJSRSET | Volume 4 | Issue 5" summarized the Comparative Study of Pre Engineered Buildings (PEB) for industrial structures worldwide and notes that, despite their introduction in India two decades ago, they are not widely adopted there. The writer aims to compare PEBs with Conventional Steel Buildings (CSB) in terms of structural design, construction methods, time, and cost. This comparison is carried out using Staad-Pro software and focuses on a case study of a PEB building in Chikmangluru, Karnataka, to address the current lack of confidence and awareness in using PEBs in India.

Muhammad UMair Saleem et.al (May 2018), [14] "Sustainability 2018, 10, 1761" this case study discusses how modern technology has improved the construction of eco-friendly steel buildings. It highlights that new methods in steel manufacturing allow for more efficient use of materials and energy. The study focuses on reducing costs in steel buildings by using pre-engineered building (PEB) technology, which customizes steel sections for specific loads, unlike traditional steel buildings that use uniform sections.

3. Problem formulation

Study of PEB Concept and CSB Concept for Multi Storey Commercial Building. These can be achieved by designing a typical multistory frame of proposed commercial building using both the concepts and analyzing the designed frames using the Structural Analysis and Design Software Staad-Pro to fulfill the following objectives.

3.1 Concept of PEB

Pre-Engineered Buildings (PEB) are structures designed in a factory and put together on location. Steel structures are the norm for PEB structures. Built-up sections are made to exact measurements in the factory, transported to the site, and assembled there using bolted connections. Industrial structures such as warehouses, metro stations, and other structures typically use this structural concept. Adopting the PEB design concept over the traditional concrete structure design concept produces several benefits, including economy and more straightforward fabrication. These structures can be completed from within to serve any purposes that benefit the design of low-rise buildings. Warehouses, canopies, factories, bridges, and other structures are pre-engineered buildings.

3.2 Components of PEB

Main Components

• There are following major components in a pre-engineered building

• Primary or Main frame

• Gable End framing or Wind columns

• Secondary frame or Purlins, girts etc.

• Roof & Wall Sheeting

• Bracing system

• Crane system

• Mezzanine system

• Insulations

• Attachments like canopies, fascia etc.

• Doors, Windows, Ventilators

• Accessories like Turbo vents, Ridge Vents, Skylights etc.

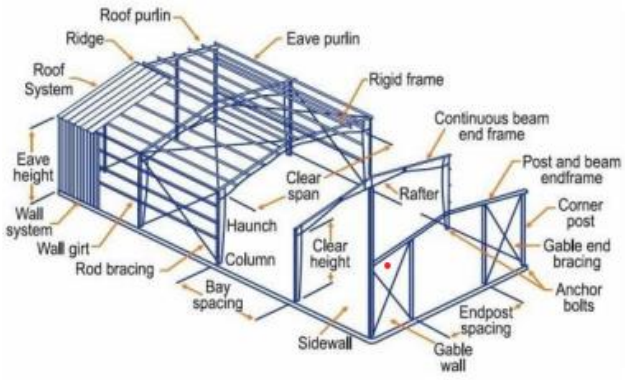


Fig 3.1 Components Parts of PEBA

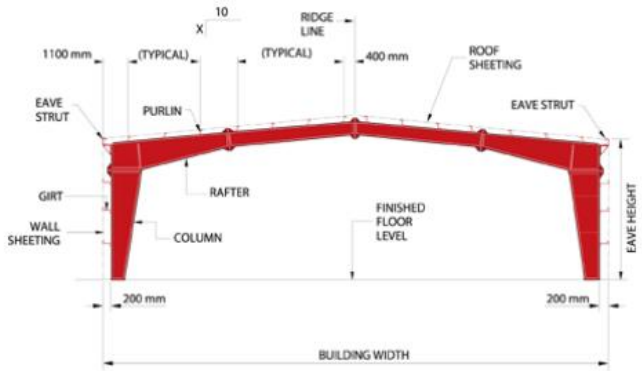
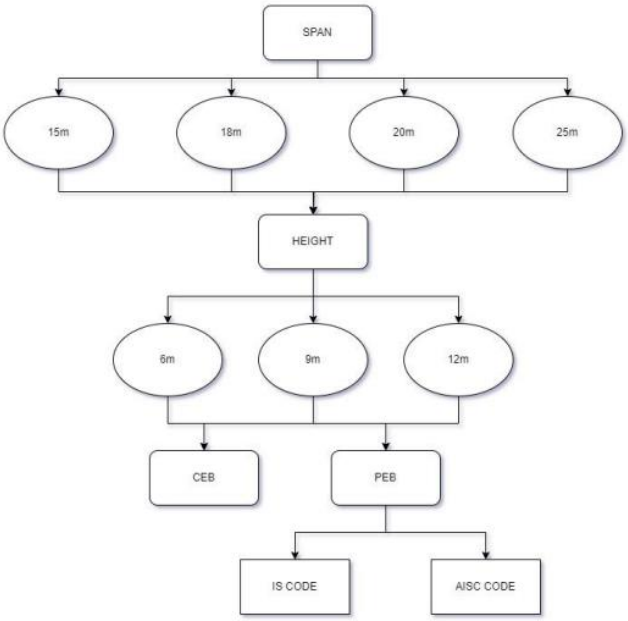


Fig 3.2 Components Parts of PEB

4. Research Methodology

In the steel industry, two primary methods for constructing industrial structures are Conventional Steel Buildings (CSB) and Pre-Engineered Buildings (PEB). CSBs use standard hot-rolled steel sections with varying designs, often incorporating concrete columns for support. They are versatile but can result in higher material wastage and lower construction precision due to bolted or welded connections. On the other hand, PEBs are designed and fabricated in factories to minimize material usage and streamline construction time. They are known for their efficient use of steel, quick assembly, and reliable performance under diverse conditions, supported by stringent design standards like IS 875 and IS 800 for load analysis and steel design, respectively. This comparison highlights PEBs' advantages in cost-effectiveness and rapid deployment, making them a preferred choice for many industrial applications seeking both efficiency and durability.

4.1 Parameter considered



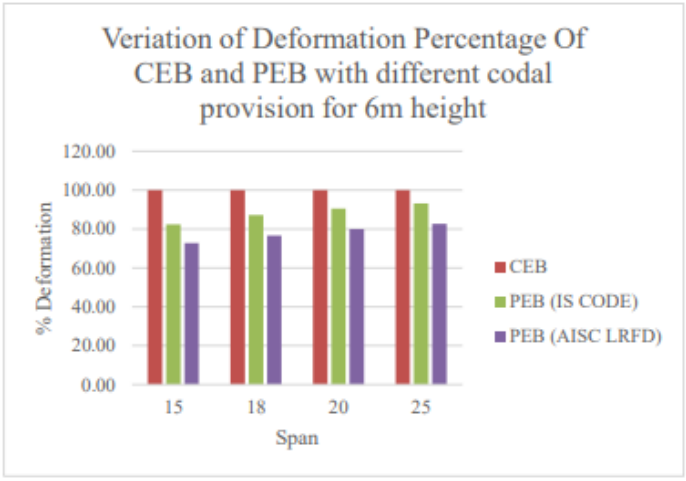
5. Results

As discussed in methodology, various cases of PEB and CEB for span of 15m, 18m, 20m, 25m with various height variations and different code provisions are analyzed Using the software Staad pro. The design parameters like axial force, shear force and bending moment are computed and comparison for these PEB and CSB has been performed. Also, the comparison of steel take off for both types of structures is done for the optimum design of the warehouse. Obtained results and their discussions are summarized in this chapter

5.1 Variation of Deformation Percentage of CEB and PEB with different Code Provision for Different Heights

As mentioned in parameter consideration, three height variations have been studied that is 6m, 9m & 12m for 15m, 18m, 20m, & 25m of spans. Analysis and design carried out for the same and a non-dimensional, Percentage deformation chart worked out as shown in subsequent points. On horizontal axis span variation have been plotted, and on vertical axis percentage of deformation with respective to CEB are plotted.

5.1.1 Variation of Deformation Percentage of CEB and PEB with different code provision for 6m height



Graph G1: Deformation Percentage of CEB and PEB with different code provision for 6m height

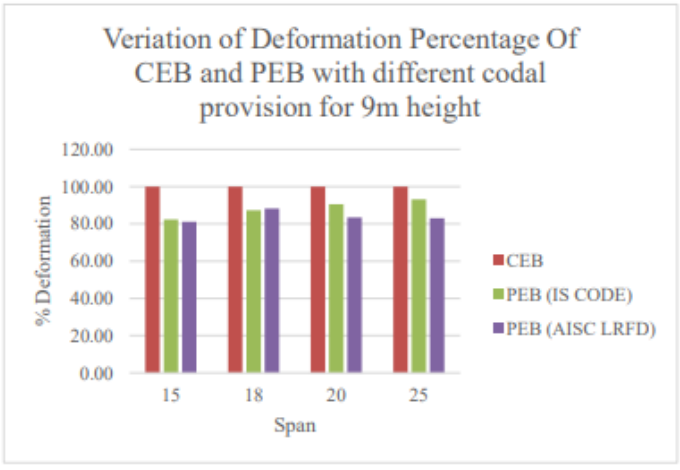
Plot G1 shows that, for 6m height of column of truss comparison of deformation percentage of CEB and PEB which have again compared with two codes that is Indian Stander Code (IS CODE) and American Code (AISC LRFD).

Following observations are noted, As Observed in plot G1 plotted with respective to CEB deformation percentage values,

1. The percentage deformation for PEB with IS CODE 20% less as compared with CEB for 15m of span.

2. As the span length increases the difference of percentage deformation is reducing PEB (IS CODE) as compared with CEB, for 18m span it is around 85%, for 20m span it is around 90% and so on.

5.1.2 Variation of Deformation Percentage of CEB and PEB with different code provision for 9m height



Graph G2 Deformation Percentage of CEB and PEB with different code provision for 9m height

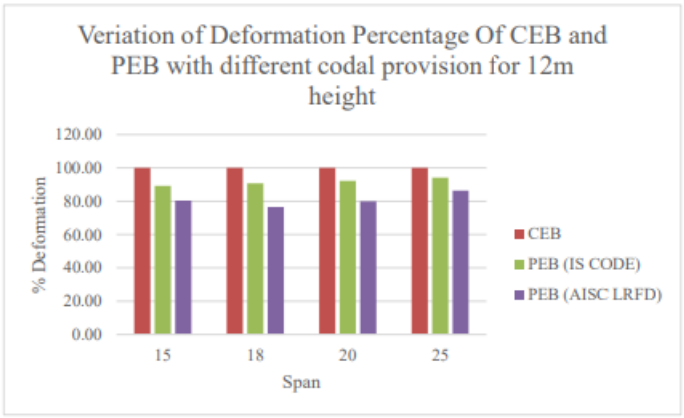
Variation of deformation percentage of CEB and PEB are considered for 9m of height of column of truss and plotted against span referring to appendix A. Plot G2 shows that, for 9m height of column of truss comparison of deformation percentage of CEB and PEB which have again compared with two codes that is Indian Stander Code (IS CODE) and American Code (AISC LRFD).

Following observations are noted, As Observed in plot G2 Plotted with respective to CEB deformation percentage values,

1. The percentage deformation for PEB with IS CODE 20% less as compared with CEB for 15m of span.

2. Percentage difference in plot G2 is nearly similar to that of plot G1 for CEB against PEB (IS CODE).

5.1.3 Variation of Deformation Percentage of CEB and PEB with different code provision for 12m height



Graph G3 Deformation Percentage of CEB and PEB with different code provision for 12m height

Variation of deformation percentage of CEB and PEB are considered for 12m of height of column of truss and plotted against span referring to appendix A. Plot G3 shows that, for 12m height of column of truss comparison of deformation percentage of CEB and PEB which have again compared with two codes that is Indian Stander Code (IS CODE) and American Code (AISC LRFD).

Following observations are noted, As Observed in plot G3 Plotted with respective to CEB deformation percentage values,

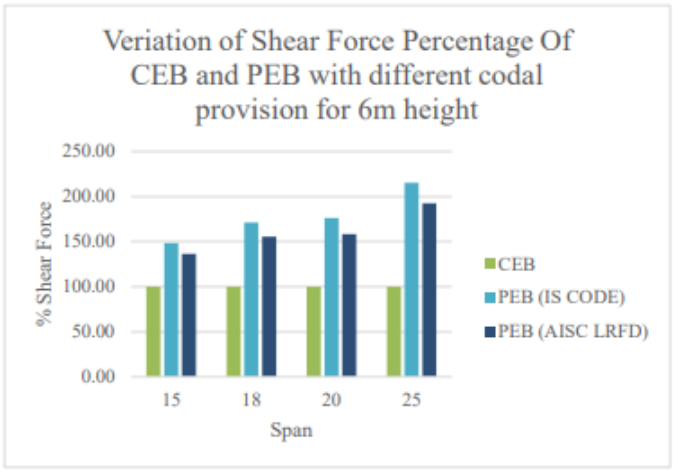
1. The percentage deformation for PEB with IS CODE is 20% less as compared with CEB for lower length span.

2. The percentage deformation for PEB with IS CODE is 10% less as compared with CEB for higher length span.

5.2 Variation of Shear Force Percentage of CEB and PEB with different Code Provision for Different Heights

In this point, on horizontal axis span variation have been plotted, and on vertical axis percentage of shear force with respective to CEB are plotted.

5.2.1 Variation of Shear Force Percentage of CEB and PEB with different code provision for 6m height



Graph G4 Shear Force Percentage of CEB and PEB with different code provision for 6m height

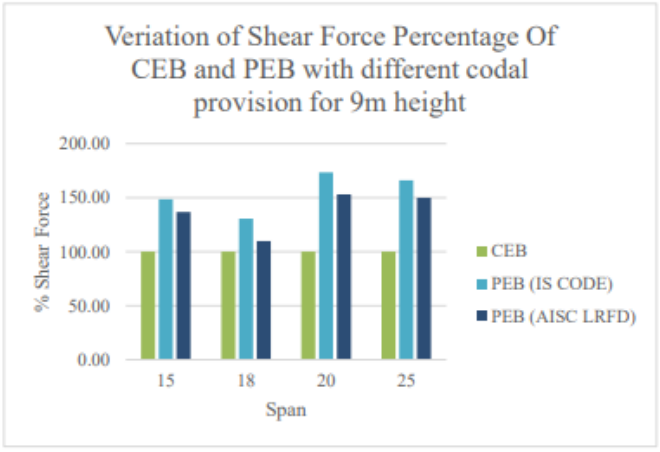
Variation of shear force percentage of CEB and PEB are considered for 6m of height of column of truss and plotted against span referring to appendix A. Plot G4 shows that, for 6m height of column of truss comparison of shear force percentage of CEB and PEB which have again compared with two codes that is Indian Stander Code (IS CODE) and American Code (AISC LRFD).

Following observations are noted, As Observed in plot G4 plotted with respective to CEB shear force percentage values,

1. The percentage shear force for PEB with IS CODE is more than 50% as compared with CEB for lower length span.

2. The percentage shear force for PEB with IS CODE is increased by 2 times as compared with CEB for higher length span.

5.3.2 Variation of Shear Force Percentage of CEB and PEB with different code provision for 9m height



Graph G5 Shear Force Percentage of CEB and PEB with different code provision for 9m height

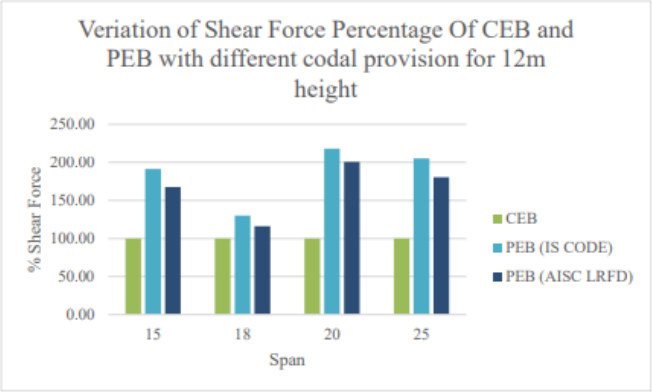
Variation of shear force percentage of CEB and PEB are considered for 9m of height of column of truss and plotted against span referring to appendix A. Plot G5 shows that, for 9m height of column of truss comparison of shear force percentage of CEB and PEB which have again compared with two codes that is Indian Stander Code (IS CODE) and American Code (AISC LRFD).

Following observations are noted, As Observed in plot G5 plotted with respective to CEB shear force percentage values,

1. The percentage shear force for PEB with IS CODE is more than 50% as compared with CEB for lower length span. And reduced on around 130% for 18m span

2. The percentage shear force for PEB with IS CODE is increased by 1.5 times as compared with CEB for higher length span

5.2.3 Variation of Shear Force Percentage of CEB and PEB with different code provision for 12m height



Graph G6 Shear Force Percentage of CEB and PEB with different code provision for 12m height

5. CONCLUSIONS

Pre-engineered steel buildings (PEB) offer significant advantages over Conventional Steel Buildings (CSB) due to their lower cost, strength, durability, design flexibility, adaptability, and recyclability. Steel, the primary material used in PEB, is sourced regionally and is infinitely recyclable, aligning with sustainable development goals. Analytical and design comparisons between PEB and CSB reveal several key findings: PEB structures generally exhibit lower deformation percentages and higher stability compared to CSB under different code provisions. They also demonstrate higher shear forces and bending moments, indicating robust structural performance, albeit with slightly increased weight. PEB's advantages include lighter structures, rapid and efficient design processes, ease of erection with reduced on-site labor and wastage, and overall lower costs due to streamlined manufacturing and construction processes. These factors underscore PEB as a preferred choice for cost-effective, sustainable, and structurally reliable industrial buildings.

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