STM JOURNALS

Recent Trends in
Civil Engineering & Technology

https://journals.stmjournals.com/rtcet

ISSN: 2249-8753 (Online)
ISSN: 2321-6476 (Print)
Volume 14, Issue 3, 2024
September–December
DOI (Journal): 10.37591/RTCET

Research RTCET

# Analysis and Design of Pre-Engineering Building Structure by Using Staad Pro Software

Krishanakant Hulsure[1,*], Swapnil Zagade[1], Shivam Jadhav[1], Vinesh Thorat[2]

***Abstract***

*The analysis and design of a Pre-Engineered Building (PEB) were conducted using STAAD Pro software, alongside manual calculations for accurate load estimation, to ensure the building's compliance with relevant engineering standards and codes. The evaluation took into account multiple load types, including dead loads, live (imposed) loads, wind loads, and relevant load combinations to replicate actual conditions the structure might face during its lifespan. This comprehensive approach provided a deep understanding of the essential design principles, construction procedures, and safety requirements for the structural components of a PEB. Key structural elements such as columns, beams, roof trusses, purlins, and connections were analyzed to ensure their strength, stability, and resilience under various load scenarios. The analysis also focused on optimizing material use to increase cost-efficiency and reduce construction time, which are major advantages of pre-engineered buildings. By utilizing STAAD Pro's advanced analysis capabilities, the design process became more streamlined, offering precise calculations and better handling of complex load combinations and distribution, particularly for wind and seismic loads. Pre-engineered buildings are known for their cost-effectiveness, quick construction, and adaptability, making them increasingly popular for various industrial, commercial, and institutional uses. The design ensured the building adhered to safety, durability, and stability requirements while meeting the project's budgetary and time constraints. Overall, the use of STAAD Pro helped produce an efficient structural design that balances performance with economy, providing a reliable and sustainable solution for modern construction needs.*

**Keywords:** STAAD Pro, tapered section, load combination, analysis

## INTRODUCTION

Pre-engineered buildings (PEBs) have become a popular choice for industrial and commercial projects due to their affordability, rapid construction, and customizable design features. The PEB method involves creating steel components off-site, which are then transported and assembled at the construction location. This approach significantly cuts down on both the time and cost associated with traditional construction methods.

These structures are commonly used in warehouses, factories, workshops, and large-scale commercial complexes. In this project, we focus on the analysis and design of a PEB structure using STAAD Pro, a widely recognized software for structural analysis and design. STAAD Pro allows engineers to model, analyse, and design a wide range of structural elements efficiently. The software helps in optimizing the design by considering various load combinations, material properties, and other critical factors that influence the safety and stability of the structure. The primary

***Author for Correspondence**
Krishanakant Hulsure
Email: krishnahulsure76208@gmail.com

[1]UG Student, Department of Civil Engineering, G H Raisoni College of Engineering & Management, Wagholi, Pune, Maharashtra, India
[2]Assistant Professor, Department of Civil Engineering, G H Raisoni College of Engineering & Management, Wagholi, Pune, Maharashtra, India

Received Date: October 14, 2024
Accepted Date: October 18, 2024
Published Date: October 21, 2024

**Citation:** Krishanakant Hulsure, Swapnil Zagade, Shivam Jadhav, Vinesh Thorat. Analysis and Design of Pre-Engineering Building Structure by Using Staad Pro Software. Recent Trends in Civil Engineering & Technology. 2024; 14(3): 1–7p.

 

objective of this project is to demonstrate the process of designing a PEB structure using STAAD Pro and to validate the software-generated results with manual calculations. This comparison will help in understanding the accuracy and reliability of STAAD Pro in the context of PEB design. By the end of this project, we aim to provide a comprehensive analysis of the PEB structure, highlighting its advantages and potential applications in the construction industry.

## LITERATURE REVIEW

Shrivastava [1] presented pre-engineered steel structures are cost-effective and offer strength, durability, and flexibility. The study suggests they are generally superior to conventional structures, but it's not a one-size-fits-all solution. PESs are not always suitable, especially in projects with limited budgets or short spans. They are based on traditional methods and may not be ideal for every situation. Tamrakar and Saxena [2] managed funds is becoming crucial across all industries, including construction. Sustainability is a key focus for everyone. In this regard, Pre-Engineered Buildings (PEBs) stand out compared to other methods. PEBs use high-quality steel and modern materials to create efficient building designs. These materials help keep costs lower without sacrificing quality. Studies show that PEBs are cost-effective while maintaining structural strength. The design and material choice in PEBs make them an economical option for construction projects. Overall, PEBs offer both financial and environmental benefits. Meera [3] explains that Pre-Engineered Buildings (PEBs) can be designed easily following standard procedures. It shows that PEBs are better than Conventional Steel Buildings (CSBs) in terms of cost, quality, construction speed, and ease of assembly. The study provides simple and affordable design ideas for PEBs. It helps readers understand the basic design process of PEB structures. Overall, PEBs offer several advantages over traditional methods. Gawad and Waghe [4] studied PEB (Pre-Engineered Buildings) are more efficient than Conventional Steel Buildings (CSB) for steel structures. PEB allows more flexibility in design choices. Research shows PEB structures are lighter than CSB for the same load capacity. PEB also needs precise design and detailing, unlike CSB. This makes PEB a popular choice for modern construction. Naik and Mahure [5] pre-Engineered Buildings (PEBs) are designed easily using IS codes and offer many advantages over conventional steel buildings. They are about 15% lighter and more cost-effective. PEBs provide strength, durability, design flexibility, and faster construction. They are ideal for large, open spaces with fewer columns. Overall, PEBs are a better choice for economical and efficient construction. Tekale and Ambadkar [6] used STAAD-Pro to evaluate and compare the structural performance of Conventional Steel Buildings (CSBs) and Pre-Engineered Buildings (PEBs). Their findings highlighted that PEBs tend to be lighter than CSBs across various spans. Due to their lighter weight and variable depth, PEB structures exhibited greater displacement; however, for long spans, this displacement difference was minimal because plate girders, customizable as needed, were utilized in PEBs. The reduced dead load in PEBs leads to smaller concrete foundations, thereby decreasing the required concrete volume. Additionally, the tapered sections used in PEBs enhance aesthetic appeal, making them suitable for building facades.

Firoz et al. [8] noted that steel is the preferred material for pre-engineered structures due to its affordability, strength, durability, design versatility, adaptability, and recyclability. Steel's use supports sustainable development principles, as it is infinitely recyclable, offers diverse shapes and colors, facilitates rapid installation, and reduces energy consumption.

Jinsha and Mathew [9] examined how bay spacing affects the weight of PEBs. They found that increasing bay spacing initially reduces weight up to a certain point, after which further increases make the structure heavier. Optimal bay spacing for economic efficiency was determined to be around 8 meters. The amount of steel required depends primarily on the primary members and purlins; as bay spacing grows, steel consumption for primary members decreases, while it increases for secondary members.

Abhinav [10] compared STAAD-Pro and ETABS software, noting that while the results from both programs are comparable within a ±5% margin, they differ in functionality. ETABS offers a superior

ISSN: 2249-8753 (Online), ISSN: 2321-6476 (Print)

graphical interface but lacks built-in connection modeling, requiring external programs for this purpose. In contrast, STAAD-Pro supports connection design through RAM Connection integration, enabling connection modeling directly within the software. Both programs can exchange data with each other.

Pandey [11] explained STAAD Pro stands out as a powerful tool for seismic analysis and design of multistorey structures, offering a comprehensive platform for engineers and designers. Its advanced features and capabilities enable users to simulate real-world seismic events, assess structural performance, and optimize designs for safety and efficiency. By utilizing STAAD Pro, engineers can accurately predict the behaviour of structures under seismic loads, ensuring that buildings are designed to withstand earthquakes and protect occupants. The software's ability to perform dynamic analysis, consider soil-structure interaction, and incorporate seismic design codes makes it a valuable asset in earthquake-prone regions. Moreover, STAAD Pro's user-friendly interface and robust analysis capabilities make it accessible to both seasoned professionals and those new to seismic design. Its integration with Building Information Modelling (BIM) platforms further enhances its utility, allowing for seamless collaboration and integration into the design process [12-16].

## METHODOLOGY

### Dead Load

As per IS: 875 (Part 1), dead loads consist of the self-weight of the structure, including the weights of the roofing, bracing, and any additional accessories attached to the structure.

### Live Load

In accordance with IS: 875 (Part 2), for roofs with no access, the live load is considered to be 0.75 kN/m². This load decreases by 0.02 kN/m² for each degree of roof slope exceeding 10 degrees.

### Wind Load

IS: 875 (Part 3) specifies that wind loads, due to the horizontal forces exerted by wind, must be factored into the design of buildings, towers, and similar structures. Wind load is influenced by factors such as wind speed, building dimensions, shape, and location. In this case, a basic wind speed of 50 m/s is used. The wind load on the roof is applied as a uniformly distributed load acting outward along the PEB rafter [17-18].

#### *Wind Load Calculation*

The basic wind speed (Vb) is 50 m/s. The design wind speed (Vz) can be calculated using the formula provided in the code.

- K1K1K1 = Probability factor (also known as the risk coefficient).

$K_2$ = Terrain, height and structure size factor
$K_3$ = Topography factor
$K_4$ = Cyclonic factor
$V_z$ = 50 m/s

Design wind pressure ($P_z$) $= 0.6 \times {V_Z}^2$
Design wind pressure, $P_d = P_z \times K_d \times K_a \times K_c$
Wind Directionality Factor, $K_d$=0.9 (Clause7.2.1of IS 875. Part3)
Area Averaging Factor, $K_a$=0.9 (Clause7.2.2of IS 875. Part3)
Combination factor, $K_c$=0.9 (Clause7.3.3. 13of IS 875. Part3)

$$K_d \times K_a \times K_c = 0.73$$

Enclosed 0.2
Partially Enclosed 0.5
Open 0.7
External Pressure Coefficient- Use table 4 from IS:875 part 3 1987

***Load Combinations***

The load combination for both strength and serviceability are as follows:

Load combination of strength

1. 1.5 DL + 1.5 LL
2. 1.2 DL + 1.2 WL
3. 0.9 DL + 1.5 WL

Load combination of serviceability

1. 1.0 DL + 1.0 DL
2. 1.0 DL + 1.0 WL

***Analysis and Design of Pre-Engineered Buildings using STAAD Pro***

STAAD Pro is software that helps in the modelling, analysis, and design of structures. In comparison to manual techniques, STAAD Pro gives accurate results. STAAD Pro has been more successful in modelling, analysis, design in 2D and 3D. It comes with intuitive, user-friendly visualisation tools, as well as powerful analysis and design capabilities with a variety of other modelling and design software products. The software consists of various country standards, including Indian standards. STAAD Pro has been the tool of choice for analysing and designing in the world Figures 1-3.

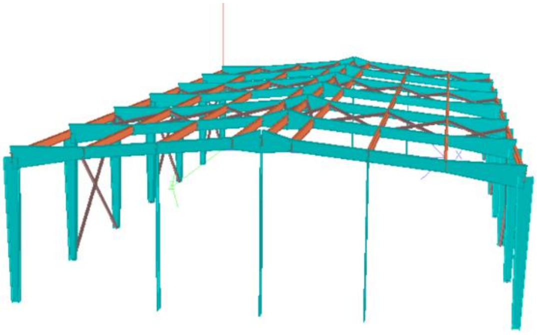

**Figure 1.** Front view of warehouse.

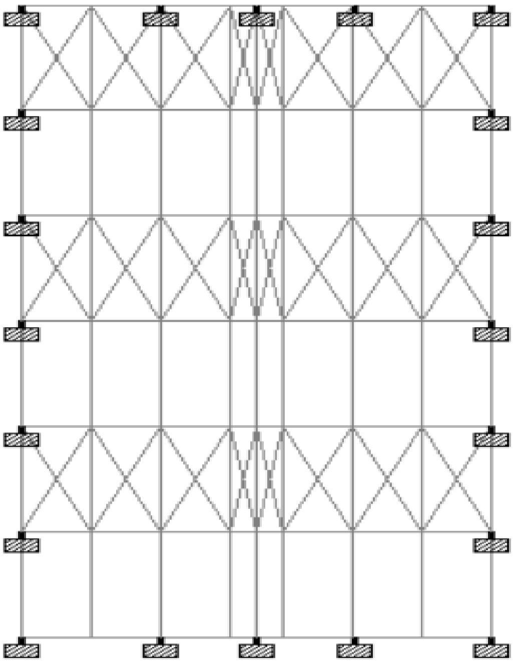

**Figure 2.** Top view of warehouse.

 

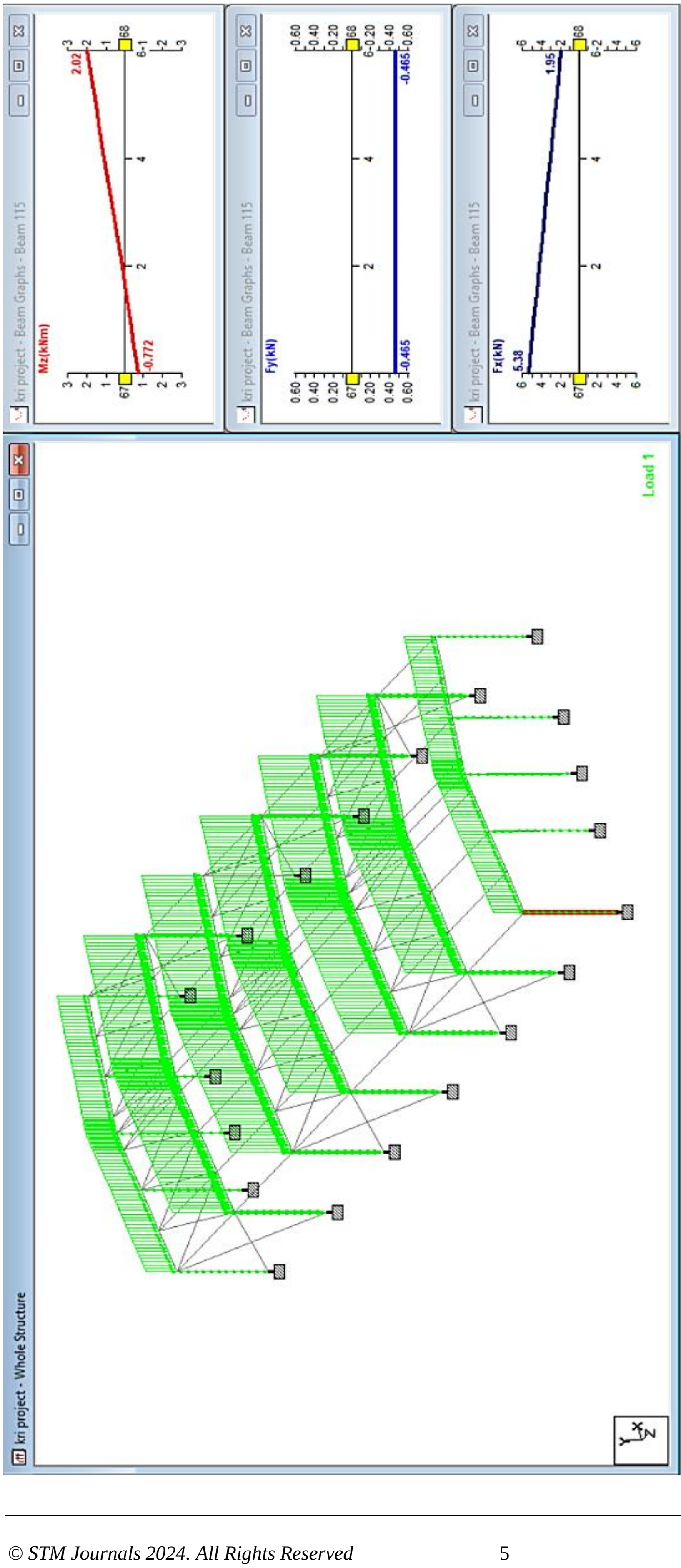


**Figure 3.** Beam graphs.

STEEL TAKE-OFF

| PROFILE | | | LENGTH (METE) | WEIGHT (KN ) |
|---|---|---|---|---|
| Tapered | MembNo: | 1 | 84.00 | 94.082 |
| Tapered | MembNo: | 5 | 84.00 | 60.011 |
| Tapered | MembNo: | 7 | 58.44 | 51.852 |
| ST | ISLC350 | | 410.40 | 156.057 |
| ST | PIP1270H | | 502.62 | 79.539 |
| Tapered | MembNo: | 187 | 40.36 | 15.347 |
| | | | TOTAL = | 456.889 |

**Figure 4.** Steel take off.

## RESULTS

The structural analysis and design of the selected frame were carried out using STAAD Pro, demonstrating the software's efficiency and effectiveness for this purpose. A representative frame from the overall structure was chosen for analysis and design following the principles of pre-engineered building (PEB) methodology. The analysis provided insights into the structural performance and design adequacy of the frame based on the applied loads and PEB design criteria Figure 4.

## APPLICATIONS

The concept of Pre-Engineered Buildings (PEBs) finds extensive use across a variety of structures, such as warehouses, factories, office buildings, workshops, gas stations, showrooms, parking structures, aircraft hangars, metro stations, schools, recreational facilities, indoor sports arenas, outdoor stadium canopies, railway platform shelters, bridges, auditoriums, and metro stations. PEBs are also versatile, as they can be designed to be relocatable, allowing for flexibility in usage.

## CONCLUSION

Numerous studies have been conducted on the design of PEB structures, focusing on various aspects such as analysis, performance, and comparative evaluations. During the planning phase, different loads—self-weight, live loads, wind, and seismic loads—are taken into account using appropriate load combinations. The building's analysis is conducted manually and verified using STAAD Pro, which also helps determine the amount of steel needed for each section. This approach offers practical and cost-effective insights into preliminary design concepts for PEBs, providing a better understanding of the overall design process for these types of structures.

## REFERENCES

1. Jinsha M. S. and Linda Ann Mathew, (2016) "Analysis of Pre –Engineered Buildings" International Journal of Science and Research (IJSR). ISSN: 2319-7064.
2. Shubham Shrivastava and Gaurav Shrivastava, (2022) "Pre-Engineered Structure study" International Research Journal of Engineering and Technology (IRJET). ISSN: 2395-0056 Vol. 09 Issue 12.
3. Jaya Tamrakar and Dr. Anil Kumar Saxena (2022) "Study, Design and Analysis of Pre-Engineered Building with Different Parameter using STAAD Pro Software. International Research Journal of Modernization in Engineering Technology and Science ISSN: 2582-5208 Vol. 04 Issue 08.
4. C. M. Meera (2013) "Pre-Engineered Building Design of an Industrial Warehouse" International Journal of Engineering Science and Emerging Technologies (IJESET). ISSN: 2231-6604 Vol. 5 Issue 2.
5. Omkareshwar Prabhakar Tekale and Dr. Swati Ambadkar (2024) "Analysis and Design of Pre-Engineered and Conventional Industrial Building" International Journal of Progressive Research in Engineering Management and Science (IJPREMS). ISSN: 2583-1062 Vol. 04 Issue 06.

 

6. Abinav (2024) "P. E. B. Framed Structure Design and Analysis using STAAD Pro" International Research Journal of Engineering and Technology (IRJET). ISSN: 2395-0056 Vol. 11 Issue 01.
7. Syed Firoz, Sarath Chandra Kumar B and S. Kanakambara Rao (2012) "Design Concept of Pre-Engineered Building" International Journal of Engineering Research and Applications (IJERA). ISSN: 2248-9622 Vol. 2 Issue 2.
8. Prakhar Pandey and Dr. Rakesh Kumar Pandey (2024) "STAAD Pro for Seismic Analysis and Design of Multistorey Structures" International Journal of Engineering Applied Science and Management ISSN: 2582-6948 Vol. 5 Issue 5.
9. Neeraj Kumar and Dr. K. S. Grover (2022) "A Comparative Study of Conventional Steel Building and Pre-Engineered Building Structure using STAAD Pro" International Journal for Research in Applied Science and Engineering Technology (IJRASET) ISSN: 2321-9653 Vol. 6 Issue 6.
10. Pornima Pritish Naik and Dr. S. H. Mahure (2021) "Comparative Study of Pre-Engineered Building and Conventional Steel Building" International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0072 Vol. 08 Issue 05
11. M. D. Gawade and U. P. Waghe "Study of Pre-Engineered Building Concept, International of Research in Engineering and Applied Sciences.
12. Aakash Varma, and Dr. Rajeev Chandak (2022) "Analaysis and Design of Pre-Engineered Building with different parameters" International Journal for Research in Applied Science and Engineerng Technology (IJRASET) ISSN: 2321-9653 Vol. 10 Issue 3.
13. Snehal Dhande, Shubham Lawande, Shubham Malve and Sailee Landge (2024) "Analaysis and Design of Pre-Engineered Bulding using STAAD Pro V8I" International Journal of Progressive Research in Engineering Management and Science (IJPREMS) ISSN: 2583-1062 Vol.04 Issue 06.
14. Abhijeet Shinde, Dr. Nitin S. Naik and Lalit N. Chaudhari (2023) "Analysis and Design of Pre-Engineered Building using Indian and Equivalent American code" International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Vol. 10 Issue 03.
15. Kalesha Shaik, B. S. S. Ratnamala Reddy and Durga Chaitanya Kumar Jagarapu (2020) "An Analytical study on Pre-Engineered Buildings using STAAD Pro"
16. Subodh S. Patil, Raviraj V. Jadhav, Pritam A. Mali, Mahesh M. Bhanuse and Murgesh R. Katti (2017) "Analysis and Design of Pre-Engineered Building of an Industrial Warehouse'' International Journal of Current Engineering and Science Research (IJCESR) ISSN: 2393-8374 Vol. 4 Issue 12.
17. G. Durga Rama Naidu, K. Srinivasa Vengala Rao, V. Divya Sri, M. Navakanth and G. V. Rama Rao (2014) "Comparative study of Analysis and Design of Pre-Engineered Building and Conventional Frames" International Journal of Engineering Research and Development ISSN: 2278-067X Vol. 10 Issue 9.
18. Humanaaz Arif Qureshi, Dr. Kuldeep R. Dabhekar, Amol Shahakar and Dr. Isha P. Khedikar (2020) "Comparative Analysis of Pre-Engineered and Conventional Steel Building" Journal of Emerging Technologies and Innovative Research (JETIR) ISSN: 2349-5162 Vol. 7 Issue 5.

 