

# EFFECTIVENESS OF SPAN FOR PREFABRICATED BUILDING FOR DIFFERENT LOADING

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**Abstract** - In this study, the construction industry in India is undergoing a significant transformation with the growing adoption of prefabricated building techniques. While conventional construction remains dominant, prefabrication offers notable advantages such as reduced construction time, improved quality control, and enhanced safety. This study focuses on evaluating the effectiveness of different spans in prefabricated buildings under varying static and dynamic loading conditions. Dynamic loading, which includes forces such as wind and seismic activity, has become a crucial factor in modern structural design due to its impact on building stability and safety. A comprehensive literature review reveals that most existing studies emphasize single-story or industrial prefabricated structures, often overlooking the influence of span variation under dynamic effects. Addressing this research gap, the present work aims to analyze the performance of prefabricated buildings across different spans and heights using structural analysis software. Both static and dynamic analyses are performed, considering variations in bracing systems to enhance structural response. The outcomes of this study include non-dimensional charts that correlate span effectiveness with building height, providing valuable design insights for engineers and architects. The findings support the feasibility of multi-story prefabricated construction and contribute to optimizing structural performance under real-world loading conditions.

**Key Words:** Prefabricated buildings, Span variation, Bracing systems, Seismic performance, ETABS / ANSYS, Construction efficiency.

## 1. INTRODUCTION

The construction industry plays a crucial role in India's economic growth and has traditionally relied on on-site, conventional building methods. Recently, however, there has been a notable shift toward prefabricated construction, which is emerging as a more modern and efficient alternative. This approach involves producing building components in a controlled factory environment and subsequently assembling them at the project site. Such a method enhances quality control, accelerates construction timelines, and promotes better safety standards. With rapid urbanization and the increasing need for quick and reliable infrastructure, prefabricated structures are becoming a

viable solution for both residential and commercial developments. Additionally, recent advancements have highlighted the significance of accounting for dynamic loads in structural design. Unlike static loads, which remain constant over time, dynamic loads—such as those generated by wind, seismic activity, or moving vehicles—fluctuate in intensity and direction. Addressing these forces requires sophisticated analytical techniques to maintain structural integrity. Methods such as modal analysis and time-history analysis enable engineers to assess how structures respond to varying loads. This dissertation investigates the performance of prefabricated buildings with different span configurations under both static and dynamic loading conditions, aiming to optimize structural efficiency and ensure safety in practical applications.

### 1.1 Aim & Objective

To evaluate the effectiveness of varying spans in prefabricated buildings under different static and dynamic loading conditions.

- 1) Compare the static and Dynamic analysis of prefabricated building.
- 2) Dynamic analysis of various spans along with different bracing system.
- 3) Preparation of non-dimensional comparative chart for effective span for various heights.

## 2. Literature Review

Buildings and houses are essential to human life, and construction methods have evolved significantly since ancient times. Modern construction demands not only structural strength but also aesthetic appeal, speed, cost-efficiency, and quality. Pre-engineered buildings (PEBs) have emerged as a practical solution to meet these needs, offering faster construction and lower costs compared to traditional methods. To gain deeper insight into PEB design and performance, various research studies and journal articles were reviewed, with key findings summarized for reference.

Contributions of researchers are presented as follows,

**Jimin He [1]** He presents a novel approach designed to pinpoint specific regions within an analytical model where errors tend to cluster. Analytical models serve as mathematical representations of real-world systems, but their predictions often differ from actual experimental outcomes. What sets his method apart is its effectiveness even when only limited or incomplete experimental data is available—a common issue in practical testing environments. By examining this partial data, the technique enables researchers to identify which areas of the model are primarily responsible for the discrepancies. This focused strategy makes it possible to refine and improve models more efficiently by targeting only the problematic sections, rather than revising the entire model. Ultimately, this enhances the accuracy and dependability of simulations, which is vital in fields such as engineering, physics, and other domains where precise modeling is essential.

**Jaillon, L., & Poon, C. S. [2]** In their 2009 study, Jaillon and Poon carried out a comparative assessment of different building structures to examine how effective prefabrication is within the construction sector. Their findings reveal that incorporating prefabricated components can significantly shorten the overall construction timeline compared to conventional methods. By producing structural elements off-site and assembling them on location, the construction process becomes more efficient and less vulnerable to setbacks caused by adverse weather or labor-related delays. Additionally, the study points out that prefabrication boosts efficiency by optimizing resource usage, minimizing material waste, and ensuring more uniform quality control. These insights underline the growing recognition of prefabricated construction as a sustainable, efficient, and practical alternative in the modern building industry.

**Hui Min Xu, Yung Yang Li, Wei Xui [3]** Researchers conducted on-site dynamic testing on four prefabricated houses built using lightweight steel structures. By applying the Stochastic Vibration Signal Analysis (SVSA) method, they were able to identify key dynamic characteristics of the buildings, including natural frequencies, damping ratios, and vibration modes. The results showed that these structures primarily exhibited shear-type vibration modes, which reflect typical deformation behavior under dynamic loads. The damping ratios observed ranged from 0.6% to 2%, aligning with the expected performance of lightweight steel systems. These findings offer valuable insights into the seismic and dynamic behavior of such prefabricated structures, reinforcing their suitability for safe, efficient, and resilient use in modern construction practices.

**Loss, C., Piazza, M., & Zandonini, R. [4]** The study investigated the innovative use of mixed materials in prefabricated construction, with a particular emphasis on combining wood and steel. The researchers highlighted the

advantages of hybrid structural systems, which merge the aesthetic appeal, environmental friendliness, and thermal properties of wood with the strength, durability, and adaptability of steel. This material combination presents a promising direction for prefabricated buildings, aiming to enhance both structural performance and sustainability. The study points out that such systems can optimize load distribution, increase seismic resilience, and enable more flexible and lightweight designs. This approach not only expands the potential of prefabricated architecture but also aligns with the growing need for eco-conscious and efficient construction practices.

**Chandrashekhar B Adin, Raveesh R. M, Praveen J.V. [5]** The researchers conducted a comprehensive study to assess how different bracing systems and dampers affect the dynamic behavior of industrial steel structures subjected to seismic and wind loads. The main goal was to evaluate how various combinations of bracings and dampers, along with changes in mass ratios and height-to-breadth ratios, impact key dynamic parameters such as natural frequencies, damping characteristics, and the overall structural response. The results highlight the critical role of careful selection and placement of bracing and damping components in enhancing structural stability and energy dissipation under dynamic forces. This research offers valuable insights for optimizing the design of industrial steel structures to improve their resilience against earthquakes and wind-induced stresses.

**Fard, M. M., Terouhid, S. A., Kibert, C. J., & Hakim, H. [6]** This research centers on enhancing safety management practices during the construction phase of prefabricated buildings. Acknowledging the specific challenges involved in assembling and installing prefabricated components, the study identifies key safety risks linked to both off-site production and on-site construction activities. While prefabrication offers benefits such as improved efficiency and reduced on-site labor, it also introduces unique safety concerns—especially related to the handling, transportation, and assembly of large structural elements. To mitigate these risks, the authors propose several practical measures, including better project planning, comprehensive worker training, improved coordination among stakeholders, and the implementation of safety protocols tailored to prefabricated systems. These recommendations aim to strengthen the overall safety culture within the prefabricated construction sector, ensuring greater worker protection and smoother project execution.

**Kasperzyk, C., Kim, M. K., & Brilakis, I. [7]** The study introduces an innovative automated system designed for the dismantling and reconfiguration of prefabricated buildings, representing a major step forward in construction automation and sustainable building practices. It responds to the increasing demand for adaptable and reusable building systems driven by changing spatial needs and environmental concerns. By incorporating advanced technologies such as

robotics and digital modeling, the system allows for the efficient disassembly of prefabricated components with minimal manual effort. These components can then be reorganized or reused in new layouts, significantly reducing construction waste and extending material lifespans. The research emphasizes the system’s potential to improve flexibility, lower labor demands, and promote circular economy principles within the prefabricated construction industry.

**Teng, Y., Li, K., Pan, W., & Thomas Ng, S. [8]** This study presents a thorough evaluation of the environmental performance of prefabricated buildings, with a particular emphasis on carbon emissions across the entire building life cycle. By analyzing both the production and operational stages, the research finds that prefabricated buildings tend to generate significantly lower carbon emissions compared to conventional construction methods. This reduction is largely due to more efficient use of materials, less construction waste, and improved energy efficiency during operation. The study also highlights the benefits of a streamlined construction process and the potential to recycle building components, further enhancing the environmental sustainability of prefabricated systems. Overall, the findings position prefabricated construction as a more eco-friendly and sustainable approach, offering meaningful advantages in reducing environmental impact and advancing green building practices.

**Li, Y. S., Hwang, B. G., Shan, M., & Looi, K. Y. [9]** The researchers developed a decision support system designed to accurately calculate the volume of prefabricated building components. Their approach integrates detailed theoretical analysis with practical simulation methods to deliver precise volume estimations, supporting more effective planning, cost forecasting, and resource management in prefabricated construction projects. By incorporating this system into the design and manufacturing stages, stakeholders can better optimize material usage, reduce waste, and improve the overall efficiency of component production and assembly.

### 3 THEORETICAL FORMULATIONS

#### 3.1 Introduction

To Do the Study of PEB Concept truss in different loading condition for different span. These can be achieved by designing a typical truss frame of proposed commercial ware house using both the concepts and analyzing the designed frames using the Structural Analysis and Design Software package.

#### 3.2 Concept of PEB

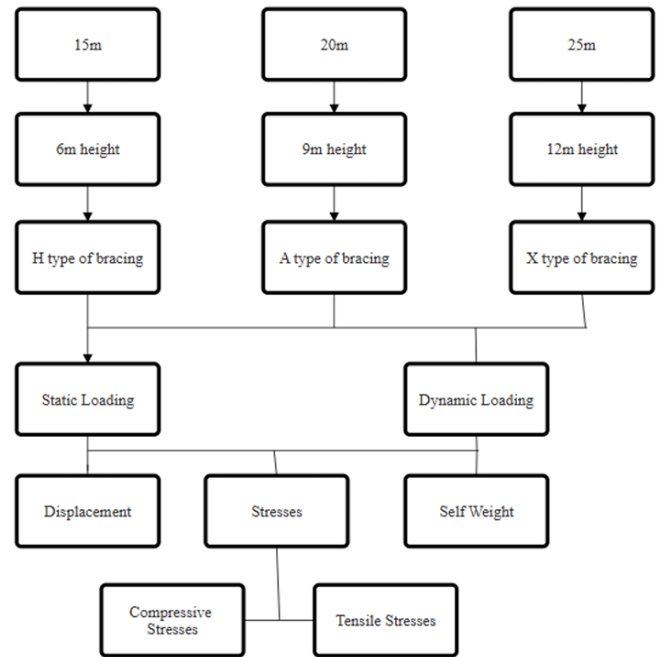


Fig. No. 3.1 span and height of ware house

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.

#### 3.3 Advantages of Pre-Engineered Buildings

**Reduced Construction Time:** Buildings are typically delivered in just a few weeks after approval of drawings. Foundation and anchor bolts are cast parallel with finished, ready for the site bolting. Our study shows that in India the use of PEB will reduce total construction time of the project by at least 50%. This also allows faster occupancy and earlier realization of revenue.

**Lower Cost:** Due to the systems approach, there is a significant saving in design, manufacturing and on-site erection cost. The secondary members and cladding nest together reducing transportation cost.

**Flexibility Of Expansion:** Buildings can be easily expanded in length by adding additional bays. Also, expansion in width and height is possible by pre designing for future expansion.

**Large Clear Spans:** Buildings can be supplied to around 80M clear spans.

**Quality Control:** As buildings are manufactured completely in the factory under controlled conditions the quality is assured.

**Low Maintenance :** Buildings are supplied with high quality paint systems for cladding and steel to suit ambient conditions at the site, which results in long durability and low maintenance coats.

**Energy Efficient Roofing and Wall Systems:** Buildings can be supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required “U” values.

**Architectural Versatility:** Building can be supplied with various types of fascias, canopies, and curved eaves and are designed to receive pre cast concrete wall panels, curtain walls, block walls and other wall systems.

**Single Source Responsibility:** As the complete building package is supplied by a single vendor, compatibility of all the building components and accessories is assured. This is one of the major benefits of the pre-engineered building systems.

### 3.4 Diversified Applications of Pre-Engineered Buildings (PEB)

Applications of pre-engineered steel buildings include (but are not limited to) the following

1. WAREHOUSES
2. FACTORIES
3. WORKSHOPS
4. OFFICES
5. GAS STATIONS
6. VEHICLE PARKING SHEDS
7. SHOWROOMS
8. AIRCRAFT HANGARS
9. METRO STATIONS
10. SCHOOLS
11. RECREATIONAL
12. INDOOR STADIUM ROOFS
13. OUTDOOR STADIUM CANOPIES
14. BRIDGES
15. RAILWAY PLATFORM SHELTERS

### 3.5 Requirement of ware house and span and heights

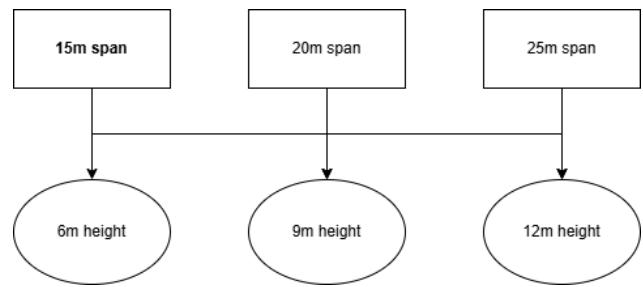


Fig. No. 3.2 span and height of ware house

### 3.6 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.

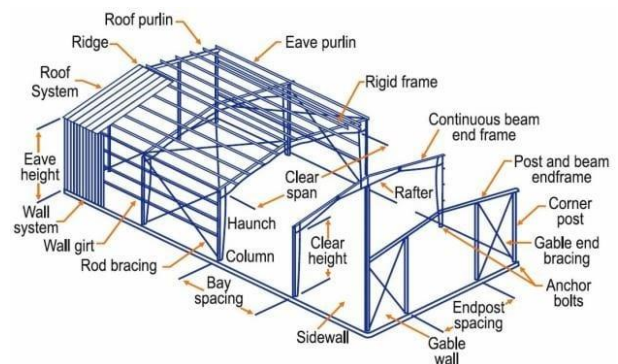
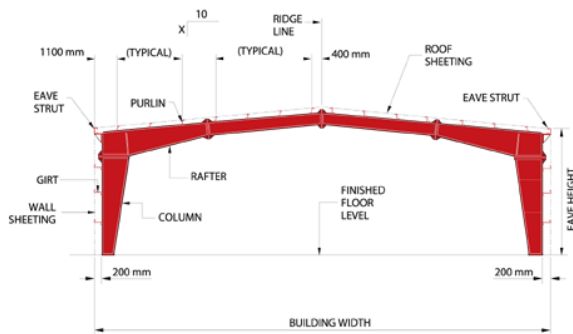


Fig 3.3 Components Parts of PEB



**Fig 3.4 Components Parts of PEB**

### 3.6.1 Main Framing

Main framing basically includes the rigid steel frames of the building. The PEB rigid frame comprises tapered/straight columns and tapered rafters (steel plate fabricated 'I' or 'H' sections are referred to as built-up members). The frame is erected by bolting the end plates of connecting sections together.

### 3.6.2 Secondary frame or Purlins, girts etc.

Purlins, girts and eave struts are also known as secondary cold-formed members. There is no welding involved in their preparation. They are prepared by press bending the HR steel coil giving it the desired shape (Z- or C-shape).

### 3.6.3 Roof & Wall Panels

Metallic plain or colour coated profiled steel sheets are used as roof and wall sheeting. The steel sheets are generally made from Zinalume or Galvalume coils in thickness range of 0.47mm to 0.55mm. The base steel is either galvanized having a zinc coating varying from a minimum Mass of 120 gsm./m<sup>2</sup> to a maximum of 275 gsm./m<sup>2</sup> (total of both sides) or a base steel coating of zinc - aluminum (zinc 45%, aluminum 55%) of total Mass of 150 gsm./m<sup>2</sup> (total of both sides) are available with permanent colour coating. The colour coating is also available in various options in polyester paint coating like regular modified polyester, silicon modified polyester and super polyester coatings. Special organic coatings like PVF2 (Poly Vinyl Fluoride) are also made available. These various colour coatings on the base steel with galvanized or zinc aluminum coating provides suitable resistance for various kinds of environment hazards. Metal roofing and siding profiles can be manufactured to any length - limited only by transportation constraints (usually to 12 meters). To eliminate water ingress, general overlap joint considered is 15 cm to 20 cm. It also has a major advantage for the designers as it allows roofing with minimum pitch which is a rare case in conventional buildings. This happens due to joint-less run of roofing as it has flexibility in cutting of lengths. Slopes as shallow as 1:20 are possible which allows

sufficient drainage of water thereby improving long term performance of the panels. These profile steel sheets are conventionally categorized into two types depending upon the type of fine-tuning arrangement followed. These two types are Through Fastened and second one is Standing Seam. Installation of this type of roofing & cladding system can provide 30 years or more of trouble-free accommodation in most environments.

### 3.6.4 Bracing system

Longitudinal cross bracing, used to provide lateral stability to the structure against wind, seismic or other forces, comprises of rods, pipes, angles or cables with an eye bolt and an adjusting nut at both ends, located near the outer flange of columns or rafters and attached at the web of the rigid frame.

### 3.6.5 Crane systems

These pre-engineered buildings can be equipped with Overhead EOT cranes, Semi-gantry cranes, wall mounted cranes, Mono rails and under slung cranes for various material and equipment handling operations inside. These buildings are being designed for crane capacities ranging from 1MT to 250MT. The crane runway beams (Gantry Girders) are simply supported built-up sections with/without cap channels and with maintenance platforms and ladders. Catwalks for crane maintenance are usually mounted alongside the crane beams, suspended under rigid frame rafters or elevated above the top of the building roof. Cranes at various levels can also be provided. PEB vendors generally do not keep the supply of rail and Crane Bridge with crane in their scope.

## 4. PROBLEM FORMULATION

### 5.1 General

In the design of Pre-Engineered Buildings (PEBs) as per IS codes, key parameters such as span variation and height variation play a crucial role in determining the structural efficiency and cost-effectiveness of the building. height variation influences the structural stability and load distribution, affecting factors like wind resistance and mezzanine floor provisions. In this chapter parameters consideration for PEB as well as variation in models has been discussed. Followed with load design, section selection has been carried out in separate spread sheet.

### 4.2 Parameter considered

1. Deformation
2. Self-Weight
3. Compressive Stresses
4. Tensile Stresses

### 4.3 General Philosophy of PEB design as per IS code DESIGN CRITERIA

#### a) Loads

##### Loads Live

Load on roof and frame shall be  $0.75\text{kN/m}^2$  as per IS-875 Part-2

##### Dead load

Dead load on roof shall be min.  $0.15\text{kN/m}^2$

##### Earthquake load

As per IS 1893 (Part-1) – 2002.

Importance Factor & Response reduction as per IS 1893 Part IV.

Wind load as per IS 875 Part 3, 1987

##### Other Loads

Design of all structures shall also consider any other relevant stresses imparted to the structure due to variation in daily and seasonal temperature, water level, erection and maintenance loads, creep shrinkage etc.

Wind and seismic forces shall not be considered to act simultaneously.

Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion etc. resulted from the most critical combinations of loads as specified below.

#### b) LOAD COMBINATON:

Strength load combination for buildings with or without equipment shall be:

$1.5^* \text{ Dead Load} + 1.5^* \text{ Live / Imposed Load}$

$1.5^* \text{ Dead Load} + 1.5^* \text{ Live / Imposed Load} + 1.5^* \text{ Piping/Firefighting Load}$

$1.5^* \text{ Dead Load} + 1.5^* \text{ (Wind / Seismic Load)}$

$0.9^* \text{ Dead Load} + 1.5^* \text{ (Wind / Seismic Load)}$

$1.2^* \text{ Dead Load} + 1.2^* \text{ Live/Imposed Load} + 1.2^* \text{ Piping/Firefighting} + 1.2^* \text{ (Wind / Seismic load)}$

Service load combinations for general buildings shall be:

$1.0^* \text{ Dead Load} + 1.0^* \text{ Live/Imposed Load}$

$1.0^* \text{ Dead Load} + 1.0^* \text{ Live/Imposed Load} + 1.0^* \text{ Piping/Firefighting Load}$

$1.0^* \text{ Dead Load} + 1.0^* \text{ (Wind/ Seismic Load)}$

$1.0^* \text{ Dead Load} + 1.0^* \text{ Piping/Firefighting Load} + 0.8^* \text{ (Wind/ Seismic Load)}$

$1.0^* \text{ Dead Load} + 0.8^* \text{ Live/Imposed Load} + 0.8^* \text{ Piping/Firefighting Load} + 0.8^* \text{ (Wind/ Seismic Load)}$

Permissible stresses for different load combinations shall be taken as per relevant IS Codes.

#### c) GENERAL

Angle/Rod bracing for roof and wall is considered.

Main frame column base considered as pinned support.

Built up & Hot rolled sections to be designed as per Manual of Steel Construction, 9th edition, American Institute of Steel Construction (AISC) & IS: 800.

Cold formed members to be designed as per 1996 Edition of Cold-Formed Steel Design Manual, American Iron and Steel, Institute (AISI), IS: 801 & IS: 513.

Welding shall be applied in accordance with: American Welding Society (AWS D1.1.98) Structural Welding Code – Steel. IS: 800, IS: 813 & IS: 816.

#### d) PERMISSIBLE DEFLECTIONS

The permissible vertical deflection for structural steel members shall be as specified below: a. For Primary Span / 180

b. For Secondary Span / 150

Steel Structure simple span Beam shall be Span / 240.

Steel Structure for cantilever span Beam shall be Span / 120.

Permissible horizontal displacement at crane level / eaves level shall be Height / 150. Permissible Deflection for Purlin shall be Span / 150.

Permissible Deflection for Side Runner Shall be Span / 150

#### e) Design of Pre-Engineered Buildings (PEB)

The main framing of PEB systems is analyzed by the stiffness matrix method. The design is based on allowable stress design (ASD) as per the American institute of Steel Construction specification or the IS 800. The design program provides an economic and efficient design of the main frames and allows the user to utilize the program in different modes to produce the frame design geometry and loading

and the desired load combinations as specified by the building code opted by the user. The program operates through the maximum number of cycles specified to arrive at an acceptable design. The program uses the stiffness matrix method to arrive at an acceptable design. The program uses the stiffness matrix method to arrive at the solution of displacements and forces. The strain energy method is adopted to calculate the fixed end moments, stiffness and carry over factors. Numerical integration is used.

### f) Design Cycle

The design cycle consists of the following steps:

1. Set up section sizes and brace locations based on the geometry and loading specified for the frame design.
2. Calculate moment, shear, and axial force at each analysis point for each load combination.
3. Compute allowable shear, allowable axial and allowable bending stress in compression and tension at each analysis point.
4. Compute the corresponding stress ratios for shear, axial and bending based on the actual and allowable stresses and calculate the combined stress ratios.
5. Design the optimum splice location and check to see whether the predicted sizes confirm to manufacturing constraints.
6. Using the web optimization mode, arrive at the optimum web depths for the next cycle and update the member data file.
7. At the end of all design cycles, an analysis is run to achieve flange brace optimization.

### g) Frame Geometry

The program has the capability to handle different types of frame geometry as follows

Frames of different type's viz. rigid frames, frames with multiple internal columns, single slope frames, lean to frames etc.

Frames with varying spans, varying heights and varying slopes etc. Frames with different types of supports viz. pinned supports, fixed supports, sinking supports, supports with some degrees of freedom released.

Unsymmetrical frames with off centric, unequal modules, varying slopes etc. User specified purlin and girt spacing and flange brace location.

### h) Frame Loading

Frame design can handle different types of loadings as described below:

All the building dead loads due to sheeting, purlins, etc. and the self-weight of the frame. Imposed live load on the frame with tributary reductions as well.

Collateral load such as false ceiling, light fixtures, AC ducting loads, sprinkler systems and many other suspended loads of similar nature.

### i) Design Codes

Following are the main design codes generally used:

- AISC** : American institute of steel construction manual
- AISI** : American iron and steel institute specifications
- MBMA** : Metal building manufacturer's code
- ANSI** : American national standards institute specifications
- ASCE** : American society of civil engineers
- UBC** : Uniform building code

### j) Types of Bracing

#### H type

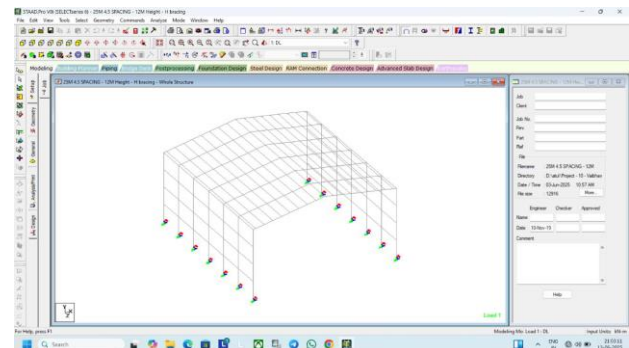


Fig. No. 4.1 H type Bracing

#### A type

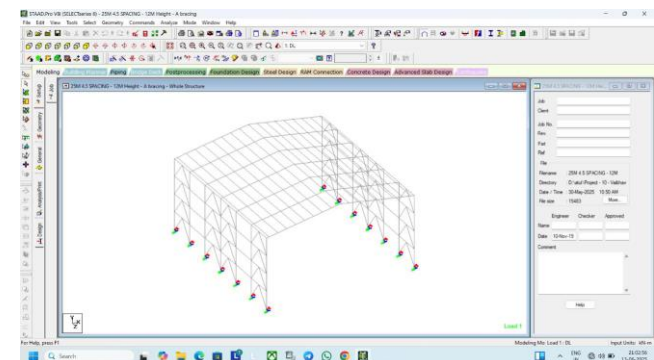


Fig. No. 4.2 A type Bracing

X type

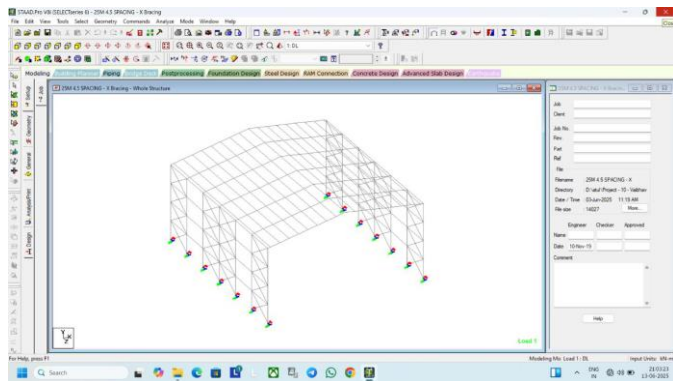


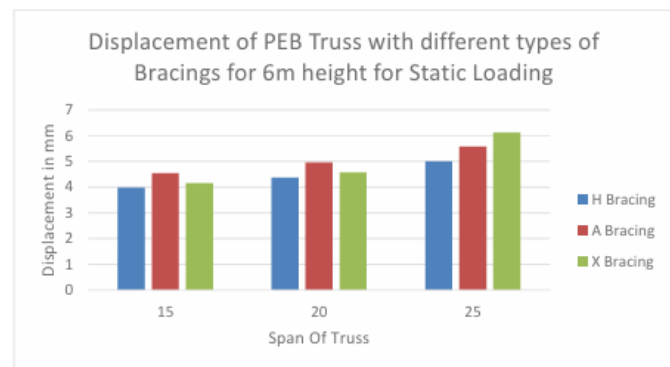
Fig. No. 4.3 X type Bracing

5. RESULTS AND DISCUSSION

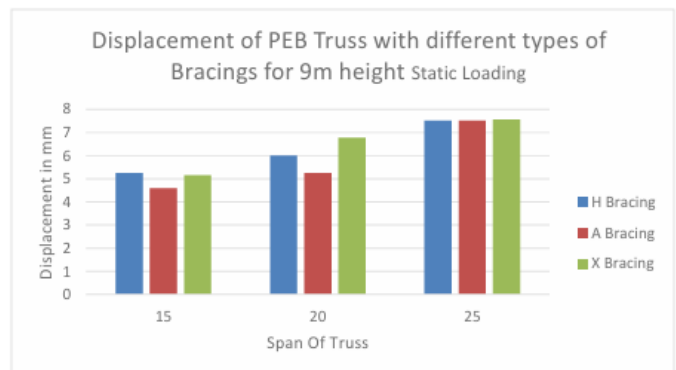
5.1 General

The current project work is to study of Effectiveness of span for Prefabricated building for different loading as per flow of project mentioned in the theoretical Formulation chapter. Heights and span of PEB warehouse truss and parameter considered for analysis of PEB with exercise as discussed in previous chapter. This chapter contains discussion of results of analyzed PEB trusses as follows,

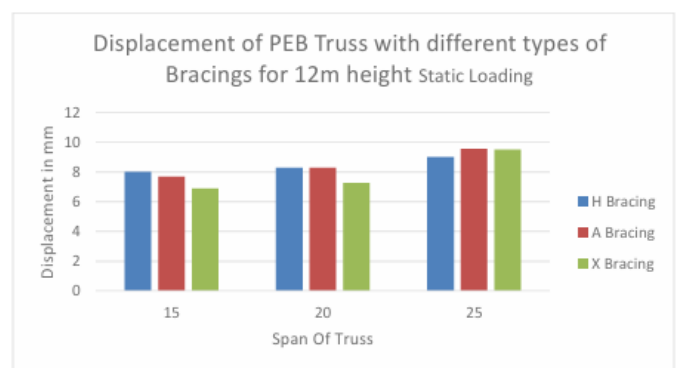
5.2 Displacement of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Static Loading



Graph no.1 Displacement of PEB Truss with different types of Bracings for 6m height for Static Loading



Graph no.2 Displacement of PEB Truss with different types of Bracings for 9m height Static Loading



Graph no.3 Displacement of PEB Truss with different types of Bracings for 12m height Static Loading

Variation of deformation of PEB truss for 6 M 9 M and 12 m of height of truss and plotted against span referring to appendix a.

Plot G1, G2, G3 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of deformation in PEB Trusses in variation with different types of bracing which are h type bracing, a type bracing and X type bracing.

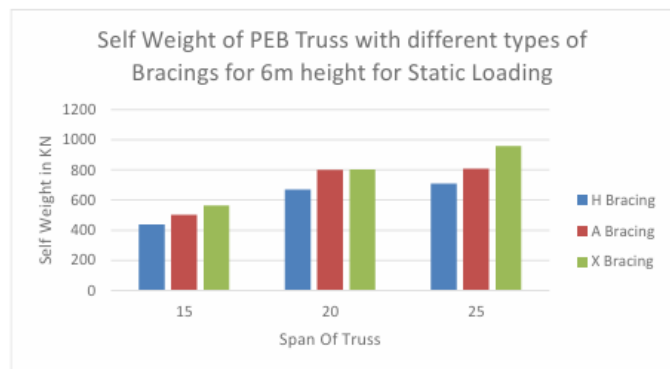
Following observations are noted,

As observed in plot G1, G2, G3 plotted with respect to different types of dressings deformation values,

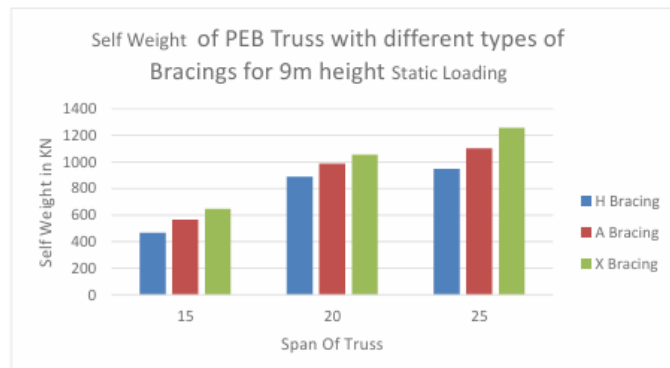
1. As we see from PlotG1, G2, G3 the values of deformation of trusses from different types of bracings varies as the height changes.
2. In plot G1 for span 15 M and 20 m A bracing shows higher displacement than other two types of bracings.
3. In plot G1 for span 25 m the value of displacement is higher for x bracing.
4. In plot G2 A bracing shows less displacement as compared to other two types of bracing for 15 M and 20 m span.

- In plot G2 for span 25 m the value of displacement shows approximately same value for all types of bracing.
- In plot G3 for height 12 m in span 15 M and 20 m the expressing shows less value of displacement other than two bracing.
- In plot G3 for height 12 m in span 25 m the values of displacement nearly same.

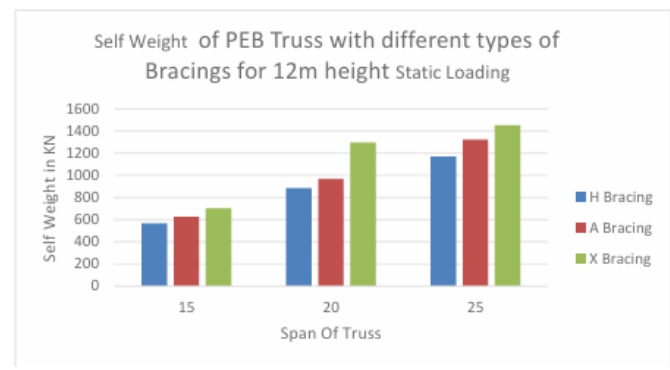
**5.3 Self-Weight of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Static Loading**



**Graph no. 2 Self-weight of PEB Truss with different types of Bracings for 6m height Static Loading**



**Graph no. 2 Self-weight of PEB Truss with different types of Bracings for 9m height Static Loading**



**Graph no. 2 Self-weight of PEB Truss with different types of Bracings for 12m height Static Loading**

Variation of self-weight in kN of PEB truss for 6 M 9 M and 12 m of height of trust and plotted against span referring to appendix a.

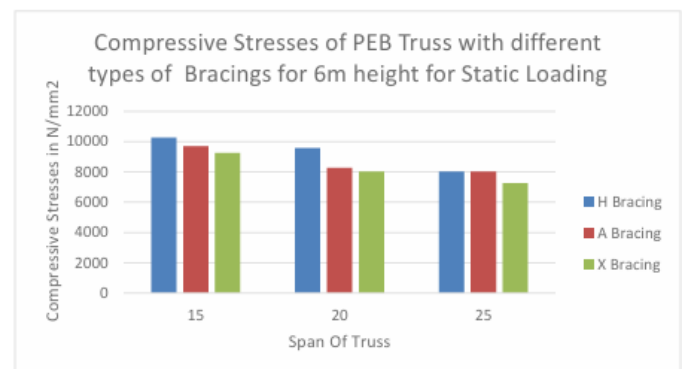
Plot G4, G5, G6 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of self-weight in PEB Trusses in variation with different types of bracing which are h type bracing, a type bracing and X type bracing.

Following observations are noted,

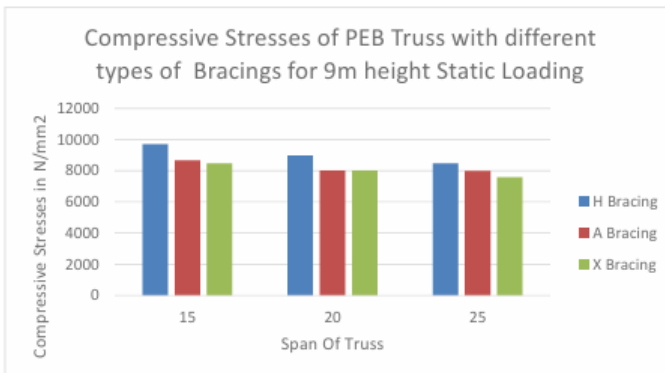
As observed in plot G4, G5, G6 plotted with respect to different types of dressings self-weight values,

- As we see from PlotG4, G5, G6 the values of self-weight of trusses from different types of bracings varies as the height changes.
- As we see in graph, as the number of members increases the self-weight of the Truss also increases. In all height the value of weight of building increases uniformly
- Maximum self-weight of the truss in this research is 1453kN for 12m height and 25m span for X type of bracing. and the minimum self-weight of the truss in this research is 438kNfor 6m height and 15m span for H type of bracing.

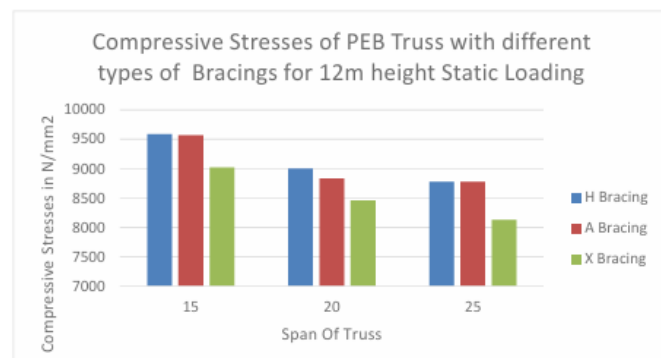
**5.4 Compressive Stresses of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Static Loading**



**Graph no.7 Compressive Stresses of PEB Truss with different types of Bracings for 6m height Static Loading**



Graph no.8 Compressive Stresses of PEB Truss with different types of Bracings for 9m height Static Loading



Graph no.9 Compressive Stresses of PEB Truss with different types of Bracings for 12m height Static Loading

Variation of Compressive Stresses in N/mm<sup>2</sup> of PEB truss for 6 M 9 M and 12 m of height of truss and plotted against span referring to appendix a.

Plot G7, G8, G9 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of Compressive Stresses in PEB Trusses in variation with different types of bracing which are h type bracing, a type bracing and X type bracing.

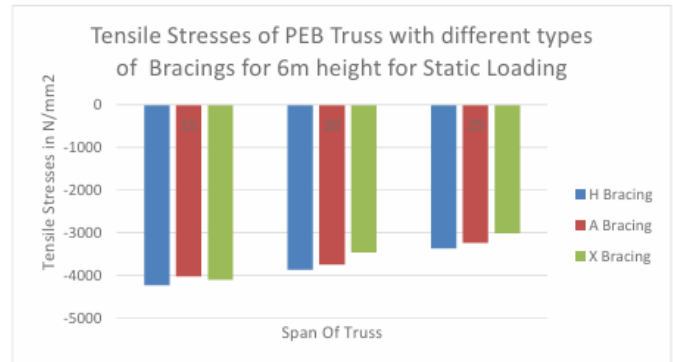
Following observations are noted,

As observed in plot G7, G8, G9 plotted with respect to different types of dressings Compressive Stresses values,

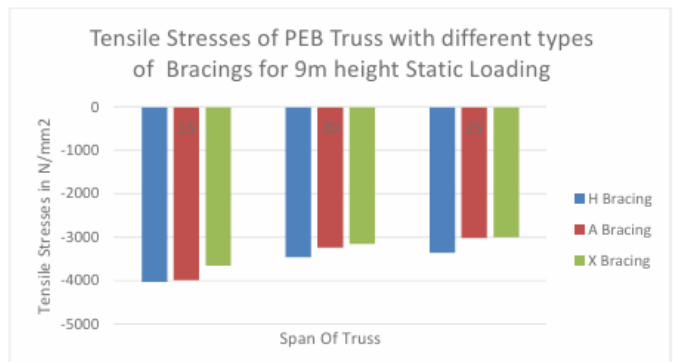
1. As we see from Plot G7, G8, G9 the values of Compressive Stresses of trusses from different types of bracings varies as the height changes.
2. In plot 7 for 6 M height in 15 M plan the value of compressive stresses are gradually decreasing. In 20 m span the stresses between a bracing and x bracing are nearly same, but in h bracing the value is a bit higher.
3. In Plot 8 for 9 M height the value of compressive stresses are again gradually decreasing.

4. In plot 9 for 12 m height compressive stresses are reducing in a large number.

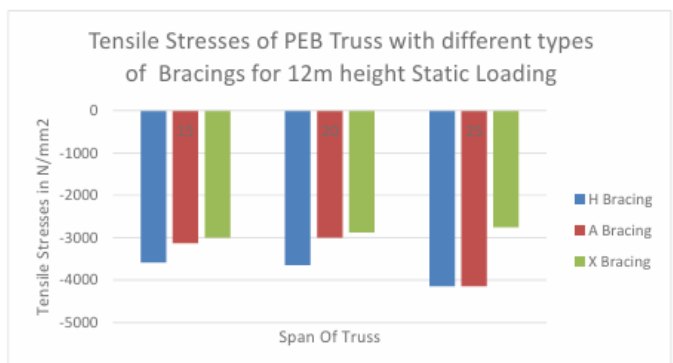
### 5.5 Tensile Stresses of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Static Loading



Graph no.10 Tensile Stresses of PEB Truss with different types of Bracings for 6m height Static Loading



Graph no.11 Tensile Stresses of PEB Truss with different types of Bracings for 9m height Static Loading



Graph no.12 Tensile Stresses of PEB Truss with different types of Bracings for 12m height Static Loading

Variation of Tensile Stresses in N/mm<sup>2</sup> of PEB truss for 6 M 9 M and 12 m of height of truss and plotted against span referring to appendix a.

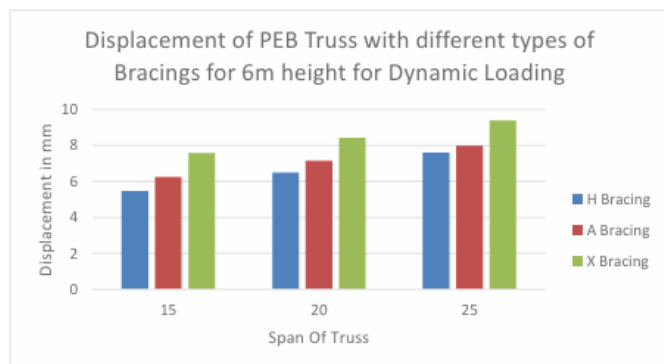
Plot G10, G11, G12 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of Tensile Stresses in PEB Trusses in variation with different types of bracing which are H type bracing, A type bracing and X type bracing.

Following observations are noted,

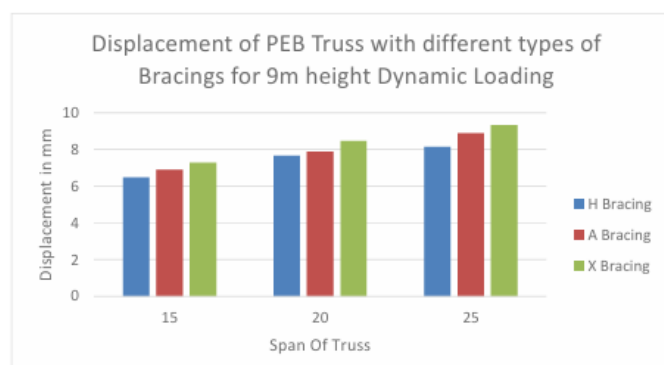
As observed in plot G10, G11, G12 plotted with respect to different types of dressings Tensile Stresses values,

1. As we see from Plot G10, G11, G12 the values of Tensile Stresses of trusses from different types of bracings varies as the height changes.
2. In plot 10 for 6 M height in 15 M plan the value of compressive stresses are gradually increasing.
3. In Plot 8 for 9 M height the value of compressive stresses are again gradually decreasing. In 15 m span the stresses between A bracing and H bracing are nearly same, but in X bracing the value is a bit lower.
4. In plot 9 for 12 m height compressive stresses are gaining in a large number.

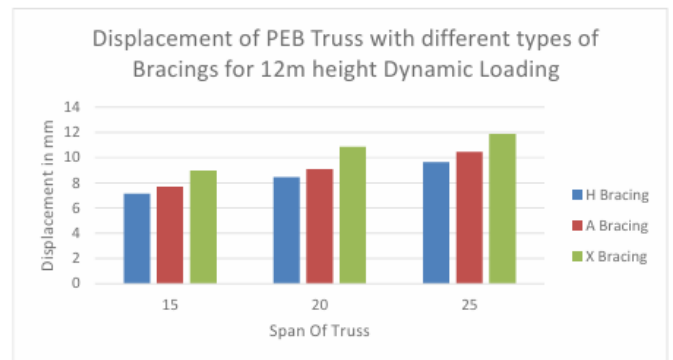
### 5.6 Displacement of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Dynamics Loading



Graph no.13 Displacement of PEB Truss with different types of Bracings for 6m height Dynamic Loading



Graph no.14 Displacement of PEB Truss with different types of Bracings for 6m height Dynamic Loading



Graph no.15 Displacement of PEB Truss with different types of Bracings for 6m height Dynamic Loading

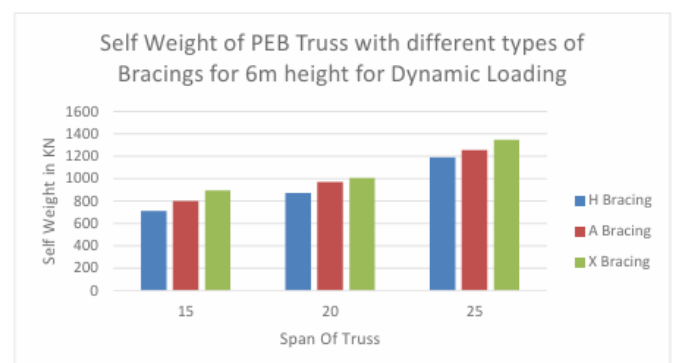
Plot G13, G14, G15 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of deformation in PEB Trusses in variation with different types of bracing which are h type bracing, a type bracing and X type bracing.

Following observations are noted,

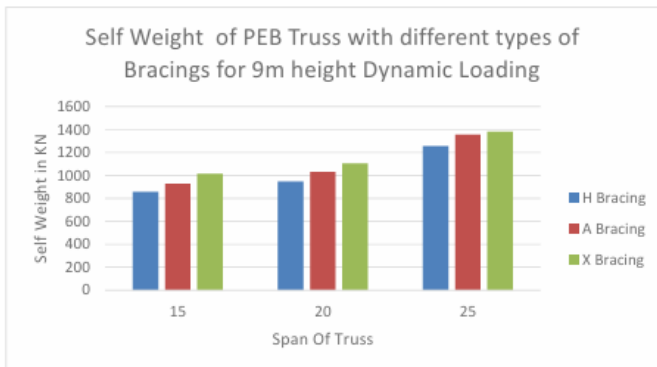
As observed in plot G13, G14, G15 plotted with respect to different types of dressings deformation values,

1. As we see from Plot G13, G14, G15 the values of deformation of trusses from different types of bracings varies as the height changes.
2. In plot G13, G14, G15 for 6 M height in 15 M plan the value of deformation are gradually increasing.
3. As the span increases the value of displacement increases.

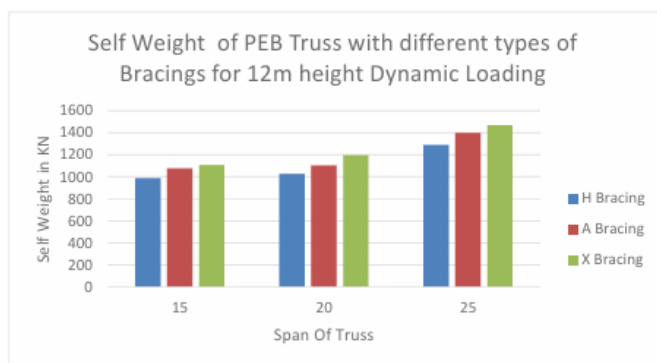
### 5.7 Self-Weight of PEB Truss with different types of Bracings for 6m, 9m and 12m height for Dynamics Loading



Graph no.16 Self-weight of PEB Truss with different types of Bracings for 6m height Dynamic Loading



**Graph no.17 Self-weight of PEB Truss with different types of Bracings for 6m height Dynamic Loading**



**Graph no.18 Self-weight of PEB Truss with different types of Bracings for 6m height Dynamic Loading**

Variation of self-weight in kN of PEB truss for 6 M 9 M and 12 m of height of truss and plotted against span referring to appendix a.

Plot G16, G17, G18 shows that for 6 m, 9m, 12m height of column of truss comparison respectively of self-weight in PEB Trusses in variation with different types of bracing which are h type bracing, a type bracing and X type bracing for dynamics loading.

Following observations are noted,

As observed in plot G16, G17, G18 plotted with respect to different types of dressings self-weight values,

1. As we see from Plot G16, G17, G18 the values of self-weight of trusses from different types of bracings varies as the height changes.
2. As we see in graph, as the number of members increases the self-weight of the Truss also increases. In all height the value of weight of building increases uniformly
3. Maximum self-weight of the truss in this research is 1467kN for 12m height and 25m span for X type of bracing. and the minimum self-weight of the truss in this

research is 707kN for 6m height and 15m span for H type of bracing.

## 6. CONCLUSIONS

This study presents a comprehensive analysis of Pre-Engineered Building (PEB) trusses and box girder bridges under various static and dynamic loading conditions. Two types of box girder cross-sections—rectangular and trapezoidal—were evaluated, highlighting the impact of span-to-depth ratio on deflection and stress development. For PEB trusses, the effects of different bracing types (H, A, and X) were studied across varying column heights (6 m, 9 m, and 12 m) and spans. Results show that bracing type significantly affects deformation, self-weight, and stress distribution. X-type bracing generally offers better control of displacement and tensile stresses, especially in taller structures, but results in higher self-weight due to its complex configuration. H-type bracing, while lighter, may not perform as effectively in stress control. Compressive and tensile stresses vary with height and span, with taller structures showing reduced compressive stresses but increased tensile forces. Under dynamic loading, deformation increases with span length, emphasizing the need for optimal bracing in large-span designs. Overall, the study concludes that truss height, span length, and bracing configuration are critical factors in optimizing the structural performance and efficiency of PEB systems.

## REFERENCES


- [1] Jimin He(1987),” Identification Of Structural Dynamic Characteristics”, Department of Mechanical Engineering Imperial College, LONDON SW7
- [2] Jaillon, L., & Poon, C. S. (2009). The Evolution of Prefabricated Residential Building Systems in Hong Kong: A Review of the Public and the Private Sector. *Automation in Construction*, 18, 239-248. <https://doi.org/10.1016/j.autcon.2008.09.002>
- [3] Hui Min Xu, Yung Yang Li, Wei Xui(2014),”Dynamic characteristic analysis of prefabricated house of light weight steel structure”, *Applied mechanics material* 578-579:483 487 DOI: 10.4028/www.scientific.net/AMM.578-579.483
- [4] Loss, C., Piazza, M., & Zandonini, R. (2016). Connections for Steel-Timber Hybrid Pre Fabricated Buildings. Part I: Experimental Tests. *Construction and Building Materials*, 122, 781-795. <https://doi.org/10.1016/j.conbuildmat.2015.12.002>
- [5] Chandrashekhar B Adin, Raveesh R. M, Praveen J.V.(2016),” Dynamic Analysis of Industrial Steel Structure by using Bracings and Dampers Under Wind Load and Earthquake Load”, Dept. of CIVIL Sri Siddhartha Institute of Technology Tumkuru, India

[6] Fard, M. M., Terouhid, S. A., Kibert, C. J., & Hakim, H. (2017). Safety Concerns Related to Modular/Prefabricated Building Construction. *International Journal for Consumer & Product Safety*, 24, 10-23. <https://doi.org/10.1080/17457300.2015.1047865>



[7] Kasperzyk, C., Kim, M. K., & Brilakis, I. (2017). Automated Re-Prefabrication System for Buildings Robotics. *Automation in Construction*, 83, 184-195. <https://doi.org/10.1016/j.autcon.2017.08.002>

[8] Teng, Y., Li, K., Pan, W., & Thomas Ng, S. (2018). Reducing Building Life Cycle Carbon Emissions through Prefabrication: Evidence from and Gaps in Empirical Studies. *Building and Environment*, 132, 125-136. <https://doi.org/10.1016/j.buildenv.2018.01.026>

[9] Li, Y. S., Hwang, B. G., Shan, M., & Looi, K. Y. (2019). Developing a Knowledge-Based Decision Support System for Prefabricated Prefinished Volumetric Construction. *IOP Conference Series Earth and Environmental Science*, 385, Article ID: 012002. <https://doi.org/10.1088/1755-1315/385/1/012002>

	<p>Nominated as member for distance learning syllabus formation committee IGNOU, Delhi. Also worked as committee member to identify centers for IGNOU for distance learning courses. Received appreciation award from ULTRATECH, Cement Solapur for contribution in M-sand Project.</p>
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