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Structural Response Comparison between PEB and CSB under Different Wind Conditions

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Abstract *- This study presents a comparative analysis between Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) used as industrial sheds. The work mainly focuses on how both structural systems behave under different wind conditions. A total of 8 models were analyzed. Different parameters like extreme wind speed (50 m/s), moderate wind speed (39 m/s), terrain category changes, and internal pressure variations due to large openings (±5) were considered during the study. The structure selected for analysis has a 20 m length, 8 m span, and 4 m eave height.*

The results showed some clear differences between both systems. PEB structures were much lighter in weight, which makes them more material efficient and economical in many cases. But at the same time, they also showed comparatively higher displacement. CSB structures, on the other hand, performed with lower displacement because of their higher stiffness, especially when the wind speed reached 50 m/s. It was interesting to observe that large openings increased the internal forces noticeably in both structures. Even small changes in wind parameters started affecting the response.

When the wind speed was reduced and terrain category changed, the structural responses also decreased for both PEB and CSB models. So, the behavior remained consistent overall. In moderate wind conditions, PEB appeared to be a more efficient and practical solution due to lower steel consumption and better economy. CSB still provided better rigidity under severe loading conditions. The study finally concludes that both systems have their own advantages, and the selection mostly depends on required stiffness, economy, and wind environment of the project.

Keywords: *PEB, CSB, Wind Load, Displacement, STAAD.Pro*

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I. INTRODUCTION

Pre-Engineered Building (PEB) are the buildings which are engineered at a factory and assembled at the site. Usually, PEB’s are the steel structure. built-up sections are fabricated at the Factory to exact Size, transported to site and assembled at the site with bolted or Welded Connections.The current study is formulated to accomplished the staggered plan-based enhancement of pre-engineered steel structure. To accomplish it, a wide range of PEB and CSB structures are considered for the study and will be planned under specific parameters to make the structure increasingly effective.The concept of the pre-designing structure is comparatively a new idea when contrasted with conventional steel building (CSB) [1-5]. As the name shows, it incorporates the pre-designing of every single basic part of the structure considering the engineering and architectural prerequisites. The structural concept of PEB is to utilize just the necessary profundity of the part that is required at that specific spot contingent on the bending moment [6-8].

A typical cross-section can be molded based on the bending moment diagram achieved at that particular section. The sections can be varying throughout the length according to the bending moment diagram. Tapered I section made with built-up thin plates of highly stressed and tested are used to achieve this configuration. The use of the optimal least section leads to beneficiary savings of steel and cost reduction [9].

Conventional steel building systems typically use truss structures. The structural members that are utilized are hot-rolled and supplied in accordance with the IS code; nevertheless, in many cases, they are heavier than what is actually needed by design. Members maintain a constant cross section regardless of how much the local stresses fluctuate throughout the length of the member [10]. The materials are moved to the location after being manufactured in the plant. Before manufacturing the raw materials are treated on the site to get the required shape and size. Modifications can be done by welding and cutting as the structure is being assembled. Secondary components, which are somewhat heavier, are supplied with standard hot rolled sections [11].

Through a variety of new goods and services, technological advancement over time has greatly improved people's quality of life. One such revolution was the Pre-engineered buildings (PEBs). Pre-engineered building concept involves the steel building systems which are predesigned and prefabricated. As the name suggests, this idea entails pre engineering structural components utilizing a pre-established register of construction materials and manufacturing processes that may be effectively used in compliance with a broadrange of structural and aesthetic design requirements [12-13]. The PEB concept is based on the idea that a section should only be provided at a location if it is necessary there. The bending moment graphic indicates that the sections may change across the length. This results in the use of rigid, non-prismatic frames with thin parts [14].

The design of industrial shade warehouse includes designs of the structural parts which includes tensile and compression members which are principal rater, roof truss, column and column base, purlin, sag rods, tie rods, gantry girder, bracings, etc [18]. Steel structures also have much better strength to eight ratios than concrete and they also be easily dismantled. Pre engineered Buildings have attach bolted attachments and yhey can also be many times reused after dismantling. pre-engineered buildings can be transported and shifted expandable as per the future requirements [15-16].

In the present study, a comparative analysis has been carried out between PEB and CSB industrial shed structures under different wind parameters. The study mainly focuses on evaluating important structural responses such as displacement, axial force, shear force, bending moment, and support reactions under varying wind speeds, terrain categories, and internal pressure conditions [17]. The objective of this study is to compare the overall structural performance and efficiency of both systems and to identify the most suitable structural solution for industrial buildings subjected to wind loading [19].

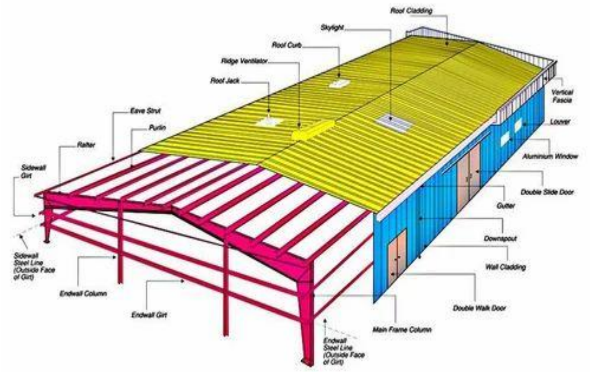

Fig. 1 Pre- Engineered Building

Fig. 2 On-site view of Pre-Engineered Building (PEB)

II. OBJECTIVES

The primary goal of this study is to determine and compare the behavior of PEB (structure) and CSB (structure) under varying wind load cases.

Objectives-

1. Modeling and Analysis of PEB and CSB structures using STAAD Pro under same geometric and loading conditions.

2. Applying wind load on both the structures as per IS 875 (Part 3) For different parameters which include:

- Basic wind speed
- Terrain Category
- Building Height

3. Comparison of responses of PEB structure and CSB structure like
   - Nodal Displacements
   - Member forces (Axial Force, Shear Force, Bending Moment)
4. Analyzing the behaviour of both structures under different Wind Parameters
5. Comparison of steel consumption for PEB structure and CSB structure.
6. Check the efficient structure out of two (PEB/CSB) as per:
   - Structural Behavior
   - Safety and Serviceability

III. METHODOLOGY

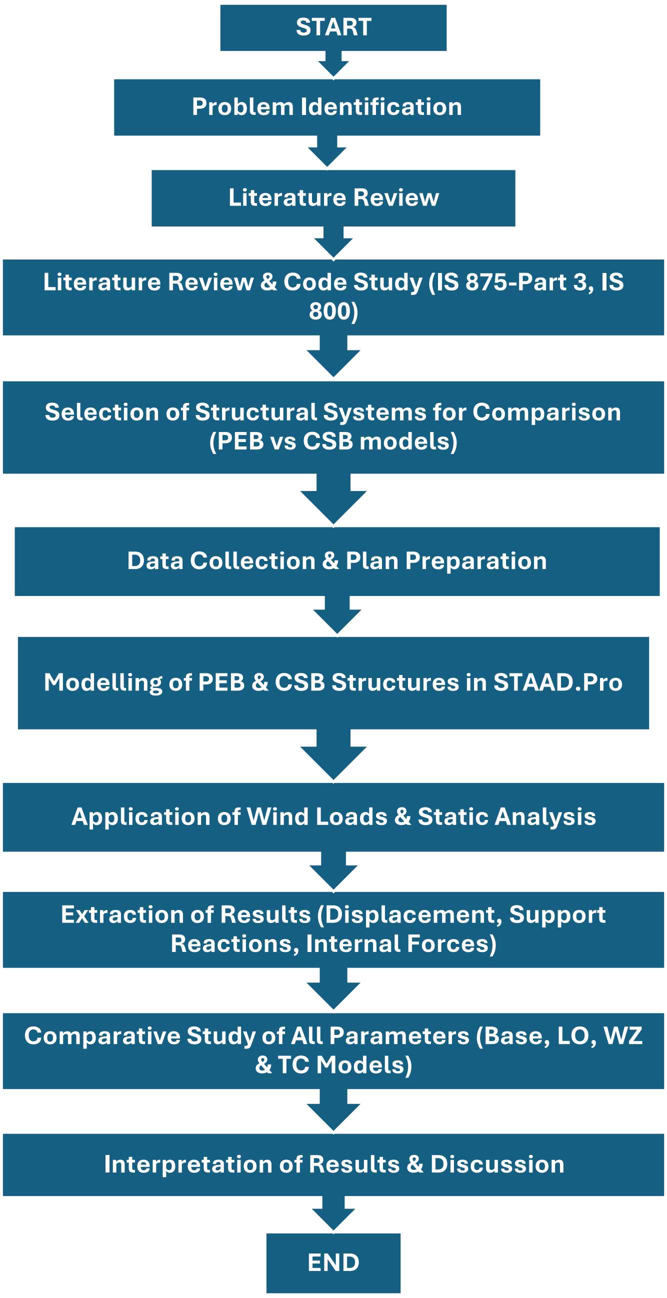

Fig.2 Flow Chart

IV. MODELLING APPROACH

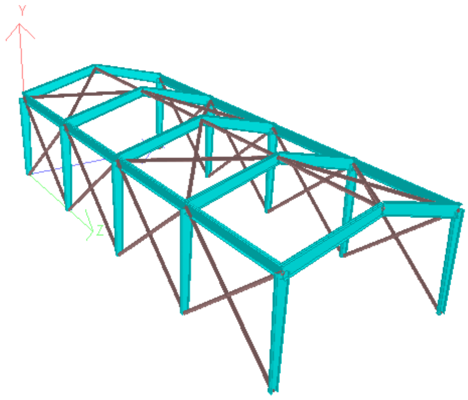

Fig.3 3D View of PEB

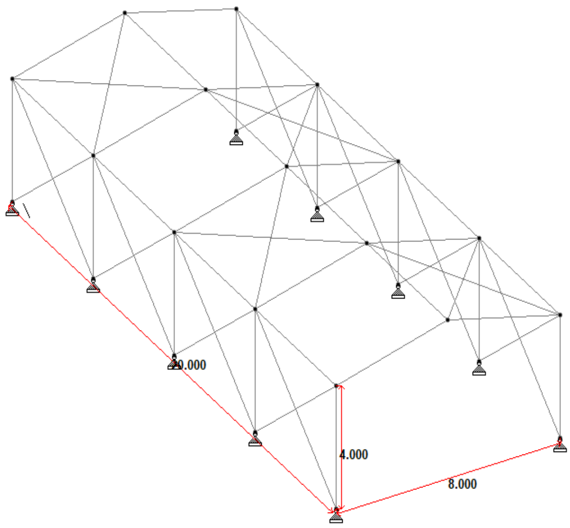

Fig.4 PEB Geometry

Table 1: Building Data

Parameters	Values
Building Type	Industrial Shed
Building Length	20m
Building Width (Span)	8m
Eave Height	4m
Ridge Height	5m
Roof Type	Gable Roof
Roof Angle	14.4
Bay Spacing	5m
Number of Bays	5

To execute a thorough comparative analysis, 8 distinct structural models were generated and analysed:

- Model 1 (PEB Base) & Model 2 (CSB Base): Analyzes the baseline response under extreme wind (50 m/s, Zone 5) in Open Terrain (TC 1) with normal internal pressure (± 2).
- Model 3 (PEB-LO) & Model 4 (CSB-LO): Analyzes stability under increased wind uplift (balloon effect) due to open shutters, utilizing 50 m/s wind in Open Terrain with an internal pressure of (± 5) [20].
- Model 5 (PEB-WZ) & Model 6 (CSB-WZ): Evaluates response in moderate wind zones (39 m/s, Zone 2) in

Open Terrain with normal internal pressure (±2) [21-25].

- Model 7 (PEB-TC) & Model 8 (CSB-TC): Studies the load reduction effects of surrounding obstructions in a City Area (TC 3) under 50 m/s wind with normal internal pressure (±2).

Table 2: Wind Load Parameters [1]

Parameter	Value/Description	Reference Code
Basic Wind Speed (V_b)	39 m/s(Moderate) & 50 m/s(Extreme)	IS 875 (Part 3)
Terrain Category	Category 1 (Open) & Category 3 (City Area)	IS 875 (Part 3)
Internal Pressure Coeff.	(±2) (Normal) & (±5) (Large Openings)	IS 875 (Part 3)

V. RESULTS AND DISCUSSION

5.1 Base Model Comparison (50 m/s)

- PEB shows higher displacement (11.31 mm) compared to CSB (9.088 mm)
- CSB exhibits higher stiffness due to heavier sections
- Support reactions and internal forces are slightly higher in CSB
- PEB is more flexible, while CSB is more rigid [26-28].

5.2 Large Openings Effect (Balloon Effect)

- Displacement increases significantly in both structures
- PEB: 25.82 mm
- CSB: 20.063 mm
- Internal forces increase sharply due to internal pressure
- Large openings create uplift forces, increasing structural demand [29].

5.3 Wind Zone Variation (39 m/s)

- Significant reduction in displacement and forces observed
- PEB: 10.82 mm
- CSB: 8.56 mm

Lower wind speed reduces structural demand, making PEB more economical [30-33].

5.4 Terrain Category Effect (TC-3)

- Wind forces reduce due to surrounding obstructions
- Displacement decreases in both structures.

Urban areas provide shielding effect, reducing wind impact.

Parameter	Sub-Category	PEB Base Model	CSB Base Model
Max Displacement	Horizontal (X-Axis)	11.31 mm	9.088 mm
	Vertical (Y-Axis)	9.45 mm	7.96 mm
	Longitudinal (Z-Axis)	2.38 mm	1.51 mm
Support Reactions	Max Horizontal (F_x)	39.36 KN	41.24 KN
	Max Vertical (F_y)	88.83 KN	98.26 KN
	Max Longitudinal (F_z)	5.305 KN	8.57 KN
Internal Forces	Maximum Axial Force	85.81 KN	88.40 KN
	Maximum Shear Force	76.14 KN	78.62 KN
	Maximum Bending Moment	97.42 KN.m	103.09 KN.m

Table 3: Base Models Comparison (Extreme Wind 50 m/s, Normal Openings)

Table 4: Comparative Structural Response of PEB and CSB Models with Large Openings (LO)

Parameter	Sub-Category	PEB-WZ Model	CSB-WZ Model
Max Displacement	Horizontal (X-Axis)	10.82 mm	8.56 mm
	Vertical (Y-Axis)	7.121 mm	6.46 mm
	Longitudinal (Z-Axis)	1.75 mm	1.14 mm
Support Reactions	Max Horizontal (F_x)	24.25 KN	25.7 KN
	Max Vertical (F_y)	75.659 KN	86.6 KN
	Max Longitudinal (F_z)	3.65 KN	5.85 KN
Internal Forces	Maximum Axial Force	72.46 KN	77.6 KN
	Maximum Shear Force	58.52 KN	62.2 KN
	Maximum Bending Moment	72.59 KN.m	77.7 KN.m

Table 5: Wind Zone (WZ) Variation (Moderate Wind 39 m/s)

Parameter	Sub-Category	PEB LO Model	CSB LO Model
Max Displacement	Horizontal (X-Axis)	25.82 mm	20.06 mm
	Vertical (Y-Axis)	9.68 mm	8.75 mm
	Longitudinal (Z-Axis)	5.41 mm	3.034 mm
Support Reactions	Max Horizontal (F_x)	51.93 KN	53.96 KN
	Max Vertical (F_y)	99.41 KN	113.5 KN
	Max Longitudinal (F_z)	9.52 KN	9.68 KN
Internal Forces	Maximum Axial Force	98.50 KN	110.4 KN
	Maximum Shear Force	81.97 KN	87.70 KN
	Maximum Bending Moment	104.021 KN.m	109.3 KN.m

Table 6: Terrain Category (TC) Variation (City Area - TC 3).

Parameter	Sub-Category	PEB-TC Model	CSB-TC Model
Max Displacement	Horizontal (X-Axis)	14.54 mm	11.4 mm
	Vertical (Y-Axis)	7.616 mm	6.72 mm
	Longitudinal (Z-Axis)	2.409 mm	1.55 mm
Support Reactions	Max Horizontal (F_x)	29.540 KN	31.06 KN
	Max Vertical (F_y)	75.830 KN	86.9 KN
	Max Longitudinal (F_z)	5.075 KN	5.82 KN
Internal Forces	Maximum Axial Force	74.092 KN	83.8 KN
	Maximum Shear Force	59.835 KN	63.6 KN
	Maximum Bending Moment	84.911 KN.m	89.7 KN.m

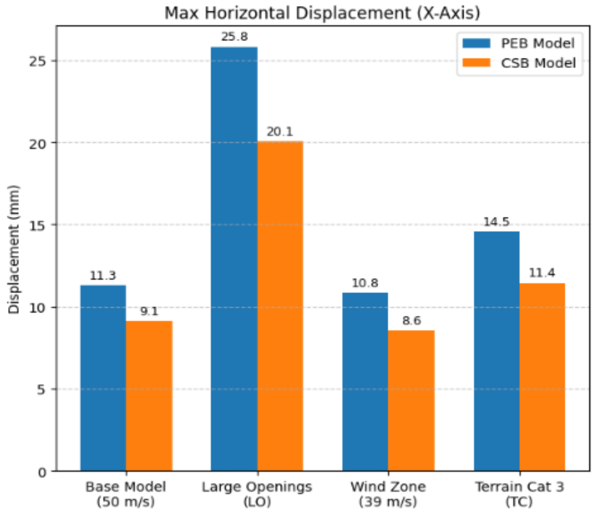

Fig.5 Maximum Displacement

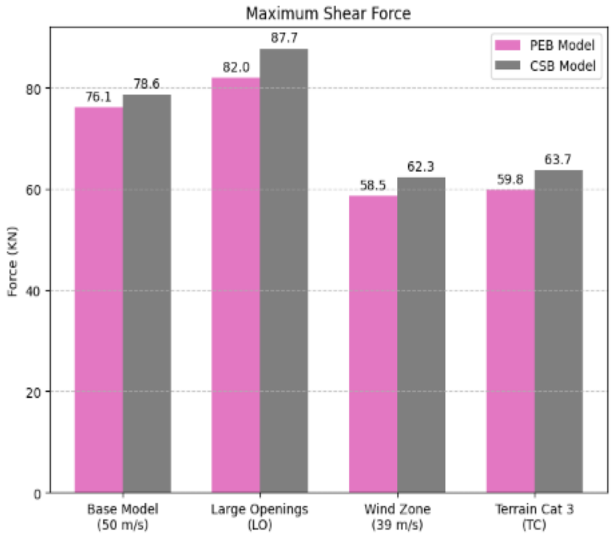

Fig.6 Maximum Shear Force

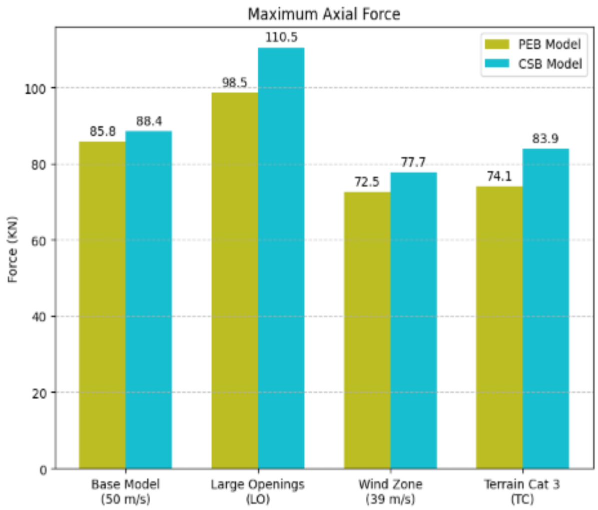

Fig.7 Maximum Axial Force

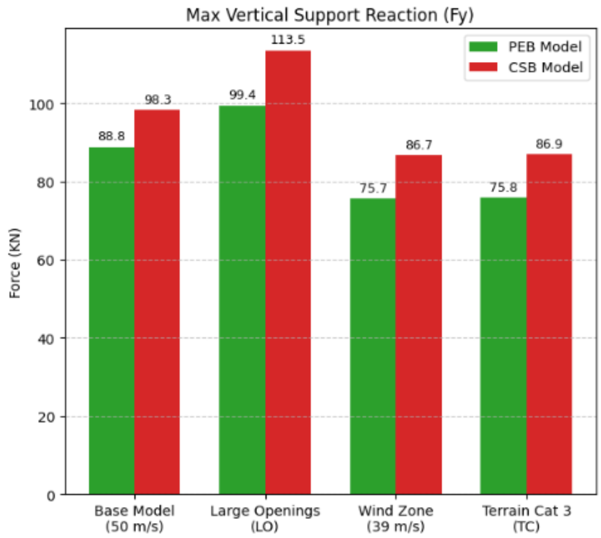

Fig.8 Maximum Support Reaction

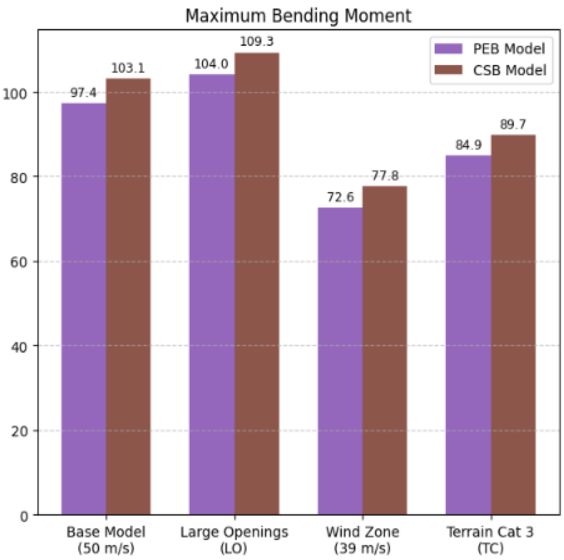

Fig.9 PEB Maximum Bending Moment

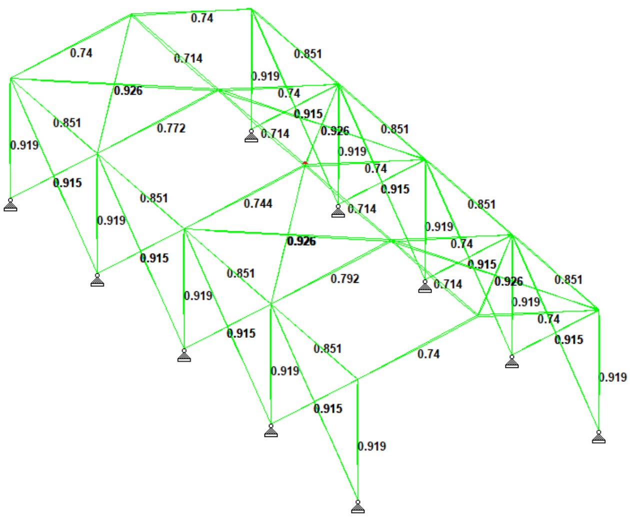

Fig.10 Utilization Ratio (PEB)

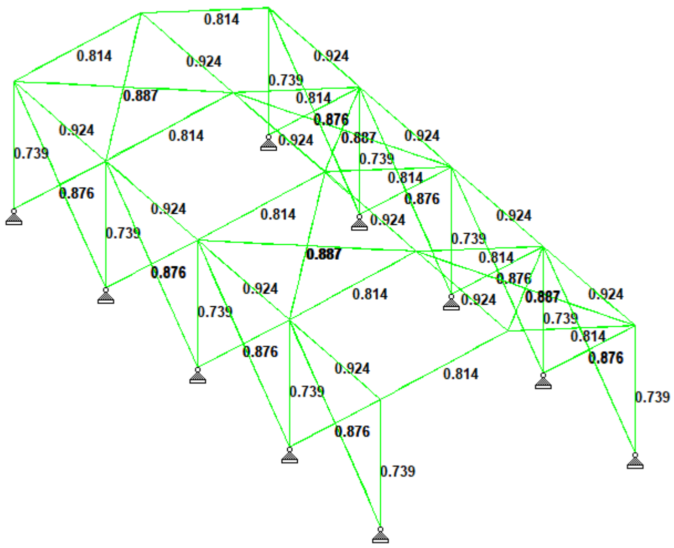

Fig.11 Utilization Ratio (CSB)

- Fig. 5 (Max Horizontal Displacement) reveals a consistent pattern: Pre-Engineered Buildings (PEB) always exhibit higher deflection compared to Conventional Steel Buildings (CSB).
- Axial and Shear Forces (Fig. 6 & 7**)**: CSB models consistently attract higher axial and shear forces across all wind conditions. For instance, in the LO scenario, CSB reaches an axial force of 110.5 KN, whereas PEB stays lower at 98.5 KN.
- Fig. 8 (Max Vertical Support Reaction) is the most vital graph for foundation design considerations.
- Bending Moments (Fig. 9): The maximum bending moment for CSB remains higher than PEB in every tested environment.
- Fig. 10 Utilization Ratio (PEB): The PEB framework shows a highly varied but controlled distribution of utilization ratios across the structure.
- Fig. 11 Utilization Ratio (CSB) : In contrast, the CSB framework utilizes standard hot-rolled sections that have a uniform depth throughout their length.

VI. CONCLUSION

- The analysis shows that PEB structures are considerably lighter than CSB structures. Since PEB systems use tapered and optimized sections, the overall steel requirement is reduced, making them more economical and material-efficient for industrial shed construction. In contrast, CSB structures use conventional rolled sections, which increase the total structural weight.
- It was also observed that CSB structures possess greater stiffness because of their heavier sections, resulting in lower lateral displacement. On the other hand, PEB structures are relatively more flexible and therefore experience higher horizontal displacement values. The maximum displacement was observed in the Large Openings (LO) condition, where the PEB model reached a displacement of 25.82 mm.
- The study further indicates that CSB models develop higher axial forces, shear forces, and bending moments under all considered wind conditions. For example, in the LO case, the axial force in the CSB model reached 110.5 KN, whereas the corresponding value in the PEB model was 98.5 KN. This suggests that CSB structures transfer larger forces to the foundation system, which may increase the requirement for stronger and more expensive foundation detailing.
- The presence of large openings increases internal air pressure inside the structure, producing the so-called "balloon effect." Due to this effect, both displacement and internal forces increase significantly in PEB as well as CSB models. This condition was found to be one of the most critical cases in the overall analysis.
- The study concludes that PEB structures offer advantages in terms of reduced weight, better material utilization, and economy, while CSB structures provide greater stiffness and lower displacement. Therefore, the selection between PEB and CSB should be based on project requirements, loading conditions, structural performance, and economic considerations.

REFERENCES

[1]. IS 875 (Part 3): Wind Loads on Structures
[2]. Smith, R.E. – Steel Structures Design
[3]. Duggal, S.K. – Limit State Design of Steel Structures
[4]. Relevant research papers on PEB vs CSB
[5]. Pal, N. (2026). "Study of Pre-Engineered and Conventional Steel Structure: A Review." International Journal for Research in Applied Science and Engineering Technology, 14(1), 323–330.
[6]. Gilbile, M. J., & Mane, S. S. (2020). "Comparative Study on Structural Analysis and Design of PEB with CSB." International Journal of Engineering Research & Technology (IJERT), Vol. 9, Issue 9.
[7]. Varshitha, M., & Rao, B. D. V. C. M. (2024). "Comparative Study of Pre-Engineered Building and Conventional Steel Building." Journal of Physics: Conference Series, 2779(1), 012050.
[8]. Upadhyay, S., & Pendharkar, U. (2023). "Analysis of Conventional Steel Building and Pre-Engineered Building Structures." International Journal for Research in Applied Science and Engineering Technology.
[9]. Shete, N. M., Pise, C. P., & Kamble, A. (2025). "Critical Review of Study of Conventional and Pre-Engineered Building." Recent Trends in Civil Engineering & Technology.
[10]. Dubey, A., & Sahare, A. (2020). "Main Frame Design of Pre-Engineered Building." International Journal of Innovations in Engineering Research and Technology.
[11]. Shah, V. K., Panchal, V. R., & Shah, B. B. (2018). Comparative studies between Indian Standard codes IS 802 (part 1/sec 1): 2015 and IS 802 (part 1/sec 1): 1995 used for overhead transmission line towers. Journal of Structural Engineering, 45(2), 155-160
[12]. Shah, V. K. S., & Joshi, A. J. (2019). Comparison between muff connector and spherical connector for transmission line tower. Journal of Analysis and Computation, 12(4).
[13]. Kagda, A. H., Bhavsar, R. V., & Shah, V. K. (2020). Concrete mix design using brick dust and coconut shell. Journal of Emerging Technologies and Innovative Research (JETIR), 7(4).
[14]. Patel, P. M., Panchal, V. R., Arekar, V. A., & Shah, V. K. (2017). Comparison of hollow spherical and solid spherical connectors used in guyed tower. International Journal of Emerging Technology and Advanced Engineering, 7(12), 302.
[15]. Darshan S.Shah , Prof. Jayeshkumar Pitroda , Prof.J.J.Bhavsar. (2013) "Pervious Concrete: New Era For Rural Road Pavement," International Journal of Engineering Trends and Technology (IJETT), vol. 4, no. 8, pp. 3495-3499, 2013. Crossref, https://doi.org/10.14445/22315381/IJETT-V4I8P141
[16]. Darshan S. Shah , Prof. Jayeshkumar Pitroda. (2013) "Assessment For Use Of Gravel In Pervious Concrete," International Journal of Engineering Trends and Technology (IJETT), vol. 4, no. 10, pp. 4306-4310, 2013. Crossref, https://doi.org/10.14445/22315381/IJETT-V4I10P105
[17]. Jaymil J Doshi, Narnarayan Shastri, Abhishek J Patel, Darshan Shah (2016) "Application of Pervious Concrete in Exploring of Gravel and Coarse Aggregate" International Journal of Engineering Trends and Technology vol. 40(5) by Seventh Sense Research Group Journals at 2016 DOI: 10.14445/22315381/ijett-v40p245
[18]. Mehta, N. S., V. Bhaiya, K. A. Patel, and S. Elias (2026) "Optimal Design of Linear Quadratic Regulator Controller for Asymmetric Structure Using Metaheuristic Algorithm." The structural Design of Tall and Special Buildings35, no. 1: e70128, https://doi.org/10.1002/tal.70128
[19]. Mehta, N. S., V. Bhaiya, K. A. Patel, and S. Elias S. (2026) "Optimal Design of Active Controlled System for Torsionally Coupled Framed Structure Using Metaheuristic Algorithms." ASCE-ASME J. Risk Uncertainty Eng. Syst., Part A: Civ. Eng., 2026, 12(1): 04025111 https://doi.org/10.1061/AJRUA6.RUENG-1755
[20]. Mehta, N. S., Bhaiya, V., Patel, K. A., & Farsangi, E. N. (2024) Predictive active control of building structures using LQR and artificial intelligence. Earthquake Engineering and Engineering Vibration, 23(2), 489–502. https://doi.org/10.1007/s11803-024-2250-z
[21]. Mehta, N. S., Bhaiya, V., Patel, K. A. (2024) Optimization of Active Controlled System for Structures Using Metaheuristic Algorithms. Earthquakes and Structures, 27(5),401-417. https://doi.org/10.12989/eas.2024.27.5.401
[22]. Raval, Parth B., Butala, A. M., Mehta, N. S. (2024) "Behavior study of precast pier of bridge for its various shape." Earth and Environmental Science. 1326 (2024) 012012. doi:10.1088/1755-1315/1326/1/012012
[23]. Vataliya, P. V., Butala, A, M., Mehta, N. S., Patel C. G., (2024) Comparison of Different Types of Structural Systems in Tall Building Under Lateral Load. International Research Journal on Advanced Engineering Hub, 02 (08), 2126-2132. https://doi.org/10.47392/IRJAEH.2024.0289
[24]. Gumudavelly Ujwal, Mehta Nirmal S., Chaudhary Rahul, Bhaiya Vishisht. (2024) Active seismic control using neural network. Earth and Environmental Science. 1326 (2024) 012007. doi:10.1088/1755-1315/1326/1/012007
[25]. Soni, Y. B., Mehta, N. S., Patel, C. G. (2020) Comparison of braced steel building with steel plate shear wall. International Journal of Engineering Research and Applications. 10(05) 7-12, DOI: 10.9790/9622-1005020712
[26]. Sneha J. Patel, Mehta, N.S. (2020) Comparison of Shear wall Building and Core wall Building. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 17(3), 2020, pp. 35-42. DOI: 10.9790/1684-1703013542
[27]. Mehta, N. S., Mevada, S. V. (2017) Seismic response of two-way asymmetric building installed with hybrid arrangement of dampers under bi-directional excitations. International Journal of Structural Engineering. 8(3) 249-271, https://doi.org/10.1504/IJSTRUCTE.2017.086421
[28]. Patel, S., Butala, A. M., Mehta, N. S. (2024). Seismic Behavior of Irregular Building Under Vertical Earthquake Excitation. In: Patel, D., Kim, B., Han, D. (eds) Innovation in Smart and Sustainable Infrastructure, Volume 2. ISSI 2022. Lecture Notes in Civil Engineering, vol 485. Springer, Singapore. https://doi.org/10.1007/978-981-97-3994-3_19
[29]. Shah, V. K., Panchal, V. R., & Shah, B. B. (2018). Comparative studies between Indian Standard codes IS 802 (part 1/sec 1): 2015 and IS 802 (part 1/sec 1): 1995 used for overhead transmission line towers. Journal of Structural Engineering, 45(2), 155-160
[30]. Shah, V. K., & Joshi, A. J. (2019). Comparison between muff connector and spherical connector for transmission line tower. Journal of Analysis and Computation, 12(4).
[31]. Kagda, A. H., Bhavsar, R. V., & Shah, V. K. (2020). Concrete mix design using brick dust and coconut shell. Journal of Emerging

Technologies and Innovative Research (JETIR), 7(4).
[32]. Patel, P. M., Panchal, V. R., Arekar, V. A., & Shah, V. K. (2017). Comparison of hollow spherical and solid spherical connectors used in guyed tower. International Journal of Emerging Technology and Advanced Engineering, 7(12), 302.
[33]. Dedania, D. M., Panchal, V. R., & Shah, V. K. (2017). Comparison of axial forces for different configuration of ultra high voltage cathead transmission tower. Journal of Emerging Technologies and Innovative Research (JETIR), 4(6).