IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Study Of Tubular Structure And Design A Warehouse Using STAAD Pro

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Abstract: Due to rapid industrial growth in India, there is a growing need for well-designed industrial warehouses to store and manufacture goods. This study focuses on the design of an industrial warehouse, considering various force/load effects. The design follows IS 800:2007, with wind load analysis based on IS 875:1987 (Part-I, II, III). Different warehouse components, such as truss members, columns, and connections are designed, and the results show that warehouses can be designed efficiently using simple procedures and IS specifications.

I. INTRODUCTION

An industrial warehouse is a large, specialized structure designed to store various types of goods, including raw materials, manufactured products, and heavy machinery. These warehouses are essential for industries, as they provide a controlled environment that ensures the safety and preservation of goods. In India, with the rapid growth of industrialization, the demand for efficient and cost-effective warehouses has significantly increased. The development of such facilities requires careful planning and consideration of structural integrity, material selection, and layout design. The objective of this study is to plan and analyse an industrial warehouse using advanced structural methods, incorporating tubular sections and pre-engineered components. The design process involves the creation of detailed plans and elevations using AutoCAD software, ensuring accurate and scalable representations of the warehouse.

The study also focuses on optimizing the warehouse design to improve space utilization, operational efficiency, and cost-effectiveness. Incorporating modern materials and construction methods, it aims to minimize long-term maintenance costs while ensuring environmental sustainability. This study aims to deliver a well-planned, efficient, and economically feasible industrial warehouse design, which can withstand the operational demands of modern industries while also offering flexibility for future expansion and adaptation. The overall goal is to create a warehouse that meets both functional and safety requirements effectively.

AIM

The analysis and design phase are conducted using STAAD-Pro software, which helps in evaluating the structural behavior and performance of the warehouse under various load conditions. The design is carried out in accordance with Indian standards, ensuring compliance with local building codes and safety regulations.

LITERATURE REVIEW

[1] Srikant Boga.

This research paper compares the optimal design of industrial warehouses using Conventional Steel Buildings (CSB) and structures with Pipe and Tube Sections. Using STAAD-Pro software, the study evaluates the effectiveness, efficiency, and economic feasibility of both designs. It highlights the importance of proper warehouse design, addressing environmental, storage, and operational factors. The findings show that tubular steel sections reduce support reactions and material usage compared to conventional steel structures.

[2] Sangi Rajashekar

This study focuses on warehouse design and analysis using STAADPRO software, highlighting safety, cost-effectiveness, and structural integrity. It details the methodology, including design considerations, preliminary design, and structural analysis under various loads and environmental conditions like wind forces. The results show that the warehouse meets safety standards, with acceptable deflections and optimized space. Overall, the study demonstrates the effectiveness of advanced software in creating efficient, adaptable, and reliable warehouse designs.

[3] Kankuntla Ashok

The study on industrial warehouse design highlights the advantages of Pre-Engineered Buildings (PEB) over Conventional Steel Buildings (CSB) in terms of structural efficiency, cost-effectiveness, and ease of fabrication. Using STAAD-Pro software, the analysis shows that PEB structures lead to lower support reactions and reduced material weight compared to CSB, which uses heavier purlin sections. While PEB structures experience higher bending moments and shear forces in columns, their overall design optimizes safety and functionality, enhancing performance and economic viability.

[4] Chaitrali Shekhar

The study focuses on the design and analysis of an industrial warehouse using hollow steel sections, specifically in accordance with European standards. Key findings include- 1. The use of hollow steel sections results in approximately 20% material savings compared to conventional steel sections. 2. Hollow sections demonstrate a higher average utilization ratio, indicating more efficient use of material. 3. These sections are more effective in resisting buckling due to their geometric properties. 4. The design of connections for tubular members is critical, with considerations for joint strength and effective lengths of welds. 5. Minimizing the number of joints in trusses can enhance fabrication efficiency.

[5] K. Narendhar

The conclusion can be summarized as follows- The document presents a comprehensive overview of the design and analysis of steel trusses and industrial buildings, emphasizing the importance of efficient structural design to withstand various loads. It reviews several research papers that discuss different methodologies for analysing and designing truss members, highlighting the need for economical and effective solutions in construction. The findings suggest that a thorough understanding of load behaviour and structural optimization is crucial for achieving reliable and resilient engineering outcomes in steel structures.

[6] Ravindra Desai

Conventional Steel Buildings (CSB), Pre-Engineered Buildings (PEB), and Tubular Structures. The analysis highlights the advantages and disadvantages of each system, emphasizing that PEBs and tubular structures are more economical and efficient compared to CSBs. Specifically, the study finds that PEBs are approximately 14.73% more economical than CSBs, while tubular structures offer a significant 39.54% cost advantage. Additionally, the research underscores the importance of design optimization, energy efficiency, and reduced construction time in modern building practices. Overall, the findings advocate for the increased adoption of PEBs and tubular structures in industrial applications due to their superior performance and cost-effectiveness.

[7] Shivani Meher

The document highlights industrial buildings use framed bays, trusses, and bracings to support roofs, resist lateral loads, reduce deflection, and increase structural stability and strength. Overall, the findings advocate for the increased adoption of PEBs and tubular structures in industrial applications due to their superior performance and cost-effectiveness.

[8] R. Kavitha

The warehouse uses RCC foundations and a pre-engineered steel superstructure, modelled in STAAD Pro with fixed and pinned supports, X-bracings, and optimized structural design. Minimizing the number of joints in trusses can enhance fabrication efficiency

[9] Anish Goswami

Industrial warehouses are low-rise steel structures with truss roofing, designed to resist lateral forces, using cladding or masonry walls, and featuring efficient structural components. Using STAAD-Pro software, the study evaluates the effectiveness, efficiency, and economic feasibility of both designs.

[10] C. M. Meera

Steel's high strength-to-weight ratio makes it ideal for industrial warehouses. This summary compares PEB and CSB systems, their components, analysis methods, and advantages. Hollow sections demonstrate a higher average utilization ratio, indicating more efficient use of material.

OBJECTIVES

1. Plan and analyse an industrial warehouse using tubular and pre-engineered sections in the design of the warehouse.
2. Draft the plan and elevation of the warehouse using AUTOCAD software and perform structural analysis and design using STAAD-Pro software.
3. Ensure compliance with Indian standards for the design and analysis process.
4. Evaluate the structural behaviour of the warehouse under various loads and forces.

METHODOLOGY

DEFINING MODELLING

Structure Type

- Type - Industrial Warehouse
- Modelling Style - Space Frame with Tubular Truss System
- Frame Geometry - Symmetrical with pitched roof
- Design Basis - Pre-engineered tubular steel structure

DEFINING LOADS

Q. Design the industrial shed for following data. Calculate load. DL. LL. WL and Panel point load.

Given Data:

- Location Waghali Pune.
- Size 40m x 15m
- Spacing 8m
- Height of truss rise 3m.
- Nos of Perlines - 10 Nos
- Eaves Height
- length of shed 40m[span]
- Roof Covering material - Ac Sheet
- Life of structure- 50year [class B]
- [Class is define from is 875 part 3]
- Terrain Categories 3d
- Opening 25% of wall
- Topography or ground slope less than 3

A. PRELIMINARY CALCULATION

(i) Angle of Roof Truss (α) $\tan\alpha = \text{Rise}/(L/2) = 3/(15/2) = 21.80°$

(ii) Length of PR (Principle Rafter)

$$\text{Length of PR} = \sqrt{7.5^2 + 3^2} = 8.07 \text{ m.}$$

(iii) Half plan area = (L/2) x Spacing of RT

= 7.5 x 8

(iv) Half slope area = length of PR x Spacing

= 8.07 x 8

B. DEAD LOAD

[IS 875: 1987 Part 2?]

For AC sheet assume 130 N/mm^2 [Thickness 6]

(i) Weight of Roofing Material

Weight of Roofing Material = 130 x Half slope area

130 x 64.56 = 8392.8 N

(ii) Weight of Purline

Assume weight of Purline 9o N/m2 on plan area

Weight of Purline = 90 x 60 = 5400 N

(iii) Self-Weight of Truss

Self-weight of Truss = 10 [Span +5] /3

= 10 [15+5] /3

= 100 N/m2

Self-weight of Truss on plan area = 100 x 60 = 6000N

(iv) Weight of wind Bracing

Assume weight of wind bracing 12N/m2 on plan area

Weight of wind bracing = 12 x 60

∴ Total dead load = (i) + (ii) + (iii) + (iv)

= 8392.8 + 5400 + 6000 + 720

= 20512.8

On each Side of truss there are 4 Panel Point

C. WIND LOAD CALCULATION

(i) Design Wind Speed [Is: 875 Part 3.Page 8 5.3]

Vb = Basic Wind Speed. [Vb = 39 m/s Pg. = 53]

Ki = Risk co-efficient

K1 = 1.0 (Page N o. 11)

K2 = Terrain, height & structure size

= 0.88

For Life = 50 year

K3 = Topography Factor

K3 = 1 + Cs

$3° < \theta < 17°$

$\theta = 3° = 1.0$

Vz = 39 x 1.0 x 0.88 x 1.0

(ii) Design Wind Pressure (Pz)

$Pz = 0.6 V^2$

$= 0.6 \times (34.32)^2$

$= 706.71 N/m^2$

(iii) Wind Load (F)

$F = [Cpe + CPI] \times A. Pz$

$= [-0.37-0.7] \times 64.56 \times 706.71$

$= -48.818 \times 10^3$ KN

D. LIVE LOAD CALCULATIONS

[Ref. IS: 875-1987, Part 2]

$\theta = 3$

$= 0.75-(\alpha-3) \times 0.02$ KN /m²

$= 0.75 - (21.80 - 3) \times 0.02$

$= 0.75 – (18.8 \times 0.02)$

$= 0.75- 0.376$

$= 0.374$KN /m²

[Pg 14. Table – 2]

Note: If it is less than 0.400KN/m²

Take mini equal to 0.400 KN/m²

Live Load on Roof Truss

= 2/3 x Live load on Purlin

= 2/3 x400 N/m²

= 266.67

Total Live Load = 266.7 x 40

= 10666.8 N

Live Load [EPP] = 10666/4 = 2666.5 N

Live Load [FPP] = 2666.7/2 = 1333.35

$= 1.335 \times 10^3$

- Final Load Result

1. Dead Load = EPP - 0.14, FPP - 2.85
2. Wind Load = EPP -12.2, FPP - 6.10
3. Live Load = EPP - 2.66, FPP - 1.33

RESULT

The project successfully achieved the planning, analysis, and design of an industrial warehouse that is structurally sound, cost-effective, and adaptable to future needs. With tubular and pre-engineered steel sections, the structure ensures material efficiency without compromising strength or durability. The detailed structural analysis using STAAD Pro validated the design under various load conditions such as dead loads, live loads, wind, and seismic forces, ensuring the warehouse's resilience and safety. Moreover, the drafting work done in AutoCAD facilitated precise planning and visualization of the structure, enabling smooth execution. The project adheres strictly to relevant Indian Standards and building codes, enhancing the reliability and legal compliance of the design. With optimized space utilization, the warehouse maximizes storage capacity while supporting efficient workflow and operations. Additionally, by incorporating sustainable materials and methods, the project minimizes environmental impact and long-term maintenance. The flexible design approach also allows for future expansion or modification, making this warehouse a forward-thinking solution tailored for modern industrial demands.

OUTCOME

- Validated the efficiency of tubular sections in reducing weight and cost.
- Improved understanding of 3D modeling and load behavior in STAAD-Pro.
- Practical exposure to real-life industrial design standards and optimization techniques.
- Prepared for future roles in structural design and consultancy work.

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