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Study and Design of Roof Truss Joint: Case Study of ITM University Extension Sport Arena Using STAAD Pro

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Abstract: Steel roof trusses are widely used in industrial and large-span structures due to their high strength, economy, and rapid construction capabilities. This study presents the analysis and design of roof truss joints for the ITM University Extension Arena using STAAD Pro software. The research emphasizes the importance of connection design, which governs the overall performance and safety of steel structures.The methodology includes site investigation, structural interpretation, modeling, load analysis, and connection design as per IS codes. Dead load, live load, and wind load combinations were applied to obtain internal forces. Additionally, an innovative Excel-based design tool was developed to facilitate customizable steel design, accessible via QR code.The results demonstrate that properly designed joints significantly enhance structural stability, and the integration of digital tools improves efficiency and practical usability in engineering design.

I. INTRODUCTION

Steel trusses are structural frameworks composed of straight members connected at joints, designed to carry loads efficiently through axial forces. They are extensively used in industrial buildings, warehouses, and large-span structures due to their efficiency and economy.

As highlighted in the reference study , steel trusses consist of essential components such as rafters, purlins, columns, and bracing systems, and are designed considering various load combinations including dead load, live load, and wind load.

The performance of a truss system largely depends on:

- Member strength
- Load distribution
- Joint (connection) design

This project focuses specifically on the design and analysis of truss joints, which are critical for ensuring safe load transfer between members.

II. OBJECTIVES OF THE STUDY

- To study the structural behavior of steel roof trusses
- To perform site analysis of ITM Extension Arena
- To design truss joints and connections
- To analyze the structure using STAAD Pro
- To develop a customizable Excel design tool
- To understand practical aspects of steel connection detailing

III. LITERATURE REVIEW

Previous studies have emphasized the importance of accurate analysis and efficient design of steel trusses.

According to :

- Steel trusses are axially loaded systems, making them highly efficient
- Load combinations as per IS codes are critical for safe design
- STAAD Pro is widely used for structural analysis and design

Researchers such as:

- Manjunath & Santhosh Kumar studied reliability using probabilistic methods
- Dubey et al. analyzed wind load effects based on IS 875
- Kim et al. evaluated truss performance using tubular sections

These studies conclude that:

✔ Proper load analysis is essential

✔ Connection design significantly influences performance

✔ Software-based analysis improves accuracy

IV. METHODOLOGY

The methodology adopted in this study includes:

1) Site Study

- Visit to ITM University Extension Arena
- Observation of structural components
- Identification of connection types

2) Structural Modeling

- Creation of truss model in STAAD Pro
- Definition of geometry and support conditions

3) Load Application

Loads considered:

- Dead Load (Self-weight + roofing)
- Live Load
- Wind Load (IS 875 Part 3)

As noted in , loads are typically applied at **panel points** in truss systems.

4) Analysis

- Determination of axial forces, shear forces, and bending moments
- Evaluation of support reactions and displacements

5) Design

- Design of members and joints as per IS 800:2007
- Verification of safety and stability

V. CASE STUDY: ITM UNIVERSITY EXTENSION ARENA

1) Structural Description

The structure consists of:

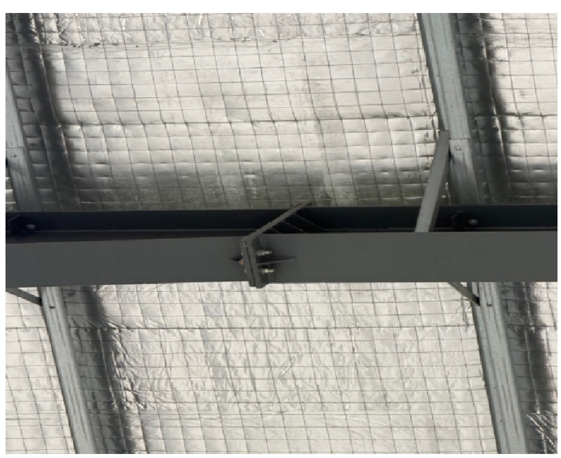
- Steel columns (I-sections)
- Roof trusses
- Purlins supporting roofing sheets
- Bolted and gusset plate connections

2) Observations from Site

- Beam-column joints use bolted end plate connections
- Truss members are connected using gusset plates
- Stiffeners are provided for additional strength
- Insulated roofing sheets are supported on purlins

The existing structure views

The column views



The middle view

3) Structural Behavior

The truss system transfers:

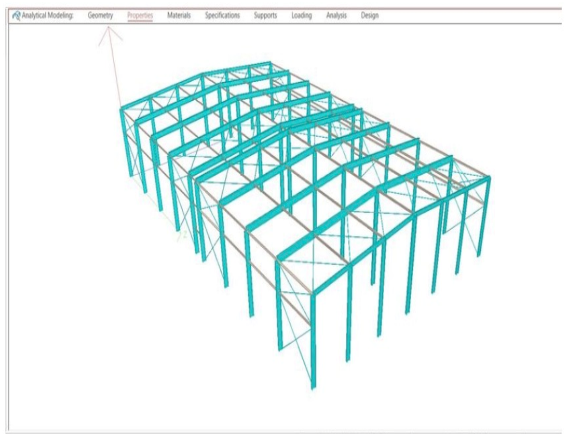
- Roof loads → purlins → truss → columns → foundation

Connections play a key role in:

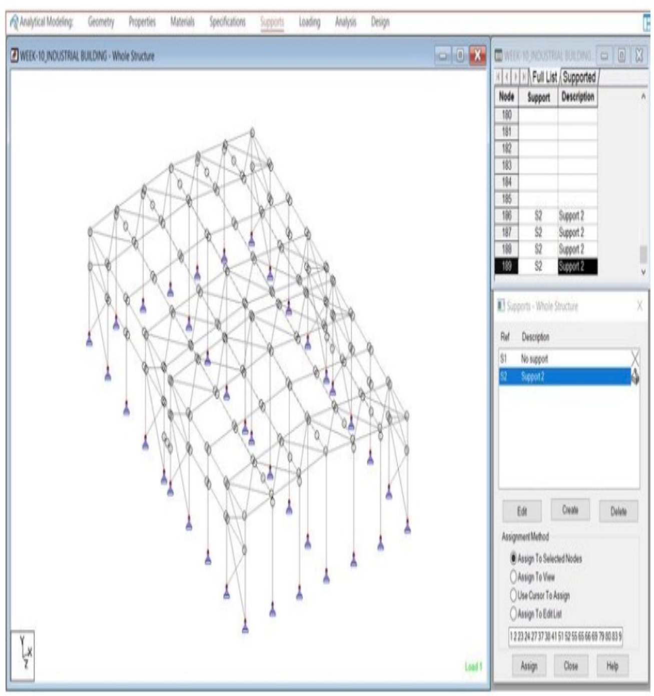
- Force transfer
- Structural integrity
- Stability under dynamic loads

VI. ANALYSIS USING STAAD PRO

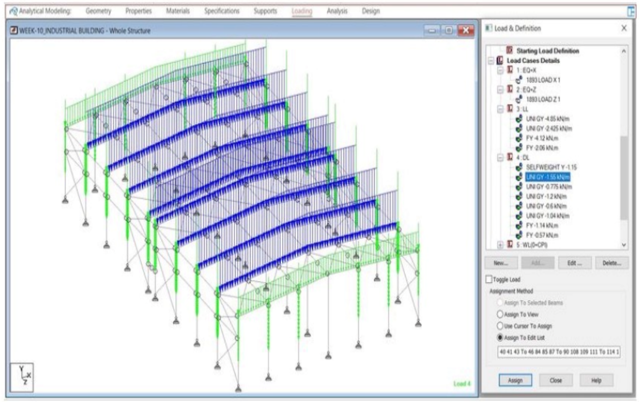
The structural model was analyzed using STAAD Pro with appropriate load combinations.



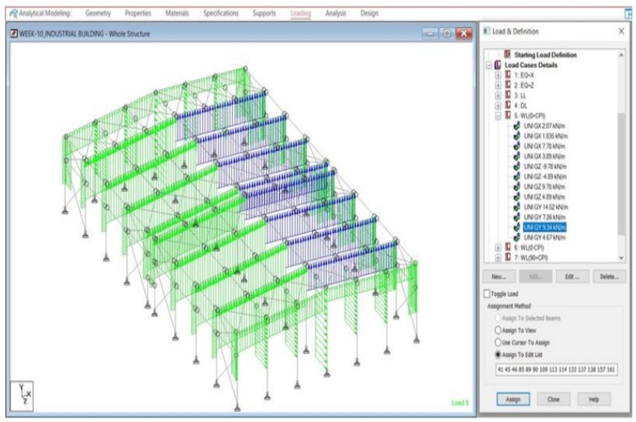
3D view object Steel



Support (pinned)



Load case definition



Wind load

Key Results (Based on Reference Study)
- Span of truss: 9.144 m
- Height of truss: 1.83 m
- Roof angle: 21.8°
- Dead load per panel: 3.09 kN
- Live load: 2.68 kN
- Wind load: up to 17.93 kN

Outputs Obtained:
- Axial force diagrams
- Shear force diagrams
- Bending moment diagrams
- Displacement results

VII. DESIGN OF JOINT CONNECTIONS

1) Types of Connections Used
- Bolted connections
- Gusset plate connections
- End plate connections

2) Design Considerations
- Bolt shear and bearing capacity
- Plate thickness
- Weld strength

- Load combinations

3) Connection Details (From Study)

- Gusset plate thickness: 10 mm
- Bolt diameter: 20 mm
- Rafter: ISA 60×40×8 mm
- Main tie: ISA 75×45×8 mm
- Strut: ISA 55×55×10 mm

Key Insight:

Connections must be designed stronger than members to avoid premature failure.

- Allows users to access and download the sheet
- Promotes practical application and knowledge sharing

VIII. RESULTS AND DISCUSSION

- STAAD Pro provided accurate force analysis
- Joint design ensured safe load transfer
- Excel tool reduced manual calculation effort
- Structural system showed good performance under load combinations
- The findings align with , confirming that:
- Load distribution at joints is critical
- Proper connection design enhances structural safety

IX. CONCLUSION

This study successfully demonstrates the **analysis and design of roof truss joints** for a real-life structure.

Key Conclusions:

- Steel trusses are efficient for large-span structures
- Joint design is the most critical aspect of steel structures
- STAAD Pro enables accurate structural analysis
- Practical site study enhances understanding of real-world behavior

The integration of theory, software, and practical innovation makes this project highly valuable for engineering applications.

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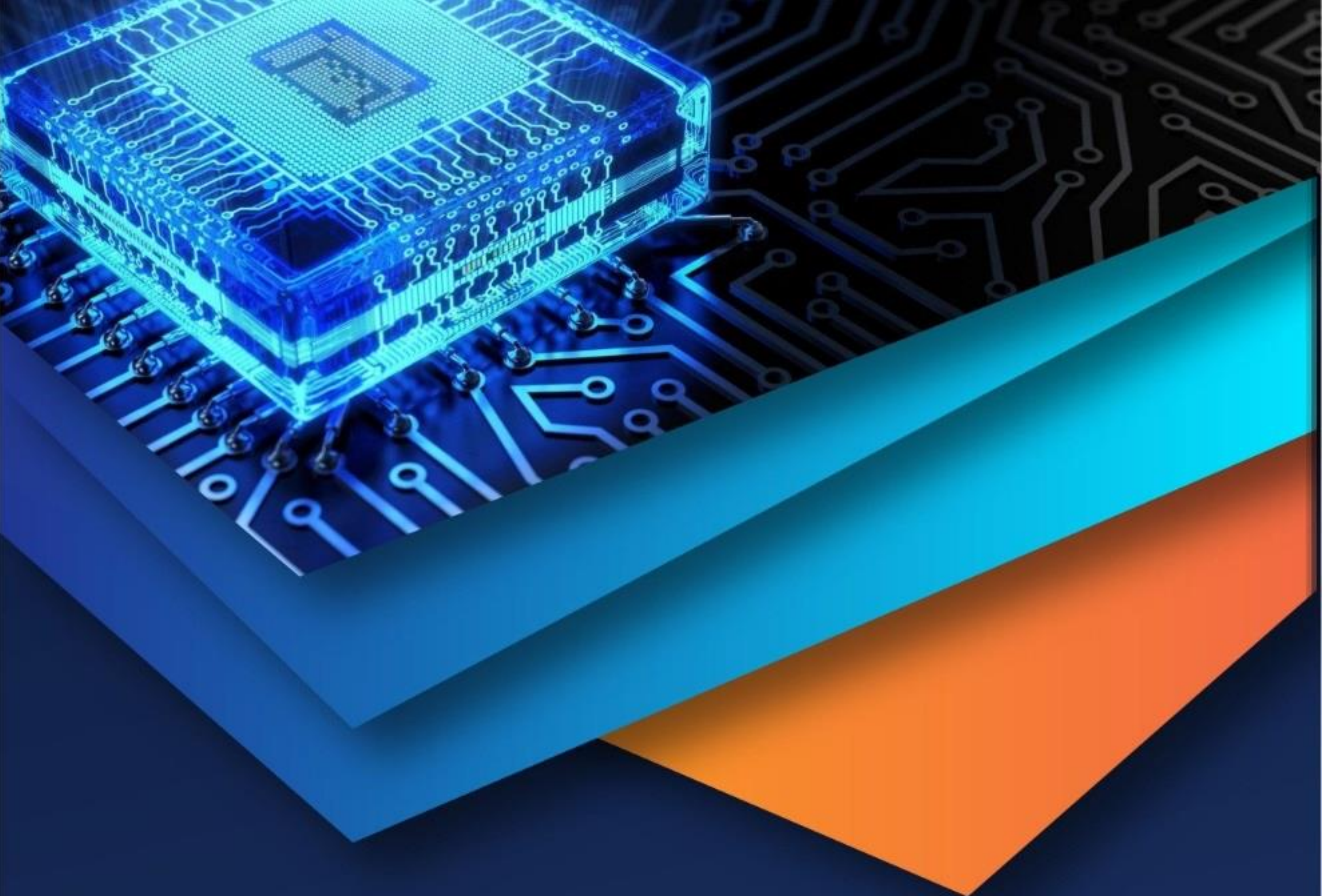

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