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Research Paper

EVALUATION OF INDUSTRIAL STEEL BUILDING ROOF TRUSS SYSTEMS: PRATT VS. LATTICE USING STAAD.PRO

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Abstract - The structural systems of industrial steel structures must be economical, strong, and serviceable in order to withstand lateral stresses and gravity. Because of their axial force transmission capabilities and great load-carrying efficiency, roof trusses are often used for large-span industrial buildings. The current research uses STAAD.Pro to examine the structural behavior of a single-story industrial steel structure with two popular roof truss configurations: Pratt truss and Lattice truss. In order to make a fair comparison, the two structural systems are modeled using the same geometric parameters, material characteristics, support conditions, and loading circumstances. This commercial structure has six bays, a length of 60 meters, a roof truss with a span of 20 meters, and column heights of 12 meters. The structural analysis is carried out in accordance with the applicable Indian Standards, such as IS 875 for loading and IS 800:2007 for steel design, and is subject to dead load, live load, and wind load scenarios. We use STAAD's finite element-based matrix stiffness method to examine the models. Before verifying the limit state design, there is the pro phase. The bending moment, shear force, deflection behavior, and total steel consumption produced by STAAD are used to assess the performance of the Pratt and Lattice truss systems.Pro evaluation and steel take-off outcomes. According to the research, the Lattice truss may reduce the total weight of the steel structure by distributing the load more efficiently across more web members, while the Pratt truss is more rigid, has better serviceability performance, and has less deflection. Roof truss layouts for industrial steel structures may be better understood by comparing the results, which show the structural trade-off between material economy and rigidity.

Important Terms - Steel design, structural analysis, Pratt trusses, lattice trusses, STAAD.Pro, IS 800:2007, IS 875, and industrial steel buildings are all part of the same category.

I. INTRODUCTION

Because of its flexibility to enormous clear spans, quick construction, and high strength-to-weight ratio, industrial steel buildings are often used for storage structures, workshops, warehouses, and hangars. Selecting appropriate frame solutions that can safely transmit gravity and lateral loads to the base is crucial to the structural efficiency of these structures. Because they rely on axial tension and compression to harness the strength of steel sections, roof trusses are among the most cost-effective structural methods for covering huge spans. The sturdy structure of a truss is formed by connecting straight elements that are attached at their ends. The ideal situation is when the joints are thought of as pin-connected, which means that the members only have to cope with axial forces. In contrast to traditional bending members, where only a small fraction of the cross-section actively resists bending forces, this behavior allows for more efficient use of steel material. Roof trusses in industrial buildings may face a variety of loadings, such as wind pressure, self-weight, pressures imposed by the roof, and even dynamic or crane loads on occasion. Building response, material consumption, manufacturing complexity, and maintenance needs in the long run are all affected by the truss arrangement choice. Because of their favorable load-carrying qualities and adaptability for medium to large spans, Pratt and Lattice trusses are among the most regularly utilized truss designs.

The diagonal members of the Pratt truss are often subject to compression due to the compression of gravity loads, while the vertical elements are mostly subject to tension. The technology is well-suited for use on industrial roofs because of the efficient load route provided by this design. The Lattice truss, in contrast, is more structurally complicated but offers better load distribution because to its tightly spaced web arrangement of diagonal elements. This design also has the potential to lower pressures acting on individual members. Thanks to developments in computational structural analysis, programs like STAAD.Pro make it possible to model, analyze, and verify designs for complicated structural systems in great detail. By simulating real-world loads using finite element models, engineers may assess how structures react to things like bending moments, shear pressures, deflections, and member utilisation ratios.

Fig. 1: A Pratt truss system that is often used in bridges and industrial buildings

An industrial steel structure with one story is the subject of this research, which employs STAAD.Pro to compare and contrast Pratt and Lattice roof truss designs. In accordance with IS 875 and IS 800:2007, both buildings are examined under the same loading and design circumstances. Investigating how different truss configurations affect structural performance, steel consumption, and industrial applicability is the main goal.

Fig. 2: The investigated structural form is exemplified by a lattice steel truss structure.

II. EVALUATION OF EXISTING LITERATURE

The significance of attaining structural safety, economy, and effective material utilisation has led to substantial research into the design and analysis of industrial steel structures. Scientists have used analytical techniques and structural analysis tools to study the behavior of steel roof trusses, framed buildings, and industrial sheds. Programs like STAAD were developed.Load analysis, code-based design verification, and structural modeling have all been greatly enhanced by Pro. Various roof truss layouts for industrial buildings have been the subject of many studies comparing their performance. According to research, the distribution of internal forces, structural stiffness, and total steel consumption are all heavily influenced by truss shape. Because axial forces are mostly carried by truss members, the effectiveness of the structural system is greatly affected by the arrangement of chord and web elements. Pratt, Warren, Howe, and Lattice trusses are some of the designs that have been studied in relation to steel roof trusses. Depending on the span length, loading circumstances, and design requirements, these configurations provide distinct structural benefits. The diagonal elements of the Pratt truss effectively resist gravity loads via tension, minimizing the risk of buckling, and this has led to its widespread adoption for usage in industrial applications. Research shows that this configuration improves the structural stability of medium-span industrial structures by distributing pressures evenly.

Due to its capacity to transfer loads over various web members, the behavior of lattice trusses has also been studied. Member sizes may be reduced due to the inclusion of more diagonal members, which lessens the force carried by individual members. Nevertheless, studies have shown that increasing the number of members makes manufacturing more complicated, adds more connections, and might cause maintenance problems because of the increased surface areas and corrosion-prone spots. Previous experiments employing STAAD.Results from pro-based analyses of industrial structures show that finite element modeling is useful for predicting how structures will react to different loads. By taking dead load, live load, wind load, and seismic impacts into account, the program has found widespread usage in analyzing steel sheds, industrial frames, and roof truss systems. By incorporating the requirements of IS 800:2007 into their work, engineers may assess the suitability of certain structural parts and conduct limit state design assessments. Wind loading is an important factor to consider when designing industrial steel buildings, according to research. This is especially true for lightweight structures with a lot of exposed surfaces. According to research based on IS 875 (Part 3), in order to guarantee safe structural performance, it is essential to properly account for topographical features, height variation, and wind pressure distribution.

Research comparing traditional steel buildings to other types of constructions has shown that cost-effectiveness is not the only factor to consider when choosing a building layout. When choosing a structure, it's important to think about things like deflection control, fabrication needs, stiffness, connection complexity, and maintenance requirements in the long run. If further strengthening or serviceability improvements are needed, a lighter construction may not be the most cost-effective option. A systematic limit state method that takes into account both strength and serviceability criteria has been created by applying IS 800:2007 to the design of steel structures. This design technique has been used in STAAD by several researchers.Adequate member verification under combined loading circumstances is achieved by using pro models. The design is examined for capacities to withstand tension, compression, buckling, bending, interaction, and deflection. Few studies have compared Pratt and Lattice roof trusses under controlled settings, despite the fact that both types of trusses have been studied extensively in relation to industrial steel buildings and specific truss configurations. The effect of truss arrangement on structural response may be better understood by comparing the two side-by-side, as this removes differences brought about by other structural characteristics. In light of this knowledge vacuum, this research employs STAAD.Pro to model and analyze Pratt and Lattice roof truss systems for a single industrial building layout. Following the specifications set forth by IS 800:2007, the overall steel consumption, bending moment, shear force, and deflection behavior are all taken into account in the comparative assessment.

III. STUDY DESIGN

Modeling, analyzing, and comparing the Pratt and Lattice roof truss systems for a one-story industrial steel structure using STAAD.Pro constitute the approach used in this work. A controlled comparison was made by developing both structural configurations with equal geometric dimensions, material qualities, loading conditions, and design parameters. Web member configuration inside the roof truss system was the only variable that was taken into account between the two models. Structures are defined, materials are assigned, design loads are applied, structural analysis is performed, steel design checks are executed in accordance with IS 800:2007, and the findings are evaluated as part of the full process. The entire technique that was used for this investigation is shown in Figure 1.

A. Organizational Layout

Steel columns and roof trusses support the roof of the one-story industrial building that is the subject of this research. With six bays set 10 meters apart, the structure measures 60 meters in the longitudinal direction. The transverse span of the roof truss is 20 meters, and it is composed of eight equal panels, each having a 2.5-meter panel length. A truss depth of 1.2 m and a column height of 12 m are maintained.

We created two distinct structural models:

1. Model of the Pratt Truss

Vertical and angled diagonal members are conventionally placed in the Pratt truss arrangement. While subjected to gravity loading, the diagonal members mostly bear compression forces while the vertical elements mainly resist tensile pressures. The roof system may transmit its load directly and efficiently to the supporting columns with this configuration.

2. Model for Lattice Trusses

Extra diagonal elements arranged in a crisscross web pattern constitute the Lattice truss construction. With more people participating on the web, there are more ways for loads to be distributed and internal pressures to be shared. We looked at this setup to see how it affected structural efficiency and total steel use.

In order to guarantee that the findings from the comparison only reflect the impact of truss arrangement, both models were built with identical span, height, support conditions, material qualities, and loading combinations.

B. Section Assignment and Material Characteristics

The whole industrial building was constructed using structural steel. In accordance with the specifications laid forth by IS 800:2007, the material characteristics were established. As part of the STAAD, we determined the density, modulus of elasticity, and yield strength.Professional modeling procedure. Using the same structural sections, the Pratt and Lattice truss models were developed:

- Sections: ISMB 450
- Members of the roof truss: ISA 20×20×3 angle sections
- Channel sections made of ISMC 225 for purlins

Assigning identical section attributes to both models allowed us to compare the impact of truss shape instead of section variation.

C. Modeling Process in STAAD.Pro

The structural modeling was done with the help of STAAD.Pro. Metric and kilonewton units were used to develop a SPACE model. With the help of the Structure Wizard, we were able to construct the roof truss geometry by entering the necessary dimensions, including the span, panel count, and truss height. The 12-meter-tall generated truss was set atop the columns. The six-bay industrial building frame was constructed by longitudinally extending the structure using translational repetition instructions. Here are the stages that were involved in the modeling procedure:

- Making the model of the building's three-dimensional structure.
- Development of Pratt and Lattice geometries for roof trusses.
- Steel material qualities are assigned.
- Sections of columns, purlins, and trusses assigned.
- Fixed supports at the base of a column are defined.
- Three types of loads: dead, living, and wind.
- Making different combinations of loads.
- Execution of structural analysis.
- Performance of IS 800:2007 steel design tests.

D. Conditions for Loading

The loads considered in the analysis include dead load, live load, and wind load. The dead load consists of the self-weight of structural members, which was automatically calculated by STAAD.Pro based on the assigned material properties and sections.The roof live load was applied as a uniformly distributed load on the purlin members. A live load intensity of 7 kN/m was considered for the analysis.

Wind loading was calculated according to IS 875 Part 3 provisions. The basic wind speed considered for the study was 44 m/s corresponding to Wind Zone IV. The design wind pressure was evaluated using the design wind speed obtained from terrain and height modification factors. The wind load was applied in both positive and negative directions to evaluate the critical structural response.

E. Methodology for Design

The structural design was executed in accordance with the requirements of the limit state design as outlined in IS 800:2007. The study took the following load combinations into account:

1.5 (DL + LL + WL)

A STAAD module for steel design.Using tensile strength, compression strength, bending capacity, and combined loading effects, Pro was utilized to assess the sufficiency of the members. The following parameters were used to compare the performance of Pratt and Lattice trusses:

- Thrust moment at its maximum
- Optimal shear stress
- Maximum angle of attack
- Weight of all steel derived from steel take-off calculations

To find the best roof truss layout for the given industrial structure, we compared the findings from both models.

IV. FINDINGS AND ANALYSIS

Industrial building models with Pratt and Lattice trusses were analyzed structurally using STAAD.Under the same loading and boundary circumstances, Pro acts as expected. Results from the comparison were derived from the examination of the governing load combination 1.5 (DL + LL + WL). When comparing response parameters, factors such as bending moment, shear force, deflection behavior, and total steel consumption are taken into account. The impact of truss arrangement on structural behavior is shown by the analytical results from both models. Differences in web arrangement cause changes in stiffness, load distribution, and steel demand, even when both structures have equal geometry and material qualities.

A. Confirmation of Analysis

The structural responses were first evaluated using the STAAD.The correctness and dependability of the models were ensured by verifying the outcomes of the pro analysis. We checked for equilibrium by comparing the overall loads applied to the system with the responses of the supports. The analytical models were validated for their accuracy and stability since the discrepancy between the applied loads and responses was determined to be insignificant. The self-weight determined using the STAAD code.After the design was executed, the steel take-off performances were also compared to Pro. Consistency between the reported steel numbers and the computed structural weights validates the modeling and analysis procedure's credibility. The sum of the structural weights returned by STAAD.The benefit was:

The Pratt truss construction has a moment of 363.134 kg. Structure with a lattice truss = 266.296 kN. Both truss layouts' material efficiency was assessed using these numbers.

B. Comparison of Steel Quantity

A look at the STAAD steel take-off results.For every building structural segment, Pro gives the overall length and weight. You can see the difference in the amount of steel used by Pratt and Lattice truss buildings in Table 1. Comparison of Pratt and Lattice Trusses for Steel Take-Off (Table 1)

Profile	Pratt Truss Weight (kN)	Lattice Truss Weight (kN)
ISMB 450 Columns	119.119	119.119
ISA 20×20×3 Truss Members	13.788	9.042
ISMC 225 Purlins	230.227	138.136
Total Steel Weight	**363.134**	**266.297**

According to the findings, the Lattice truss uses a lot less steel than the Pratt truss. Compared to the Pratt arrangement, the Lattice configuration uses around 27% less steel overall. A decrease in the need for structural elements in the longitudinal frame system and an improvement in the distribution of forces among more web members are the primary causes of the steel weight reduction. Stiffness and serviceability are also important factors to think about, thus a lighter construction doesn't always mean superior structural performance.

C. Evaluate the Effects of Bending Moments Contrasted

This is the STAAD-derived distribution of bending moments.The structural reaction varies between the two truss arrangements, as shown by the pro analysis. The combined influence of vertical loads and lateral wind forces causes the greatest bending moments to occur mostly at the base of the columns and the areas where the columns and trusses join. Bending moment values are greater in the Pratt truss model than in the Lattice truss model. About half of the maximum bending moment was determined to be different between the two setups. The varied distribution of stiffness and force transmission mechanism of the Pratt truss are responsible for its increased bending moment response. Certain structural components experience a larger concentration of forces in a Pratt truss because the load is primarily transmitted via a certain arrangement of diagonal and vertical members. The extra diagonal members in a lattice truss allow more members a chance to bear the load and spread it out. Peak bending moment values are lower as a consequence when contrasted with the Pratt arrangement.

D. Evaluation of Contrast in Shear Force Reactions

With the governing load combination in mind, we compared the two structural models' shear force distributions. It was determined that the two designs might vary in shear force by up to 74.94%. The diagonal and vertical members of a Pratt truss mainly act as resistive elements to the shear force. Individual members experience greater forces as a result of fewer web members contributing to load transmission. The Lattice truss, on the other hand, is made up of extra diagonal elements that are crisscrossed. The maximum force that any one component could encounter is reduced since the applied shear forces are divided across many parts in this configuration. According to the data, the Lattice arrangement offers superior force distribution characteristics since it has more load routes.

E. Behavior in Deflection

For industrial buildings with extensive spans, deflection is a crucial serviceability metric. The most displacement that STAAD could find.We compared the two truss layouts using Pro analysis. The findings reveal that the deformation properties of Pratt and Lattice trusses are substantially different. About 96.81% of the maximum deflection was determined to be different between the two systems. The Pratt truss's increased structural rigidity and effective load transfer mechanism result in less deformation. Rigidity is enhanced by creating a direct load route between the laden chord and supports via the inclined diagonal arrangement. The total rigidity of the structure is not proportionately improved despite the fact that the Lattice truss utilizes less steel due to the greater number of web members. Deflection is increased because certain members primarily contribute to force distribution instead of enhancing global stiffness. The Pratt truss offers superior performance in terms of deformation control, which becomes a key design factor for the 20 m span industrial building.

F. A Comprehensive Analysis

Table 2 summarizes the findings of comparing Pratt and Lattice trusses. Table2: Pratt and Lattice Trusses Compared in Terms of Performance

Parameter	Pratt Truss	Lattice Truss
Total Steel Weight	363.134 kN	266.296 kN
Weight Reduction	—	27% lower
Bending Moment Difference	Higher	Lower
Shear Force Difference	Higher	Lower
Deflection Behaviour	Lower deformation	Higher deformation
Structural Stiffness	Higher	Lower
Fabrication Complexity	Lower	Higher

While the Pratt truss offers greater stiffness and serviceability performance, the Lattice truss offers better material economy, according to the data. Design objectives, such as reduced steel consumption or enhanced structural behavior, should be considered while choosing an appropriate truss layout. Although it requires more steel, the Pratt truss offers a better balanced structural solution for the industrial structure that is being studied here, where span length and serviceability requirements are crucial.

V. CONCLUSION

In this STAAD.Pro-based analysis, we compared the Pratt and Lattice roof truss systems for a steel structure with one story of industrial use. With the same geometric features, material qualities, loading circumstances, and design goals, both structural models were created to assess how truss arrangement affects structural performance. Dead load, live load, and wind load were taken into account in accordance with IS 875 standards, while the analysis and design were carried out in accordance with IS 800:2007 Limit State Design rules. Steel consumption, bending moment, shear force, and deflection response were the metrics used for the comparison, which were derived via STAAD.Pro analysis. The research drew the following main conclusions:

When comparing the Lattice truss layout to the Pratt truss, the former offers superior material economy. There was a roughly 27% decrease in steel consumption due to the fact that the Lattice structure's total steel weight was determined to be 266.296 kN, whereas the Pratt truss needed 363.134 kN. The inclusion of more web members in a lattice truss helps distribute loads more evenly and reduces the force demand on individual members, which is the major reason why the steel amount is reduced. On the other hand, fabrication becomes more complicated as the number of members increases. In terms of structural rigidity, the Pratt truss outperformed the Lattice truss. The Pratt truss offers superior control over structural deformation, as seen by the maximum deflection difference of around 96.81% between the two structures. The two setups differed by around 50.5% in the maximum bending moment response. Because the forces were distributed across more web members, the peak bending moment values of the Lattice truss were lower.

The shear force comparison showed that the Pratt trusses and the Lattice trusses were around 74.94% different. By distributing shear stresses throughout its many diagonal members, the Lattice truss efficiently decreases the concentration of force on any one member. The design criteria of IS 800:2007 were met by both structural configurations under the controlling load combination 1.5 (DL + LL + WL). Under the specified loads, the selected structural sections proved to be sufficient. The Lattice truss significantly reduces steel weight, but the Pratt truss's stronger rigidity and lower deformation properties make it ideal for serviceability. Where structural dependability and deflection control are key design criteria, the Pratt truss is suggested for the 20 m span industrial structure that was studied in this research. Research shows that cutting down on steel consumption isn't the only criterion to consider when choosing a roof truss system. When looking for a reliable industrial structural system, it's important to take all of the following factors into account: strength, stiffness, fabrication needs, maintenance considerations, and serviceability performance. To further improve our understanding of optimizing industrial steel buildings, future studies could compare additional truss configurations like Warren, Howe, Fink, and Fan trusses; consider the effects of crane loading; investigate parametric variation of span and bay spacing; and design detailed connections.

REFERENCES

[1] IS 800 : 2007, General Construction in Steel - Code of Practice (Third Revision), Bureau of Indian Standards, New Delhi.

[2] IS 875 (Part 1) : 1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Dead Loads, Bureau of Indian Standards, New Delhi.

[3] IS 875 (Part 2) : 1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Imposed Loads, Bureau of Indian Standards, New Delhi.

[4] IS 875 (Part 3) : 1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Wind Loads, Bureau of Indian Standards, New Delhi.

[5] IS 2062 : 2011, Hot Rolled Medium and High Tensile Structural Steel - Specification (Seventh Revision), Bureau of Indian Standards, New Delhi.

[6] SP 6 (1) : 1964, ISI Handbook for Structural Engineers - Part 1: Structural Steel Sections, Bureau of Indian Standards, New Delhi.

[7] SP 38 : 1987, Handbook of Typified Designs for Structures with Steel Roof Trusses (As Per IS Codes), Bureau of Indian Standards, New Delhi.

[8] Bentley Systems, STAAD.Pro V8i - Technical Reference Manual, Bentley Systems Incorporated.

[9] Dr. S. K. Dubey, Prakash Sangamnerkar and Prabhat Soni (2012), "Behaviour of Steel Roof Truss under Normal Permeability Condition," International Journal of Civil Engineering and Technology.

[10] D. Thakar, Jatin (2013), "Analysis and Design of Industrial Structure using STAAD.Pro," National Conference on Advances in Civil Engineering.

[11] K. Ghogare, Kavitha (2016), "Design and Analysis of Industrial Shed with Different Configurations Using STAAD.Pro," International Journal of Engineering Research and Technology.

[12] M. Sunitha, Gillela (2016), "Design and Analysis of Industrial Building with Gabled Roof Using STAAD.Pro," International Journal of Civil Engineering.

[13] Vrushali Bahadure and Prof. R. V. R. K. Prasad (2013), "Comparative Study of Analysis and Design of Industrial Steel Structures," International Journal of Modern Engineering Research.

[14] Mr. Aditya P. Mehendale and Prof. Dr. A. K. Gupta (2016), "Comparative Study of Roof Trusses for Industrial Structures Using STAAD.Pro," International Journal of Innovative Research in Science.

[15] Darshan Kalantri, Sujay Deshpande and Pavan Gudi (2017), "Comparative Study of Pre-Engineered Buildings and Conventional Steel Buildings," International Journal of Engineering Science and Technology.

[16] Prabin Kumar and Sunny Prakash (2018), "Planning, Analysis and Design of Industrial Building (Hangar) using STAAD.Pro," International Journal of Civil Engineering.

[17] Kavya (2019), "Analysis and Industrial Design of Multi-Storey Building using STAAD.Pro and E-TABS," International Journal of Engineering and Technology.

[18] Subramanian, N., Design of Steel Structures, Oxford University Press, New Delhi.

[19] Arya, A. S. and Ajmani, J. L., Design of Steel Structures (IS 800:2007), Nem Chand and Bros, Roorkee.

[20] Ramachandra, Design of Steel Structures (Vol. I and II), Scientific Publishers, Jodhpur.