International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

UTILIZING STAAD, WE ANALYZED THE STRUCTURE AND EVALUATED THE DESIGN OF A STEEL ROOF TRUSS.VERSION PRO WITH CONNECT

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Abstract - The large-span constructions, warehouses, and industrial buildings that make use of steel roof trusses do so because of its effective load transfer mechanism and high strength-to-weight ratio. Safe and cost-effective designs can only be achieved with precise prediction of structural behavior, including member forces, support responses, and overall structural integrity. The purpose of this research was to use STAAD to model, analyze, and evaluate the performance of a steel roof truss with just one support.Professional Connect Edition. The result is a two-dimensional Pratt truss that uses 45 members and 24 nodes to achieve a span of 15.3 meters and a rise of 1.53 meters. The structure is examined under dead load, live load, and wind uplift scenarios in accordance with the Indian Standard, and all members are first given ISA 20×20×3 equal angle sections. In order to simulate real-world boundary conditions, the numerical model includes a pinned support and a roller support. Load combinations are developed in accordance with the design standards of IS 800:2007, whereas dead load, live load, and wind load scenarios are established according to the guidelines of IS 875. In order to get the nodal displacements, support responses, and member axial forces, linear elastic static analysis is run. Under dead load, the chosen ISA 20×20×3 section deforms excessively, with a maximum vertical displacement of 168.7 mm at the midspan, beyond the acceptable serviceability limit of span/300, according to the findings. Dead load causes the bottom chord's maximum compression force to reach about 60.37 kN, while the combined effects of gravity and other loads bring that force up to roughly 248 kN. Furthermore, the impact of wind uplift is assessed in the research, which leads to a total reversal of the behavior of the member forces when subjected to wind loads alone. According to the results, the original section selection was not feasible and has to be redesigned. For various member groups, we suggest appropriate replacement portions to enhance strength and serviceability performance. Proof that STAAD is effective is provided by the work.For the purpose of computationally analyzing steel truss structures and evaluating structural behavior, we recommend Pro CONNECT Edition.

Important Terms - Analysis of steel roof trusses using STAAD.Pro CONNECT Edition, Pratt trusses with ISA angle sections, axial force, deflection, wind uplift, and load combinations; standards 800:2007 and 875.

I. INTRODUCTION

When it comes to covering big spans in buildings like warehouses, industrial complexes, train stations, and institutional buildings, steel roof trusses are among the most efficient structural solutions. One major benefit of truss systems is that, instead of bending, external loads may be transferred via axial forces in individual members. Affordable options for long-span roof construction, trusses provide exceptional structural efficiency with little material consumption because to their triangulated arrangement. The ends of straight structural elements are joined in a traditional truss at regular intervals, with the joints often considered to act as pin connections. In a perfect world, the members would only experience axial compression and tension pressures; bending moments would be completely absent. Since steel has a high tensile strength and an appropriate compression capacity when constructed correctly to prevent buckling, this behavior enables the efficient utilization of steel members. Since the industrial revolution, when structural steel technology was developed, steel roof trusses have been extensively employed. Industrial sheds, railway workshops, storage facilities, and public infrastructure projects in India often used steel trusses because of its long-lasting nature, simplicity in manufacture, and capacity to support moderate to large spans. Considerations like as span, loading, architectural style, and available space dictate the truss design that is used. Common options include Pratt, Howe, Fink, North-Light, and Warren trusses.

Due to its advantageous force distribution under gravity loads, the Pratt truss is one of the most often utilized truss types for steel roof applications. The loading pattern determines whether the

Received: 20-06-2026 | Accepted: 25-07-2026 | Published: 31-07-2026

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diagonal parts resist tension or compression in this configuration. This research looks at the structural response of a 15.3-meter-long modified Pratt-type steel roof truss under various loads. It is essential to take into account the geometry, material qualities, support conditions, and loading combinations while conducting an accurate structural analysis of steel trusses. While the method of joints and method of sections may be used to derive member forces in basic trusses, computer-based analysis techniques are necessary for effective assessment of complicated structural models. Fast and precise answers are provided by structural analysis software by taking into account many members, realistic boundary conditions, and various combinations of loads. Both professionals and students in the field of civil engineering rely on Pro CONNECT Edition, a popular platform for structural analysis and design software. Engineers may use it to build models of structures, give those models material qualities, apply different loading conditions, run linear and nonlinear analyses, and see how their structures react visually and numerically. The program gives you all the data you need about structural equilibrium checks, node displacements, support responses, and member forces.

This research makes use of STAAD to create a two-dimensional model of a steel roof truss.The Pro CONNECT Edition employs a network of twenty-four nodes and forty-five participants. The ISA 20×20×3 equal angle sections are used for the truss members from the outset, and the structure is examined in accordance with the loading regulations of the Indian Standard under dead load, live load, and wind uplift scenarios. The governing structural reaction is determined by generating load combinations in accordance with IS 800:2007. The primary goal of this study is to use numerical modeling to examine the behavior of a steel roof truss and to assess the suitability of the chosen steel sections in relation to the deflection and member force requirements. The research also suggests ways to improve the structure's performance by modifying appropriate sections and looks at how wind uplift affects member force reversal.

This research aims to accomplish the following:

- To create a STAAD model of a steel roof truss.Professional Connect Edition.
- To specify the geometry, material qualities, and support conditions that are necessary for a simply supported truss system.
- To examine the building in three different loads: dead, living, and wind uplift.
- Aiming to assess axial forces, nodal displacements, and support responses in structural components.
- To detect essential parts under controlling load combinations.
- The objective is to determine whether ISA 20×20×3 sections are suitable and to suggest sections that are better for safe structural performance.

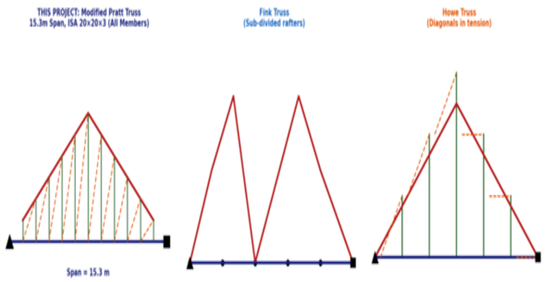

Figure 1 – Three Common Styles of Steel Roof Trusses: Howe, Modified Pratt, and Fink

This research focuses only on the linear elastic analysis of a steel roof truss in two dimensions. Global structural behavior, distribution of member forces, and serviceability performance are the main areas of inquiry. The scope of this study does not include detailed connection design, foundation design, or three-dimensional stability analysis.

II. SURVEY OF LITERATURE

Because of its significance in long-span structural applications, steel roof trusses have been the subject of much research into their analysis and design. Principles of balance, such as the technique of joints and the method of sections, were the basis of early advancements in truss analysis. Ritter (1862) created the technique of sections to determine internal member forces by applying equilibrium equations to chosen areas of a truss, whereas Whipple (1847) established systematic methods to truss structural analysis by resolving forces at specific joints. Validating the findings of numerical analyses still relies on these traditional approaches, which laid the groundwork for comprehending the behavior of axial forces in triangulated structural systems. Accurate assessment of serviceability, stability, and strength needs was brought about by the establishment of structural steel design techniques. When designing steel buildings, it is important to take into account the constraints of tension, compression, buckling resistance, and deflection, as outlined in Indian Standard codes like IS 800:2007. The computation of various design loads, including as dead loads,

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imposed loads, and wind loads, is outlined in the IS 875 series. In Indian building practice, these guidelines are used to ensure that steel roof trusses are designed in a safe and affordable manner. Evaluation of steel structures is now much more efficient and accurate because to the use of computer-aided structural analysis tools. The stand.The capacity of Pro to manage complicated geometries, various loading circumstances, and thorough structural response calculations has led to its widespread use as a tool for modeling and analyzing steel trusses. The numerical analytical findings produced by STAAD have been proven in previous investigations.When proper modeling assumptions and boundary conditions are taken into account, Pro strongly correlates with standard analytical approaches.

Research by Narayanan and Kalyanaraman on the bending behavior of steel roof trusses brought attention to the fact that long-span truss systems are often designed with serviceability in mind. True moment of inertia, member stiffness, and truss depth are the three main factors that affect deflection performance, according to their study. Even when the applied loads are within permitted strength limits, smaller angle sections may not be stiff enough for medium and long-span roof constructions, according to their findings. Researchers Kulkarni and Bhatt looked into STAAD's validity.An examination of steel roof trusses based on the software's performance in comparison to traditional virtual work techniques. In their study, they found that numerical and theoretical deflection values agreed closely, which proved that STAAD is reliable.Perfect for uses involving structural analysis. The research also highlighted the need of precisely describing support conditions, especially roller supports, in order to prevent structural models from using unrealistic restraint forces. The impact of panel arrangement and geometric proportions on the behavior of Pratt-type steel trusses was examined by Tiwari, Gupta, and Mishra. They used STAAD to their parametric study.The effects of structural efficiency, member forces, and total steel consumption of changing the panel aspect ratio were shown by Pro. According to their findings, using the right truss proportions may cut down on material needs without sacrificing strength or serviceability.

Based on the requirements of IS 875 Part 3, Singh and Sharma studied how steel roof trusses behaved when exposed to wind uplift. Their research proved that wind suction on slanted roofs may change the internal force distribution and even reverse the forces acting on the members. Their main point was that members that are normally tested under gravity loads should also be tested under uplift circumstances. This is because, during severe wind events, compression and tension behavior might switch places. A number of scholars have also investigated how the assumptions used in structural modeling affect the performance of trusses. Since erroneous boundary conditions might cause the introduction of fake stresses and impact the dependability of analysis findings, it is crucial to accurately depict pinned and roller supports. The stand.Engineers may accurately portray idealistic truss behavior and partly restrained supports with the use of Pro's commands like MEMBER TRUSS and ENFORCED BUT supports. Steel truss analysis has been the subject of many research, however most of these publications only detail the modeling processes and software results without checking if the assumed sections are sufficient for the design. Also, software statics tests for precise equilibrium verification and the impact of wind-induced force reversal are hardly addressed in detail. Consequently, these considerations are addressed in the current work via the analysis of a STAAD model of a steel roof truss.Using the PRO CONNECT Edition, we can assess the impacts of load reversal, member force distribution, displacement behavior, and propose modifications to sections that meet the standards set by IS 800:2007.

III. STUDY DESIGN

A. Depiction of Structural Models

This research employs STAAD to analyze and evaluate the performance of a steel roof truss with simple supports.Professional Connect Edition. Because of its widespread use in industrial sheds and medium-span roofing structures, a modified Pratt-type steel roof truss system is chosen for numerical research. As a result of the loading circumstances, the members of the two-dimensional plane truss system mostly resist axial forces in the structural model. A center rise of 1.53 meters and a total span of 15.3 meters make up the truss model. With the help of 24 nodes and 45 members, the whole structural configuration is created. Each of the twelve equal panels that make up the bottom chord is 1.275 meters long. The slanted roof profile is created by symmetrically arranging the upper chord members around the center ridge point. For optimal stability and load transmission, web members are supplied at right angles to the top and bottom chords.

Stad.Pro CONNECT Edition (Version 22.00.00.15) is used to generate the structural model. The method of linear elastic static analysis is used to conduct the analysis. Load combinations, support

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ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

conditions, steel characteristics, member connectivity, and joint coordinates are all defined throughout the modeling phase. Displacements at nodes, responses at supports, and axial forces generated by individual members make up the metrics used to assess the structural response. We chose this truss arrangement to test how steel roof trusses react to various loads and to see how well the originally allocated ISA 20×20×3 angle sections hold up. Finding crucial members and suggesting appropriate alterations to enhance structural performance are further uses of the research findings.

Detail Table 1 for the Structural Model

Parameter	Description
Structural System	Steel Roof Truss
Configuration	Modified Pratt Truss
Analysis Software	STAAD.Pro CONNECT Edition
Span	15.3 m
Rise	1.53 m
Number of Panels	12
Panel Length	1.275 m
Number of Nodes	24
Number of Members	45
Analysis Type	Linear Elastic Static Analysis
Structural Plane	Two-dimensional X-Y Plane

B. Pattern of Geometry for Steel Roof Truss

A symmetrical pitched roof arrangement provides the basis for developing the geometry of the roof truss. The lower chord runs between the two supports, while the upper chord progressively climbs to the node in the middle of the ridge. With the truss's rise-to-span ratio maintained at 1:10, the roof slope is around 11.3°. By placing intermediate nodes throughout the span, twelve equal panels are formed by the bottom chord. The top chord nodes are positioned in accordance with the pitch of the roof, with the center ridge having the highest elevation. A successful triangulated structural system is formed by the arrangement of vertical and diagonal web elements to transmit axial loads.

The statically determinateness of the truss is guaranteed by the structural geometry. To ensure static determinacy in a planar truss, the following must be satisfied:

$$m = 2j - 3$$

where,

m = number of members

j = number of joints

For the present model:

$$m = 45$$

$$2j - 3 = 2(24) - 3 = 45$$

Therefore, the truss may be studied according to principles based on equilibrium since it meets the determinacy criteria.
Tabular 2: Truss Geometrical Parameters

Parameter	Value
Total Span	15.3 m
Truss Rise	1.53 m
Roof Pitch	11.3°
Number of Panels	12
Panel Spacing	1.275 m
Total Nodes	24
Total Members	45
Structural Configuration	Modified Pratt Truss

C. Characteristics of Materials and Choice of Sections

The steel roof truss is designed using structural components that are modeled using equal angle sections that adhere to Indian Standard. All 45 participants are given ISA 20×20×3 equal angle portions in the first study, in accordance with IS 808: 1989. A lightweight truss system's structural reaction and adequacy under the applied loading conditions are investigated in this section. In the STAAD.Pro model, structural steel is the material property for every member. Standard steel characteristics utilized in structural design practice in India are used to assign material qualities.

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Numerical analysis of elastic behavior requires the specification of density, Poisson's ratio, and modulus of elasticity. Table 3 displays the main material and section attributes that were taken into account throughout the research.

Material Characteristics and Cross-Section Information (Table 3)

Property	Value
Section Type	ISA Equal Angle
Section Size	ISA 20×20×3
Cross-sectional Area	1.11 cm²
Modulus of Elasticity (E)	2.05 × 10⁸ kN/m²
Density of Steel	76.82 kN/m³
Poisson's Ratio	0.30
Yield Strength (Fy)	250 MPa
Ultimate Strength (Fu)	410 MPa
Section Standard	IS 808:1989
Material Standard	IS 2062:2011

In comparison to the specifications needed for a medium-span roof truss, the chosen ISA 20×20×3 section has a cross-sectional area and radius of gyration that are much less. As a result, the structural behavior as a whole is mainly assessed for the impact of inadequate member stiffness. To ascertain whether the chosen section fulfills the strength and serviceability criteria, the deflection and member force values are computed.

D. Methodology for STAAD.Pro Modeling

Using STAAD, the structural modeling method was executed.By following a methodical process, you may create geometry, assign properties, define supports, load applications, and execute analyses in Pro CONNECT Edition. Beginning with the two end support nodes defined and the intermediate nodes inserted at equal spacing, the bottom chord was first built. Along the 15.3 m span, eleven intermediary nodes were constructed to form twelve equal panels. The needed roof slope dictated the introduction and connection of the top chord nodes, which formed the inclined roof profile. When the node creation was finished, the web members were made by linking the nodes for the top chord and the bottom chord. Representing the whole modified Pratt truss structure, the final model has 24 joints and 45 members.

This is the STAAD model.Included in Pro are:

1. Joint coordinates are generated based on the chosen truss shape.
2. Constructing member incidences between related nodes.
3. The characteristics of the ISA 20×20×3 steel angle are assigned.
4. Structured steel material properties defined.
5. Application of support conditions at both ends.
6. The terminology for the three types of loads: dead, living, and wind.
7. Code generation in accordance with IS 800:2007.
8. Linear static analysis is carried out.
9. Reactions, displacements, and member forces are extracted from the analysis findings.

To assess the performance of both individual members and the whole truss system, the STAAD.Pro environment gives comprehensive numerical results and graphical representations of the structural model.

E. Limitations and Back-Up Modeling

Obtaining trustworthy findings from structural analyses relies on precisely defining support conditions. A steel roof truss with a single pinned support and a single roller support arrangement is modeled as a simply supported system in this research. This arrangement of supports resists loads in the vertical direction while letting them move horizontally as a result of structural deformation and thermal expansion. A pinned support is designated at the left end of the truss, which is at Node 1. Aside from facilitating rotational movement, the pinned support restricts X, Y, and Z translations. This state stabilizes the structure horizontally and vertically and stops the body from translating rigidly. Node 3, the right-hand end of the truss, is represented as a roller support in the STAAD model.However, the directive is pro-enforced. While enabling horizontal movement in the span direction, the roller support restricts vertical displacement. Representing the behavior of an ideal simply supported truss, this eliminates the creation of extra horizontal reactions. Conditions used for STAAD assistance.Table 4 displays the pro models.

See Table 4 for the STAAD Support Conditions.Expert Model

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Node	Support Type	Restrained Degrees of Freedom	Free Degrees of Freedom
Node 1	Pinned Support	Fx, Fy, Fz	Mx, My, Mz
Node 3	Roller Support (ENFORCED BUT)	Fy	Fx, Fz, Mx, My, Mz

By preventing undesirable motions while allowing specified degrees of freedom to stay free, the ENFORCED BUT command accurately represents roller behavior. By simulating a statically determinate truss system, this method of modeling eliminates the need to include fake horizontal forces. Verification of structural balance by STAAD is also made possible by the support arrangement.Data from a professional statistics check. The model is verified to meet equilibrium conditions by comparing the responses derived from the analysis with the applied loads.

F. Problems with Loading

The three main loading conditions that are used to analyze the steel roof truss are dead load (DL), live load (LL), and wind load (WL). The loading requirements stated in IS 875 are followed while applying the loads. Under both typical and high loads, these loading scenarios illustrate the primary external factors that affect roof truss constructions. The dead load, or LC1, is the sum of the roof's own weight plus any other permanent structural loads. The upper chord nodes receive it as concentrated loads that go downward. The intermediate top chord nodes are subjected to a load of −2.2 kN, while the end nodes are subjected to half-load values of −1.1kN. There is a total dead load of 26.4 kN acting on the structure. Roof loading conditions mandated by IS 875 Part 2 are shown by the Live Load (LC2). The live load is applied as focused downward pressures at the upper chord nodes, much as the dead load. A force of −3.837 kN is exerted at the primary loading locations, whereas the terminal nodes experience a force of −1.918 kN. There is a total live load of 46.043 kN operating on the structure. The Wind Load (LC3) is a measure of the uplift and wind suction forces acting on an angled roof surface in accordance with IS 875 Part 3. The wind load is transmitted to the upper chord rafter elements as focused upward forces. The uplift pressures on the main rafter members are +7.277 kN, whereas the uplift forces on the end members are +3.638 kN. In all, 85.626 kN of wind uplift force is taken into account in the study.

Table 5 : Real-World Load Examples

Load Case	Description	Load Direction	Total Applied Load
LC1	Dead Load	Downward (-Y)	26.4 kN
LC2	Live Load	Downward (-Y)	46.043 kN
LC3	Wind Load	Upward (+Y)	85.626 kN

Because wind uplift loading has the potential to reverse the pressures acting on interior members, its application is of paramount importance. Hence, essential structural conditions are identified by evaluating the impact of wind loading both independently and in conjunction with gravity loads.

G. Multiple Load Setups

In order to determine the most important design condition, the structural behavior of the steel roof truss is examined under various load combinations. For the purpose of designing steel structures, the load combinations are created in accordance with the requirements of IS 800:2007. These permutations take into account the cumulative impact of wind impacts, applied loads, and permanent loads. This research takes into account two main load combinations. The first set of parameters stands for the most severe gravity loading scenario, while the second set of parameters assesses the impact of both gravity and wind uplift. The ways in which STAAD loads resources.Table 6 displays the results of the pro analysis.

Table 6. Analyzed Load Combinations

Load Combination	STAAD.Pro Expression	Purpose
LC4	1.5(DL + LL)	Maximum gravity loading condition
LC5	1.2(DL + LL + WL)	Combined gravity and wind loading condition

Due to the combined downward action of the dead load and live load, Load Combination LC4 is anticipated to generate the highest axial forces in truss members. In order to determine which members influence compressionand tension, this combination is used. When wind uplift and gravity loads are applied concurrently, the structural reaction is assessed using Load Combination LC5. Internal member pressures may be reduced or reversed by wind uplift because it operates in opposition to both dead and live loads. This combination is therefore crucial for assessing the impacts of force reversal on roof truss components' stability.

Received: 20-06-2026 | Accepted: 25-07-2026 | Published: 31-07-2026

International Journal of
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ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

H. Data Extraction and Analysis Process

With the structural modeling, material property assignment, support definition, and loading condition applications finished in STAAD.Pro CONNECT Edition, a linear elastic static analysis was run. An important part of the analytical process was using the stiffness approach to resolve the structural equilibrium equations. The stand.When loading circumstances and member stiffness characteristics are taken into account, Pro is able to compute nodal displacements, member forces, and support responses.

The STAAD was used to retrieve the following results.Expert evaluation:

- The values of the node displacements in the X, Y, and Z axes.
- The assessment of nodal serviceability is based on the resulting displacements.
- Responses to vertical and horizontal supports.
- Member axial forces under distinct load conditions.
- Member force fluctuations under load combinations.
- Structural equilibrium proof by statics check.

A comparison between the greatest vertical deflection and the acceptable limit stated in IS 800:2007 was done to assess the truss's serviceability performance using the displacement data. The span-to-deflection ratio criterion was used to determine the maximum permitted deflection. We identified crucial tension and compression members by analyzing the member force findings. Various loading circumstances were used to establish the maximum compression and tension in the bottom and top chord parts, respectively. By contrasting the orientations of member forces under gravity loading and wind loading, we were able to learn more about the impact of wind uplift. This is the STAAD.In order to ensure that the analytical model was accurate, we used the Pro statics check tool. To verify that the structural system was in equilibrium, the applied loads and estimated responses were compared to make sure that the difference between the two was close to zero. Steel roof trusses may have their structural performance and the appropriateness of individual steel sections tested under a variety of loads using the comprehensive analysis technique.

IV. FINDINGS AND ANALYSIS

The findings from the structural analysis acquired using STAAD.Presented and covered here are the Pro CONNECT Edition. As part of the assessment, the nodal displacement behavior, responses of the support, axial pressures on the member, impacts of load combinations, and the suitability of the originally chosen ISA 20×20×3 sections are taken into consideration. The data is examined in order to comprehend the whole structural reaction of the steel roof truss to various loads.

A. An Analysis of Nodal Displacement

The findings of the STAAD nodal displacement analysis.The deformation behavior of the steel roof truss under applied loads may be better understood with the help of pro analysis. In order to assess the structure's serviceability and ensure compliance with the deflection limitations specified in IS 800:2007, a displacement analysis is crucial. Under Dead Load (LC1) conditions, the largest displacement happens. According to the results, the midspan node is the location of the bottom chord's largest downward displacement, which causes substantial vertical deformation. There is a maximum vertical displacement of around 168.7 mm at Node 9, which is in the middle of the bottom chord.

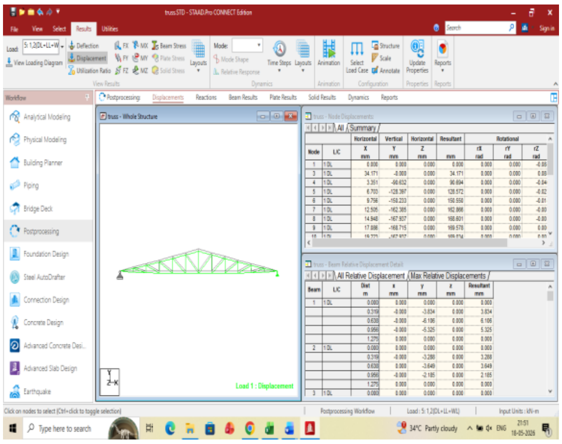

Figure 2 – Image 08: Summary of Node Displacement (DL, LC1) and Beam Relative Displacement

A symmetrical deformation pattern around the truss center is shown by the estimated displacement distribution. As it rises from the supports towards the midspan, the vertical displacement proportionately reduces, and then rises again as it approaches the opposing support. Such behavior is in line with what one would anticipate from a simply supported truss that is loaded symmetrically. There is no vertical displacement at Node 3, however there is a horizontal displacement of around 34.17 mm at the roller support. The

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results show that the ENFORCED BUT support state effectively resists vertical loads while allowing horizontal mobility. The maximum deflection that the study yields is then compared to the allowable serviceability limit that is laid forth in IS 800:2007. The truss with a 15.3-meter span is:

$$\text{Allowable Deflection} = \frac{L}{300}$$

$$= \frac{15300}{300} = 51 \text{ mm}$$

A maximum deflection of 168.7 mm was measured, which is almost 3.31 times more than the allowable limit. Maximum Nodal Displacement under Dead Load (Table 7)

Location	Node	Vertical Displacement
Left Support	Node 1	0 mm
Right Support	Node 3	0 mm
Bottom Chord Midspan	Node 9	-168.7 mm
Apex Node	Node 15	-168.0 mm

The lack of adequate stiffness for the span and loading condition is shown by the severe deformation in the ISA 20×20×3 section. From a practicality standpoint, the chosen portion is insufficient, even if the structural model meets equilibrium criteria.

B. Back Up Reaction Testing

The responses that were retrieved from STAAD as evidence.The structural model's equilibrium condition is checked by evaluating the pros. The correctness of the analysis is confirmed by comparing the responses under various load situations with the total applied loads. The total downward load applied to the structure under Dead Load (LC1) is 26.4 kN. The research verifies the truss's symmetrical behavior by producing 13.2 kN vertical responses at both supports.

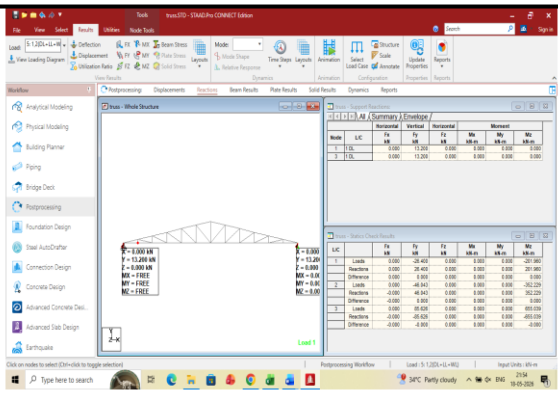

Figure 3 – Image 09: Results of the Support Reactions and Statics Check (Load 1: DL)

The STAAD Statics Check findings.According to the results, the structural model meets the equilibrium criteria since there is no discrepancy between the applied loads and the estimated responses. With a total applied load of 46.043 kN for Live Load (LC2), both supports respond with reactions of around 23.02 kN each. A force of 85.626 kN is exerted upwards for Wind Load (LC3). The responses show that the effects of wind suction are accurately portrayed by acting downward to keep the system in balance. Table 8: Results of Supporting Reactions

Load Case	Total Applied Load	Reaction at Left Support	Reaction at Right Support
Dead Load (LC1)	26.4 kN downward	13.2 kN upward	13.2 kN upward
Live Load (LC2)	46.043 kN downward	23.02 kN upward	23.02 kN upward
Wind Load (LC3)	85.626 kN upward	42.81 kN downward	42.81 kN downward

The proper implementation of the fastened and roller support arrangement is confirmed by the equal and opposing responses. The fact that the roller support does not exhibit any horizontal response provides more evidence that the ENFORCED BUT modeling technique is successful.

C. Analyzing Member Forces and the Effects of Load Combinations

Under various loading situations, the axial force distribution inside the steel roof truss members was determined using the member force analysis. The study largely focuses on the tension and compression behavior of individual members since, in an ideal truss system, axial forces are the primary loads carried. Dead Load (LC1) causes compression stresses on the lower chord members and tension forces on the upper chord members. When loaded downwards by gravity, this action is

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typical of Pratt-type trusses. Close to the outside panels is where the bottom chord is most compressed. The study yielded a maximum compressive force of about -60.37 kN in the lower chord elements close to the supports. Near the midspan panels, the compression force reaches a minimum of about −38.50 kN and then steadily declines as it moves towards the center. Under the stress of gravity, the elements of the upper chord undergo tensile forces. The outer rafter member experiences the most tensile force, at about +61.54 kN. Depending on their orientation and location inside the truss, the web members exhibit alternating tension and compression behavior. Important Member Forces at Dead Load (LC1), Table 9.

Member Location	Force Value	Nature of Force
Bottom Chord Outer Panels	-60.37 kN	Compression
Bottom Chord Central Panels	-38.50 kN	Compression
Outer Top Chord Member	+61.54 kN	Tension
Web Diagonal Members	-56.09 kN	Compression
Vertical Web Members	+61.54 kN	Tension

The results of the beam end forces as determined by STAAD.According to the pros, the bending moments in the truss members are almost nonexistent. The members mainly act as components that convey axial forces, as the highest bending moment values are negligible or near zero. Uplift loading due to wind was also considered. When subjected just to Wind Load (LC3), the internal member forces are reversed. When subjected to gravity stress, compressive members undergo tension forces, while tensional members undergo compression. The wind uplift causes this effect because its direction of action is counter to that of gravity. With dead load, the bottom chord compresses, but with wind uplift, it tensions, and under dead load,compression sets in on the top chord. Slender steel members need to be tested for both tension and compression capability, therefore this force reversal is significant in practical design. It was determined that LC4 = 1.5(DL + LL) was the ruling load combination. The combination of dead load and live load results in the greatest internal forces experienced by the truss members, since they both act downward. The maximum compression of the bottom chord under LC4 is about −248 kN, whereas the maximum tension of the top chord is at +253 kN. The data show that the ISA 20×20×3 sections that were chosen originally do not have enough strength to support the needed load.

The Critical Member Forces as a Function of Load Combinations (Table 10)

Member	LC1 (DL)	LC3 (WL)	LC4 = 1.5(DL+LL)	Governing Condition
Bottom Chord Member 1	-60.34 kN	+42.8 kN	-247.9 kN	Compression
Bottom Chord Member 6	-38.50 kN	+27.4 kN	-158.1 kN	Compression
Top Chord Member 13	+61.54 kN	-43.6 kN	+252.9 kN	Tension
Web Vertical Member	+61.54 kN	-43.6 kN	+252.9 kN	Tension

The results show that different loading combinations have a significant impact on the forces acting on the members. Wind loading brings crucial reversal effects that must be addressed during steel truss design, in contrast to gravity loading, which restricts the maximum design forces.

D. Assessment of Section Appropriateness and Redesign

The ISA 20×20×3 sections were used for all truss members in the first structural study. Due to high deflection and insufficient load bearing capability, the study findings show that this section size is unsuitable for the 15.3 m span truss that is being examined. In compression, the maximum bottom chord force under the LC4 governing combination is around 248 kN. The tension that formed in the chosen ISA 20×20×3 segment may be roughly calculated as:

$$\sigma = \frac{P}{A}$$

where the coefficient of compression, P, The area of a cross-section is denoted by A.

Under the governing load condition, the chosen section will fail due to the computed stress being far higher than the yield strength of structural steel. It is clear that bigger steel sections are needed due to the high member stresses and considerable deflection. Different member groups are advised to use greater ISA angle sections according to the analysis findings.

Table 11: Suggested Changes to the Section

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ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

Member Group	Maximum Force	Recommended Section
Bottom Chord	248 kN Compression	ISA 60×60×6
Top Chord	253 kN Tension	ISA 65×65×6
Vertical Web Members	Approx. 100 kN Tension	ISA 45×45×5
Diagonal Web Members	Compression	ISA 50×50×5

Strength and serviceability are two metrics that should be enhanced by the reworked parts. Before putting the design into action, however, it is important to verify it thoroughly, checking for things like buckling, connection design, and conformity with the IS 800:2007 code.

E. Outline of Generalized Structural Behavior

This is the STAAD.The findings of the pro study show how a steel roof truss with just one support would typically behave when loaded with wind and gravity. As an axial force system, the truss mainly compresses the bottom chord members and resists tension pressures on the top chord and vertical web members when subjected to dead and live loads. It is confirmed that the truss arrangement is successful in transmitting loads by direct tension and compression, since the observed beam force data demonstrate that bending moments in individual members are insignificant. According to the dead load study, the midspan section of the truss has the most vertical deflection. According to IS 800:2007, the maximum allowable deflection at the central bottom chord node is about 168.7 mm. The very low rigidity of the ISA 20×20×3 angle section used for all elements is responsible for the severe deformation. The section's small size and low radius of gyration make it unfit for actual building applications, but it's enough for showing how a truss system behaves. The selected boundary conditions are validated by the support response findings. It is evident that the load distribution and structural symmetry are properly addressed by the equal vertical responses achieved at both supports. It is confirmed that the ENFORCED BUT support condition allows for horizontal movement while preserving vertical stability since there is no horizontal response at the roller support. We used STAAD to get the findings of the statistics check.The structural model is accurate, as shown by the fact that there is no imbalance between the applied loads and support responses.

Steel roof truss design must take load reversal effects into account, as shown in the wind uplift study. Members that are normally under compression undergo tension and vice versa when subjected to wind loading alone, causing a dramatic shift in the internal force distribution. Slender steel angle sections must exhibit this behavior because members designed for compression might fail under reversal pressure. Maximum axial force develops in the chord members at the governing load combination LC4 = 1.5(DL + LL), as derived from the analysis. At its most, the bottom chord compresses to about 248 kN, while at its most, the upper chord tensions to about 253 kN. Based on these numbers, it can be fairly concluded that the ISA 20×20×3 section that was originally chosen cannot withstand the design forces. For this reason, higher cross-sectional area and stiffness, together with wider angle sections, are necessary to attain satisfactory strength and serviceability parameters. Taken together, the results show that STAAD.Pro is a great tool for dealing with steel roof truss modeling, analysis, and evaluation. The research shows that the whole structural reaction is affected by member stiffness, loading circumstances, and support behavior. Before implementing any structural system in real-world scenarios, it is crucial to carefully pick sections and use code-based verification, as shown in the findings.

V. CONCLUSION

Using STAAD.Pro CONNECT Edition, this research examined the structural behavior of a steel roof truss with a 15.3 m span. In accordance with the requirements of IS 875 and IS 800:2007, a full two-dimensional modified Pratt truss model was created and tested under various loads, including dead load, live load, wind uplift load, and relevant load combinations. The model included 24 nodes and 45 members. The results accurately reflected the behavior of a truss system that is simply supported, with a pinned end and a roller end. The condition in STAAD that is mandatory but not enforced.Because Pro only let you move horizontally and not vertically, it was able to accurately mimic the roller's action. After conducting a statics check, it was determined that there was no imbalance between the applied loads and structural responses, and the resultant support reactions met the equilibrium criteria. Confirming the perfect truss action, the findings demonstrated that the truss members mostly supported axial stresses with little bending moments. When subjected to gravity loading, the members of the bottom chord felt compression forces, whereas those of the top chord and vertical web felt tension forces. Under dead load, the lowest chord could be compressed to a maximum of about 60.37 kN, while the highest tension could be attained to a maximum of about 61.54 kN.

Based on the results of the serviceability study, the original model's ISA 20×20×3 section was not

International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

suitable for the span under consideration. Midspan vertical deflection of up to 168.7 mm was beyond the 300-span limit allowed by IS 800:2007. This means the chosen piece isn't rigid enough to be used as a roof truss. Significant force reversal behavior inside the truss members was shown by the wind uplift research. Compression members transformed into tension members and tension members into compression members when just the wind load was applied. This proves that, especially for thin angle sections, it is crucial to think about different loading scenarios when designing steel trusses. The maximum member forces of around 248 kN compression in the bottom chord and 253 kN tension in the top chord were produced by the load combination LC4 = 1.5(DL + LL), which was used to determine the governing design condition. In light of these findings, it was suggested that various member groups use bigger angle sections to enhance structural safety and serviceability, since the current ISA 20×20×3 section was deemed inadequate. Results show that STAAD.Pro CONNECT Edition is a powerful program for evaluating the performance of steel roof trusses and for modeling their structures. While lowering the restrictions associated with standard manual calculations, the program allows for precise prediction of member forces, deformation behavior, and support responses. To achieve safe and cost-effective steel roof truss designs, the results highlight the significance of accurate modeling, realistic loads, appropriate boundary conditions, and code-based section selection.

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Received: 20-06-2026 | Accepted: 25-07-2026 | Published: 31-07-2026

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