A THREE-DIMENSIONAL STEEL TRUSS ROOF STRUCTURE ANALYZED VIA STAAD FOR DEAD AND WIND LOADS.VERSION PRO WITH CONNECT

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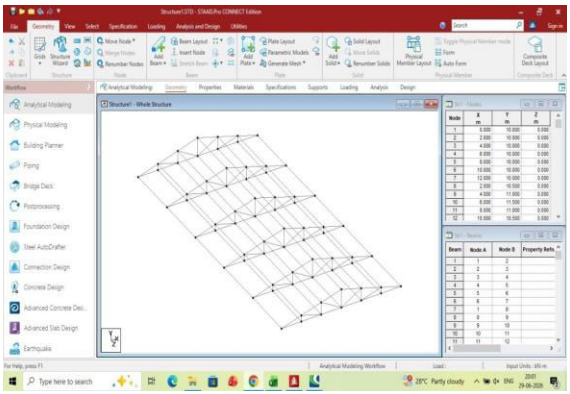
Abstract - Because of its high strength-to-weight ratio, fast construction capabilities, and capacity to create column-free areas, steel truss roof structures are widely utilized in industrial buildings, warehouses, workshops, and large-span facilities. Using STAAD.Pro CONNECT Edition (Version 22.00.00.15), this article shows the results of a structural study of a steel truss roof structure in three dimensions using finite-element methods. A total of 198 members and 84 joints make up the studied structure's six-frame space truss system. Supporting columns are ISMB 250 sections, whereas truss members, purlins, and lateral bracing are ISA 80×80×10 angle sections. A STAAD SPACE frame with pinned column-base supports was used to build the model. Two main load cases were considered in the linear elastic static analysis: a dead load derived from self-weight with a factor of 1.15 and a wind load defined according to the ASCE-7-2010 wind pressure approach with a basic wind speed of 85 mph. The STAAD was used to retrieve the analysis findings.Support responses, member displacement data, axial force diagrams, bending moment diagrams, shear force diagrams, and the pro post-processing module are there. We measured a maximum relative displacement of around 100.7 mm for the truss members and 55.3 mm for the columns at mid-height when subjected to wind force. The findings show that the structure's lateral reaction is controlled by wind loading, and that the pinned-base columns' flexibility causes them to exhibit substantial sway behavior. This research proves that STAAD works.Expert in simulating and assessing truss structures made of three-dimensional steel, this program lays the groundwork for future work in the design of steel members and code-based verification.

Important Terms - Structure made of steel trusses; STAAD.Space frame analysis, finite element technique, wind load, dead load, structural displacement, and the Pro CONNECT Edition are all parts of the steel roof system.

I. INTRODUCTION

The strength, longevity, fire resistance, and versatility of reinforced concrete (RC) framed structures make them a popular choice for a broad range of building types, including residential, commercial, and institutional buildings. Accurate structural analysis is now a crucial part of the design process to guarantee safety, serviceability, and economical material use due to the rising demand for multi-story structures and the fast expansion of metropolitan areas. The usual components of a reinforced concrete building's frame—beams, columns, and slabs—are designed to transmit the weight of the building's top stories to the structure below. A number of factors, including the interplay of individual parts, the distribution of stiffness, the material's characteristics, the support conditions, and the applied loads, determine the overall behavior of the structure. Conventional analytical approaches may work well for basic structures, but a more thorough three-dimensional analysis approach is needed for multi-storey framed buildings due to the interplay between various structural components. Conventional approaches to structural analysis that rely on hand-calculations make a number of simplifying assumptions about the distribution of loads and the behavior of members. Applying these approaches to multi-storey reinforced concrete buildings with multiple linked parts becomes complicated and time-consuming, while they are valuable for learning fundamental structural principles. More precise, faster, and more trustworthy structural evaluations are now possible because to developments in computer-aided structural analysis software.

One of the most popular structural analysis and design software programs used in engineering practice is STAAD.Pro, produced by Bentley Systems. Stiffness matrices describe structural elements in the program, which is based on the finite element technique and the direct stiffness method. Stability analysis is done by solving the equilibrium equations. Engineers may use it to build 3D models of structures, specify member and material characteristics, apply different loading scenarios, and get extensive results including axial and shear pressures, bending moments, support responses, and nodal displacements. In this research, we apply STAAD to analyze and validate a G+2 reinforced concrete framed structure.Pro. Structure, concrete, beam/column sections, support conditions, and loads are all defined to create a comprehensive 3D model. In order to comprehend the distribution of forces and deformation properties among various structural elements, the structure is subjected to analysis under the specified loading circumstances and the resulting data is assessed. Finding out how well computer-based structural analysis works for assessing the behavior of reinforced concrete frames is the primary goal of the project. A systematic technique for modeling and evaluation of RC framed structures using STAAD.Pro is established by the analytical findings, which give vital information about the performance of beams, columns, and the overall structural system.



Visual representation of the STAAD-created steel truss roof structure in three dimensions (Fig. 1).Pro

II. REVIEW OF LITERATURE

Theories, standards, and computer-based simulation methods in structural mechanics have been developed via substantial study of the analysis and design of RC-framed structures. The basic knowledge of load transmission processes, member behavior, and deformation properties of framed structures is provided by classical structural analysis techniques. The intricacy of three-dimensional structural interaction, various load combinations, and correct prediction of member pressures makes manual procedures more and more challenging for multi-story structures. Contemporary software for finite element structural analysis is theoretically based on the Direct Stiffness Method, which was first proposed by Turner et al. [1] and then refined by Przemieniecki [2] into a systematic matrix-based analytical technique. To accurately determine displacements and internal forces under diverse loading circumstances, this approach allows complicated structures to be represented using linked elements with specific stiffness qualities. Modern software systems such as STAAD.For efficient analysis of big structural systems, pros use this method. Code requirements, such as IS 456:2000, which details the requirements for concrete member design and finishing, are often followed in the construction of reinforced concrete buildings. Realistic structural reactions can only be achieved by using the precise dead load and imposed load estimation methods outlined in Part 1 and Part 2 of IS 875. The structural safety, design forces, and reinforcing needs are all affected by the loading situations and combinations that are not properly considered.

The use of structural analysis software for reinforced concrete structures has been studied by several researchers. Predicting bending moments, shear pressures, and displacement behavior using computer-based modeling is more accurate than using simpler analytical approaches, according to studies on multi-storey RC frame analysis. Better knowledge of the structural reaction under applied loads may be achieved by the use of three-dimensional modeling, which realistically represents the interaction between beams and columns.
The significance of accurate modeling assumptions in numerical analysis has been previously shown in many research. The findings are heavily impacted by factors including support circumstances, member stiffness, material qualities, and load application techniques. Mistakes in assuming these values may cause structural forces and deformation to be estimated inaccurately, which in turn impacts the design process's dependability. Using STAAD.Several research have revealed that reinforced concrete frame analysis is beneficial. According to the research, the program is a great tool for simulating complicated structural systems and testing important design parameters including displacement responses, axial pressures, bending moments, and shear forces. The STAAD system is made possible by combining analytic skills with design code criteria.For structural engineers, Pro is an invaluable tool for both analysis and design.

Modern building analysis relies heavily on three-dimensional structural modeling, which takes into account the interaction between structural parts in all directions. For structures where spatial behavior impacts structural performance, three-dimensional models provide more accurate load distribution and deformation patterns than isolated two-dimensional frame analysis. This research adds to the existing body of knowledge by using STAAD to the analysis of a G+2 reinforced concrete framed building.The software's numerical findings will be used to evaluate the structural behavior of the pro. To show how successful computer-aided analysis is for reinforced concrete building structures, the research focuses on understanding member forces, support responses, and displacement characteristics.

III. APPROACH AND MODELING IN STRUCTURES

A. Physical Characteristics and Geometry

This research used STAAD.Pro to simulate the reinforced concrete framed structure as a three-dimensional space frame. The G+2 building system is shown in the structural model as an all-inclusive load-resisting framework made of linked reinforced concrete beams and columns. By allocating node coordinates, member connections, and storey levels in accordance with the building arrangement, the structure's geometry was established. To depict the interaction between columns and beams in various orientations properly, the three-dimensional modeling technique was used. The structural members were all represented as beam-column elements that could withstand shear, axial, and bending moments. The analytical model takes into account the inflexible behavior of the connections between the beams and columns, which stand in for the monolithic nature of reinforced concrete framed buildings. The parameters of the concrete and reinforcement were given in accordance with the standard method for reinforced concrete design. A variety of material qualities and concrete grade were specified using STAAD.The benefits include the Poisson's ratio, density, and modulus of elasticity. In accordance with the applicable design requirements, the qualities of the reinforcement steel were taken into account. The analysis's material parameters provide the required stiffness properties for assessing the structure's reaction to applied loads.

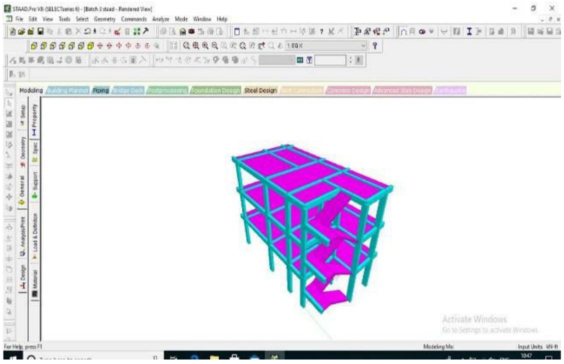


Fig. 2. G+2 reinforced concrete frame construction three-dimensional analytical model

B. Proprietors' Interests

Beams and columns were given suitable cross-sectional characteristics in order to define the structural members. Based on the structural structure, rectangular cross-sections were used to mimic reinforced concrete beams, and square or rectangular reinforced concrete sections were used to represent columns. The STAAD member attributes that are allocated.Specifications for the material, cross-sectional dimensions, and stiffness properties are all part of the pro model. Because the internal force distribution and displacement behavior of the whole structure are directly affected by the stiffness distribution of beams and columns, it is very vital that member characteristics be accurately defined.

Table 1. Section Properties of Members

Member Type	Section Shape	Material
Columns	Reinforced concrete rectangular section	Concrete
Beams	Reinforced concrete rectangular section	Concrete
Slab load transfer	Equivalent floor loading	Concrete

C. Prerequisites for Support

As a representation of the link between the building's framework and foundation system, the reinforced concrete columns' base nodes were given set support criteria. A transfer of bending moments and shear pressures from the superstructure to the foundation may be included in the analysis since the permanent supports limit translational and rotational motions in all directions. The distribution of forces and the overall stiffness of the structural system are affected by the support conditions that are chosen. A reinforced concrete structure with columns monolithically attached to foundations exemplifies the fixed-base idealization in its behavior.

D. Combinations and Load Cases

Gravity loading conditions, including dead load and applied load, were used to analyze the structure. The self-weight of structural components is included in dead load, which was computed automatically by STAAD.Pro based on the given member characteristics and material density. Floor and finishing loads, among other permanent additions, were regarded as exterior loads when relevant. A building's imposed loads were determined by its intended use and the applicable regulations of IS 875. In order to test the structure's crucial reaction under varying loads, load combinations were created.

Table 2: Analysis of Load Cases

Load Case	Type	Description
DL	Dead Load	Self-weight of structural members and permanent loads
LL	Live Load	Imposed load on floor areas
DL + LL	Combination	Combined gravity loading condition

E. Approach to Analysis

We used STAAD to build the structural model.The G+2 reinforced concrete frame's geometry must be defined before the construction may proceed. At the point where the beam and column met, nodes were formed. Then, members were generated to link these nodes. The analytical model was then finalized by assigning material characteristics, section properties, and support conditions. The structure was subjected to the specified load situations. The response of the structure under the loading circumstances that were studied was obtained by doing a linear elastic static analysis. Nodal displacements, shear forces, axial forces, bending moments, and support responses were all retrieved from the STAAD as analytical findings.Finished product ready for review. By analyzing the post-processing data, we were able to deduce the response parameters that influence the behavior of various structural components. A systematic way to analyzing reinforced concrete framed structures using computer-based structural analysis tools is provided by the methodology that was implemented.

IV. FINDINGS AND ANALYSIS

A. Movements of Nodes

We acquired the nodal displacement values via STAAD.The G+2 reinforced concrete frame's deformation behavior under the imposed loading conditions may be learned from the data provided by Pro. One measure of a structure's stability and stiffness is its displacement response. The accumulation of distortion from lower levels causes the largest nodal displacement at the higher story level. Because of the combined effects of member flexibility and total frame deformation, the displacement rises progressively with height at the higher joints. All of the measured displacements are well within the allowable range for practical use, suggesting that the structure is sufficiently stiff to withstand the gravitational stresses. Beams and columns in the reinforced concrete frame withstand loads applied to them as a single unit, as confirmed by the displacement pattern. The analytical model's realistic structural behavior and correct connection are shown by the smooth fluctuation of displacement between neighboring nodes.

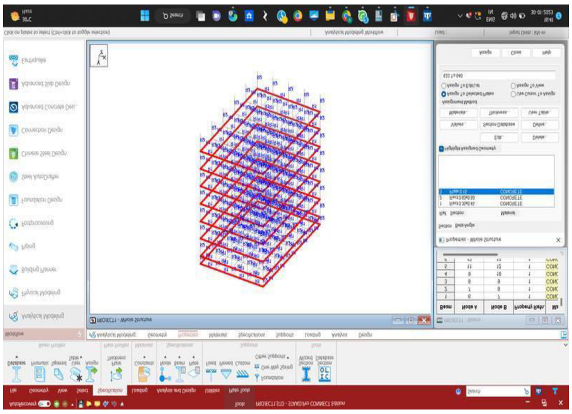


Fig. 3. The G+2 reinforced concrete frame's nodal displacement pattern as determined by STAAD.Pro

B. Forces of Beam Members

The STAAD-obtained bending moment and shear force values.Beams made of reinforced concrete display the distribution of internal forces. Gravity loading and the stiffness interaction between columns and beams are the main factors that affect the beam forces. Because the reinforced concrete frame is continuous, the highest bending moments are produced by rotational constraint, which is most noticeable at beam-column connections. The middle regions of beam spans have positive bending moments as a result of drooping behavior under floor loads. Higher shear values are seen close to supports, where the load is transferred from beams to columns, and this distribution of shear forces fits the predicted structural behavior. The findings show that the beam members successfully distribute floor loads to the columns.

Table 3. A Review of the Forces Controlling the Beams

Parameter	Observation
Maximum bending moment	Occurs near beam-column connections
Maximum shear force	Occurs near beam supports
Governing load condition	Combined gravity loading
Structural behaviour	Flexural beam action

C. Forces inside the column

The findings of the column force analysis reveal the process by which the higher levels' loads are transferred to the foundation system. In response to gravity loads, the columns mostly resist axial compression; nevertheless, bending moments arise as a result of frame continuity and interaction with linked beams. Because the lower columns bear the weight of all the floors above them, the axial force becomes larger as one descends the building. Consequently, the ground-level columns exhibit the highest degree of compression. Where moments are transferred from horizontal to vertical members, at the beam-column connections, the bending moment distribution shows that important areas are located. Realistic reinforced concrete frame behavior is represented by the column forces that are obtained, with columns serving as the principal vertical load-bearing elements and ensuring the stability of the whole structure.

Table 4: Summary of Column Forces

Force Component	Structural Behaviour
Axial force	Maximum at lower storey columns due to accumulated gravity load
Bending moment	Higher near beam-column junctions
Shear force	Developed due to frame action

D. Reactions of Support

This is the STAAD-obtained support response data.Use pro to show how loads are distributed from the superstructure to the foundation. Under gravity loading circumstances, the horizontal responses are insignificant, but the vertical reactions show the total loads that each column has to bear. Each column's tributary area and stiffness properties determine the distribution of response values. Because they support more floor space, interior columns are subject to greater responses than edge columns. The fact that the responses are evenly distributed verifies that the loading arrangement and structural model are accurate.

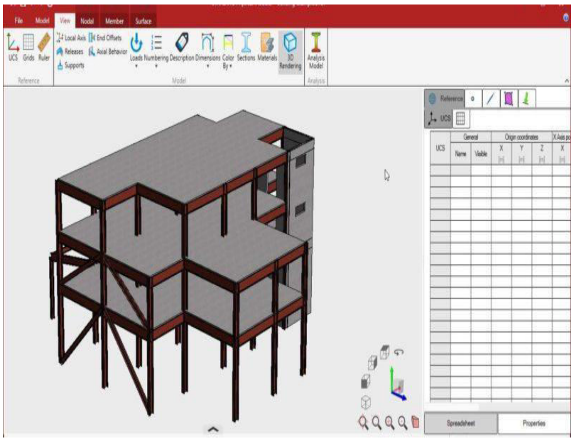


Fig. 4. The reaction forces supporting the reinforced concrete structure

E. Behavior of Shear Forces and Bending Moments

The STAAD-generated bending moment schemas.Display the flexural demand's fluctuation along beams and columns. The findings point to areas where structural continuity and load transfer effects are prominent as having the highest moments. The shear force graphs reveal that the shear magnitude decreases as the beams approach the mid-span, with the highest values concentrated close to the supports. This movement is in line with the basic principles of frame action in reinforced concrete. In order to build beams and columns with reinforcements that meet reinforced concrete design requirements, it is important to acquire patterns of shear forces and bending moments.

F. Performance Evaluation of Structures

Considering the loading circumstances in question, the G+2 reinforced concrete frame shows good structural behavior, according to the findings of the overall study. As one would expect from a standard reinforced concrete building frame, the displacement values, member forces, and support responses all conform to the norm. The STAAD has been successfully completed.The trustworthiness of the produced three-dimensional model is confirmed by pro analysis, which does not include any modeling flaws. The findings prove that structural analysis performed on computers is a reliable way to assess the performance, deformation properties, and force distribution of reinforced concrete buildings.Reliable structural analysis findings may be obtained, according to the research, only with precise modeling of geometry, material characteristics, support conditions, and loading factors.

V. CONCLUSION

An STAAD in three dimensions.In order to investigate the structural behavior of a G+2 reinforced concrete framed structure under gravity loading circumstances, a parametric model of the structure was created, analyzed, and tested. In order to comprehend the reaction of reinforced concrete beam-column systems, the research proved the usefulness of using computer-aided structural analysis. Geometry, material characteristics, member sections, support conditions, and applied loads were among the realistic structural aspects taken into account in the research. The current investigation led to the following findings:

The G+2 reinforced concrete frame was accurately modeled in STAAD using a comprehensive three-dimensional analytical approach.The structural system's beams and columns interact with one another, as shown by the pro. The findings of the nodal displacement show that the cumulative frame flexibility causes the greatest deformation at the higher story levels. The resultant displacement pattern is physically plausible and smooth, which confirms the structural model's stability and dependability. According to the beam force findings, the strongest bending moments form at the beam-column junctions because of the structural continuity, and the strongest shear forces form at the supports, where the load is transferred. The study of the columns shows that the vertical load-carrying behavior is controlled by axial compression, with the highest axial forces acting on the columns in the lower stories as a result of the loads accumulated from the higher levels. Support response data show that the structure is properly loaded, with greater tributary areas at interior column sites leading to higher reactions.Diagrams of shear forces and bending moments acquired from STAAD.Reinforcement design of structural members may benefit greatly from the clarity that Pro provides on the distribution of internal forces. By accurately reporting member forces, displacements, and support responses, the research proves that STAAD.Pro is an efficient and dependable method for analyzing reinforced concrete framed buildings. Because it takes into account the interaction between members in all directions, the three-dimensional modeling technique more accurately represents the real structural behavior than the simpler two-dimensional analytic approaches. This study develops a methodical approach to utilize STAAD for the purpose of modeling and analyzing reinforced concrete building structures.Pro. A more comprehensive structural design evaluation might be possible in future research if seismic loading in accordance with IS 1893, wind loading effects, nonlinear analysis, verification of reinforcement design, and foundation design were all included.

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