BUILDING’S DESIGN AND ANALYSIS USING STAAD PRO

# ACKNOWLEDGEMENT

We express our gratitude to Mr........., the HOD of our Civil Engineering Department who offered us the opportunity, as well as the time, resources, and required assistance, to ensure that the project was finished on schedule and to the satisfaction of the project's goals. We are delighted to have Mr................... as our project supervisor. Throughout our endeavor, he guided us, supported us, and coached us. With his guidance and mentoring, we are able to learn, grow, and fulfill project objectives.

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Neeraj Sureshbhai Patel

Members

# DECLARATIONS

We declare the project " **Building’s design and Analysis using STAAD pro**" is achieved following the guidelines of Sardar Vallabhbhai Patel Institute of Technology and that it is submitted and presented to the university's Civil Engineering department as the requirement for the completion of a bachelor's degree in Civil Engineering. This project is performed under the supervision of ............. under the Code of subject ………….

The project is done utilizing a unique method that involves self-learning and the application of existing ideas and knowledge. The project’s process and outcomes, we say, are completely unique. Informations was gathered from various writers and properly recognized and cited. We recognize that duplicating other people's ideas and labor is wrong, and we affirm that the project is free of plagiarism.

We recognize that plagiarism is wrong, and we will not permit the copying of our content or ideas without the consent of the parties involved. If such duplicates and duplicating without authorization or consent are discovered, it will be punished administratively.

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# ABSTRACT

The analysis of structure under different loading conditions is necessary to predict the response of the structure and ensures safety. With the development of matrix system, lots of computer software are employed for the design and analysis of structures. STAAD pro is one of the most popular software in civil design and analysis because of it easier user interface, alignment with IS standard and accurate results.

The structure's design and analysis are done using STAAD Pro software in this project. In addition, a comparison with the manual approach is presented. Journals and previous research articles are read in the early stages to gain a better understanding of previous studies and factors related to structural design, load determination, and calculations. After that, an idea for designing the structure in STAAD pro is created. The loads addressed during the design and analysis include dead load, living load, and wind load for a G+5 story structure. Furthermore, an RCC frame with 4 bays in the Z-axis and 5 bays in the X-axis is used, with the G+5 floors considered in the y axis. The floor height is set at 3 meters. Following that, the structure is exposed to loading situations that include dead load, self-load, and load. The IS code is used to establish the parameters for the loading conditions. The earthquake load is not taken into account in the design and analysis for the Zone V region. The fundamental wind pressure for the design region is 44 m/s, with a maximum wind pressure of 151 m/s taken for the determination of a load of wind and a number of 461 nodal points. The outcome demonstrates that STAAD Pro is an accurate and dependable structural analysis program. Its superiority to the manual technique in the design and analysis of the structure is demonstrated by the comparison. However, when it comes to the design of slabs and footings, the manual technique outperforms STAAD pro. It's also been found that the design parameters may be utilized in accordance with IS Code, and STAAD pro can calculate the reinforcement required for the concrete section. The structure's beams are also intended to withstand shear, torsion, and flexure.

# INTRODUCTION

## 1.1 Overview

One of the important parts of structural design is the structural analysis of the structure and checking the safety plus the stability of the structure in case of any given loading conditions. To analyze the response of the structure under the different loading conditions different approaches can be used. Structural analysis of the structure must be performed to determine the outcome or the response. Software analysis of the structure is one of the commonly preferred methods of analysis. Some of the most common software used for the analysis of structure are SAP, STAAD pro, SAFE, ETABS etc. Analyzing structure prior to the construction of the structure helps to reduce the loss of the property, reduces the cost and life. RCC is a common type of structure. Assembly of beams, columns and foundation makes RCC frame.

In the project, the design and analysis of the G+5 building are performed using STAAD Pro. In the process of design and analysis, live load dead load and wind load are considered. Further in the design and analysis, the 3D RCC frame is considered to have 4 bays on the Z-axis and 5 bays on the X-axis. G+5 floor is taken for the y-axis. From the analysis, deflection is checked and the bearing need of the structure for safety is considered. The choice of STAAD pro is done in the analysis because of its easy interference, accurate outcome, IS code conformity and versatility in solving the problem.

## 1.2 Historical background

The development in the structure had progressed with time. At different stages of history, different structures were used. Upon the realization of a more strong structure, advancement, rejection and acceptance of different structures marked the success and failure of structures. The great pyramid was constructed in 2630 B. The first structural engineer was considered to be the Egyptian Imhotep. Pythagoras developed the right angle theorem in 500 BC and Archimedes developed the static principle in 212 BC. Another noteworthy development was the development of the number system. In the seventeenth century, the principle for the analysis of the structure was developed. Andreas Palladio developed the system for modern truss in the middle of the 15th century. The method of joint truss was developed in 1847. In 1870, the analysis for the truss was developed and the method for determination of deflection was published. The deflection theorem was accomplished in 1864, the leas weigh method theorem was developed in 1873 and in 1873 moment area theorem was also developed. The method of slope deflection was developed in 1915 by George Maney. Continues beam deflection was done following the method and the method was also utilized for the determination of the beam’s deflection. The analysis and the development of the system of concrete were done in 1929. The portal method was introduced by Albert Smith for the analysis of the frame which was subjected to the wind and seismic condition of loading. This worked nicely for buildings that had a maximum of 25 stories. In the 20th century, the matrix method was used for analysis. On the basis of the matrix method, computer software was developed and its analysis was performed.

## 1.3 Objectives

The main objective of this project is to perform the design and analysis of the building using STAAD pro and compare it with the manual approach. Along with this primary objective, some other objectives of the project are as follows:

* To determine the accuracy of STAD pro and its reliability.
* To make the structure stronger against different loading conditions and effects.
* To analyze and focus on the importance of computer software in structure analysis.

## 1.4 Problem Statement

In the case of any structures like buildings, towers etc. the prediction, as well as the determination of safety of life and property, is important. Various loads such as live load, wind load, dead load, seismic load etc. act on a structure. It is necessary to study the effects brought by such loading conditions on the structure so that cost and loss of life and properties can be saved. Structural analysis of any structure helps to determine the effect of loading conditions on the structure and the response of the structure. The analysis helps in strengthening the structure in case if it’s necessary. Analysis software has an important role in the phase of analysis. At a low cost, the structure’s response can be achieved with the help of analysis software. Apart from the cost, alignment with the standards, user-friendly nature of the software, easy access, and reliability are some of the important criteria for the design and analysis.

## 1.5 Scope of the project

The project is concerned with performing the design and analysis of building using STAAD pro. The project makes a comparison between the analysis made using STAAD pro and the manual approach. The project uses the manual method for the load calculation and performs the analysis of the structure using STAAD pro. The project helps in predicting the outcome of the structure of self-weight, dead load, live loads and wind loads. In the project, the design and analysis are done conforming to IS standard and the deflection of the structure is checked on the loading conditions.

## 1.6 Methodology

The project “Building’s design and Analysis using STAAD pro” is initiated by performing literature research and study of past papers relevant to the design and analysis of buildings and structures. Further study of different methods for the load calculation for the building is done and IS code is reviewed. In addition, a review of the skills is done to facilitate the design and analysis of Building in STAAD pro. After that, loading parameters, building size, beam and columns dimensions etc are determined for the building. IS code is taken as a reference in determining the parameters and some assumptions are made. Then, loads are calculated manually for the structure. Live load, dead load and wind load are considered for the structure. After the calculation of load, STAAD pro is used for the design and analysis of the building structure. The design is performed for the Slab and footing. G+5 storey building is considered for the design and analysis. Further, a 3D RCC frame is also developed. In the STAAD pro, a combination of the load is done and its deflection is checked on the combined loading condition. Along with it, the conformity was also done as it aligns with the IS standard or not. The result obtained is observed and analyzed. From the analysis, the comparison is also made for the analysis using STAAD pro and manual method.

Figure Methodology

# LITERATURE REVIEW

(Kilar & Fajfar, 1996) The paper summarized the method for the structural analysis of a building that is subjected to the loading condition that is increasing monotonically and is horizontal. The paper mentioned the mathematical model which was the extension of a pseudo-3D model for the structure in the range of nonlinear analysis. The computation of the top displacement and base shear was done and their relationship was determined by the step-wise analysis in the project mentioned in the paper. Also, the paper described that the plastic hinges development and the analysis could be monitored of the building as mentioned in the paper. The implementation of the strategy was done in the prototype. The prototype was of the computer program. The paper also described the mathematical model, the relationship between the base shear and the top displacement for various types of the macro element. The step-wise procedure for the computation was also described. In the paper, it was mentioned that the application of the method was done for the seven-story building with a reinforced concrete wall frame. In addition, the asymmetric, as well as symmetric variant of the structure, was analyzed.

(Watson & Perera, 1997) In the paper, the review of design based on the case and its application in the design of the building of a particular case was presented. The paper mentioned the use of reasoning based on the case for the process of design. It was also mentioned in the paper that the designers use earlier designs in the development of the new design. Because of such application, the paper summarized the application and use of earlier designs. In the paper, the problems of different cases were identified, represented ad the presentation, adaptation as well as retrieval of the case was done. In addition, the paper also mentioned the maintenance with creativity, ethical issues and legal issues. These issues need to be addressed by the system of CBD. A comprehensive review of the CDB system was provided in the paper and was used for the development of the design of the building. The paper also presented a detailed comparison of the review of the CBD system. 1997

(Fritz, 2004) The paper illustrated the development of the model for the estimation of the period’s value and the expected damping in the case of the actual structure. The paper also mentioned the analysis and compilation of comprehensive data for the measurement. In the paper, the ANOVA was used for the identification of no stories for period data, number of the stories and the vibration level for the data obtained from the damping which could be the key factor and could impact the parameters. The paper also described the estimation model that was developed for various combinations of model performance and the factors. The performance was measured with the help of the standard error which was observed in order to improve the additional forces. The paper had simplified the models by constraining variations in the coefficient of the model as well as were considered so that the state of art in the estimation of damping and period could be improved.

(M.A.Rosenman, 1990) In the paper, the application of an expert system in the demonstration of the evaluation and analysis of the design was presented. In the field of design, the greater part of the process was dedicated to knowledge rather than computation. The paper also mentioned that many parts of the knowledge were experiential and it led to the expert system. In the paper, the analogy was also made between the interpretation and the analysis. Also, the analysis was made between the interpretation’s comparison and the evaluation. In the paper, three examples were demonstrated for performing the design, analysis and evaluation of the expert system for different domains. From the obtained result, it was mentioned in the paper that the graphical interface and the elements of the model which were within the domain were an essential part of any system of the design.

(Zhihao Lu, 2004) The application of pushover analysis in determining the seismic activity of a steel arc bridge was reported in this study. The article, which was based on the pushover analysis, mentioned demand and capacity, forecast producer. Two arch bridges were examined in the study, as well as the transverse application of the described technique on a two arch bridge with variable spans. With the use of the pushover analysis, the obtained displacement capabilities for the structure were stated in the study. The failure criterion that was used in the study was also described in the article. The use of the pushover analysis for seismic evaluation was also explored in the article, as well as the limits of the methodology. The article also compared the pushover analysis to the time-history analysis to make the comparison. The reaction was also seen in higher settings. This was also utilized to establish the scope of pushover analysis applications for various modes.

(B STAFFORD SMITH, 1985) The proposed concept of building construction with a resistance core was summarized in the article. The study discusses the identification of the resistance's center employing a 2D model for the examination of the building's planer model. The knowledge regarding the center's position aids in determining the torque produced on the floor, according to the report. Total torques can be determined using torque of the floor in a storey, and this is done without having to create the building's three dimensional analysis. To prove the notion, several comparison was made between the proposed technique with 3D analysis examples for various building structures. Three distinct instances of the structure of the building were used in the study in the paper.

(Chaw, 2005) In the paper, the comparative study and the analysis are performed for different software used in the design and analysis process. In the paper, it was mentioned that there has been extensive use of computers in the process of design and analysis of different structures. The practice had been employed in the design of complex buildings, structures, aircraft, space crafts, high buildings etc. The paper also mentioned that along with the areas of use, different software was available for the design process and analysis process. The paper primarily focused on the comparative analysis of that available software. In the process of comparison, efficiency was taken as the factor. In the paper, it was mentioned that for the study, a different combination of the bay and height of buildings were taken. The paper also mentioned that for the comparison two most popular structural software i.e. STAAD pro and Prokon were taken. The paper also declared the superiority of STAAD pro as compared to Prokon in the modeling and analysis as per the comparison. It was also mentioned that efficient and economical design was produced with the help of STAAD pro.

(Seong, 2004) In this paper, the analysis of the different parameters for the design of tall buildings having a height of 200 m to 250 m was done. Different parameters that could influence the grades of concrete were considered for a better structural system. It was based on the rigid frame and system of the shear wall. In the process of analysis, STAAD PRO was used. In the paper, it was mentioned that there was a high reduction in the size of the dimension of the column and thickness of the shear wall. The result was obtained from the analysis of the design analysis using computer software. It was also discussed that The maximum drift shown by the system of hear wall at the level of the roof was lower although the maximum value of drift of analytical values was obtained within the acceptable limit for the frame. In the paper, the system of wall shear is studied and the different configurations, as well as the arrangement of the walls, were considered. This also had an impact on the maximum drift.

# THEORETICAL DESCRIPTION

## 3.1 Beams

One of the critical components of the structure is the beam. It is responsible for holding the permanent loads in the structure. The orientation of the beam is horizontal and the load it carries is longitudinal weight. The main use of beam is it is responsible for holding the weight of the roof, weight of the ceiling, the weight of the floor etc. The selection of materials for the beam is also considered an important aspect of the design of the structure. The materials for the beam are selected on the basis of the circumstances like stress, characters of the materials, geometry and other different factors. Some of the common materials used in the beam area are steel, wood etc. The long span of the beam, geometry of the beam restriction and the deflection of the beam are some of the other essential elements of the beam. (structuralengineeringbasics, n.d.)

## 3.2 Columns

The column is another vital component of the structure as it is made to withstand the tensile load and compression load in the structure. The structure’s vertical component carries the weight of the structure and the load is transferred into the longitudinal axis. One of the forms of the column is the reinforced column made up of concrete. Some other columns are the Pilotis column, post-column, piers and knotted columns. (structuralengineeringbasics, n.d.)

## 3.3 Frame

The frame comprises the horizontal and vertical components of the structure. If the component is horizontal, then it is referred to as beam and if the component is vertical it is referred to as a column. The frame can be of two types namely sway frame and non-sway frame. IF the frame is permitted to have lateral movement then, it is called a sway frame. If the frame is not permitted to have lateral movement and it is called a non-sway frame. (Structural load, n.d.)

## 3.4 Structural loads

In order to guarantee the structure’s life span and safety, analysis of the structure needs to bed one. A structure can be subjected to several loading conditions depending upon the location, type, and environment. Determining the effect of each load on the structure helps to determine the response of the structure and ensures safety. (Structural load, n.d.)

### 3.4.1 Live load

When the load changes over time or is only present for a short period of time, it is called live load. The loads such as the impact load, fatigue of the materials and vibrations are considered as the live loads in the structure. The live load also includes people who load the structure or the cars who load the bridge. (Structural load, n.d.)

### 3.4.2 Dead load

Dead load refers to the load which remains constant in the structure for a long period of time. The loads due to the walls, floors, or the structure are constant over time and remain throughout the life of the structure. In the case of building materials, they can be considered as the dead load when the construction is complete. (Structural load, n.d.)

### 3.4.3 Environmental loads

The environment also plays a vital role in the structure. Different environmental forces and consequences like snow, earthquake, wind and natural disaster adds to the current loads as the environmental loads for the building. Other loads such as the shrinkage of materials, explosion, vibration, fire etc. should also be addressed in different cases. In that conditions, they are also included as the environmental loads. (Structural load, n.d.)

## 3.5 STAAD Pro

STAAD Pro is a structural analysis program that employs the matrix technique. In the STAAD pro program, the analysis is done using a technique called matrix displacement. The structure should be moved to meet the displacement compatibility as well as force equilibrium requirements. The geometry is then constructed by combining joint coordinates with command member incidence. The building's characteristics are assigned based on the code and personal judgment. The building's nodal supports are then installed, and loads such as live, dead, earthquake, and wind loads are determined for the structure. The defined load is then applied to the building's and floor's elements. The structure is then analyzed, and findings in terms of deflection, reaction force, and so on are generated.

# Design and Calculations

## 4.1 Concept Development

At first, the concept is developed before performing the design and analysis of the structure. The research study is conducted at the initial stage of the project to collect information and ideas regarding the structural design and analysis of the building. Skills regarding STAAD pro are reviewed to assist the designing of the structure and analyzing the structure. IS code is reviewed for the determination of parameters is also studied then. Then, the calculation of load is done manually and STAAD pro is used for the design and analysis of the RCC G+5 Structure. The dead load, live load and Wind load are determined for the structure and the slab design and footing design are done. Then the loadings are combined and the structure is checked for deflection. Along with this conformity with IS standard is also done and comparison is made.

## 4.2 Modelling of the structure

In the project, a Multi-story structure is considered to have a 3D frame fixed jointed.

The external columns of the structure are considered of size 0.24 m \* 0.41 m until the ground floor. All the internal columns are considered of size 0.24 m \* 46 m until the ground floor. Columns of size 0.41 m \*0.41 m are taken for the ground floor. The size of external beams is taken of 0.24 \* 0.51 m and the main internal beam area taken of size 0.24 m \* 0.46 m. In the modeling process, the secondary beam of size 0.24 m by 0.36 m is taken. All the slabs used in the modeling process are taken 0.16 m thick. The terracing is also considered to be 0.16 m thick. The parapet for the model is considered to have 0.116 m thick walls. These modeling considerations can be summarized in the below table:

|  |  |
| --- | --- |
| Modeling Parameters | Values |
| Structure Type | The multi-story structure having Fixed Joined 3D frame |
| Internal Column Dimensions | 0.24 m \* 0.46 m |
| External Column Dimension | 0.24 m \* 0.41 m |
| Ground Floor Column | 0.41 m \* 0.41 m |
| Internal Beam Dimension ( main) | 0.24 m \* 0.46 m |
| External Beam Dimension (main) | 0.24 m \* 0.51 m |
| Slab thickness | 0.16 m |
| Terracing thickness | 0.16 m |
| Secondary beam dimensions | 0.24 m \* 0.36 m |
| Parapet thickness | 0.116 m |

Table Modelling Parameters for Structure

## 4.3 Load Considerations

Different loads act on the structure and they must be considered for the analysis and design of the structure. The loads can be dead loads like the walls weight, false ceilings, floor finishes, etc. In addition, there are also imposed loads like the dust load, vibration load, load due to movable parts etc. Along with that the wind load, risk coefficient etc. are considered for the modeling.

## 4.4 Types of Load

### 4.4.1 Dead Load:

Wall’s weight, False ceiling, building’s permanent constructions, false floors, etc. are included in the dead load. For different members, dead loads can be calculated using the member's dimension and weight of the unit. For the plain concrete as well as the reinforced concrete, the following material properties are taken. The concrete is made from gravel and sand or the aggregate is made from crushing natural stone.

|  |  |
| --- | --- |
| Parameters | Values |
| The density of reinforced concrete | 26 KN/m3 |
| The density of plain concrete | 25 KN/m3 |
| The density of Brick Masonry | 20 KN/m3 |
| The density of Flooring Material | 21 KN/m3 |
| The density of Fly ash | 6 KN/m3 |

Table Density table for the construction materials

### 4.4.2 Load Imposed

Load is imposed on the structure by the intended application of the building’s occupancy. This includes the distributed load, concentrated load, movable partition’s weight, load because of the wind, load due to the seismic activity, load due to the change in temperature, load due to snow, etc. Temperature load might result in the shrinkage of the structure, creep etc. To model the structure, live loads are applied using the IS 875-86 code.

The values for loads are given by

|  |  |  |
| --- | --- | --- |
| SN | Parameters | Value |
| 1 | Live load applied on Slabs | 3 KN/m3 |
| 2 | Live Load applied on Stairs | 3 KN/m3 |
| 3 | Live load applied on passage | 3 KN/m3 |

Table Loading values

### 4.4.3 Wind Load

Air traveling in motion is termed wind. Due to the variation in the terrestrial radiations and due to the rotation of the earth, the wind is caused. The wind is blown in the horizontal direction at high speed. The speed of the winds is accessed with the help of anemographs or anemometers. These devices have installed the observatories of Metrologic stations and are generally at heights. These heights can be 10 m from the level of the ground to 30m above the ground’s level.

## 4.5 Speed of the wind (V)

For the design, the speed of the wind is taken into considerations. Different factors such as level of the risk, the roughness of the terrain, size of the structure and its height, local topography affect the design speed of the wind. These factors considered can give different speeds for the winds for different structures. The mathematical expression for the design speed of the wind is given as

V = K1 \* K2 \* K3 \* Vb

Where

K1 is the probability factor or the risk coefficient

K2 is the height, terrain, and size of the structure factor

K3 is the topology factor

Vz is the design speed of the wind for height z (m/s).

### 4.5.1 Risk coefficient factor:

The risk coefficient factor for the wind is taken for category 2 terrain region, as it is applicable of the height if 10 meters above the level of the ground on the time period of 50 years. The regional basis of the speed of the wind having a return period of 50 years is used for the design of the building and the structure. The risk factor or the K1 factor for the design is taken as 1.

### 4.5.2 Structure size, height, and terrain factor (K2)

The selection of the terrain is taken considering the obstruction’s effect that consists of the roughness of the surface of the ground. The category of the terrain in the case of designing the structure varies based upon the direction of the wind considered. The planning of the orientation of the building is done based upon the information available for the direction of the wind as per the meteorological data. In the modeling of the structure,0.98 is taken as the K2 factor for the structure.

### 4.5.3 Topography factor (K3)

The speed of the wind, Vb considers the sea level of the site. Features of Local topography like the hills, cliffs, valleys, ridges and escarpments etc are not allowed that might affect eh speed of the wind significantly. The topography has an effect in accelerating the speed of the wind near the summit or the crests of eh cliffs, hills, ridges and escarpments. The deceleration of the wind near the valley or the cliff’s foot, ridges, and escarpments are also examples of the topography effect in accelerating and decelerating wind.

## 4.6 Considerations for the design

In the design of the multi-storey buildings, different considerations are made. For the design of the concrete member which is reinforced, IS 456-2000 is taken into considerations and a method called limit state is used. For the live loads applied on the floor and the roofs, the considerations are made according to the IS 875 part 2 which gives the value of live load applied on the floor as 3 KN/m2 and live load applied on the roof as 1.5 KN/m2. Finishes on the floor and finished on the roof are considered based on the IS 875 part 1 and its corresponding value is 1 KN/m2. For the concrete members, the grade of M25 is used for the concrete. For the RCC members, the bars are considered as per IS 1786. As per the code, deformed bars having high yield strength are taken. The bearing capacity of 251 KN/m2 is considered safe as per the report of the soil for the footing design. For the calculation of base shear, the first part of IS 1893 is taken. Considering Zone 2, a Zone factor of 0.1 is taken for the design and modeling. Similarly, the important factor of 3 is taken and the coefficient of acceleration response is taken from the curve as 2.6.

## 4.7 Design of the Slab

For the Slab, the RCC slab is considered and it is one of the most commonly used elements of the structure. The thin flexural element that is used in roofs and floors is called slab and is used for carrying different loads as well as supporting the beams or walls along the edges of the edges.

### 4.7.1 One-way Slab

The one-way slab is the type of slab which is supported along any two edges which are opposite to each other. The aspect ratio for the condition is taken as (ly/lx) greater than 2. The bending moment is assumed to be resisted with the help of the environment such that the short span, as well as the steel’s distribution, is provided along the span pf length that rarely takes the shrinkage stress and the temperature. But the bending moment is not taken.

### 4.7.2 Two-way Slab

In the case of the two-way slab, four edges support the slab and the ratio of aspect is lesser than 2. During loading, the two-way slab bends such that there is bending in both directions of long span and the moment of bending is caused in both directions. Main reinforcement is used to resist the slab in case of both directions and for the bending moment, two-way slabs are treated as a two-way slab. The design constraints for the M25 mix for the concrete and steel are taken. In the design, the slab of the floor is divided into S1 panel to S8 panel and the plan of the layout is divided based on the condition of their edges.

### 4.7.3 Torsional Reinforcement

The corners of the two-way slab deflect in such a way that the slab in both directions gets twisted. As they are subjected to the moment of twisting. In order to prevent this twisting, the reinforcement is provided laving, at edges, edges that are discontinuous. The provision is that there must be four layers of torsional reinforcement, two-layer at the top and at the bottom at the edges of the slab which are discontinuous.

### 4.7.4 Slab’s Design

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Slab | d  (mm) | D  (mm) | Lx  (m) | Ly  (m) | Load  (kN/m2) | L/L  X | Bending Moment  (kN/m) | Coefficient of Bending Moment | Spacing |
| s1 | 131 | 151 | 3.615 | 5.67 | 13 | 1.574 | 12.638 | negative/  positive | 9 mm at the rate of 177 cm3 |
| s2 | 131 | 151 | 3.615 | 6.07 | 13 | 1.618 | 13.82 | negative/  positive | 9 mm at the rate of 308 cm3 |
| s3 | 131 | 151 | 3.615 | 5.67 | 13 | 1.524 | 12.638 | negative/  positive | 9 mm at the rate of 281 cm3 |
| s4 | 131 | 151 | 3.615 | 6.07 | 13 | 1.678 | 13.82 | negative/  positive | 9 mm at the rate of 201 cm3 |
| s5 | 131 | 151 | 3.615 | 5.67 | 13 | 1.564 | 12.638 | negative/  positive | 9 mm at the rate of 281 cm3 |
| s6 | 131 | 151 | 3.615 | 6.07 | 13 | 1.618 | 13.82 | negative/  positive | 9 mm at the rate of 201 cm3 |
| s7 | 131 | 151 | 3.385 | 5.67 | 13 | 1.67 | 12.293 | negative/  positive | 9 mm at the rate of 271 cm3 |
| s8 | 131 | 151 | 3.385 | 6.07 | 13 | 1.791 | 13.82 | negative/  positive | 9 mm at the rate of 308 cm3 |

Table Slab design values

### 4.7.5 Staircase Design

Access towards the floor is given by the staircase at various levels. Step series are provided in the staircase having suitable intervals for the staircase. For the width of the staircase, types of buildings are considered. The variation ranges from 1 m to 2m for the public buildings. Flight is defined as the staircase’s length that is located between the two landings. For the step’s number in case of flight, various steps’ tread is taken into considerations. Types of buildings decide the rise of steps of the building and it varies from 150 mm to 300 mm. The variation of tread lies between 200 mm to 300 mm

## 4.8 Footing design

For the design of the footing, loads were passed to both frames to the footing and were determined as 699.60 KN including load factors. The design of the footing is done of the punching shear as well as the bending shear. Suitable reinforcement is also done.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SN | Design of footing | SBC | Condition of maximum loading | Size of footing | Direction in X | Direction in Y |
| 1 | F1, F12, F18, F20 | 251 | 961 | 3.83 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |
| 2 | F2, F7, F8 | 251 | 1004.2 | 4.00 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |
| 3 | F3, F7, F8 | 251 | 1004.2 | 4.00 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |
| 4 | F4, F9, F11 | 251 | 1004.2 | 4.00 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |
| 5 | F5, F16, F17 | 251 | 966 | 3.85 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |
| 6 | F6, F14, F19 | 251 | 981 | 3.91 | 17 mm at the rate of 181 mm  c/c | 17 mm at the rate of 61 mm c/c |

Table Footing design values

For the modeling of the 3D frame, an idealized frame is presented in the image below. The front view is presented in the second image. In the third image below, properties of members are shown and finally, the wind loading for the building is shown in the fifth figure

Figure G+5 storey structure 3D model in STAAD pro

Source : figure 1 , page 31

Figure Structure's Front View

Source figure 2, page 32

Figure Members property generation

Source: figure 3, page 32

Figure Loads for the floor

Source figure 4, page 32

Figure Loads due to load for the structure

Source figure 5, page 33

# RESULTS AND DISCUSSIONS

## 5.1 Results

From the design, the structure of the G+5 storey building is obtained considering the live load, dead load and wind load. The deflection for the combination of the load is obtained to be normal and the result resides with IS code and standard. STAAD Pro software is used for the design and analysis. STAAD Pro is determined as the suitable and accurate method for the analysis of the structure as compared to the manual analysis. In the case of the design of the footing, slabs manual design is taken as the accurate method as compared to the STAAD PRO analysis

## 5.2 Discussions

For the analysis of the structure, STAAD pro is taken as the analysis and design software. STAAD Pro is chosen as the accurate and relevant method because of the wide range of applications and ability to demonstrate the accurate result. For the analysis, the comparison is made between the manual and STAAD pro methods. From the result and observation, It is concluded that analysis and design of the structure can be better achieved using STAAD pro as compared to the Manual method of analysis. For the design of the footing and the slabs, the manual method is considered the best method when compared to the STAAD pro method for the analysis.

For the analysis, the frame and the structure considered are the linear frames and the linear structure for the dead load, live load, and wind load. Earthquake load is not considered for the region in zone V. The basic pressure of the wind for the region for the design is 44 m/s and the pressure of 151 m/s of wind is taken to determine a load of wind and number of 461 nodal points are used in the frame.  
IS codes are used for the determination of loads for the structures. For the live load, IS 875-86 is used. The design of the RCC building was done as per the IS 456-2000 and the dead loads are determined for the structure using the first part of the IS 875. To determine the reinforcement percentage and depth of the reinforcement, SP 16 code is used and employed. The detailing of the structure is done being based upon the SP 34 code and standard.

# CONCLUSION

In the project, the design and analysis of the structure are completed using STAAD Pro software. Along with that comparison is made with the manual method. At the early stage, journals and past research papers are studied to understand earlier works and parameters about the structural design, load determination and calculations. After that, a concept is developed to design the structure in STAAD pro. G+5 storey building is considered and the loads included for the design and analysis are dead load, live load and wind load. Further, the RCC frame having 4 bays on the Z-axis and 5 bays on X-axis are taken where the G+5 floors are considered on the y-axis. The height for the floor is taken as 3m. After that, the structure is subjected to the loading conditions such that dead load, self-load and load are included. The parameters for the loading conditions are determined based on the IS code. For the design and analysis, earthquake load is not considered for the region in zone V. The basic pressure of the wind for the region for the design is 44 m/s and the pressure of 151 m/s of wind is taken to determine a load of wind and the number of 461 nodal points are considered. the result obtained shows that STAAD Pro is accurate and reliable software for the analysis of the structure. Form the comparison proves its superiority to the manual method in the design and analysis of the structure. However, for the design of the slabs and footings, a better result can be acquired using the manual method as compared to the STAAD pro. It is also determined that the parameters necessary for the design can be used as per IS Code and STAAD pro has the ability to determine the reinforcement needed for the section of concrete. The beams in the structure are also designed for shear, torsion and flexure.

## 6.1 Advantages

The project “Building’s design and Analysis using STAAD pro” offers several advantages and some of them are mentioned below:

* The project provides a systematic way of performing the building’s design using STAAD pro and then perform its analysis in STAAD pro.
* The project provides information about the load calculation for analysis purposes manually.
* The project helps in the study of wind load along with dead and live load in any structure.
* The project provides the idea for the design of beam for shear, flexure and torsion.

## 6.2 Disadvantages

Along with advantages, the project also has some downsides. Some of them are mentioned below:

* Knowledge and skills regarding STAAD pro are needed to perform the design and analysis of the building.
* Knowledge regarding IS code is needed for the selection of loading conditions and parameters.
* The design and analysis for the building are performed assuming lots of parameters. The result might vary in real case scenario
* Different loading conditions such as temperature load, the seismic load are not considered for the design and analysis of the project.

## 6.3 Future Scopes

In the future, the project can be improved and made more applicable. Several activities can be performed in the future to widen the scope of the project. In addition to STAAD pro, other software can be used for the analysis and the design of the structure and comparison can be made between the software on the basis of accuracy, cost, user-friendly nature and time for the computation. Also other different loading parameters such as the environment loads, seismic loads can be used for the purpose of design and analysis of the structure. This would make the result more accurate. In addition to the deflection, other types of analysis like modal analysis, seismic analysis etc. can be performed for the structure in the future so that more reliable design and analysis can be computed.

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