A PROJECT REPORT ON

ANALYSIS AND DESIGN OF A MULTI STOREYED RESIDENTIAL BUILDING BY USING STAAD PRO

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CERTIFICATE

This is to certify that the project entitled **"ANALYSIS AND DESIGN OF A MULTI STOREYED RESIDENTIAL BUILDING BY USING STAAD PRO"** is a bonafide work of **L.SUBHASHINI REDDY, G.PUSHPA LATHA, K.MUKUNDA REDDY, M.NITHIN SAI, U.VENKATA SATISH, B.KISHORE** is submitted to the faculty of Civil Engineering, in partial fulfilment of the requirements for the award of degree of **BACHELOR OF TECHNOLOGY in CIVIL ENGINEERING** from Jawaharlal Nehru Technological University Anantapur, College of Engineering (*Autonomous*), Ananthapuramu.

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DECLARATION

We, **L SUBHASHINI REDDY** bearing Admission number **15001A0102, G PUSHPA LATHA** bearing Admission number **15001A0130, K MUKUNDA REDDY** bearing Admission number **15001A0138, M NITHIN SAI** bearing Admission number **15001A0127**, **U VENKATA SATISH** bearing Admission number **15001A0107**, **B KISHORE** bearing Admission number **15001A0142**, hereby declare that the project report entitled **"ANALYSIS AND DESIGN OF A MULTI STOREYED RESIDENTIAL BUILDING BY USING STAAD PRO"** under the guidance of **Dr VAISHALI G GHORPADE**, Professor in department Of Civil Engineering, JNTUA College of Engineering, Anantapuramu is submitted in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Civil Engineering.**

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Project Associates…

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ANALYSIS AND DESIGN OF A (G+4) MULTI STOREY

RESIDENTIAL BUILDING BY USING STAAD PRO

Abstract

In order to compete in the ever growing competent market it is very important for a structural engineer to save time. As a sequel to this, an attempt is made to analyse and design a multi-storeyed building by using a software package called staad pro.

For analysing a multi storeyed building one has to consider all the possible loadings and see that the structure is safe against all possible loading conditions.

There are several methods for analysis of different frames like kani's method, cantilever method, portal method, matrix method.

The present project deals with the analysis of a multi storeyed residential building of G+4 consisting of 4 houses in each floor. The dead load & live loads are applied and the design for beams, columns, footing is obtained.

STAAD Pro with its new features surpassed its predecessors, and competitors with its data sharing capabilities with other major software like AutoCAD, and MS Excel.

We conclude that Staad Pro is a very powerful tool which can save much time and is very accurate in designs.

Thus it is concluded that Staad Pro package is suitable for the design of a multi storeyed building.

Assumptions and notations used:

The notations adopted throughout the work is same IS-456-2000

Assumptions

1. Using partial safety factor for loads in accordance with clause 36.4 of IS-456-2000 as 1.5
2. Partial safety factor for material in accordance with clause 36.4.2 of IS-456-2000 taken as 1.5 for concrete and 1.15 for steel.
3. Using partial safety factors in accordance with clause 36.4 of IS-456-2000 combination of load as D.L+L.L or D.L+L.L+W.L.

Density of materials used:

MATERIAL	DENSITY
1) Plain concrete	24 KN/m^3
2) Reinforced concrete	25 KN/m^3
3) Flooring material	20 KN/m^3
4) Brick masonry	19 KN/m^3
5) Fly ash	5 KN/m^3

LIVE LOADS: In accordance with IS:875-86

1) Live loads on slabs – 3 KN/m^3

2) Live loads on beams – 4 KN/m^3

3) Live loads on stairs – 2 KN/m^3

DESIGN CONSTANTS:

Using M_{30} grade concrete and Fe 415 grade steel for beams, slabs, footings, columns.

Therefore:-

f_{ck} = Characteristic strength of concrete – 30 N/mm^2

f_y = yield strength of steel – 415 N/mm^2

Assumptions regarding design:

1) Slab is assumed to be continuous over interior support and partially fixed on edges, due to monolithic construction and due to construction of walls over it.

2) Beams are assumed to be continuous over interior support and they frame into the column at ends.

Assumptions on design:

1) M_{30} grade concrete is used.

2) Fe 415 is used for both main and distribution reinforcement.

3) Fe 250 is used for shear reinforcement.

INTRODUCTION

INTRODUCTION:

Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses.

Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. The security civic sense of the responsibility. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses.

Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout, etc, of the buildings. Draughtsmen are responsible for doing the drawing works of building as for the direction of engineers and architects. The draughtsman must know his job and should be able to follow the instruction of the engineer and should be able to draw the required drawing of the building, site plans and layout plans etc, as for the requirements.

A building frame consists of number of bays and storey. A multi-storey, multi-panelled frame is a complicated statically indeterminate structure. A design of R.C building of G+4 storey frame work is taken up. The building in plan (48*48) consists of columns built monolithically forming a network. The size of building is 48*48 ft. The numbers of columns are . it is residential building.

The design is made using software on structural analysis design (Staad-pro). The building subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and wind load as **per IS 875**. The building is designed as two dimensional vertical frame and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per **IS 456-2000**. The help is taken by software available in institute and the computations of loads, moments and shear forces and obtained from this software.

1.1 Early modern and the industrial age:

With the emerging knowledge in scientific fields and the rise of new materials and technology, architecture engineering began to seperate, and the architect began to concentrate on aesthetics and the human aspects, often at the expense of technical aspects of building design.

Meanwhile, the industrial revolution laid open the door for mass production and consumption. Aesthetics became a criterion for the middle class as ornamental products, once within the province of expensive craftsmanship, became cheaper under machine production.

Vernacular architecture became increasingly ornamental. House builders could use current architectural design in their work by combining features found in pattern books and architectural journals.

1.1.1 Modern architecture:

The dissatisfaction with such a general situation at the turn of the 20th century gave rise to many new lines of thought that served as precursors to modern architecture. Notable among these is detachers' derkbund, formed in 1907 to produce better quality machine made objects. The rise of the profession of industrial design is usually placed here. Following this lead, the Bauhaus school, founded in Weimar, Germany in 1919, redefined the architectural bounds prior set throughout history viewing the creation of a building as the ultimate synthesis—the apex—of art, craft and technology.

When modern architecture was first practiced, it was an avant-garde moment with moral, philosophical, and aesthetic underpinning. Immediately after World War I, pioneering modernist architects sought to develop a completely new style appropriate for a new post-war social and economic order, focused on meeting the needs of the middle and working classes. They rejected the architectural practice of the academic refinement of historical styles which served the rapidly declining aristocratic order.

1.2 Statement of project

Salient features:

Utility of building	Residential Building
No of stories	G+4
Shape of the building	Apartment
No of stair cases	10
No. of flats	4

Type of Construction:

Types of walls	**B**rick wall

Geometric details:

Ground floor	12 feet
Floor to floor height	12 feet.
Height of plinth	0.6m
Depth of foundation	500mm

Materials

Concrete grade	M30
All steel grades	Fe415 grade
Bearing capacity of soil	200KN/M^2

1.3 Literature review:

Method of analysis of statistically indeterminate portal frames:

1. Method of flexibility coefficients.

2. Slope displacements methods(iterative methods)

3. Moment distribution method

4. Kani's method

5. Cantilever method

6. Portal method

7. Matrix method

8. STAAD Pro

1.3.1 Method of flexibility coefficients:

The method of analysis comprises reducing the hyper static structure to a determinate structure form by:

Removing the redundant support (or) introducing adequate cuts (or) hinges.

Limitations:

It is not applicable for degree of redundancy>3.

1.3.2 Slope displacement equations:

It is advantageous when kinematic indeterminacy <static indeterminacy. This procedure was first formulated by axle bender in 1914 based on the applications of compatibility and equilibrium conditions.

The method derives its name from the fact that support slopes and displacements are explicitly comported. Set up simultaneous equations is formed the solution of these parameters and the joint moment in each element or computed from these values.

Limitations:

A solution of simultaneous equations makes methods tedious for manual computations. This method is not recommended for frames larger than too bays and two storeys.

Iterative methods:

These methods involve distributing the known fixed and moments of the structural member to adjacent members at the joints in order satisfy the conditions of compatibility.

Limitations of hardy cross method:

It presents some difficulties when applied to rigid frame especially when the frame is susceptible to side sway. The method cannot be applied to structures with intermediate hinges.

1.3.3 Kani's method:

This method over comes some of the disadvantages of Hardy cross method. Kani's approach is similar to H.C.M to that extent it also involves repeated distribution of moments at successive joints in frames and continues beams. However there is a major difference in distribution process of two methods. H.C.M distributes only the total joint moment at any stage of iteration.

The most significant feature of Kani's method is that process of iteration is self corrective. Any error at any stage of iterations corrected in subsequent steps consequently skipping a few steps error at any stage of iteration is corrected in subsequent consequently skipping a few steps of iterations either by over sight of by intention does not lead to error in final end moments.

Advantages:

- It is used for side way of frames.

Limitations:

- The rotational of columns of any storey should be function a single rotation value of same storey.
- The beams of storey should not undergo rotation when the column undergoes translation. That is the column should be parallel.
- Frames with intermediate hinges cannot be analysis.

1.3.4 Approximate method:

Approximate analysis of hyper static structure provides a simple means of obtaining a quick Solution for preliminary design. It makes Some simplifying assumptions regarding Structural behaviour so to obtain a rapid solution to complex structures.

The usual process comprises reducing the given indeterminate configuration to a determinate structural system by introducing adequate no of hinges. it is possible to sketch the deflected profile of the structure for the given loading and hence by locate the print inflection.

Since each point of inflection corresponds to the location of zero moment in the structures. The inflection points can be visualized as hinges for the purpose of analysis. The solution of structures is sundered simple once the inflection points are located. The loading cases are arising in multi-storeyed frames namely horizontal and vertical loading. The analysis carried out separately for these two cases.

Horizontal cases:

The behaviour of a structure subjected to horizontal forces depends upon its heights to width ratio among their factor. It is necessary ti differentiate between low rise and high rise frames in this case.

Low rise structures:

- Height < width
- It is characterized predominately by shear deformation.

High rise buildings:

- Height > width
- It is dominated by bending action

Matrix analysis of frames:

The individual elements of frames are oriented in different directions unlike those of continues beams so their analysis is more complex neverthless the rudimentary flexibility and stiffness methods are applied to frames stiffness method is more useful because its adaptability to computer programming stiffness method is used when degree of redundancy is greater than degree of freedom. However stiffness method is used degree of freedom is greater than degree of redundancy especially for computers.

1.4 Design of multi storied residential building:

General:

A structure can be defined as a body which can resist the applied loads without appreciable deformations.

Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures.

Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system.

The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution.

The objective of the design is

1. Foundation design
2. Column design
3. Beam design
4. Slab design
5. Stair case design

These all are designed under limit state method

1.4.1 Limit state method:

The object of design based on the limit state concept is to achieve an acceptability that a structure will not become unserviceable in its life time for the use for which it is intended. I.e it will not reach a limit state. In this limit state method all relevant states must be considered in design to ensure a degree of safety and serviceability.

Limit state:

The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state.

Limit state of collapse:

This is corresponds to the maximum load carrying capacity.

Violation of collapse limit state implies failures in the source that a clearly defined limit state of structural usefulness has been exceeded. However it does not mean complete collapse.

This limit state corresponds to :

a) Flexural
b) Compression
c) Shear
d) Torsion

Limit state of serviceability:

This state corresponds to development of excessive deformation and is used for checking member in which magnitude of deformations may limit the rise of the structure of its components.

a) Deflection
b) Cracking
c) Vibration

SOFTWARES

This project is mostly based on software and it is essential to know the details about these software's.

List of software's used

1. Staad pro(v8i)

2. Staad foundations 5(v8i)

3. Auto cad

Staad pro **Staad Foundations** **Auto Cad**

STAAD

Staad is powerful design software licensed by Bentley. Staad stands for structural analysis and design

Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. this we do after the analysis.

To calculate S. F.D and B. M. D of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour's staad is a best alternative for high rise buildings.

Now a days most of the high rise buildings are designed by Staad which makes a compulsion for a civil engineer to know about this software. These software can be used to carry rcc, steel, bridge , truss etc according to various country codes.

2.1 Alternatives for Staad:

Struts, robot, sap, adds pro which gives details very clearly regarding reinforcement and manual calculations. But these software's are restricted to some designs only where as Staad can deal with several types of structure.

2.2 Staad Editor:

Staad has very great advantage to other software's i.e., Staad editor. staad editor is the programming. For the structure we created and loads we taken all details are presented in programming format in staad editor. This program can be used to analyze another structures also by just making some modifications, but this require some programming skills. So load cases created for a structure can be used for another structure using staad editor.

Limitations of Staad pro:

1. Huge output data
2. Even analysis of a small beam creates large output.
3. Unable to show plinth beams.

2.3 Staad foundation:

Staad foundation is a powerful tool used to calculate different types of foundations. It is also licensed by Bentley software's. All Bentley software's cost about 10 lakhs and so all engineers can't use it due to heavy cost.

Analysis and design carried in Staad and post processing in staad gives the load at various supports. These supports are to be imported into this software to calculate the footing details i.e., regarding the geometry and reinforcement details.

This software can deal different types of foundations

SHALLOW (D<B)

1. Isolated (Spread) Footing
2. Combined (Strip) Footing
3. Mat or Raft Foundation

DEEP (D>B)

1.Pile Cap

2. Driller Pier

1. Isolated footing is spread footing which is common type of footing.

2. Combined Footing or Strap footing is generally laid when two columns are very near to each other.

3. Mat foundation is generally laid at places where soil has less soil bearing capacity.

4. Pile foundation is laid at places with very loose soils and where deep excavations are required.

So depending on the soil at type we has to decide the type of foundation required.

Also lot of input data is required regarding safety factors, soil, materials used should be given in respective units.

After input data is give software design the details for each and every footing and gives the details regarding

1. Geometry of footing

2. Reinforcement

3. Column layout

4. Graphs

5. Manual calculations

These details will be given in detail for each and every column.

Another advantage of foundations is even after the design; properties of the members can be updated if required.

The following properties can be updated

- Column Position
- Column Shape
- Column Size
- Load Cases
- Support List

It is very easy deal with this software and we don't have any best alternative to this.

AutoCAD:

AutoCAD is powerful software licensed by auto desk. The word auto came from auto desk company and cad stands for computer aided design. AutoCAD is used for drawing different layouts, details, plans, elevations, sections and different sections can be shown in auto cad.

It is very useful software for civil, mechanical and also electrical engineer.

The importance of this software makes every engineer a compulsion to learn this software’s.

We used AutoCAD for drawing the plan, elevation of a residential building. We also used AutoCAD to show the reinforcement details and design details of a stair case.

AutoCAD is a very easy software to learn and much user friendly for anyone to handle and can be learn quickly. Learning of certain commands is required to draw in AutoCAD.

PLAN AND ELEVATION

PLAN

The auto cad plotting represents the plan of a G+4 building. The plan clearly shows the entire view of an apartment.

In an apartment the entire floor consists of 4 flats where each flat consists a double bed room house. It represents a rich locality with huge areas for each house.

It is a G+4 proposed building, So for 4 floors we have 4*4=16 flats.

The plan shows the details of dimensions of each and every room and the type of room and orientation of the different rooms like bed room, bathroom, kitchen, hall etc.. All the flats in an apartment have similar room arrangement.

The entire plan area is about 580 sq. m. Cellar is provided to the building for parking of vehicles. The plan gives details of arrangement of various furniture like sofa etc.

The plan also gives the details of location of stair cases. We have 2 stair cases for each floor and designing of stair case is shown.

So these represent the plan of our building and detailed explanation of remaining parts like elevations and designing is carried in the next sections.

Elevation:

AutoCAD drawing represents the proposed elevation of building. It shows the elevation of a G+4 building representing the front view which gives the overview of a building block.

The figure represents the site picture of our structure which are taken at the site .the building is actually under constructions and all the analysis and design work is completed before the beginning of the project.

Each floor consists of height 3.2m and ground floor is of height 3m which is taken as per GHMC rules for residential buildings.

The building is not designed for increasing the number of floors in future. So the number of floors is fixed for future also for this building due to unavailability of the permissions of respective authorities.

Also special materials like fly ash and self-compacted concrete were also used in order to reduce the dead load and increase life of the structure and also improve economy. But these materials were not considered while designing in staad to reduce the complexity and necessary corrections are made for considering the economy and safety of the structure as it is a very huge building with 16 flats.

The below figure represents the centre line diagram of our building in Staad pro. Each support represents the location of different columns in the structure. This structure is used in generating the entire structure using a tool called translational repeat and link steps. After using the tool the structure that is created can be analyzed in Staad pro under various loading cases.

Below figure represents the skeletal structure of the building which is used to carry out the analysis of our building.

All the loadings are acted on this skeletal structure to carry out the analysis of our building. This is not the actual structure but just represents the outline of the building in staad pro. A mesh is automatically created for the analysis of these building.

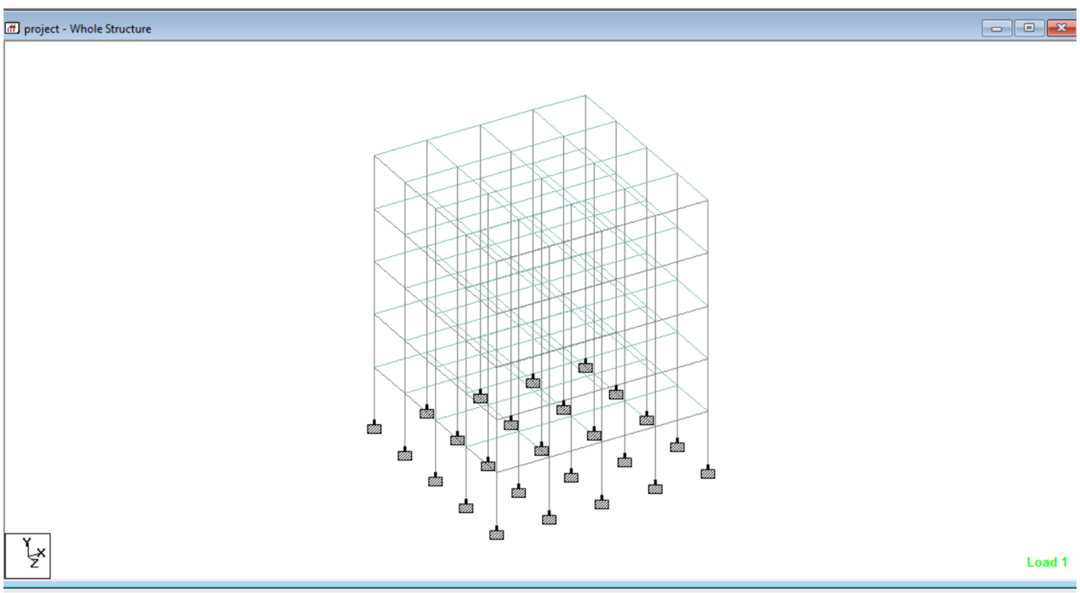


Fig 3.2-b: Skeletal structure of the building

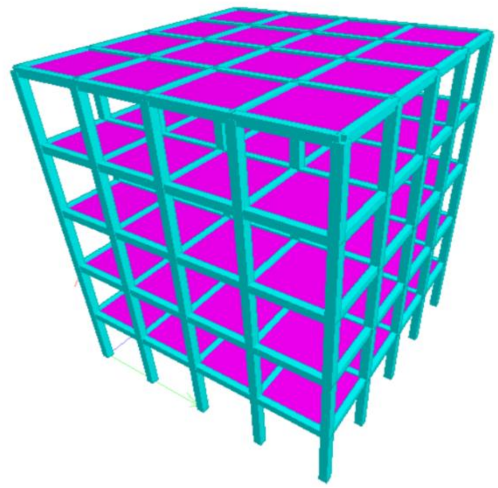


Fig 3.2-c shows 3-D view of the structure

LOADINGS

4.1 Load Conditions and Structural System Response :

The concepts presented in this section provide an overview of building loads and their effect on the structural response of typical wood-framed homes. As shown in Table, building loads can be divided into types based on the orientation of the structural action or forces that they induce: vertical and horizontal (i.e., lateral) loads. Classification of loads are described in the following sections.

4.2 Building Loads Categorized by Orientation:

Types of loads on an hypothetical building are as follows.

- Vertical Loads
- Dead (gravity)
- Live (gravity)
- Snow(gravity)
- Wind(uplift on roof)
- Seismic and wind (overturning)
- Seismic(vertical ground motion)

4.2.1 Vertical Loads :

Gravity loads act in the same direction as gravity (i.e., downward or vertically) and include dead, live, and snow loads. They are generally static in nature and usually considered a uniformly distributed or concentrated load. Thus, determining a gravity load on a beam or column is a relatively simple exercise that uses the concept of tributary areas to assign loads to structural elements, including the dead load (i.e., weight of the construction) and any applied loads(i.e., live load). For example, the tributary gravity load on a floor joist would include the uniform floor load(dead and live) applied to the area of floor supported by the individual joist. The structural designer then selects a standard beam or column model to analyze bearing connection forces (i.e., reactions) internal stresses (i.e., bending stresses, shear stresses, and axial stresses) and stability of the structural member or system a for beam equations.

The selection of an appropriate analytic model is, however no trivial matter, especially if the structural system departs significantly from traditional engineering assumptions are particularly relevant to the structural systems that comprise many parts of a house, but to varying degrees. Wind uplift forces are generated by negative (suction) pressures acting in an outward direction from the surface of the roof in response to the aerodynamics of wind flowing over and around the building.

As with gravity loads, the influence of wind up lift pressures on a structure or assembly(i.e., roof) are analyzed by using the concept of tributary areas and uniformly distributed loads. The major difference is that wind pressures act perpendicular to the building surface (not in the direction of gravity) and that pressures vary according to the size of the tributary area and its location on the building, particularly proximity to changes in geometry (e.g., eaves, corners, and ridges).Even though the wind loads are dynamic and highly variable, the design approach is based on a maximum static load (i.e., pressure) equivalent. Vertical forces are also created by overturning reactions due to wind and seismic lateral loads acting on the overall building and its lateral force resisting systems, Earthquakes also produce vertical ground motions or accelerations which increase the effect of gravity loads. However, Vertical earthquake loads are usually considered to be implicitly addressed in the gravity load analysis of a light-frame building.

4.2.2 Horizontal (Lateral) Loads:

Direction of loads is horizontal w.r.t to the building.

- Wind
- Seismic(horizontal ground motion)
- Flood(static and dynamic hydraulic forces
- Soil(active lateral pressure)

The primary loads that produce lateral forces on buildings are attributable to forces associated with wind, seismic ground motion, floods, and soil. Wind and seismic lateral loads apply to the entire building. Lateral forces from wind are generated by positive wind pressures on the windward face of the building and by negative pressures on the leeward face of the building, creating a combined push and-pull effect. Seismic lateral forces are generated by a structure's dynamic inertial response to cyclic ground movement.

The magnitude of the seismic shear (i.e., lateral)load depends on the magnitude of the ground motion, the buildings mass, and the dynamic structural response characteristics(i.e., dampening, ductility ,natural period of vibration ,etc).for houses and other similar low rise structures, a simplified seismic load analysis employs equivalent static forces based on fundamental Newtonian mechanics(F=ma) with somewhat subjective(i.e., experience-based) adjustments to account for inelastic, ductile response characteristics of various building systems. Flood loads are generally minimized by elevating the structure on a properly designed foundation or avoided by not building in a flood plain.

Lateral loads from moving flood waters and static hydraulic pressure are substantial. Soil lateral loads apply specifically to foundation wall design, mainly as an “out-of-plane” bending load on the wall. Lateral loads also produce an overturning moment that must be offset by the dead load and connections of the building.

Therefore, overturning forces on connections designed to restrain components from rotating or the building from overturning must be considered.

Since wind is capable of the generating simultaneous roof uplift and lateral loads, the uplift component of the wind load exacerbates the overturning tension forces due to the lateral component of the wind load. Conversely the dead load may be sufficient to offset the overturning and uplift forces as is the case in lower design wind conditions and in many seismic design conditions.

4.3 Structural systems :

As far back as 1948,it was determined that “conventions in general use for wood, steel and concrete structures are not very helpful for designing houses because few are applicable”(NBS,1948).More specifically, the NBS document encourages the use of more advanced methods of structural analysis for homes. Unfortunately. the study in question and all subsequent studies addressing the topic of system performance in housing have not led to the development or application of any significant improvement in the codified design practice as applied to housing systems.

This lack of application is partly due to conservative nature of the engineering process and partly due to difficulty of translating the results of narrowly focused structural systems studies to general design applications. Since this document is narrowly scoped to address residential construction, relevant system

Based studies and design information for housing are discussed, referenced, and applied as appropriate. If a structural member is part of system, as it typically the case in light frame residential construction, its response is altered by the strength and stiffness characteristics of the system as a whole.

In general, system performance includes two basic concepts known as load sharing and composite action. Load sharing is found in repetitive member systems(i.e., wood framing) and reflects the ability of the load on one member to be shared by another or, in the case of a uniform load, the ability of some of the load on a weaker member to be carried by adjacent members. Composite action is found in assemblies of components that, when connected to one another, from a "composite member" with greater capacity and stiffness than the sum of the component parts.

However, the amount of composite action in a system depends on the manner in which the various elements are connected. The aim is to achieve a higher effective section modulus than the component members are taken separately. For example, when floor sheathing is nailed and glued to floor joists, the floor system realizes a greater degree of composite action than a floor with sheathing that is merely nailed; the adhesive between components helps prevents shear slippage, particularly if a rigid adhesive is used.

Slippage due to shear stresses transferred between the component parts necessitates consideration of partial composite action, which depends on the stiffness of an assembly's connections. Therefore, consideration of the floor system of fully composite T-beams may lead to an un conservative solution.

Whereas the typical approach of only considering the floor joist member without composite system effect will lead to a conservative design. This guide addresses the strength-enhancing effect of sharing and partial composite action when information is available for practical design guidance. Establishment of repetitive member increase factors (also called system factors) for general design use is a difficult task because the amount of system effect can vary substantially depending on system assembly and materials.

Therefore, system factors for general design use are necessarily conservative to cover broad conditions. Those that more accurately depict system effects also require a more exact description of and compliance with specific assembly details and material specifications. It should be recognized however that system effects do no t only affect the strength and stiffness of light-frame assemblies(including walls, floors and roofs).They also alter the classical understanding of how loads are transferred among the various assemblies of a complex wood-framed home. For example, floor joists are sometimes doubled under non load-bearing partition walls "because of the added dead load and resulting stresses" determined in accordance with accepted engineering practice.

Such practice is based on a conservative assumption regarding a load path and the structural response. That is, the partition wall does create an additional load, but the partition wall is relatively rigid and actually acts as a deep beam, particularly when the top and bottom are attached to the ceiling and floor framing, respectively. As the floor is loaded and deflects, the interior wall helps resist the load. Of course, the magnitude of effect depends on the wall configuration (i.e., amount of openings) and other factor. The above example of composite action due to the interaction of separate structural systems or subassemblies points to the improved structural response of the floor system such that it is able to carry more dead and live than if the partition wall were absent .on whole-house assembly test has demonstrated this effect (Hurst,1965).Hence ,a double joist should not be required under a typical non load-bearing partition; In fact, a single joist may not even be required directly below the partition, assuming that the floor sheeting is adequately specified to support the partition between the joists. While this condition cannot yet be duplicated in a standard analytic form conductive to simple engineering analysis, A designer should be aware of the concept when making design assumption regarding light frame residential constructions.

At this point, the readership should consider that the response of a structural system, Not just its individual elements, determines the manner in which a structure distributes and resists horizontal and vertical loads.

For wood framed systems, the departure from calculations based are classical engineering mechanics (i.e., single members with standard tributary areas and assumed elastic behavior)and simplistic assumptions regarding load path can be substantial.

4.4 Design loads for residential buildings:

General

Loads are a primary consideration in any building design because they define the nature and magnitude of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability)throughout the structure’s useful life. The anticipated loads are influenced by a building’s intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions).Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration.

Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. While the buildings considered in this guide are primarily single-family detached and attached dwellings, the principles and concepts related to building loads also apply to other similar types of construction, such as low-rise apartment buildings. In general, the design loads recommended in this guide are based on applicable provisions of the ASCE 7 standard-Minimum Design ;loads for buildings and other structures (ASCE,1999).the ASCE 7 standard represents an acceptable practice for building loads in the United states and is recognized in virtually all U.S. building codes. For this reason, the reader is encouraged to become familiar with the provisions, commentary, and technical references contained in the ASCE 7 standard. In general structural design of housing has not been treated as a unique engineering discipline or subjected to a special effort to develop better, more efficient design practices. Therefore, this part of the guide focuses on those aspects aspects of ASCE 7 and other technical resources that are particularly relevant to the determination of design loads for residential structures.

The guide provides supplemental design assistance to address aspects of residential construction where current practice is either silent or in need of improvement. Residential buildings methods for determining design loads are complete yet tailored to typical residential conditions. as with any design function, the designer must ultimately understand and approve the loads for a given project as well as the overall design methodology, including all its inherent strengths and weakness.

Since building codes tend to vary in their treatment of design loads the designer should, as a matter of due diligence, identify variances from both local accepted practice and the applicable code relative to design loads as presented in this guide, even though the variances may be considered technically sound.

Complete design of a home typically requires the evaluation of several different types of materials. Some material specifications use the allowable stress design (ASD) approach while others use load and resistance factor design (LRFD).

4.4.1 Dead Loads:

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.

In Staad pro assignment of dead load is automatically done by giving the property of the member.

In load case we have option called self weight which automatically calculates weights using the properties of material i.e., density and after assignment of dead load the skeletal structure looks red in colour as shown in the figure.

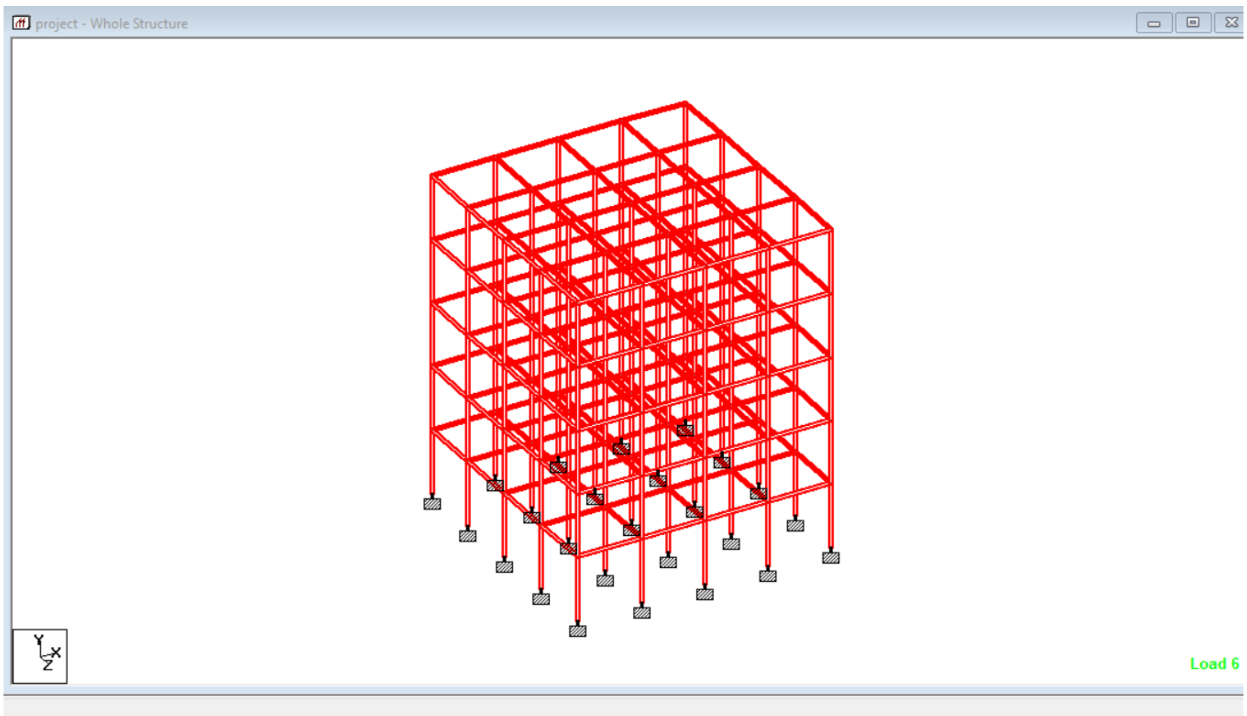


Fig 4.4.1a Fig showing Dead load

Dead load calculation:

Weight=Volume x Density

Self weight floor finish=0.12*25+1=3kn/m^2

The above example shows a sample calculation of dead load.

Dead load is calculated as per **IS 875 part 1**

4.4.2 Live Loads:

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously n a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in end-use conditions. For example, The stair load of 2 kN/m^2 should be applied to the centre of the stair tread between supports.

In Staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below. Live loads are calculated as per **IS 875 part 2.**

For our structure live load is taken as **4 kN/m^2** for design.

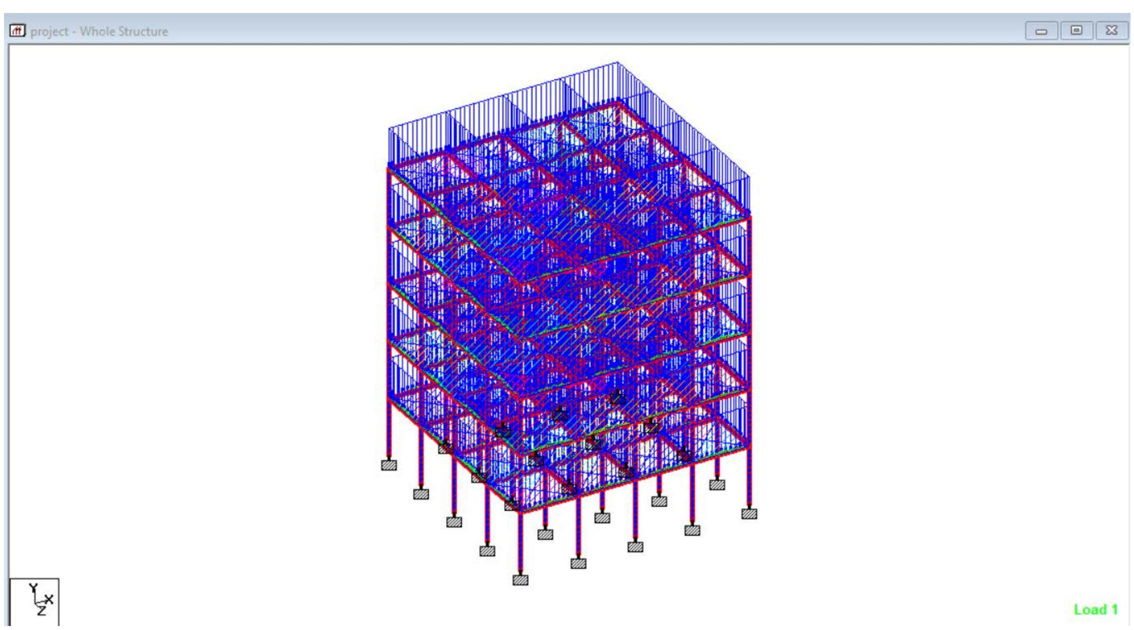


Fig 4.4.2a Fig showing Live Load

4.4.3 Wind loads:

In the list of loads we can see wind load is present both in vertical and horizontal loads.

This is because wind load causes uplift of the roof by creating a negative(suction) pressure on the top of the roof.

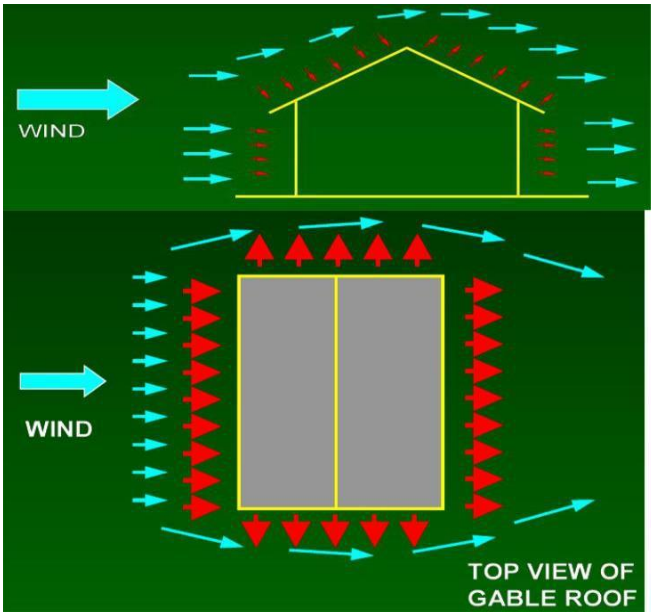


Fig 4.4.3a diagram of wind load

Wind produces non static loads on a structure at highly variable magnitudes. the variation in pressures at different locations on a building is complex to the point that pressures may become too analytically intensive for precise consideration in design. Therefore, wind load specifications attempt to amplify the design problem by considering basic static pressure zones on a building representative of peak loads that are likely to be experienced. The peak pressures in one zone for a given wind direction may not, However, occur simultaneously in other zones. For some pressure zones, The peak pressure depends on an arrow range of wind direction. Therefore, the wind directionality effect must also be factored into determining risk consistent wind loads on buildings.

In fact, most modern wind load specifications take account of wind load directionality and other effects in determining nominal design loads in some simplified form(sbcci,1999; ASCe,1999).this section further simplifies wind load design specifications to provide an easy yet effective approach for designing designing typical residential buildings. Because they vary substantially over the surface of a building. wind load star considered at two different scales. on large scale, the load produced on the overall building are on major structural systems that sustain wind loads from from more than one surface of building, are considered the main wind force resisting systems (MWFRS).the MWFRS of a home includes the shear walls, Diaphragms that create the lateral force resisting systems(LFRS).As well as the structural systems such as trusses that experience loads from two surfaces are regimes of the building.

The wind loads applied to the MWFRS account for the large affects of time varying wind pressures on the surface are surfaces of the building. On a Smaller scale, pressures are somewhat greater on localized surface area of the building, particularly near abrupt changes in building geometry (i.e., eaves, ridges, and corners). These higher wind pressures occur on smaller areas, particularly affecting the loads borne by components and cladding (e.g., sheathing, windows, doors, purling, studs).

The components and cladding (C&C) transfer localized time-varying loads to the MWFRS, at which point the loads average out both spatially and temporally since, at a given time, some components may beat near peak loads while others are at substantially less than peak.

The next section presents a simplified method for determining both MWFRS and C&C wind loads. Since the loads in the section 3.6.2 are determined for specific applications, the calculation of MWFRS and C&C wind loads is implication the values provided. Design example 3.2 in section 3.10 demonstrate the calculation of wind loads by applying the simplified method of the following section 3.6.2to several design conditions associated with wind loads and the load combinations.

Century, modernism morphed into the international style, an aesthetic epitomized in many ways by the Twin Towers of New York’s world trade center.

Many architects resisted modernism, finding it devoid of the decorative richness of ornamented styles. Yet as the of the movement lost influence in the late 1970s, postmodernism developed as a reaction against the austerity of Modernism. Robert ventures’ contention that a “decorated shed” (an ordinary building which is functionally designed inside and embellished on the outside) was better than a “Duck” (a building in which the whole form and its function are tied together) gives an idea of this approach.Assignment of wind speed is quite different compared to remaining loads.We have to define a load case prior to assignment.

After designing wind load can be assigned by calculating wind load as per **IS 875 part 3.**

4.4.3.1 Basic wind speed:

Given basic wind speed of India, as applicable to 1m height above means ground level for different zones of the country. Basic wind speed is based on peak just velocity averaged over a short time interval of about 3 seconds and corresponds to mean heights above ground level in an open terrain.

4.4.3.2 Design wind speed:

The basic wind speed (Vb) for any site shall be obtained the following effects to get design wind velocity at any height (Vz) for the chosen structure.

- Risk level
- Terrain roughness, height and size of the structure and
- Local topography

It can be mathematically expressed as follows:

Vs.=Vb* K1* K2* K3

where,

Vz= design wind speed at any height Z in m/s

K1= probability factor (risk coefficient)

K2=terrain height and structure size factor and

K3=topography factor

4.4.4 Floor load:

Floor load is calculated based on the load on the slabs. Assignment of floor load is done by creating a load case for floor load. After the assignment of floor load our structure looks as shown in the below figure.The intensity of the floor load taken is 3 kN/m^2.

-ve sign indicates that floor load is acting downwards.

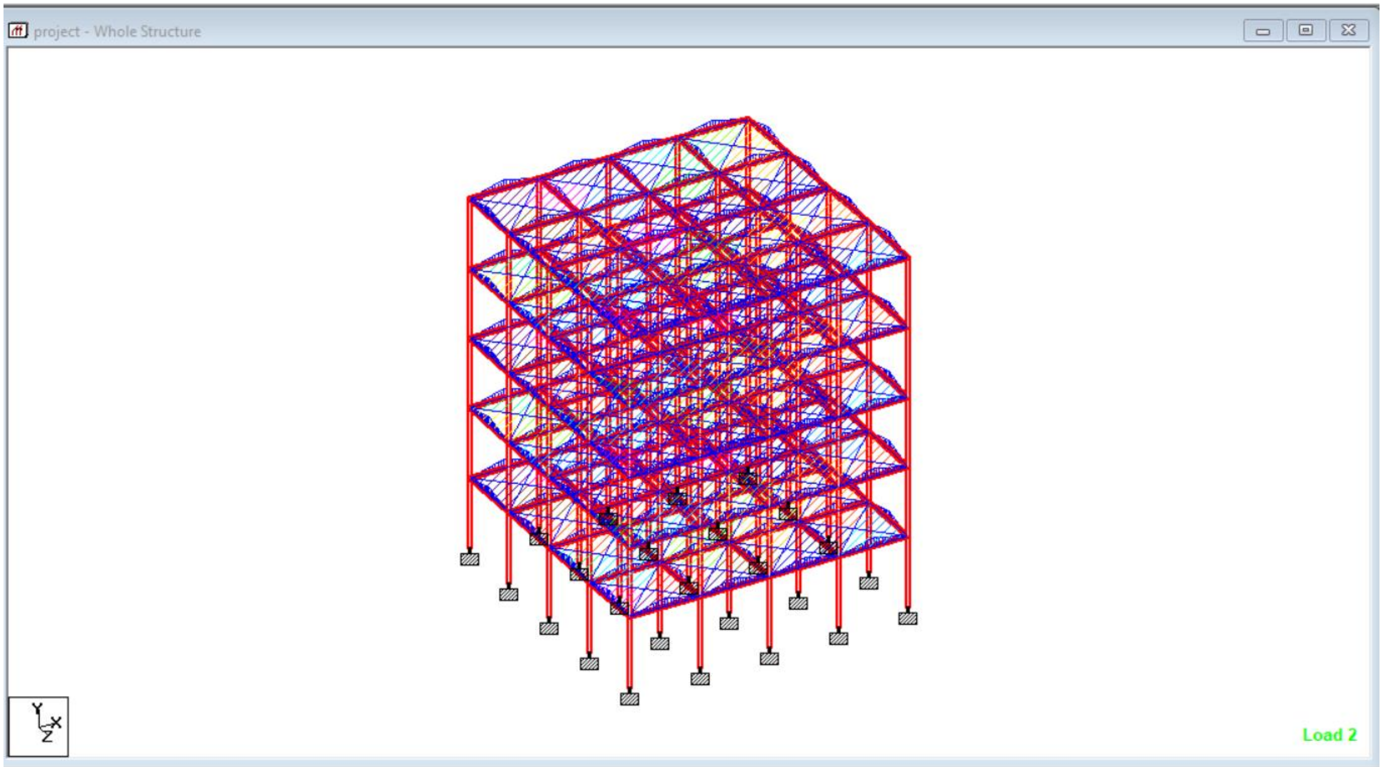


Fig 4.4.4 Diagram showing floor load

4.4.5 Load combinations:

All the load cases are tested by taking load factors and analyzing the building in different load combination as per **IS 456** and analyzed the building for all the load combinations and results are taken and maximum load combination is selected for the design.

Load factors as per **IS456-2000**

Table-4.4.5 Showing Factor of Safety

	D.L	L.L	W.L
D.L+L.L	1.5	1.5	-
D.L+L.L+W.L	1.2	1.2	1.2

When the building is designed for both wind and seismic loads maximum of both is taken.

Because wind and seismic do not come at same time as per code.

Structure is analysed by taking all the above combinations.

BEAMS

Beams transfer load from slabs to columns .beams are designed for bending.

In general we have two types of beam: single reinforced beam and double reinforced beam. Similar to columns geometry and perimeters of the beams are assigned. Design beam command is assigned and analysis is carried out, now reinforcement details are taken.

5.1 <u>Beam design:</u>

A reinforced concrete beam should be able to resist tensile, compressive and shear stress induced in it by loads on the beam.

There are three types of reinforced concrete beams

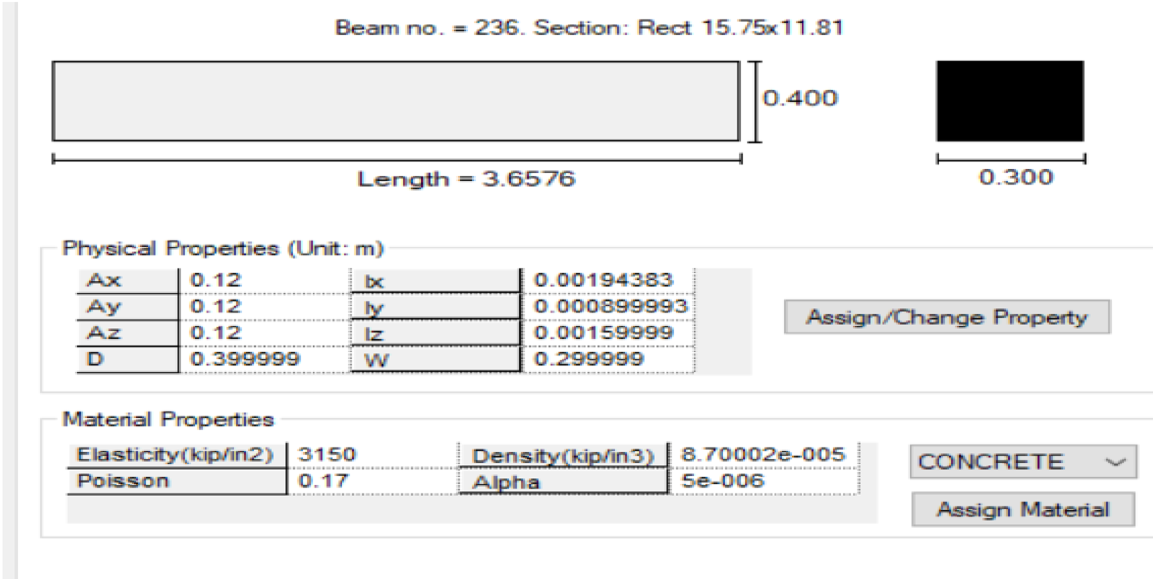
- Single reinforced beams
- Double reinforced concrete
- Flanged beams

5.1.1 Singly reinforced beams:

In singly reinforced simply supported beams steel bars are placed near the bottom of the beam where they are more effective in resisting in the tensile bending stress. In cantilever beams reinforcing bars placed near the top of the beam, for the same reason as in the case of simply supported beam.

5.1.2 Doubly reinforced concrete beams:

It is reinforced under compression tension regions. The necessity of steel of compression region arises due to two reasons. When depth of beam is restricted. The strength availability singly reinforced beam is in adequate. At a support of continuous beam where bending moment changes sign such as situation may also arise in design of a beam circular in plan.



B E A M N O. 11 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3657.6 mm SIZE: 300.0 mm X 400.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	914.4 mm	1828.8 mm	2743.2 mm	3657.6 mm
TOP REINF.	355.45 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	0.00 (Sq. mm)	339.76 (Sq. mm)
BOTTOM REINF.	0.00 (Sq. mm)	227.35 (Sq. mm)	227.35 (Sq. mm)	227.35 (Sq. mm)	0.00 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	914.4 mm	1828.8 mm	2743.2 mm	3657.6 mm
TOP REINF.	5-10í 1 layer(s)	3-10í 1 layer(s)	3-10í 1 layer(s)	3-10í 1 layer(s)	5-10í 1 layer(s)
BOTTOM REINF.	3-10í 1 layer(s)	3-10í 1 layer(s)	3-10í 1 layer(s)	3-10í 1 layer(s)	3-10í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c	2 legged 8í @ 150 mm c/c

----

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 570.0 mm AWAY FROM START SUPPORT

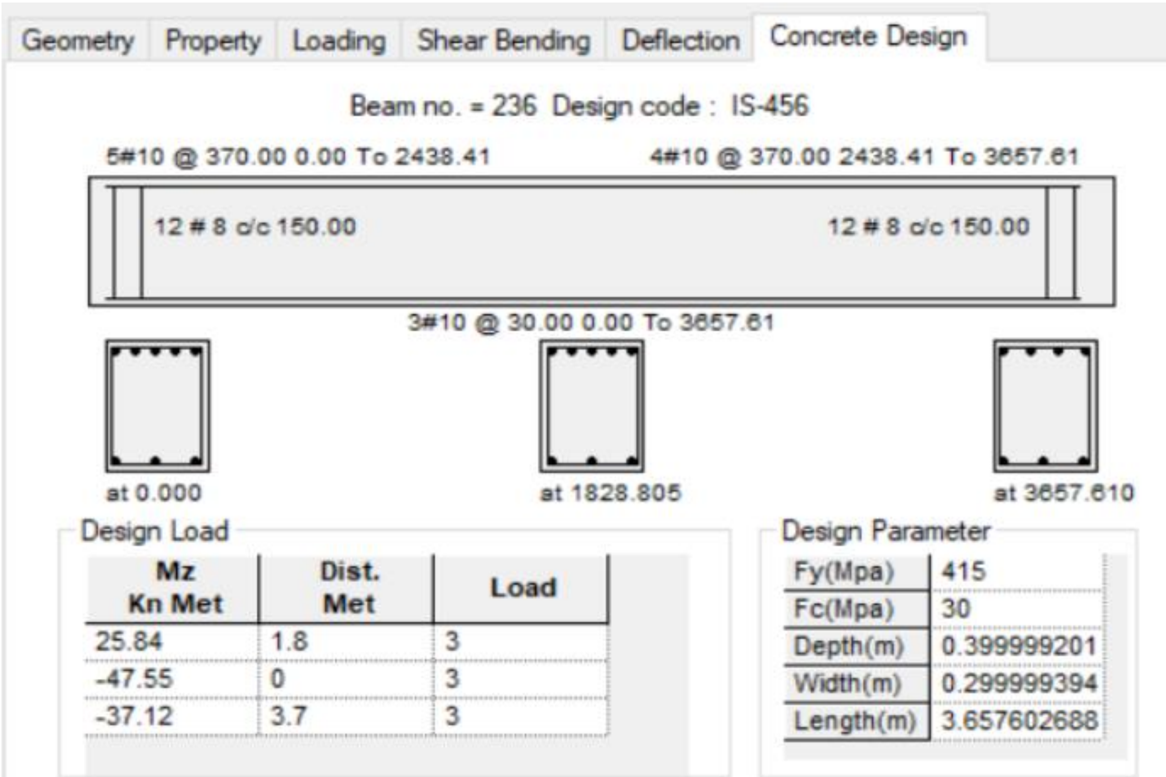
VY = 51.70 MX = 0.16 LD= 3

Provide 2 Legged 8í @ 150 mm c/c

SHEAR DESIGN RESULTS AT 570.0 mm AWAY FROM END SUPPORT

VY = -51.37 MX = 0.16 LD= 3

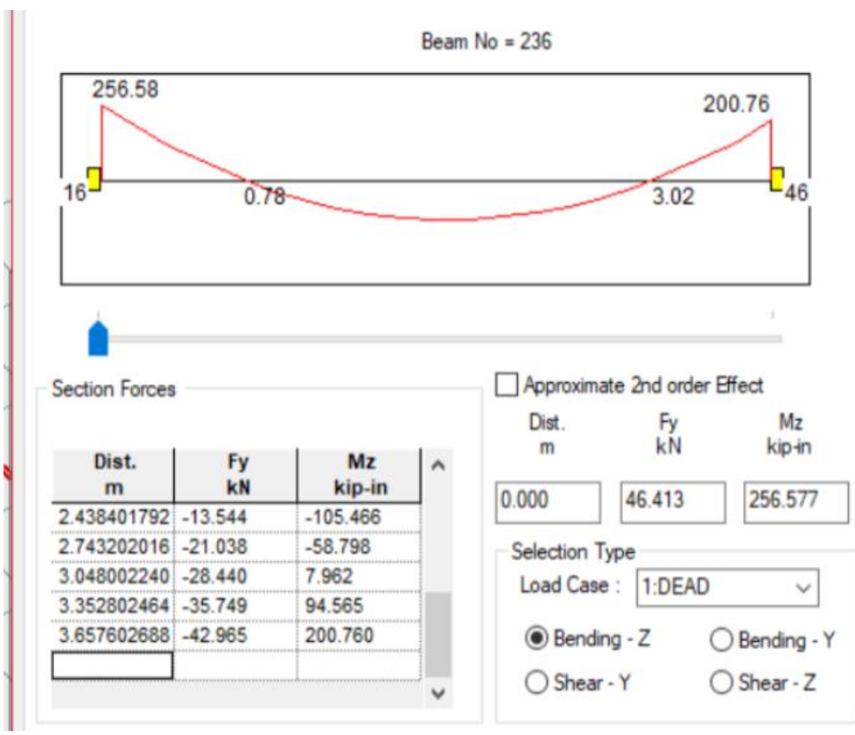
Provide 2 Legged 8í @ 150 mm c/c



Mz Kn Met	Dist. Met	Load
25.84	1.8	3
-47.55	0	3
-37.12	3.7	3

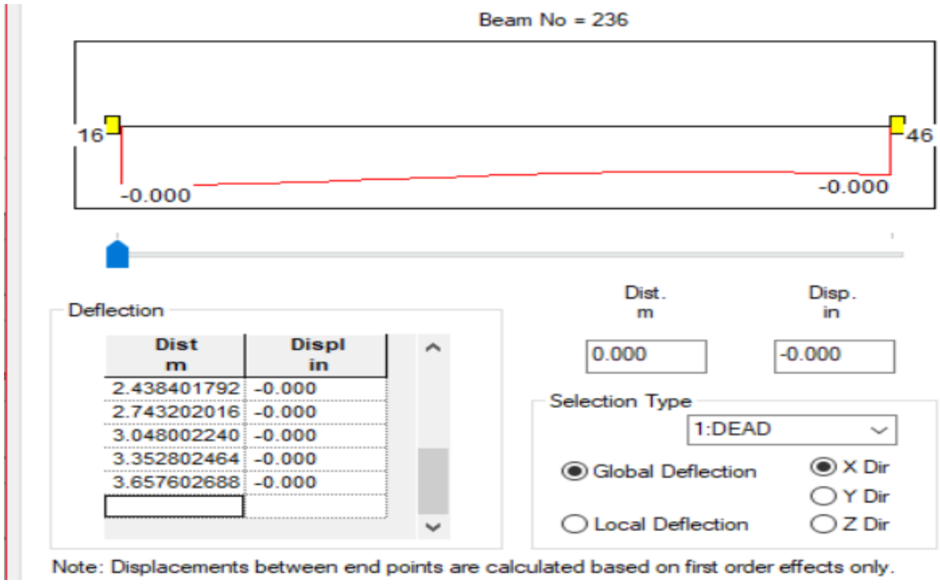
Fy(Mpa)	415
Fc(Mpa)	30
Depth(m)	0.399999201
Width(m)	0.299999394
Length(m)	3.657602688

Fig 5.3 shows the reinforcement details of the beam



Dist. m	Fy kN	Mz kip-in
2.438401792	-13.544	-105.466
2.743202016	-21.038	-58.798
3.048002240	-28.440	7.962
3.352802464	-35.749	94.565
3.657602688	-42.965	200.760

Fig 5.1 shows the shear bending of beam



Dist m	Displ in
2.438401792	-0.000
2.743202016	-0.000
3.048002240	-0.000
3.352802464	-0.000
3.657602688	-0.000

Fig 5.2 shows the deflection profile of the beam

COLUMNS

A column or strut is a compression member, which is used primary to support axial compressive loads and with a height of at least three it is least lateral dimension.

A reinforced concrete column is said to be subjected to axially loaded when line of the resultant thrust of loads supported by column is coincident with the line of C.G 0f the column I the longitudinal direction.

Depending upon the architectural requirements and loads to be supported RC columns may be cast in various shapes i.e square ,rectangle, and hexagonal ,octagonal, circular. columns of L shaped or T shaped are also sometimes used in multi-storied buildings.

The longitudinal bars in columns help to bear the load in the combination with the concrete. The longitudinal bars are held in position by transverse reinforcement, or lateral binders.

The binders prevent displacement of longitudinal bars during concreting operation and also check the tendency of their buckling towards under loads.

6.1 Positioning of columns:

Some of the guiding principles which help the positioning of the columns are as follows:-

1. Columns should be preferably located at or near the corners of the building and at the intersection of the wall, but for the columns on the property line as the following requirements some area beyond the column, the column can be shifted inside along a cross wall to provide the required area for the footing with in the property line. alternatively a combined or a strap footing may be provided.
2. The spacing between the column is governed by the lamination on spans of supported beams, as the spanning of the column decides the span of the beam. As the span of the of the beam increases, the depth of the beam, and hence the self weight of the beam and the total.

Effective length:

The effective length of the column is defined as the length between the points of contra-flexure of the buckled column. The code has given certain values of the effective length for normal usage assuming idealized and conditions shown in appendix D of IS - 456(table 24).

A column may be classified based as follows based on the type of loading:

1. Axially loaded column
2. A column subjected to axial load and uneasily bending
3. A column subjected to axial load and biaxial bending.

6.2 Axially loaded columns:

All compression members are to be designed for a minimum eccentricity of load into principal directions. In practice, a truly axially loaded column is rare, if not existent. Therefore, every column should be designed for a minimum eccentricity .clause 22.4 of IS code

e_{min}=(L/500)+(D/300) ,subjected to a minimum of 20 mm.

where L is the unsupported length of the column (see 24.1.3 of the code for definition unsupported length) and D is the lateral dimension of the column in the direction under the consideration.

6.2.1 Axial load and uniaxial bending:

A member subjected to axial force and bending shall be designed on the basis of

1) The maximum compressive strength in concrete in axial compression is taken as 0.002
2) The maximum compressive strength at the highly compressed extreme fibre in concrete subjected to highly compression and when there is no tension on the section shall be 0.0035-0.75 times the strain at least compressed extreme fibre.

Design charts for combined axial compression and bending are in the form of

intersection diagram in which curves for $P_u/(f_{ck}* bD)$ versus $M_u/f_{ck} bD^2$ are plotted for

different values of p/f_{ck} where p is reinforcement percentage.

6.2.2 Axial load and biaxial bending:

The resistance of a member subjected to axial force and biaxial bending shall be obtained on the basis of assumptions given in 38.1 and 38.2 with neutral axis so chosen as to satisfy the equilibrium of load and moment about two weeks.

Alternatively such members may be designed by the following equation:

$$(M_{ux}/ M_{uy})^2 +(M_{uy}/ M_{uy1})^2 <=1.0$$

M_{ux}&M_{uy}=moment about x and Y axis due to design loads

M_{ux1}&M_{uy1}=maximum uniaxial moment capacity for an axial load of P_u bending about x and y axis respectively.

αn is related to P_u/p_{uz}

$P_{uz}=0.45*f_{ck}*A_c+0.75*f_y*A_{sc}$

For values of P_u/P_{uz}=0.2 to 0.8, the values of αn vary linearly from 1.0 to 2.0 for values less than 0.2, αn is values greater than 0.8 , α_n is 2.0

The main duty of column is to transfer the load to the soil safely. columns are designed for compression and moment. The cross section of the column generally increase from one floor to another floor due to the addition of both live and dead load from the top floors. Also the amount if load depends on number of beams the columns is connected to. As beam transfer half of the load to each column it is connected.

6.3 Column design:

A column may be defined as an element used primary to support axial compressive loads and with a height of a least three times its lateral dimension. The strength of column depends upon the strength of materials, shape and size of cross section, length and degree of proportional and dedicational restrains at its ends.

A column may be classify based on deferent criteria such as

- Shape of the section
- Slenderness ratio(a=l+d)
- Type of loading, land
- Pattern of lateral reinforcement.

The ratio of effective column length to least lateral dimension is released to as slenderness ratio.

In our structure we have 3 types of columns.

1. Column with beams on two sides
2. Columns with beams on three sides
3. Columns with beams on four sides

So we require three types of column sections. So create three types of column sections and assign to the respective columns depending on the connection. But in these structure we adopted same cross section throughout the structure with a rectangular cross section .In foundations we generally do not have circular columns if circular column is given it makes a circle by creating many lines to increase accuracy.

The column design is done by selecting the column and from geometry page assigns the dimensions of the columns. Now analyze the column for loads to see the reactions and total loads on the column by seeing the loads design column by giving appropriate parameters like Minimum reinforcement, max, bar sizes, maximum and minimum spacing.

1. Select the appropriate design code and input design column command to all the column.
2. Now run analysis and select any column to collect the reinforcement details

The following figure shows the reinforcement details of a beam in staad.

The figure represents details regarding

1. Transverse reinforcement

2. Longitudinal reinforcement

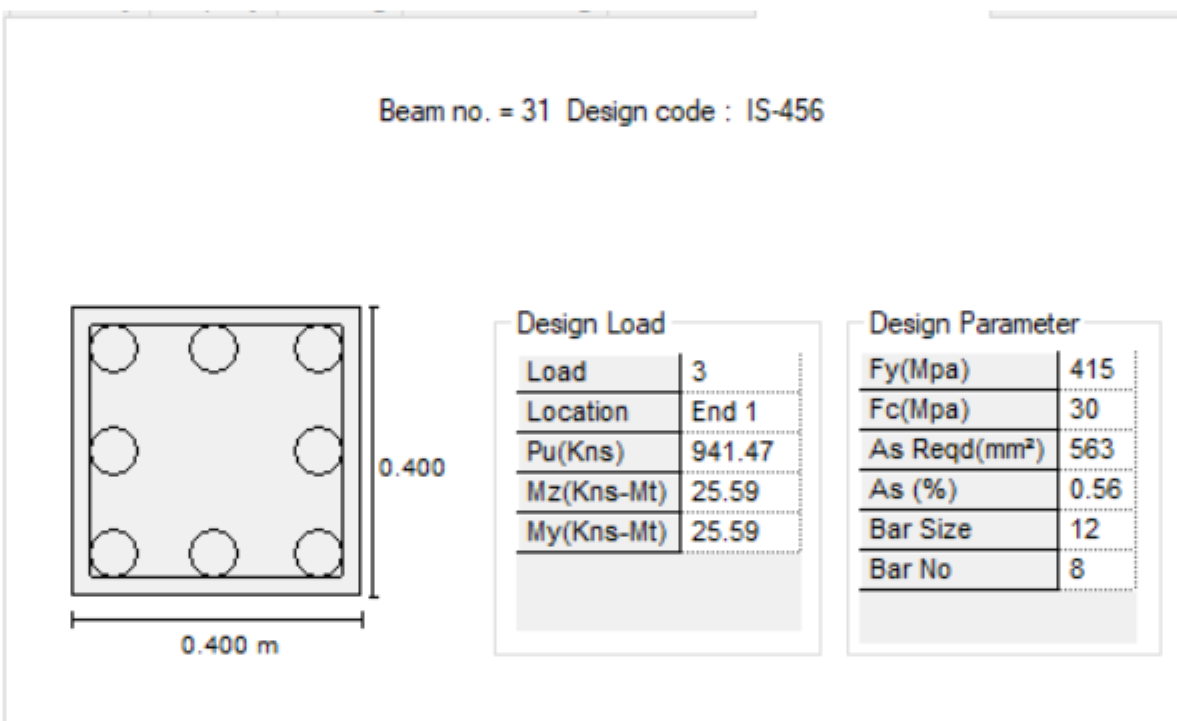


Fig 6.3a Fig showing reinforcement details of a column

Output:

Due to very huge and detailed explanation of staad output for each and every column we have shown a column design results below showing the amount of load, moments, amount of steel required, section adopted etc.The main problem with staad is it takes all columns also as beams initially before design and continue the same..

DESIGN COLUMN 21

C O L U M N N O. 21 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3657.6 mm CROSS SECTION: 400.0 mm X 400.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 3 END JOINT: 1 SHORT COLUMN

REQD. STEEL AREA : 927.24 Sq.mm.

REQD. CONCRETE AREA: 115905.10 Sq.mm.

MAIN REINFORCEMENT : Provide 4 - 20 dia. (0.79%, 1256.64 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 2436.09 Muz1 : 111.76 Muy1 : 111.76

INTERACTION RATIO: 0.23 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 3

END JOINT: 1 Puz : 2534.16 Muz : 130.84 Muy : 130.84 IR: 0.19

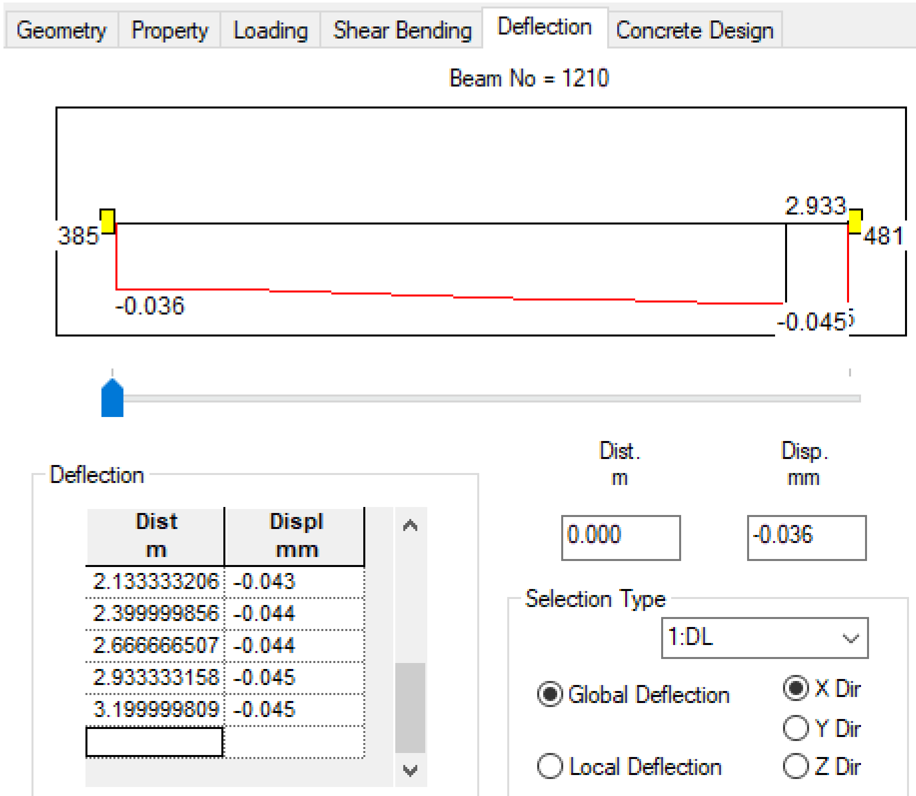
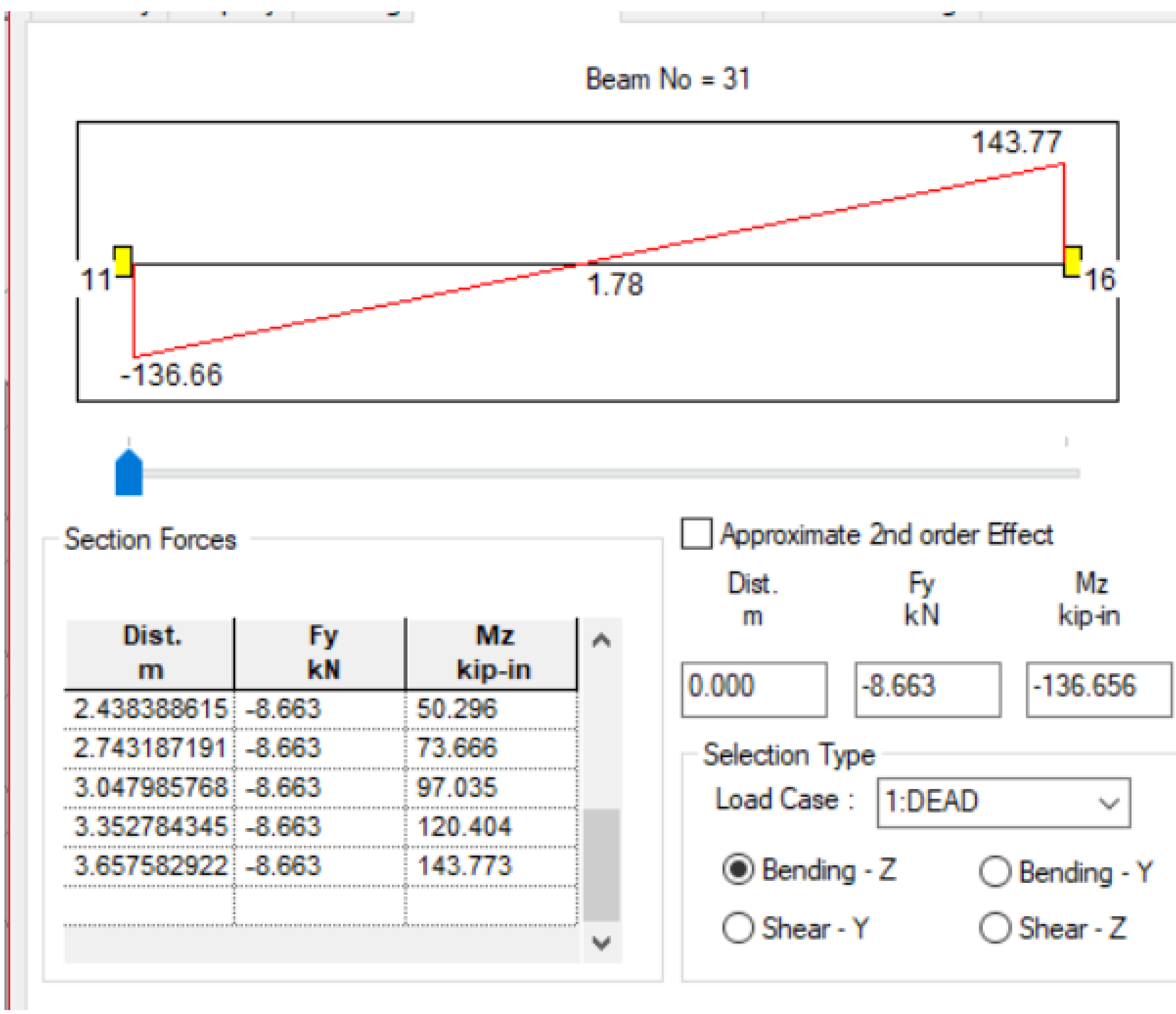


Figure 6.3b shows the deflection of column.



SLABS

7.1 Slab design:

Slab is plate elements forming floor and roofs of buildings carrying distributed loads primarily by flexure.

One way slab:

One way slab are those in which the length is more than twice the breadth it can be simply supported beam or continuous beam.

Two way slab:

When slabs are supported to four sides two ways spanning action occurs. Such as slab are simply supported on any or continuous or all sides the deflections and bending moments are considerably reduces as compared to those in one way slab.

Checks:

There is no need to check serviceability conditions, because design satisfying the span for depth ratio.

a.) Simply supported slab

b.) Continuous slab

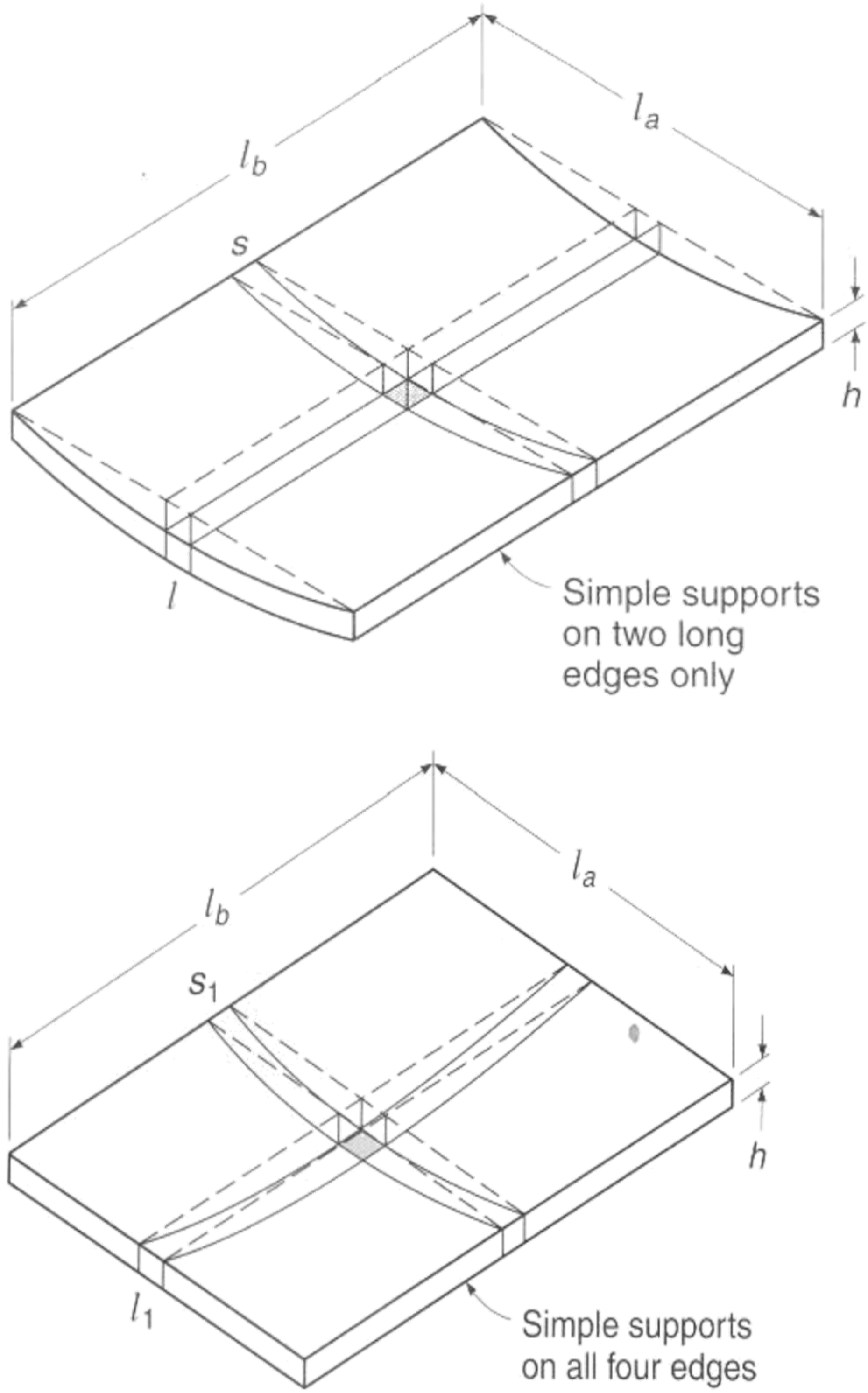


Fig 7.1. a Diagrams of slab deflection in one way and two way slabs

Following figures shows the load distributions in two slabs.

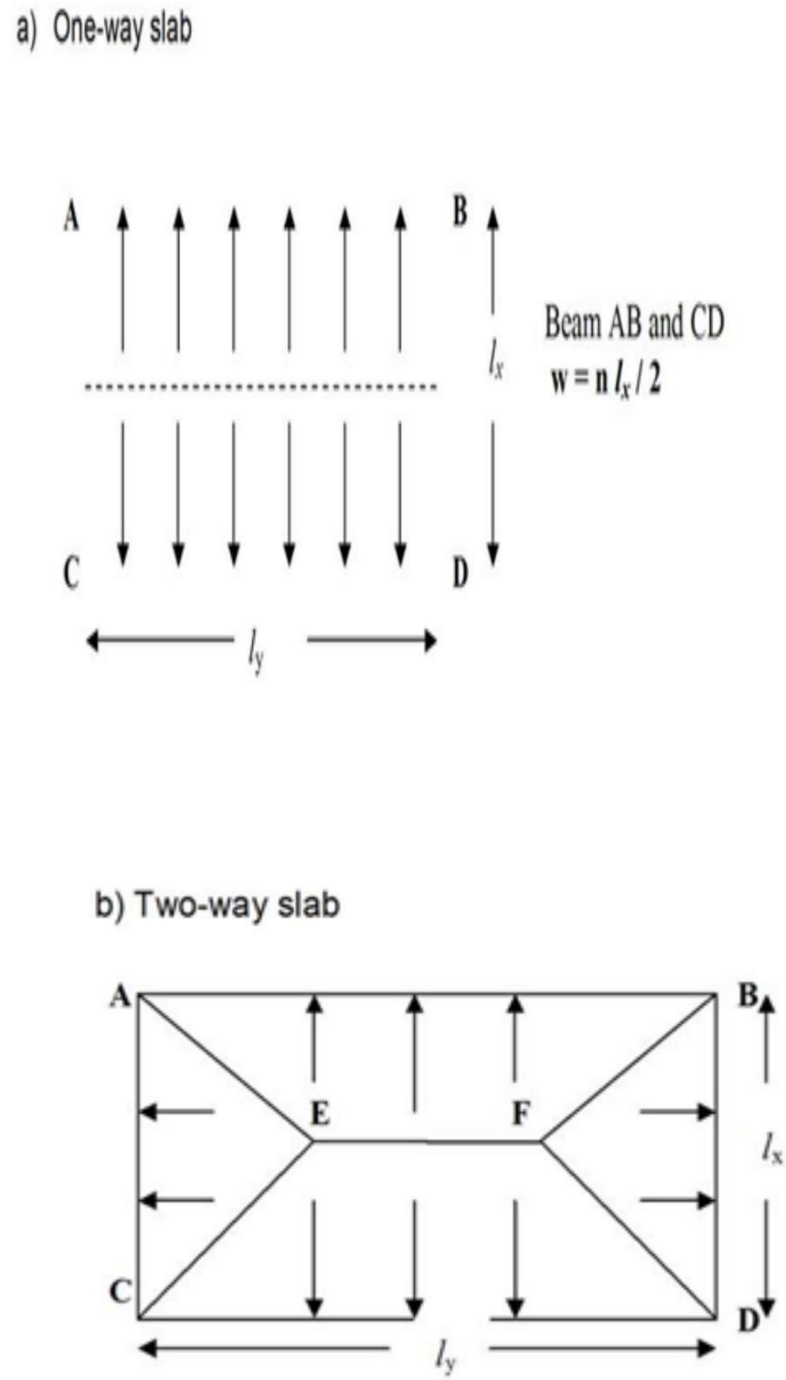


Fig 7.1.b Diagram of load distribution of one way and two way slabs

Slabs are designed for deflection. Slabs are designed based on yield theory

This diagram shows the distribution of loads in two slabs.

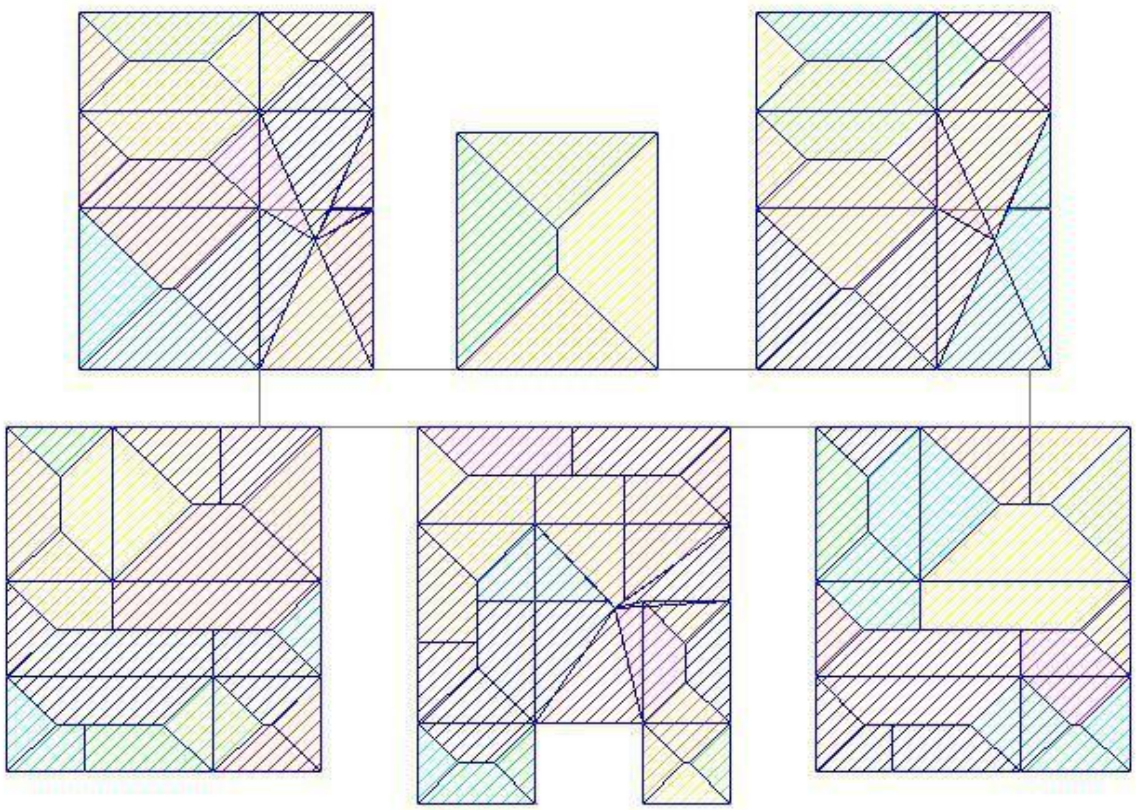


Figure 7.1.c Distribution of loads in two slabs.

In order to design a slab we has to create a plate by selecting a plate cursor. Now select the members to form slab and use form slab button. Now give the thickness of plate as 0.12 m. Now similar to the above designs give the parameters based on code and assign design slab command and select the plates and assign commands to it. After analysis is carried out go to advanced slab design page and collect the reinforcement details of the slab.

Slabs are also designed as per **IS456-2000**

The following figure shows the monolithic connection between beam, column and slab

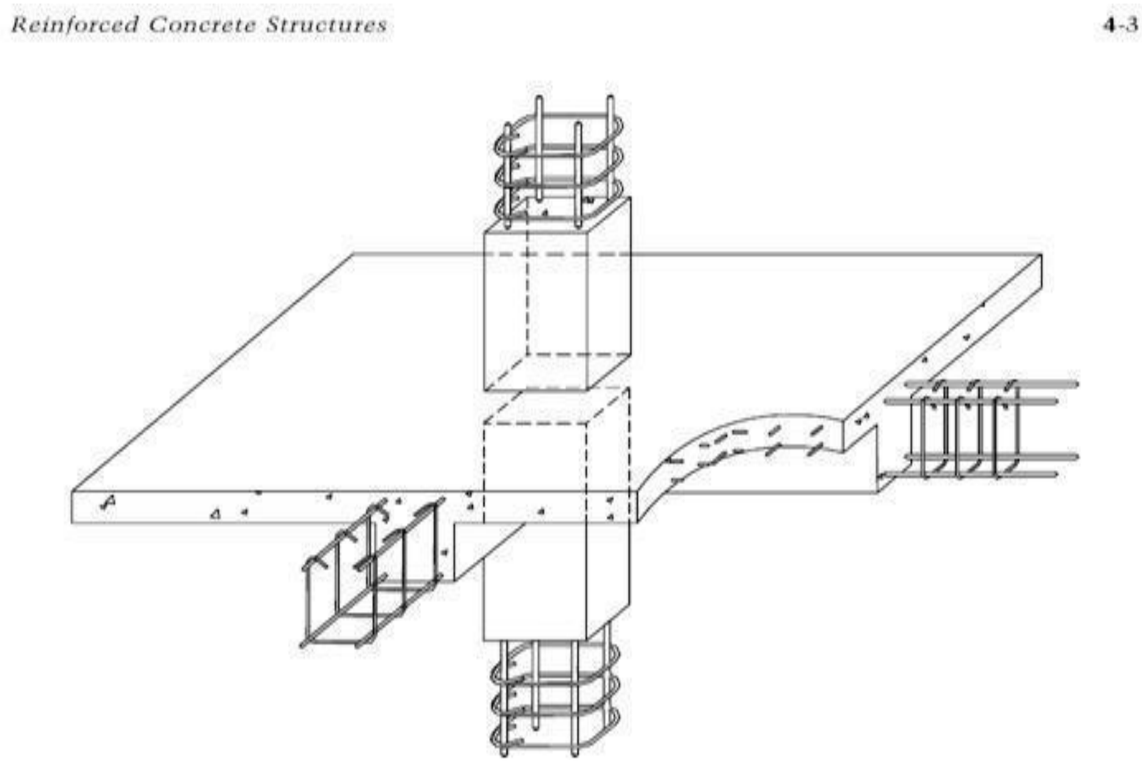
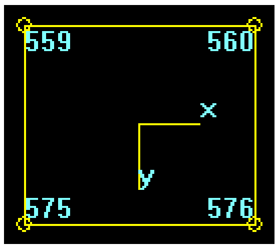


Figure 7.1.d monolithic connection between beam, column and slab

Princ Stress and Disp | Corner Stresses

Geometry | Property Constants | Center Stresses

Plate No : 1470



Node	X m	Y m	Z m
559	23.39999888	19	15.8
560	28	19	15.8
576	28	19	19.5
575	23.39999888	19	19.5

Edge Lengths & Area

	AB	BC	CD	DA
Length (m)	4.600000381	3.699999809	4.600000381	3.699999809
Area (cm2)	170200.0045776			

Fig 7.1e showing Geometry of plate

FOOTINGS

Foundations are structural elements that transfer loads from the building or individual column to the earth .If these loads are to be properly transmitted, foundations must be designed to prevent excessive settlement or rotation, to minimize differential settlement and to provide adequate safety against sliding and overturning.

GENERAL:

1. Footing shall be designed to sustain the applied loads, moments and forces and the induced reactions and to assure that any settlements which may occur will be as nearly uniform as possible and the safe bearing capacity of soil is not exceeded.
2. Thickness at the edge of the footing: in reinforced and plain concrete footing at the edge shall be not less than 150 mm for footing on the soil nor less than 300mm above the tops of the pile for footing on piles.

BEARING CAPACITY OF SOIL:

The size foundation depends on permissible bearing capacity of soil. The total load per unit area under the footing must be less than the permissible bearing capacity of soil to the excessive settlements.

8.1 Foundation design:

Foundations are structure elements that transfer loads from building or individual column to earth this loads are to be properly transmitted foundations must be designed to prevent excessive settlement are rotation to minimize differential settlements and to provide adequate safety isolated footings for multi storey buildings. These may be square rectangle are circular in plan that the choice of type of foundation to be used in a given situation depends on a number of factors.

1. Bearing capacity of soil
2. Type of structure
3. Type of loads
4. Permissible differential settlements
5. Economy

A footing is the bottom most part of the structure and last member to transfer the load. In order to design footings we used Staad foundation software.

These are the types of foundations the software can deal.

Shallow (D<B)

1. Isolated (Spread) Footing

2. Combined (Strip) Footing

3.Mat (Raft) Foundation

Deep (D>B)

1.Pile Cap

2. Driller Pier

The advantage of this software is even after the analysis of staad we can update the following properties if required.

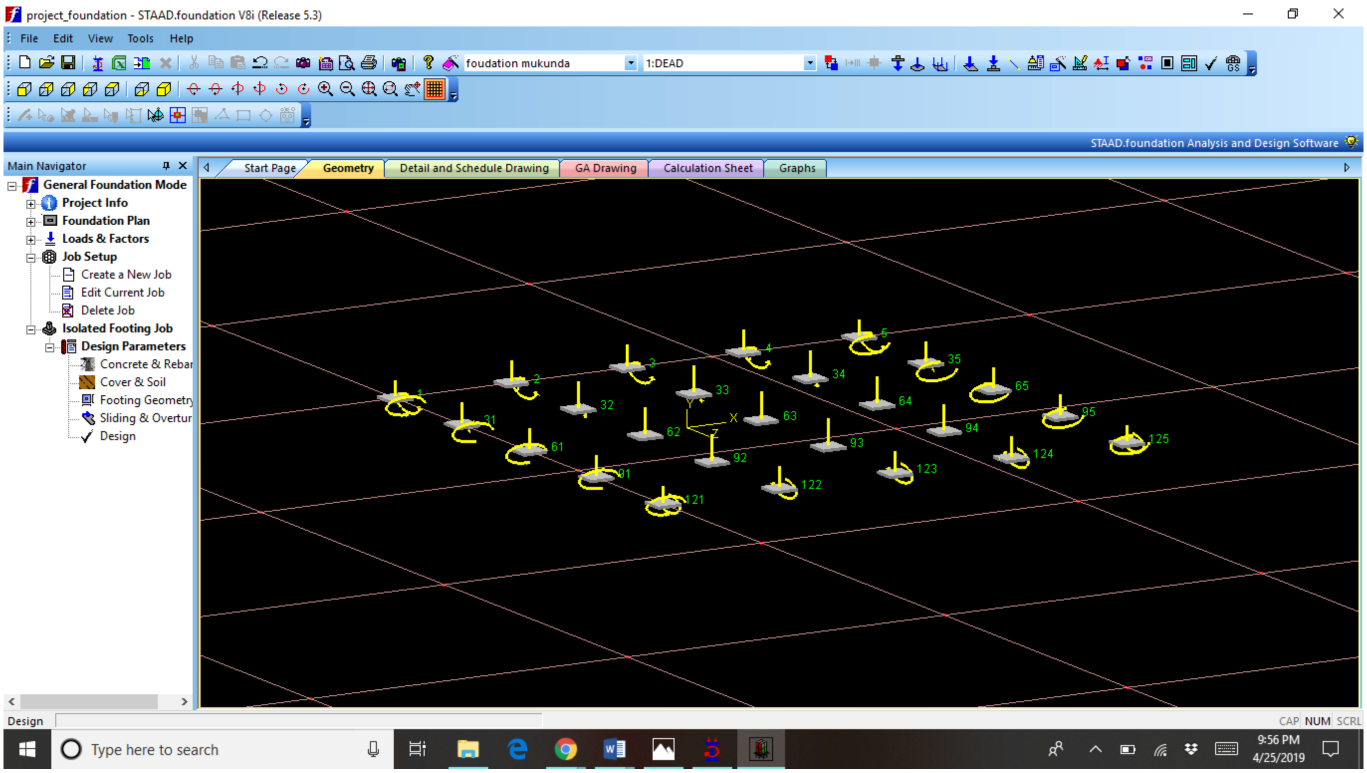
The following Parameters can be updated:

- Column Position
- Column Shape
- Column Size
- Load Cases
- Support List

After the analysis of structure at first we has to import the reactions of the columns from staad pro using import button.

After we import the loads the placement of columns is indicated in the figure.

Fig 8.1a Placement of columns



After importing the reactions in the staad foundation the following input data is required regarding materials, Soil type, Type of foundation, safety factors.

- Type of foundation: ISOLATED.
- Unit weight of concrete:25kN/m^3
- Minimum bar spacing:50mm
- Maximum bar spacing:500mm
- Strength of concrete:30 N/mm^2
- Minimum bar size:6mm
- Bottom clear cover:50mm
- Unit weight of soil:22 kN/m^3
- Soil bearing capacity:200 kN/m^3
- Minimum width:1000mm
- Minimum thichness:500mm
- Yield strength of steel:415 N/mm^2
- Maximum length:12000mm
- Maximum width:12000mm
- Maximum thickness:1500mm
- Plan dimension:50mm
- Aspect ratio:1

- Safety against friction,overturning,sliding:0.5,1.5,1.5

After this input various properties of the structure and click on design.

After the analysis detailed calculation of each and every footing is given with plan and elevation of footing including the manual calculation.

The following tables show the dimensions and reinforcement details of all the footings.

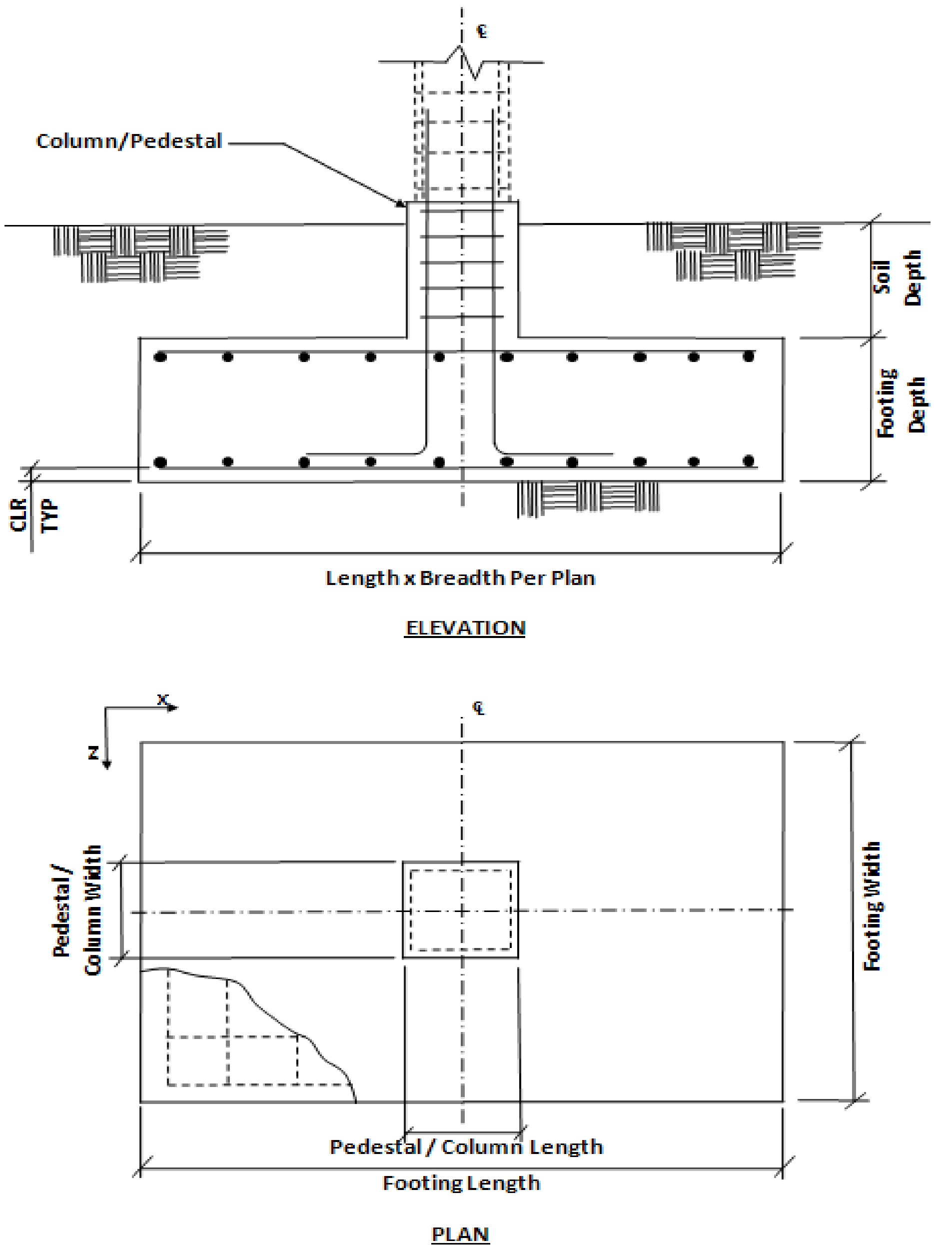
Table 8.1a showing Geometry of Footings

Footing No.	Group ID	Foundation Geometry		
-	-	Length	Width	Thickness
1	1	1.650 m	1.650 m	0.305 m
2	2	1.800 m	1.800 m	0.305 m
3	3	1.800 m	1.800 m	0.305 m
4	4	1.800 m	1.800 m	0.305 m
5	5	1.800 m	1.800 m	0.305 m
6	6	1.800 m	1.800 m	0.305 m
7	7	1.800 m	1.800 m	0.305 m
8	8	1.650 m	1.650 m	0.305 m
9	9	1.850 m	1.850 m	0.305 m
10	10	2.050 m	2.050 m	0.355 m
11	11	2.050 m	2.050 m	0.355 m
12	12	2.050 m	2.050 m	0.355 m
13	13	2.050 m	2.050 m	0.355 m
14	14	2.050 m	2.050 m	0.355 m
15	15	2.050 m	2.050 m	0.355 m
16	16	1.850 m	1.850 m	0.305 m
17	17	1.850 m	1.850 m	0.305 m
18	18	2.000 m	2.000 m	0.355 m
19	19	2.050 m	2.050 m	0.355 m
20	20	2.000 m	2.000 m	0.355 m
21	21	2.000 m	2.000 m	0.355 m
22	22	2.050 m	2.050 m	0.355 m
23	23	2.000 m	2.000 m	0.355 m
24	24	1.850 m	1.850 m	0.305 m
25	25	1.850 m	1.850 m	0.305 m

Table 8.1b showing reinforcement details of footings

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
-	Bottom Reinforcement(M_z)	Bottom Reinforcement(M_x)	Top Reinforcement(M_z)	Top Reinforcement(M_x)	Main Steel	Trans Steel
1	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
2	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
3	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
4	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
5	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
6	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
7	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
8	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
9	Ø6 @ 55 mm c/c	Ø6 @ 55 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
10	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
11	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
12	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
13	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
14	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
15	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
16	Ø6 @ 55 mm c/c	Ø6 @ 55 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
17	Ø6 @ 55 mm c/c	Ø6 @ 55 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
18	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
19	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
20	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
21	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
22	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 70 mm c/c	Ø6 @ 70 mm c/c	N/A	N/A
23	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
24	Ø6 @ 55 mm c/c	Ø6 @ 55 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A
25	Ø6 @ 55 mm c/c	Ø6 @ 55 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	N/A	N/A

Isolated Footing 1



Input Values

Footing Geomtery

Design Type : Calculate Dimension

Footing Thickness (Ft) : 305.000 mm

Footing Length - X (Fl) : 1000.000 mm

Footing Width - Z (Fw) : 1000.000 mm

Eccentricity along X (Oxd) : 0.000 mm

Eccentricity along Z (Ozd) : 0.000 mm

Column Dimensions

Column Shape : Rectangular

Column Length - X (Pl) : 0.500 m

Column Width - Z (Pw) : 0.500 m

Pedestal

Include Pedestal?

Pedestal Shape :

Pedestal Height (Ph) : N/A

Pedestal Length - X (Pl) : N/A

Pedestal Width - Z (Pw) : N/A

Design Parameters

Concrete and Rebar Properties

Unit Weight of Concrete : 25.000 kN/m3

Strength of Concrete : 25.000 N/mm2

Yield Strength of Steel : 415.000 N/mm2

Minimum Bar Size : Ø6

Maximum Bar Size: Ø32

Minimum Bar Spacing : 50.000 mm

Maximum Bar Spacing : 500.000 mm

Pedestal Clear Cover (P, CL) : 50.000 mm

Footing Clear Cover (F, CL) : 50.000 mm

Soil Properties

Soil Type : Drained

Unit Weight : 22.000 kN/m3

Soil Bearing Capacity : 200.000 kN/m2

Soil Surcharge : 0.000 kN/m2

Depth of Soil above Footing : 0.000 mm

Cohesion : 0.000 kN/m2

Min Percentage of Slab : 0.000

Sliding and Overturning

Coefficient of Friction : 0.500

Factor of Safety Against Sliding : 1.500

Factor of Safety Against Overturning : 1.500

Load Combination/s- Service Stress Level	
Load Combination Number	**Load Combination Title**
1	DL
2	LL

Load Combination/s- Strength Level	
Load Combination Number	**Load Combination Title**
1	DL
2	LL
3	FL
3	FL

Applied Loads - Service Stress Level

LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
1	490.632	-1.998	-1.346	-1.606	2.320
2	99.572	-1.620	-0.987	-1.159	1.869
3	79.287	-1.779	-0.951	-1.134	2.056

Applied Loads - Strength Level

LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
1	490.632	-1.998	-1.346	-1.606	2.320
2	99.572	-1.620	-0.987	-1.159	1.869
3	79.287	-1.779	-0.951	-1.134	2.056

Design Calculations

Footing Size

Initial Length (L_o) = 1.000 m

Initial Width (W_o) = 1.000 m

Uplift force due to buoyancy = 0.000 kN

Effect due to adhesion = 0.000 kN

Area from initial length and width, $A_o = L_o \times W_o$ = 1.000 m^2

Min. area required from bearing pressure, $A_{min} = P / q_{max}$ = 2.491 m^2

Note: A_{min} is an initial estimation.

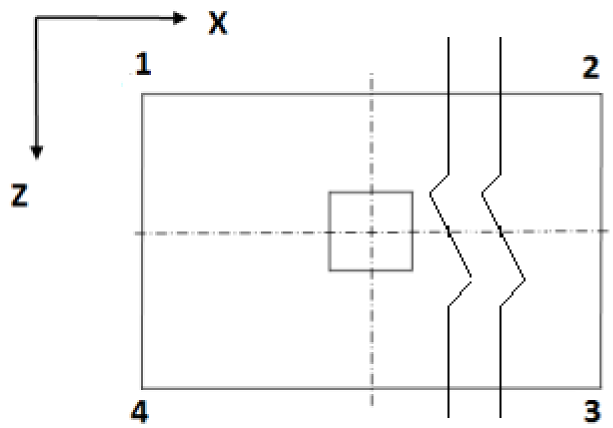
P = Critical Factored Axial Load(without self weight/buoyancy/soil).

q_{max} = Respective Factored Bearing Capacity.

Final Footing Size

Length (L_2) =	1.650	m	Governing Load Case :	# 1
Width (W_2) =	1.650	m	Governing Load Case :	# 1
Depth (D_2) =	0.305	m	Governing Load Case :	# 1
Area (A_2) =	2.723	m^2		

Pressures at Four Corner



Load Case	Pressure at corner 1 (q_1) (kN/m2)	Pressure at corner 2 (q_2) (kN/m2)	Pressure at corner 3 (q_3) (kN/m2)	Pressure at corner 4 (q_4) (kN/m2)	Area of footing in uplift (A_u) (m^2)
1	**194.4443**	186.6202	181.2332	189.0573	0.000
1	194.4443	**186.6202**	181.2332	189.0573	0.000
1	194.4443	186.6202	**181.2332**	189.0573	0.000
1	194.4443	186.6202	181.2332	**189.0573**	0.000

If A_u is zero, there is no uplift and no pressure adjustment is necessary. Otherwise, to account for uplift, areas of negative pressure will be set to zero and the pressure will be redistributed to remaining corners.

Summary of adjusted Pressures at Four Corner

Load Case	Pressure at corner 1 (q_1) (kN/m2)	Pressure at corner 2 (q_2) (kN/m2)	Pressure at corner 3 (q_3) (kN/m2)	Pressure at corner 4 (q_4) (kN/m2)
1	**194.4443**	186.6202	181.2332	189.0573
1	194.4443	**186.6202**	181.2332	189.0573
1	194.4443	186.6202	**181.2332**	189.0573
1	194.4443	186.6202	181.2332	**189.0573**

Details of Out-of-Contact Area

(If Any)

Governing load case = N/A

Plan area of footing = 2.723 sq.m

Area not in contact with soil = 0.000 sq.m

% of total area not in contact = 0.000%

Check For Stability Against Overturning And Sliding

-	Factor of safety against sliding		Factor of safety against overturning	
Load Case No.	Along X-Direction	Along Z-Direction	About X-Direction	About Z-Direction
1	127.997	189.998	209.215	144.046
2	37.135	60.950	67.982	42.011
3	28.117	52.603	57.958	31.767

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding X Direction

Critical Load Case for Sliding along X-Direction :	3
Governing Disturbing Force :	-1.779 kN
Governing Restoring Force :	50.023 kN
Minimum Sliding Ratio for the Critical Load Case :	28.117
Critical Load Case for Overturning about X-Direction :	3
Governing Overturning Moment :	-1.424 kNm
Governing Resisting Moment :	82.537 kNm
Minimum Overturning Ratio for the Critical Load Case :	57.958

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding Z Direction

Critical Load Case for Sliding along Z-Direction :	3
Governing Disturbing Force :	-0.951 kN
Governing Restoring Force :	50.023 kN
Minimum Sliding Ratio for the Critical Load Case :	52.603
Critical Load Case for Overturning about Z-Direction :	3
Governing Overturning Moment :	2.598 kNm
Governing Resisting Moment :	82.537 kNm
Minimum Overturning Ratio for the Critical Load Case :	31.767

Moment Calculation

Check Trial Depth against moment (w.r.t. X Axis)

Critical Load Case = #1

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.252 m

Governing moment (M_u) = 49.719 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 (K_{umax}) = $\frac{700}{(1100 + 0.87 \times f_y)}$ = 0.479107

Limiting Factor2 (R_{umax}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 3444.291146 kN/m2

Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 360.891754 kNm

M_u <= M_{umax} hence, safe

Check Trial Depth against moment (w.r.t. Z Axis)

Critical Load Case = #1

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.252 m

Governing moment (M_u) = 49.974 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 (K_{umax}) = $\frac{700}{(1100 + 0.87 \times f_y)}$ = 0.479107

Limiting Factor2 (R_{umax}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 3444.291146 kN/m2

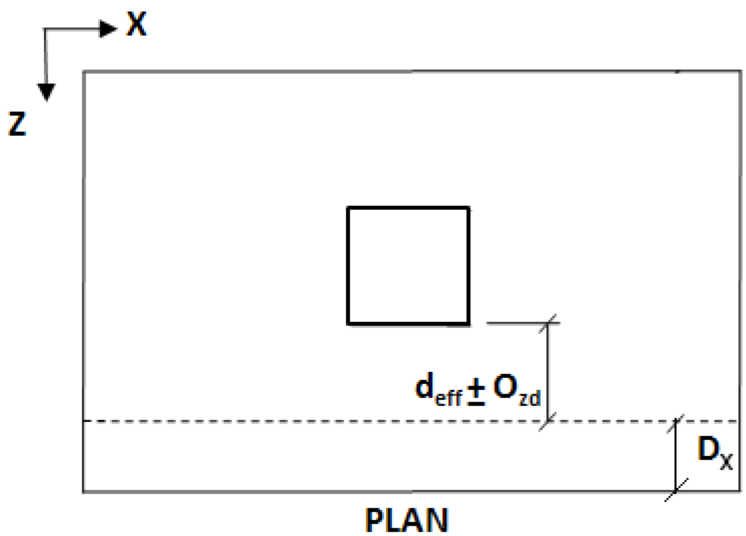
Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 360.891754 kNm

M_u <= M_{umax} hence, safe

Shear Calculation S

Check Trial Depth for one way shear (Along X Axis)

(Shear Plane Parallel to X Axis)



Critical Load Case= #1

DX =0.252m

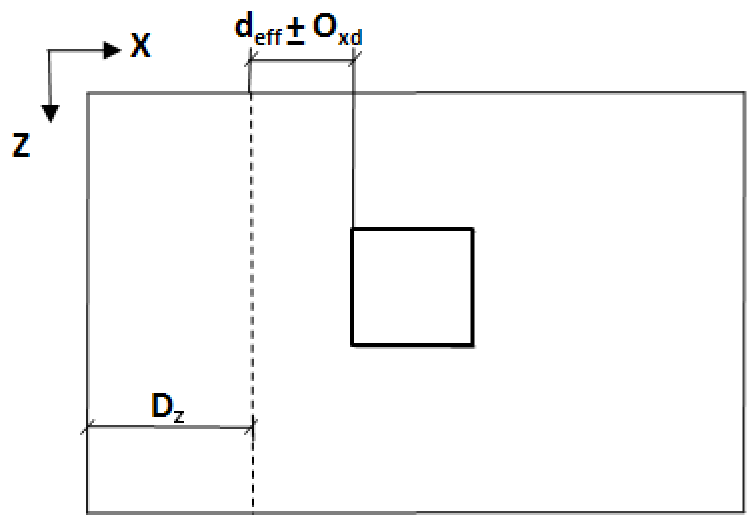
Shear Stress(Tv) = 233.764746 kN/m2

Percentage Of Steel(Pt) = 0.1452

Shear force = 97.199 kN

Check Trial Depth for one way shear (Along Z Axis)

(Shear Plane Parallel to Z Axis)



PLAN

Critical Load Case = #1

D_Z = 0.252 m

Shear Force(S) = 97.722 kN

Shear Stress(T_v) = 235.020887 kN/m2

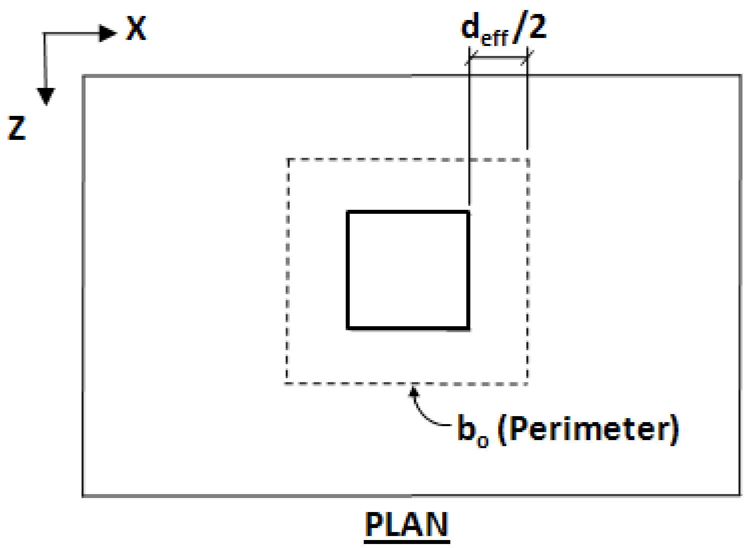
Percentage Of Steel(P_t) = 0.1452

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 286.768 kN/m2

$T_v < T_c$ hence, safe

Check Trial Depth for two way shear



Critical Load Case = #1

Shear Force(S) = 388.720 kN

Shear Stress(T_v) = 512.813 kN/m2

As Per IS 456 2000 Clause 31.6.3.1

$K_s = \min[(0.5 + \beta), 1] = 1.000$

Shear Strength(T_c)= $0.25 \times \sqrt{f_{ck}}$ = 1250.0000 kN/m2

$K_s \times T_c$ = 1250.0000 kN/m2

$T_v \leq K_s \times T_c$ hence, safe

Reinforcement Calculation

Calculation of Maximum Bar Size

Along X Axis

Bar diameter corresponding to max bar size (d_b) = 12 mm

Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \tau_{bd}}$ = 0.484 m

Allowable Length(l_{db}) = $\left[\frac{(B - b)}{2} - cc\right]$= 0.525 m

l_{db} >=l_d hence, safe

Along Z Axis

Bar diameter corresponding to max bar size(d_b) = 12 mm

As Per IS 456 2000 Clause 26.2.1

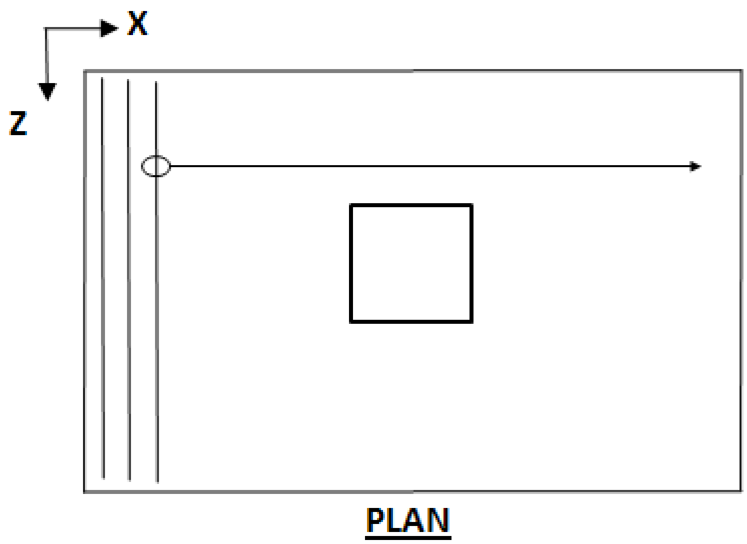
Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \tau_{bd}}$ = 0.484 m

Allowable Length(l_{db}) = $\left[\frac{(H - h)}{2} - cc\right]$= 0.525 m

l_{db} >=l_d hence, safe

Bottom Reinforcement Design

Along Z Axis



For moment w.r.t. X Axis (M_x)

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case	**= #1**
Minimum Area of Steel (A_{stmin})	= 603.900 mm2
Calculated Area of Steel (A_{st})	= 558.938 mm2
Provided Area of Steel ($A_{st,Provided}$)	= 603.900 mm2
A_{stmin}<= $A_{st,Provided}$	Steel area is accepted

Selected bar Size (d_b)	= Ø6
Minimum spacing allowed (S_{min})	= 46.000 mm
Selected spacing (S)	= 73.524 mm

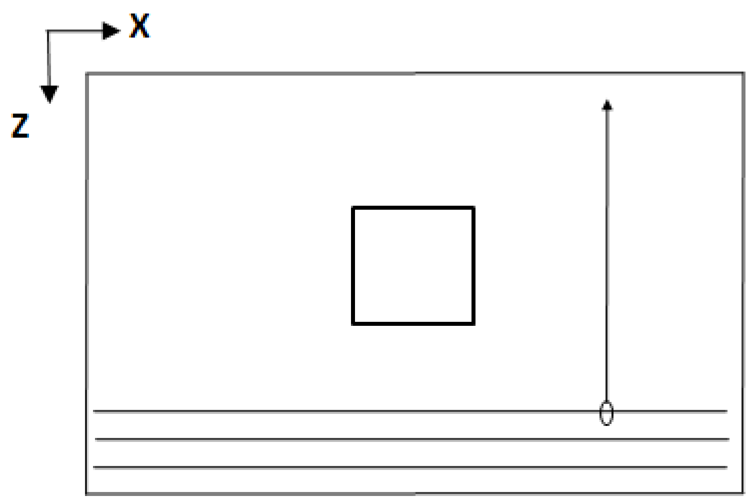
S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 70.000 mm o.c.

Along X Axis



PLAN

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case	**= #1**
Minimum Area of Steel (A_{stmin})	= 603.900 mm2
Calculated Area of Steel (A_{st})	= 561.873 mm2
Provided Area of Steel ($A_{st,Provided}$)	= 603.900 mm2
A_{stmin}<= $A_{st,Provided}$	Steel area is accepted

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min}) = 50.000 mm

Selected spacing (S) = 73.524 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

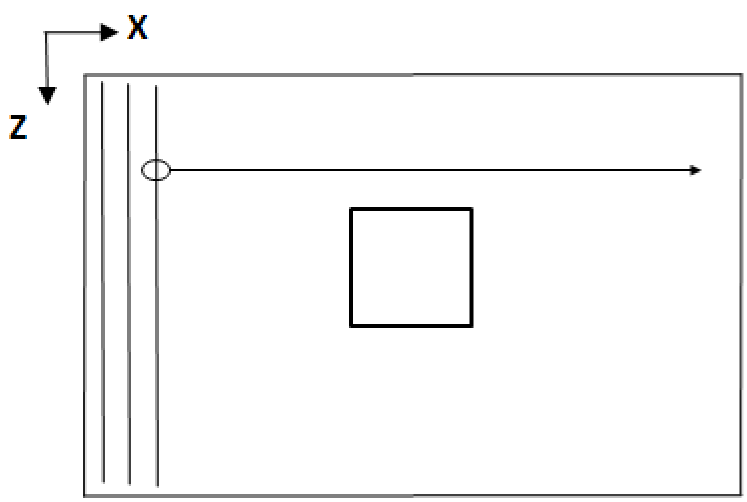
The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 70.000 mm o.c.

Top Reinforcement Design

Along Z Axis



PLAN

Calculated Area of Steel (A_{st}) = 603.900 mm2

Provided Area of Steel ($A_{st,Provided}$) = 603.900 mm2

$A_{stmin} <= A_{st,Provided}$ Steel area is accepted

Governing Moment = 2.311 kNm

Minimum Area of Steel (A_{stmin}) = 603.900 mm2

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min}) = 50.000 mm

Selected spacing (S) = 73.524 mm

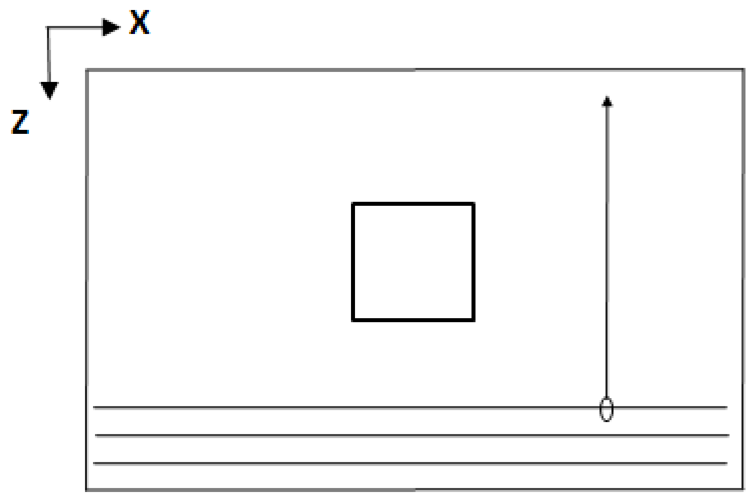
$S_{min} <= S <= S_{max}$ and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 70 mm o.c.

Along X Axis



PLAN

Calculated Area of Steel (A_{st}) = 603.900 mm2

Provided Area of Steel ($A_{st,Provided}$) = 603.900 mm2

A_{stmin}<= $A_{st,Provided}$ Steel area is accepted

Governing Moment = 2.311 kNm

Minimum Area of Steel (A_{stmin}) = 603.900 mm2

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min}) = = 50.000 mm

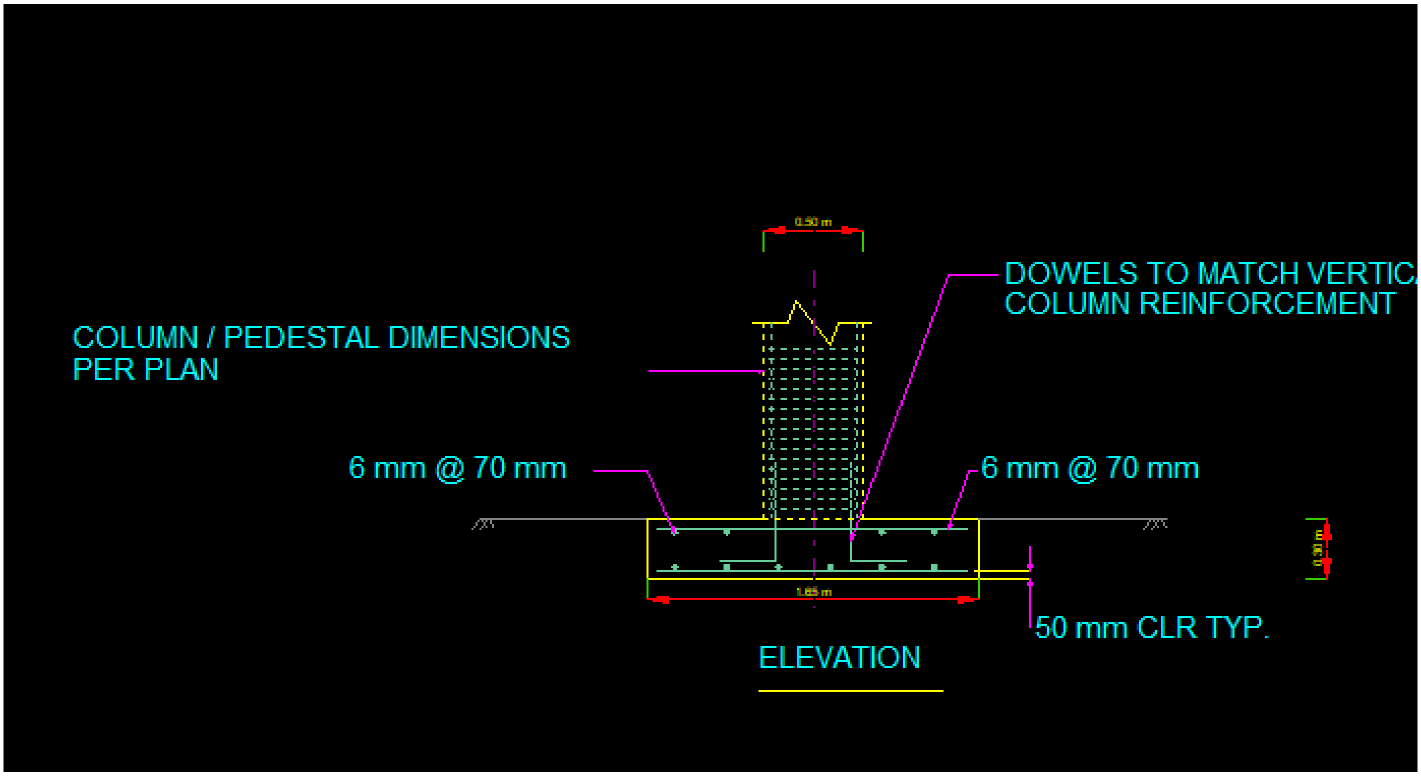
Selected spacing (S) = 73.524 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 70 mm o.c.



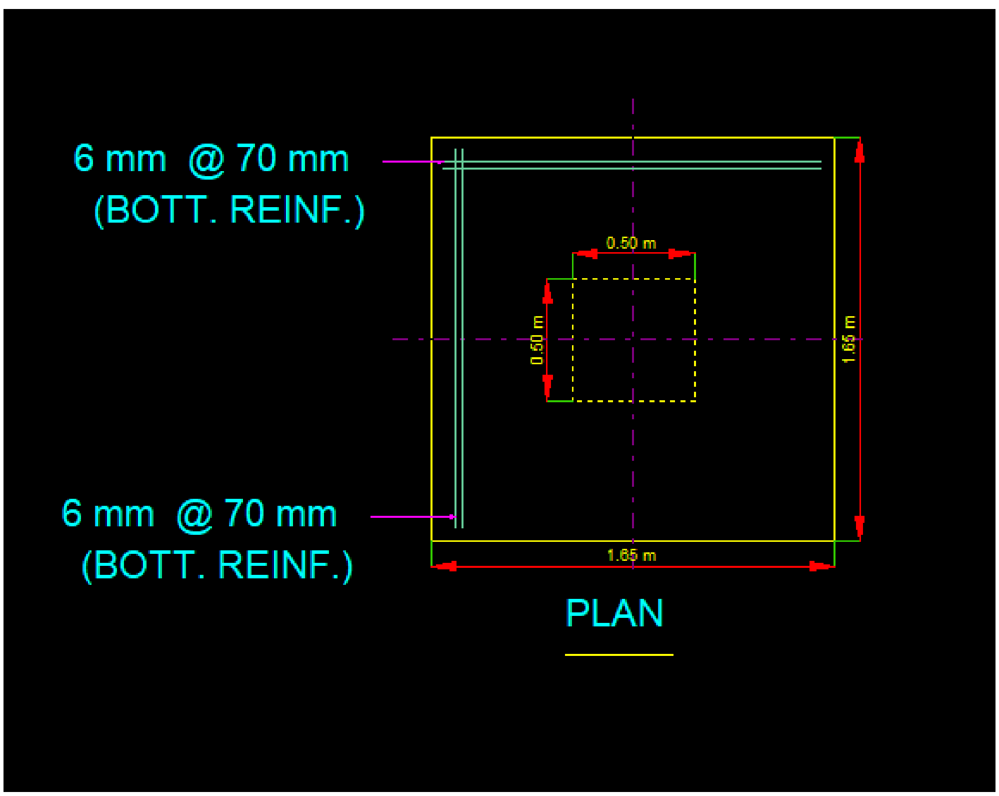


Fig 8.2b showing Plan and Elevation of a Footing

STAIRCASE

Staircase:

The purpose of stair case is to provide pedestrian access to different levels The geometrical forms of staircases may be quite different on the individual circumstances involved. The two main components of are stairs and landing slab. The stairs and landing slab can be arranged staircase are stars and forms together in different types of staircases.

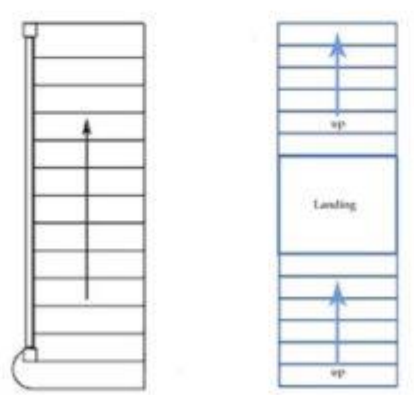
- Type of construction of the structure around the staircase i.e. load bearing brick structure or reinforced concrete frame structure.
- Availability of space

Rise and tread are two terms associated with a stair. The term rise refers to the vertical height of a step and the term represents the horizontal dimensions where foot placed.

<u>CLASSIFICATION OF STAIRS</u>:

Depending upon the various arrangement of steps, stairs can be classified under following categories:

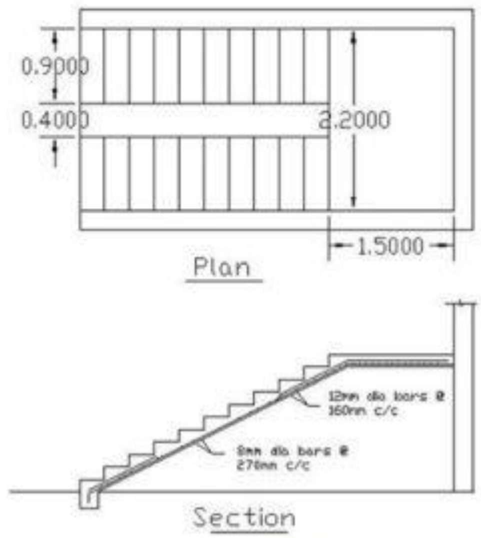
1. Straight stair :



Straight Stair

In this stair, all the steps are arranged continuously along in one direction. One flight may be split into one or more than one flight by interposing a landing. This stair can be used where narrow and long space is available for a staircase such as entrance, porch etc.

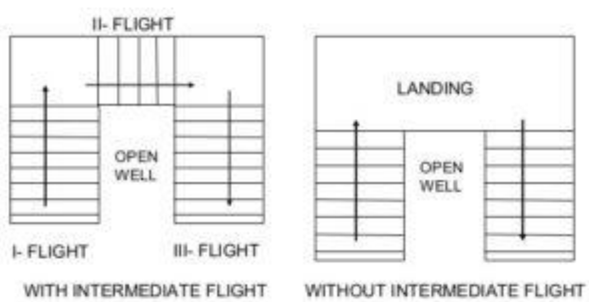
2.Dog-legged stair :



Dog-legged Stair

This stair consists of two straight flights of steps with direct turns between them. This stair is very useful where the total width of the stair is just twice the width of the steps.

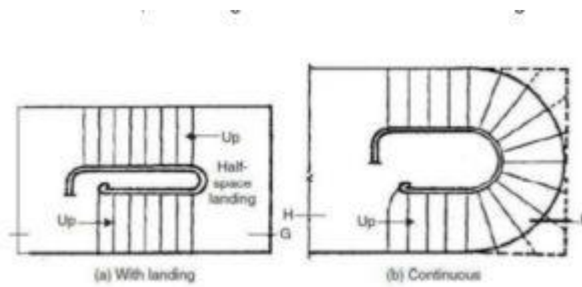
3. Open well stair :



Open Newel Stairs

This type of stair consists of two or more flights arranging a well or opening between the backward and forward flights. When all the steps are difficult to arrange in two flights, a short third flight of 3 to 6 steps may be provided along the direction perpendicular to the hall. Open newel stair is mostly adopted in the lift.

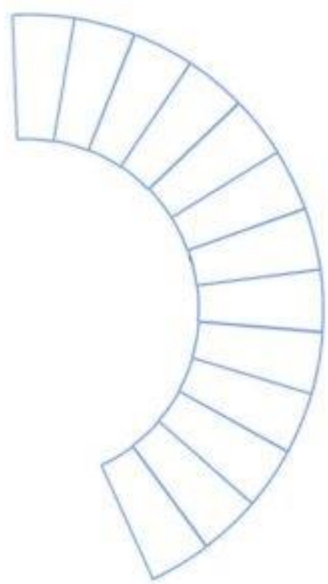
4. Geometrical stair :



Geometrical Stair

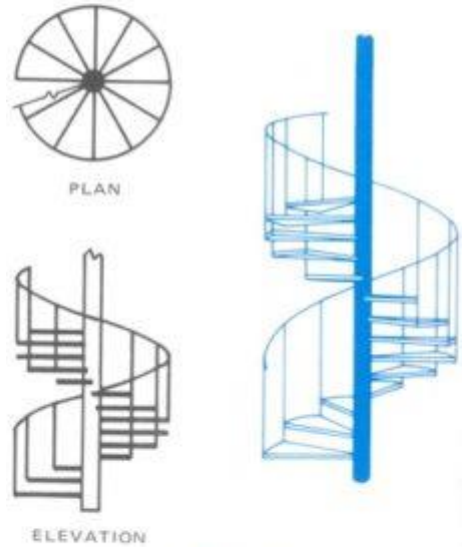
This is another type of open newel stair where the open well between the forward and the backward flight is curved. This stair may contain different geometrical shape. Here the change in direction is achieved by using winders.

5. Circular stair :



In this type of stair, all the steps radiate from a newel or well hole, in the form of winders. The circular stair is adopted at the back side of a building to access its various floors.

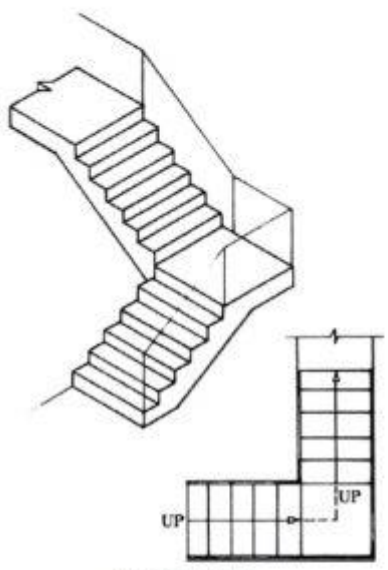
6. Spiral stair:



Spiral Stair

Spiral stair is very similar to a circular stair. It consists of individual steps or treads, connecting to a centre column. The overall diameter of the stair may range from 1 to 2.5 m.

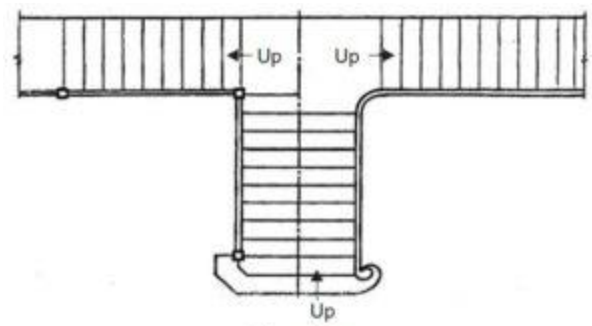
7. Quarter-turn stair:



Quarter-turn Stair

The quarter-turn stair can be defined as the stairs that are turned at 90 degrees with the help of level landing.

8. Bifurcated stair :



Bifurcated Stair

This type of stair is provided in modern public buildings as well as residential buildings. In this stair, the flight is so arranged that there is a wide flight at the start which is sub-divided into narrow flights at the mid-landing. The narrow flights start from either side of the mid landing.

GENERAL RULES:

- Between consecutive floors there should be an equal rise for every parallel step. Similarly, there should be equal thread.
- The sum of tread of single step, twice the rise should be in 550mm and 700mm.
- The rise of step should not be more than 240mm and tread should not be less than 240mm.

DESIGN PROCEDURE OF STAIRCASES:

Step 1: Dimensions:

Need to derive appropriate dimensions to design for staircase such as rise, thread etc.

Step 2: Depth of waist slab:

Derive the dimensions of waist slab with regarding dimensions on step1.

i.e. $b = \sqrt{R^2 + T^2}$

$D = t + R \times T/b$

Then calculate overall and effective depth.

Step 3: Design loads:

The total factored loads are to be determined adding the estimated dead load of the slab, load of the floor finish, given or assumed live loads etc. after multiplying each of them with the respective partial safety factors.

Step 4: Design of waist slab:

- **On going:**

i. **Bending moments:**

The design bending moments which depends on type of slab and coefficients are taken from IS 456:2000 table 12 and 13 and limited bending moments from IS 456:2000 clause38.1.

ii. **Area of Reinforcement:**

Area of steel reinforcement along the direction of main reinforcement should be determined given below as reference.

$$M_u = 0.87\ f_y\ A_{st}\ d\ \{1 - (A_{st})(f_y)/(f_{ck})(bd)\}$$

The above equation is applicable as the slab in most of the cases is under reinforced due to the selection of depth larger than the computed value in Step 6. The area of steel so determined should be checked whether it is at least the minimum area of steel as mentioned in clause.26.5.2.1 of IS 456:2000.

The amount of steel reinforcement along the large span shall be the minimum amount of steel as per clause.26.5.2.1 of IS 456:2000.

- **On landing:**

i. **Bending moments:**

The design bending moments which depends on type of slab and coefficients are taken from IS 456:2000 table 12 and 13 and limited bending moments from IS 456:2000 clause38.1.

ii. **Area of Reinforcement:**

Area of steel reinforcement along the direction of main reinforcement should be determined given below as reference.

$$M_u = 0.87\ f_y\ A_{st}\ d\ \{1 - (A_{st})(f_y)/(f_{ck})(bd)\}$$

The above equation is applicable as the slab in most of the cases is under reinforced due to the selection of depth larger than the computed value in Step6. The area of steel so determined should be checked whether it is at least the minimum area of steel as mentioned in clause.26.5.2.1 of IS 456:2000.

The amount of steel reinforcement along the large span shall be the minimum amount of steel as per clause.26.5.2.1 of IS 456:2000.

Step 5: Reinforcement details

DESIGN OF STAIR CASE:

Step 1: Dimensions:

Rise	= 150mm
Thread	= 230mm
f_{ck}	= 25 N/mm^2
f_y	= 500 N/mm^2
Width of flight	= 1.37m
Height of each floor (h)	= 3m
Height of flight	= 3/2 = 1.5m
No of steps	= 1500/500 = 10 numbers
Length of flight	= 10 x 230 = 2300mm

$b = \sqrt{R^2 + T^2}$

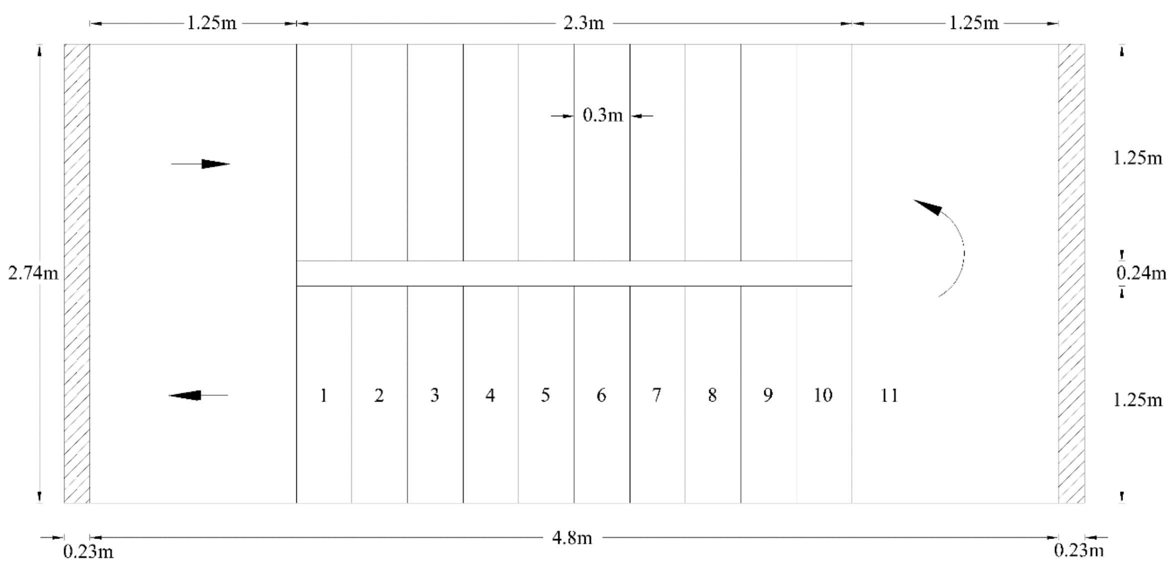
$= \sqrt{150^2 + 230^2}$

$= 274.59$mm

$D = t + R \times T/b$

$= 1370/20 + 20$

$=88.5$mm



Step 2: Depth of waist slab:

Overall depth (D) = 88.5 + 150 x 230/274.59

= 214.14 mm ≅ 220mm

Effective depth (d) = D - Ø/2 –cover

= 220- 12/2 – 20

d = 194mm

Step 3: Design loads:

Dead load of waist slab per meter width of stair

W_1 = b x t x s x 1

= 0.0885 x 0.274 x 1 x 25

= 0.6028 KN-m

W_2 = ½ x R x T x s

= ½ x 0.150 x 0.230 x 25

= 0.4312 KN/m

Total dead load of steps = 10 x 0.4312

= 4.31 KN/m

For each flight = 4.31 KN/m

Total load = 0.4312 + 4.31+1 = 5.74 KN/m

Live load = 5 KN/m

Total load per meter width of step = 5.74 + 5 = 10.74 KN/m

On loading:

Weight of slab = 0.15 x 25 x 1.37 = 5.13 KN/m

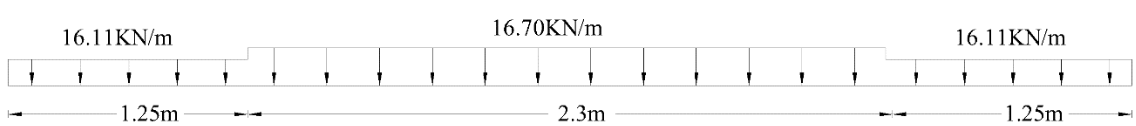
Floor finish = 1 KN/ m

Live load = 5 KN/ m

Total load = 5.13 +1 + 5 =11.13 KN/m

Factored load on going = 1.5 x 10.74 = 16.11 KN/m

Factored load on loading = 1.5 x 11.13 = 16.70 KN/m



Step 4:

Design of waist slab:

(a) Ongoing:

i. Bending moments:

Ultimate moment M_u = 1.5 $wl^2/8$

= 1.5 x 16.70 x 3.3^2

= 34.09 KN-m

Limiting moment M_{ulim} = 0.36 f_{ck} b 0.46d (d-0.42 x 0.48d)

According to IS 456:2000 clause38.1,

x_{ulim} for fe_{500} = 0.46

M_{ulim} = 0.36 fck b 0.46d (d-0.42 x 0.46d)

= 0.36 x 25 x 274.59 x 0.46 x 194 (194 – 0.42 x 0.46 x 194) x 10^6

=34.51 KN-m

ii. Area of Reinforcement:

Hence area of tension reinforcement A_{st} obtained from IS-456:2000 clause G 1.1

M_u = 0.87 f_y A_{st} d{(1 – ($A_{st}f_y$ /f_{ck} b d)}

= 0.87 x 500 x A_{st} x 194{(1 – (A_{st} x 500/25 x 274.59x 194)}

34.09 x 10^6 = 84390 A_{st} – 31.68 A_{st}^2

31.68 A_{st}^2-84390A_{st} +34.09 x 10^6 = 0

A_{st} = 496.49 mm^2

Provide 10mm diameter,

$A_{st} = \pi/4 \times 10^2$ =78.53 mm^2

Spacing = 78.53/496.49 x 1000 = 945.68mm

Provide 10mm dia @ 800mmc/c

Minimum reinforcement:

According to IS456:2000 Clause 26.5.2.1

= 0.12% b d

$= 0.12/100 \times 194 \times 274.59$

$= 63.92\ mm^2$

Use 8mm Ø bars

$A_{st} = \pi/4 \times 8^2 = 50.26\ mm^2$

Spacing (s) $= a_{st}/A_{st} \times 1000$

$= 50.26 / 83.04 \times 1000$

$= 605.25mm$

Distribution steel:

$= 0.12\%\ b\ d$

$= 0.12/100 \times 1000 \times 220$

$= 264\ mm^2$

Use 8 mm bars

$A_{st} = \pi/4 \times 8^2 = 50.26\ mm^2$

Spacing (s) $= a_{st}/A_{st} \times 1000 = 50.26/264 \times 1000 = 190mm$

Provide 8mm Ø bars 180 c/c

(b) On landing:

i. Bending moments:

Weight of landing slab = 16.70 KN

Length of landing slab = 230 + 300/2 + 300/2 = 530mm

Ultimate moment $M_u = 1.5 \times wl^2/8$

$= 1.5 \times 6.11 \times 1.25^2 / 8$

$= 1.79$ KN-m

$M_{ulim} = 0.133\ f_{ck}\ b\ d^2$

$= 0.133 \times 25 \times 274.59 \times 194^2$

$= 34.36$KN-m

$M_u < M_{ulim}$

ii. Area of Reinforcement:

Hence area of tension reinforcement A_{st} obtained from IS-456:2000 clause G 1.1

$M_u = 0.87\ f_y\ A_{st}\ d(1 – A_{st}f_y\ /f_{ck}\ b\ d)$

$16.70 \times 10^6 = 0.87 \times 500 \times A_{st} \times 194 \times [1\text{-}500A_{st}/25 \times 194 \times 274.59]$

$A_{st} = 215.29mm^2$

Minimum reinforcement:

According to IS456:2000 Clause 26.5.2.1

0.12% b d = 0.12x274.59x194/100

= 63.92mm^2

Use 10mmØ bars (ast) = $\pi/4 \times 10^2$ =78.53 mm^2

Spacing (s) = a_{st}/A_{st} x 1000

= 78.54/215.29 x 1000

= 364.81mm

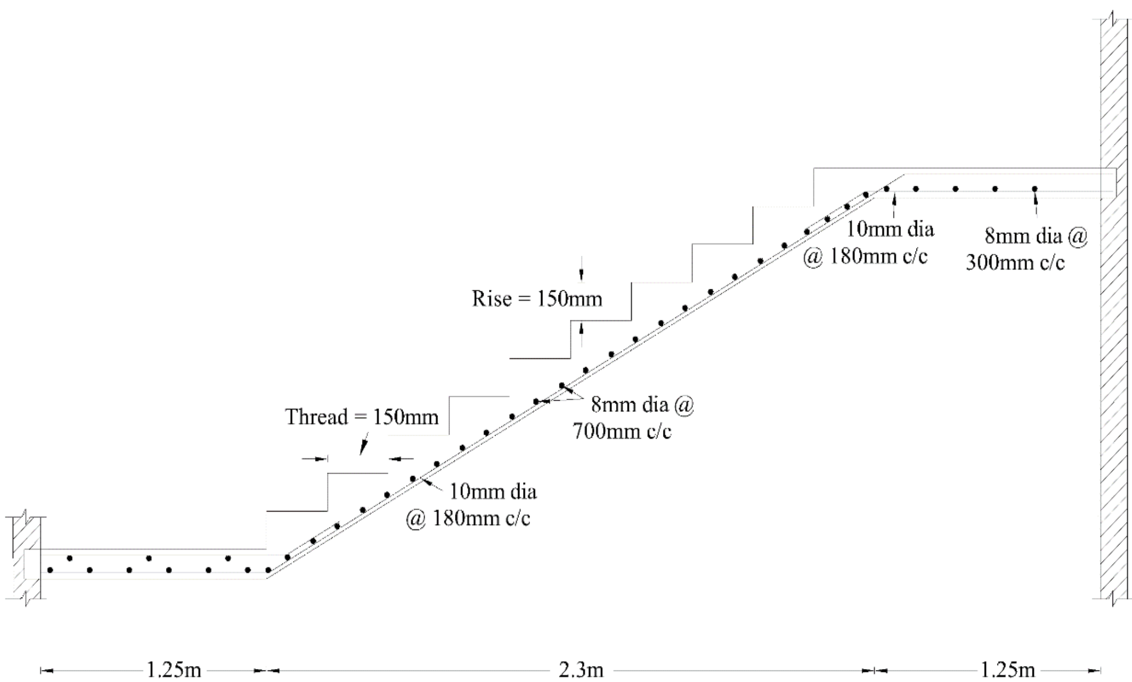
Provide 10mm Ø bars @ 300mm c/c

Distribution steel:

A_{st} = 0.12% bd = (0.12/100) x 1000 x 200 = 264 mm^2

Use 8mm Ø bars with 180 c/c spacing.

Step 5: Reinforcement details :



CONCLUSIONS

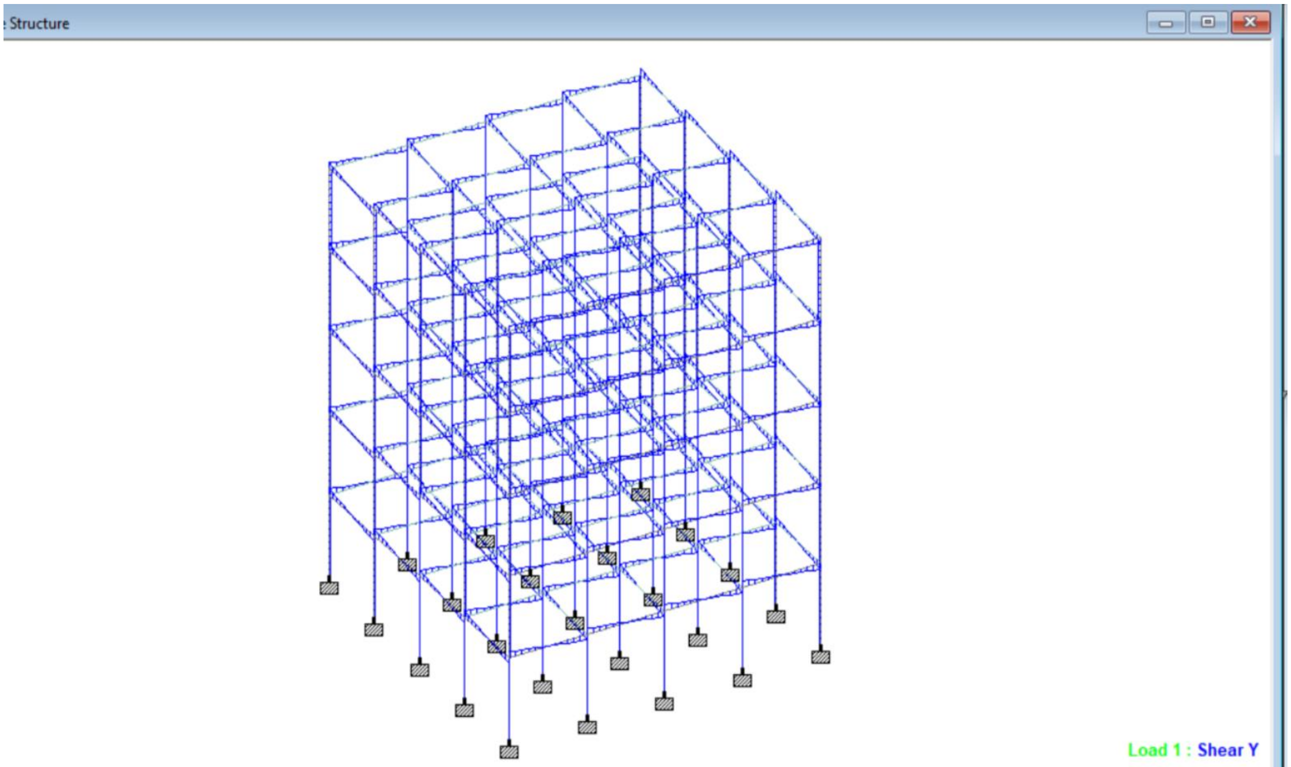


Fig shows the shear force variation along the frame

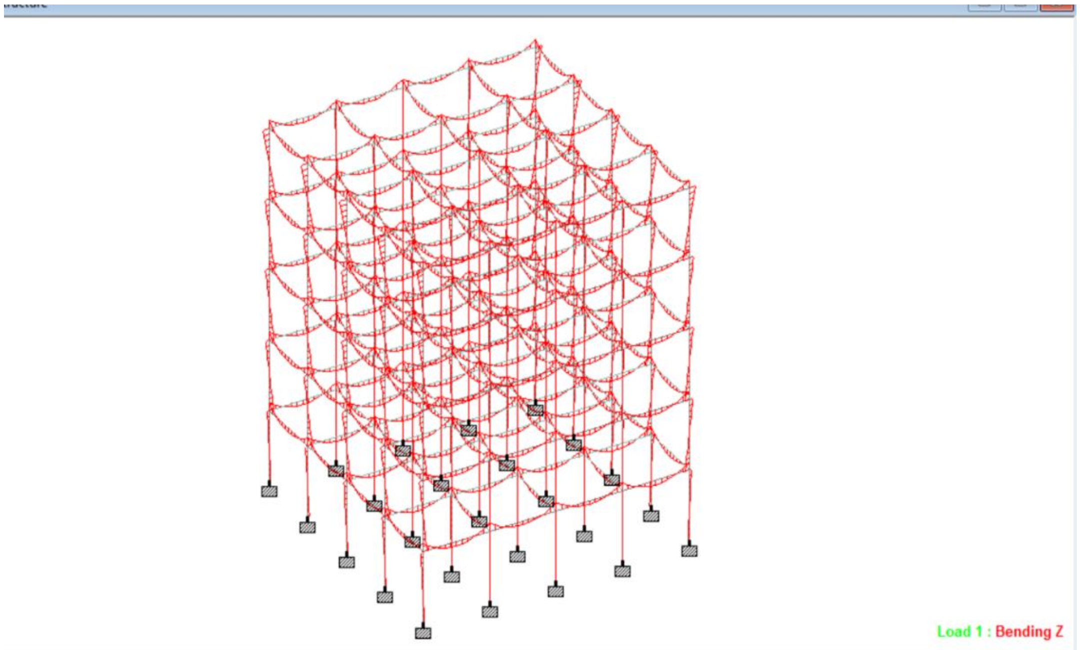


Fig shows the variation of Bending moment along the frame

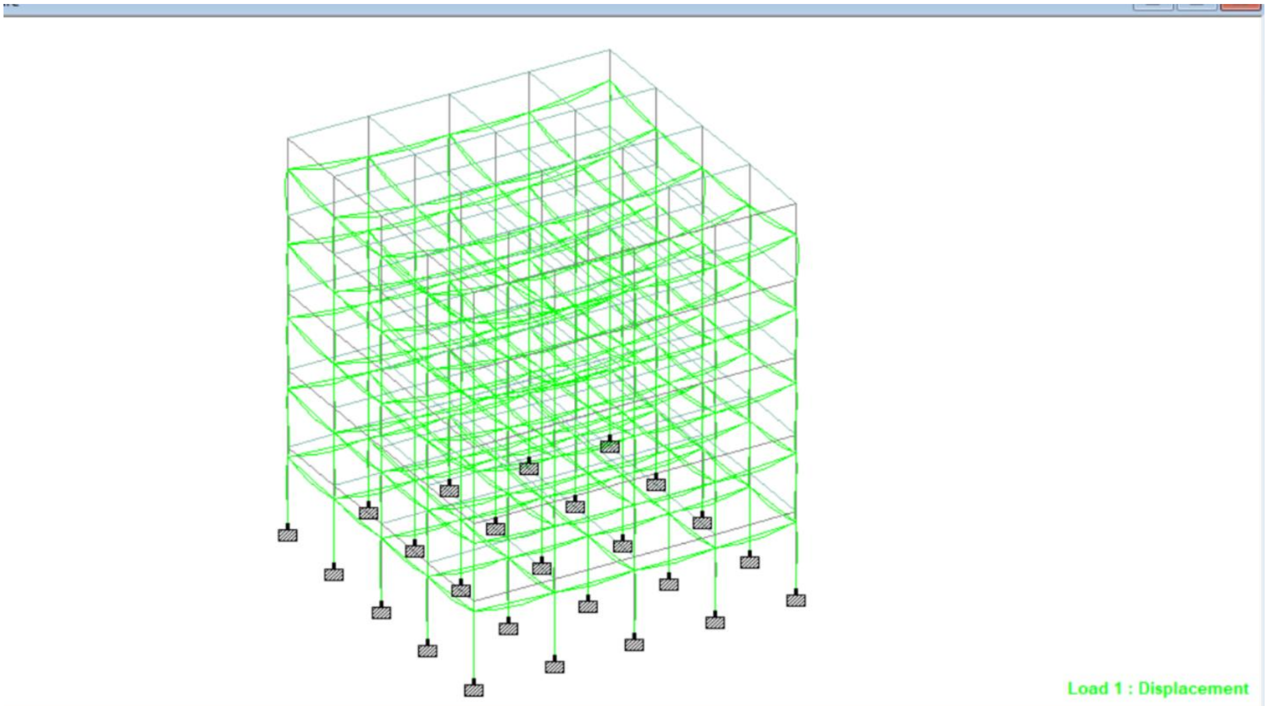


Fig shows the Displacement profile along the frame for various loads

STAAD OUTPUT

STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 25-Apr-19
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 3.65761 0 0; 3 7.31521 0 0; 4 10.9728 0 0; 5 14.6304 0 0;
6 0 3.65761 0; 7 3.65761 3.65761 0; 8 7.31521 3.65761 0; 9 10.9728 3.65761 0;
10 14.6304 3.65761 0; 11 0 7.31521 0; 12 3.65761 7.31521 0;
13 7.31521 7.31521 0; 14 10.9728 7.31521 0; 15 14.6304 7.31521 0;
16 0 10.9728 0; 17 3.65761 10.9728 0; 18 7.31521 10.9728 0;
19 10.9728 10.9728 0; 20 14.6304 10.9728 0; 21 0 14.6304 0;
22 3.65761 14.6304 0; 23 7.31521 14.6304 0; 24 10.9728 14.6304 0;
25 14.6304 14.6304 0; 26 0 18.288 0; 27 3.65761 18.288 0; 28 7.31521 18.288 0;
29 10.9728 18.288 0; 30 14.6304 18.288 0; 31 0 0 3.65761; 32 3.65761 0 3.65761;
33 7.31521 0 3.65761; 34 10.9728 0 3.65761; 35 14.6304 0 3.65761;
36 0 3.65761 3.65761; 37 3.65761 3.65761 3.65761; 38 7.31521 3.65761 3.65761;
39 10.9728 3.65761 3.65761; 40 14.6304 3.65761 3.65761; 41 0 7.31521 3.65761;
42 3.65761 7.31521 3.65761; 43 7.31521 7.31521 3.65761;
44 10.9728 7.31521 3.65761; 45 14.6304 7.31521 3.65761; 46 0 10.9728 3.65761;
47 3.65761 10.9728 3.65761; 48 7.31521 10.9728 3.65761;
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52 3.65761 14.6304 3.65761; 53 7.31521 14.6304 3.65761;
54 10.9728 14.6304 3.65761; 55 14.6304 14.6304 3.65761; 56 0 18.288 3.65761;
57 3.65761 18.288 3.65761; 58 7.31521 18.288 3.65761;
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142 3.65761 14.6304 14.6304; 143 7.31521 14.6304 14.6304;
144 10.9728 14.6304 14.6304; 145 14.6304 14.6304 14.6304; 146 0 18.288 14.6304;
147 3.65761 18.288 14.6304; 148 7.31521 18.288 14.6304;
149 10.9728 18.288 14.6304; 150 14.6304 18.288 14.6304;

MEMBER INCIDENCES

1 6 7; 2 7 8; 3 8 9; 4 9 10; 5 11 12; 6 12 13; 7 13 14; 8 14 15; 9 16 17;
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219 139 144; 220 140 145; 221 141 146; 222 142 147; 223 143 148; 224 144 149;
225 145 150; 226 6 36; 227 7 37; 228 8 38; 229 9 39; 230 10 40; 231 11 41;
232 12 42; 233 13 43; 234 14 44; 235 15 45; 236 16 46; 237 17 47; 238 18 48;
239 19 49; 240 20 50; 241 21 51; 242 22 52; 243 23 53; 244 24 54; 245 25 55;
246 26 56; 247 27 57; 248 28 58; 249 29 59; 250 30 60; 251 36 66; 252 37 67;
253 38 68; 254 39 69; 255 40 70; 256 41 71; 257 42 72; 258 43 73; 259 44 74;
260 45 75; 261 46 76; 262 47 77; 263 48 78; 264 49 79; 265 50 80; 266 51 81;
267 52 82; 268 53 83; 269 54 84; 270 55 85; 271 56 86; 272 57 87; 273 58 88;
274 59 89; 275 60 90; 276 66 96; 277 67 97; 278 68 98; 279 69 99; 280 70 100;
281 71 101; 282 72 102; 283 73 103; 284 74 104; 285 75 105; 286 76 106;
287 77 107; 288 78 108; 289 79 109; 290 80 110; 291 81 111; 292 82 112;
293 83 113; 294 84 114; 295 85 115; 296 86 116; 297 87 117; 298 88 118;
299 89 119; 300 90 120; 301 96 126; 302 97 127; 303 98 128; 304 99 129;
305 100 130; 306 101 131; 307 102 132; 308 103 133; 309 104 134; 310 105 135;
311 106 136; 312 107 137; 313 108 138; 314 109 139; 315 110 140; 316 111 141;
317 112 142; 318 113 143; 319 114 144; 320 115 145; 321 116 146; 322 117 147;
323 118 148; 324 119 149; 325 120 150;
ELEMENT INCIDENCES SHELL
326 21 22 52 51; 327 22 23 53 52; 328 23 24 54 53; 329 24 25 55 54;
330 51 52 82 81; 331 52 53 83 82; 332 53 54 84 83; 333 54 55 85 84;
334 81 82 112 111; 335 82 83 113 112; 336 83 84 114 113; 337 84 85 115 114;
338 111 112 142 141; 339 112 113 143 142; 340 113 114 144 143;
341 114 115 145 144; 342 136 137 107 106; 343 137 138 108 107;
344 138 139 109 108; 345 139 140 110 109; 346 106 107 77 76; 347 107 108 78 77;
348 108 109 79 78; 349 109 110 80 79; 350 76 77 47 46; 351 77 78 48 47;
352 78 79 49 48; 353 79 80 50 49; 354 46 47 17 16; 355 47 48 18 17;
356 48 49 19 18; 357 49 50 20 19; 358 11 41 42 12; 359 41 71 72 42;
360 71 101 102 72; 361 101 131 132 102; 362 12 42 43 13; 363 42 72 73 43;
364 72 102 103 73; 365 102 132 133 103; 366 13 43 44 14; 367 43 73 74 44;
368 73 103 104 74; 369 103 133 134 104; 370 14 44 45 15; 371 44 74 75 45;
372 74 104 105 75; 373 104 134 135 105; 374 126 127 97 96; 375 127 128 98 97;
376 128 129 99 98; 377 129 130 100 99; 378 96 97 67 66; 379 97 98 68 67;
380 98 99 69 68; 381 99 100 70 69; 382 66 67 37 36; 383 67 68 38 37;
384 68 69 39 38; 385 69 70 40 39; 386 36 37 7 6; 387 37 38 8 7; 388 38 39 9 8;
389 39 40 10 9; 390 26 27 57 56; 391 27 28 58 57; 392 28 29 59 58;
393 29 30 60 59; 394 56 57 87 86; 395 57 58 88 87; 396 58 59 89 88;
397 59 60 90 89; 398 86 87 117 116; 399 87 88 118 117; 400 88 89 119 118;
401 89 90 120 119; 402 116 117 147 146; 403 117 118 148 147;
404 118 119 149 148; 405 119 120 150 149;
ELEMENT PROPERTY
326 **TO** 405 **THICKNESS** 0.2
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17184e+007
POISSON 0.17
DENSITY 23.6158
ALPHA 5e-006
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27578.9

END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
21 **TO** 45 66 **TO** 90 111 **TO** 135 156 **TO** 180 201 **TO** 225 **PRIS YD** 0.4 **ZD** 0.4
1 **TO** 20 46 **TO** 65 91 **TO** 110 136 **TO** 155 181 **TO** 200 226 **TO** 325 **PRIS YD** 0.4 **ZD** 0.3
CONSTANTS
MATERIAL CONCRETE ALL
SUPPORTS
1 **TO** 5 31 **TO** 35 61 **TO** 65 91 **TO** 95 121 **TO** 125 **FIXED**
DEFINE WIND LOAD
TYPE 1 **WIND** 1
SNIP 2011 **PRESSURE** 2 **TERRAIN** B **CLASSIFICATION** 1
EXP 1 **JOINT** 1 **TO** 150
DEFINE 1893 **LOAD**
ZONE 0.16 **RF** 3 **I** 1 **SS** 1 **ST** 1
LOAD 1 **LOADTYPE** Dead **TITLE** DEAD
SELFWEIGHT Y -1
MEMBER LOAD
1 **TO** 325 **UNI GY** -20.688
FLOOR LOAD
YRANGE 0 18.288 **FLOAD** -1 **GY**
LOAD 2 **LOADTYPE** Live **REDUCIBLE TITLE LOAD CASE** 2
FLOOR LOAD
YRANGE 0 18.288 **FLOAD** -2 GY
LOAD COMB 3 **GENERATED INDIAN CODE GENRAL_STRUCTURES** 1
1 1.5 2 1.5
LOAD COMB 4 **GENERATED INDIAN CODE GENRAL_STRUCTURES** 2
1 1.2 2 1.2
LOAD COMB 5 **GENERATED INDIAN CODE GENRAL_STRUCTURES** 3
1 1.5
LOAD COMB 6 **GENERATED INDIAN CODE GENRAL_STRUCTURES** 4
1 0.9
PERFORM ANALYSIS
START CONCRETE DESIGN
CODE INDIAN
FC 30000 ALL
FYMAIN 415000 **ALL**
DESIGN BEAM 1 TO 20 46 **TO** 65 91 **TO** 110 136 **TO** 155 181 **TO** 200 226 **TO** 325
DESIGN COLUMN 21 **TO** 45 66 **TO** 90 111 **TO** 135 156 **TO** 180 201 **TO** 225
DESIGN ELEMENT 326 **TO** 405
CONCRETE TAKE
END CONCRETE DESIGN
PERFORM ANALYSIS
FINISH

TOTAL VOLUME OF CONCRETE = 160.9 CU.METER

BAR DIA (in mm)	**WEIGHT** (in New)
8	30905
10	20645
12	28631
16	11439
20	16986
TOTAL =	108607

Conclusions:

1. Design using Software's like Staad reduces lot of time in design work.
2. Details of each and every member can be obtained using Staad pro.
3. All the List of failed beams can be obtained and also Better Section is given by the software.
4. The design of slab, beam, column, rectangular footing aand staircase are done in limit state method which is safe at control of deflection and in all aspects.
5. Using Staad Pro software, the design consideration has been taken as per the IS codes. The design is safe in all conditions.
6. On comparison with drawing, manual design and the geometrical model using Staad pro the area of steel required for the beam, column, footing and slab are comparatively similar to that of requirement.

References:

1. Theory of Structures by Ramamrutham for literature review on kani,s method.
2. Theory of structures by B. C. Punmia for literature on moment distribution method.
3. Reinforced concrete Structures by A.K. Jain and B.C. Punmia for design of beams, columns and slab.
4. Fundamentals of Reinforced concrete structure by N. C. Sinha .

Code Books:

- IS 456-2000 code book for design of beams, columns and slabs.
- SP-16 for design of columns.
- IS 875 for consideration of loads.