A

PROJECT REPORT ON

ANALYSIS AND DESIGN OF MULTI STOREY(G+6) RESIDENTIAL BUILDING USING STAAD PRO

SUBMITTED BY

K. Hari Prasad	**08241A0116**
P.Praveen Reddy	**08241A0128**
V.Satish Kumar	**08241A0140**
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DEPARTMENT OF CIVIL ENGINEERING

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In the partial fulfilment of requirements for the award of, **“Bachelor of Technology**”   Degree of JNTU during the year 2011-2012.

DEPARTMENT OF CIVIL ENGINEERING

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INTERNAL GUIDE   HEAD OF THE DEPARTMENT

(CIVIL ENGINEERING)

DECLARATION BY THE CANDIDATES

We, **K.Hari Prasad, P.Praveen Reddy, V. Satish kumar,B.Sandeep reddy** hereby declare that the project report entitled "**Analysis and design of multistory(G+6) residential building using Staad Pro** ", Under the guidance of **Prof. Mode hussain sir** is submitted in the fulfillment of the requirements for the **MAIN-PROJECT**. This is a bonafide work carried out by us and the results embodied in this project report have not been reproduced/copied from any source. The results embodied in this project report have not been submitted to any other university or institution for the award of any other degree or diploma.

Date:

Place:

Civil Engineering Department

GRIET, Hyderabad.

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We profoundly thank **Mr. G.Venkataramana**, Head of the Department of CIVIL Engineering who has been an excellent guide and also a great source of inspiration to my work.

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ANALYSIS AND DESIGN OF A (G + 6) MULTI STOREY RESIDENTIAL BUILDING 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 analyze and design a Multistoried building by using a software package staad pro.

For analyzing a multi storied 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+6 consisting of 5 apartments 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 compotators 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 multistoried building.

<u>Assumptions and Notations used:</u>

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

Assumptions in Design:

1.Using partial safety factor for loads in accordance with clause 36.4 of IS-456-2000 as Υ_t=1.5

2.Partial safety factor for material in accordance with clause 36.4.2 is IS-456-2000 is 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.

D.L+L.L. 1.5

D.L+L.L+W.L 1.2

Density of materials used:

MATERIAL:	**DENSITY**
i) Plain concrete	24.0KN/m^3
ii) Reinforced	25.0KN/m^3
iii) Flooring material(c.m)	20.0KN/m^3
iv) Brick masonry	19.0KN/m^3
v) Fly ash	5.0KN/m^3

4.LIVE LOADS: In accordance with IS. 875-86

i) Live load on slabs = 20.0KN/m^2

ii) Live load on passage = 4.0KN/m^2

iii)Live load on stairs = 4.0KN/m^2

DESIGN CONSTANTS:

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

Therefore:-

f_{ck} = Characteristic strength for M30-30N/mm^2

f_y = Characteristic strength of steel-415N/mm^2

Assumptions Regarding Design:

i) 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.

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

Assumptions on design:-

1) M_{20}grade is used in designing unless specified.

2) Tor steel Fe 415 is used for the main reinforcement.

3) Tor steel Fe 415 and steel is used for the distribution reinforcement.

4) Mild steel Fe 230 is used for shear reinforcement.

Symbols:

The following symbols has been used in our project and its meaning is clearly mentioned respective to it:

A	-Area
Ast	- Area of steel
b	- Breadth of beam or shorter dimension of rectangular column
D	-Overall depth of beam or slab
D_L	-Dead load
d^1	-effective depth of slab or beam
D	- overall depth of beam or slab
$M_{u,max}$	-moment of resistance factor
F_{ck}	-characters tic compressive strength
F_y	-characteristic strength of of steel
L_d	-devlopment length
LL	-live load
L_x	-length of shorter side of slab
L_y	- length of longer side of slab
B.M.	-bending moment
M_u	-factored bending moment
M_d	-design moment
M_f	-modification factor
M_x	-mid span bending moment along short span

M_y	- mid span bending moment along longer span
M'_x	-support bending moment along short span
M'_y	- support bending moment along longer span
p_t	-percentage of steel
W	-total design load
W_d	-factored load
$T_{c\ max}$	-maximum shear stress in concrete with shear
T_v	-shear stress in concrete
T_v	-nominal shear stress
ϕ	-diameter of bar
P_u	-factored axial load
$M_{u,lim}$	-limiting moment of resistance of a section with out compression reinforcement
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 moment x and Y axis respectively
A_c	- area of concrete&
A_{sc}	-area of longitudinal reinforcement for column

CHAPTER 1

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. Draughtsman 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-paneled frame is a complicated statically intermediate structure. A design of R.C building of G+6 storey frame work is taken up. The building in plan (40*28) consists of columns built monolithically forming a network. The size of building is 40x28m. The number of columns are 85. it is residential complex.

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 separate, and the architect began to concentrate on aesthetics and the humanist 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 Bauhaus Dessau architecture department from 1925 by Walter Gropius.

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 complex

No of stories : G+6

Shape of the building : 5 APARTMENTS

No of staircases : 5

No. of flats: 30

No of lifts : 4

Type of construction : R.C.C framed structure

Types of walls : brick wall

Geometric details:

Ground floor : 3m

Floor to floor height : 3m.

Height of plinth : 0.6m

Depth of foundation: 500mm

Materials:

Concrete grade : M30

All steel grades: Fe415 grade

Bearing capacity of soil: $300KN/M^2$

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. Kane'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 is 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 storey's. .

Iterative methods:

These methods involves 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:

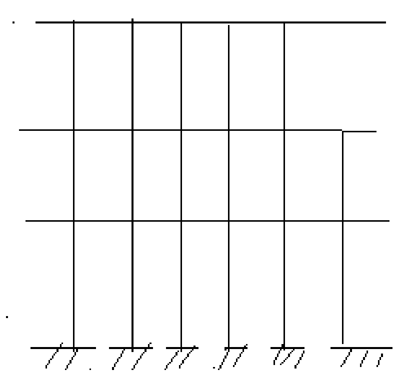
It is used for side way of frames.

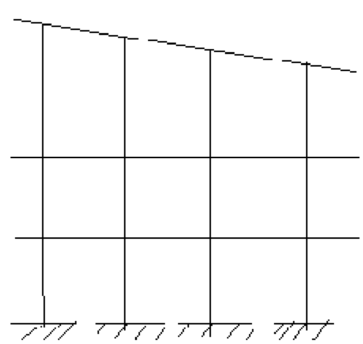
Limitations:

The rotational of columns of any storey should be function a single rotation value of same storey.

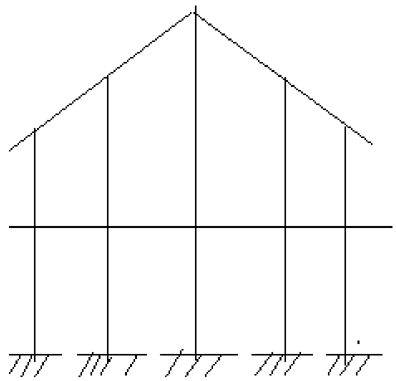
The beams of storey should not undergo rotation when the column undergoes translation. That is the column should be parallel.

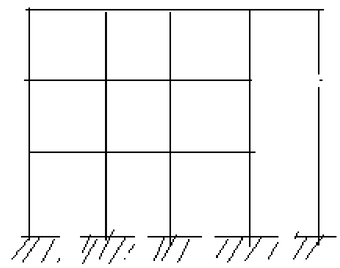
Frames with intermediate hinges cannot be analysis.





Applicable





Not applicable

1.3.4 <u>Approximate method:</u>

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 behavior so to obtain a rapid solution to complex structures.

The usual process comprises reducing the given indeterminate configuration to a determine 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 multistoried frames namely horizontal and vertical loading. The analysis carried out separately for these two cases.

<u>Horizontal cases:</u>

The behavior 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 .never the less 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 thee 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

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 rech 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 survivability:

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

CHAPTER 2

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 these 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 (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.

CHAPTER 3

PLAN AND ELEVATION

PLAN

The auto cad plotting no.1 represents the plan of a g+6 building. The plan clearly shows that it is a combination of five apartments. We can observe there is a combination between each and every apartments.

The Apartments are located at gachibouli which is surrounded by many apartments.

In each block the entire floor consists of a three bed room house which occupies entire floor of a block. It represents a rich locality with huge areas for each house.

It is a g+6 proposed building, So for 5 blocks we have 5*6=30 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 five apartments have similar room arrangement.

The entire plan area is about 1100 sq.m. There is some space left around the building for parking of cars. The plan gives details of arrangement of various furniture like sofa etc.

The plan also gives the details of location of stair cases in different blocks. we have 2 stair cases for each block and designing of stair case is shown in AutoCAD plot no.3

In the middle we have a small construction which consists of four lifts and those who want to fly through lift can use this facility and we know for a building with more than g+4 floors should compulsory have lift and the charges for the facilities is collected by all the members. At that junction we have a club for our enjoyment and charges are collected by all the building occupants every month.

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 plot no.2 represents the proposed elevation of building. It shows the elevation of a g+6 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 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 30 apartments.

The construction is going to complete in the month of June 2012 and ready for the occupancy.

This is regarding the plan and details of the site and next section deals with the design part of the building under various loads for which the building is designed.

Figure 3.2a Elevation of the building

Center line plan

The above figure represents the center 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 transitional 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.

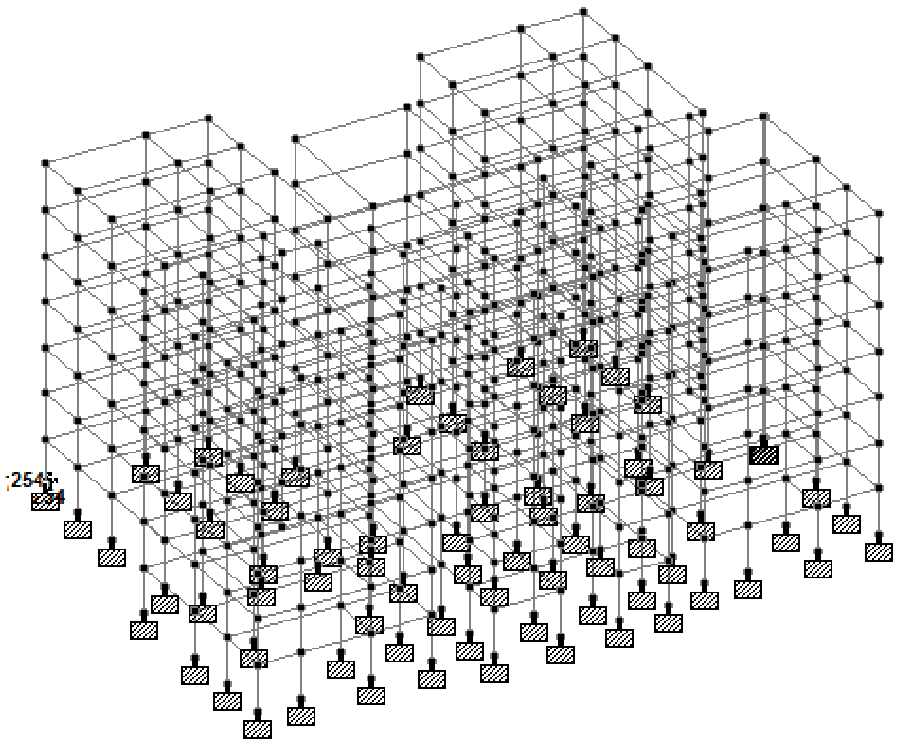


Figure 3.2b Skeletal structure of the building

CHAPTER 4

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 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)

4.2.2 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.

4.2.3 Lateral Loads:

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)through out 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 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 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 color as shown in the figure.

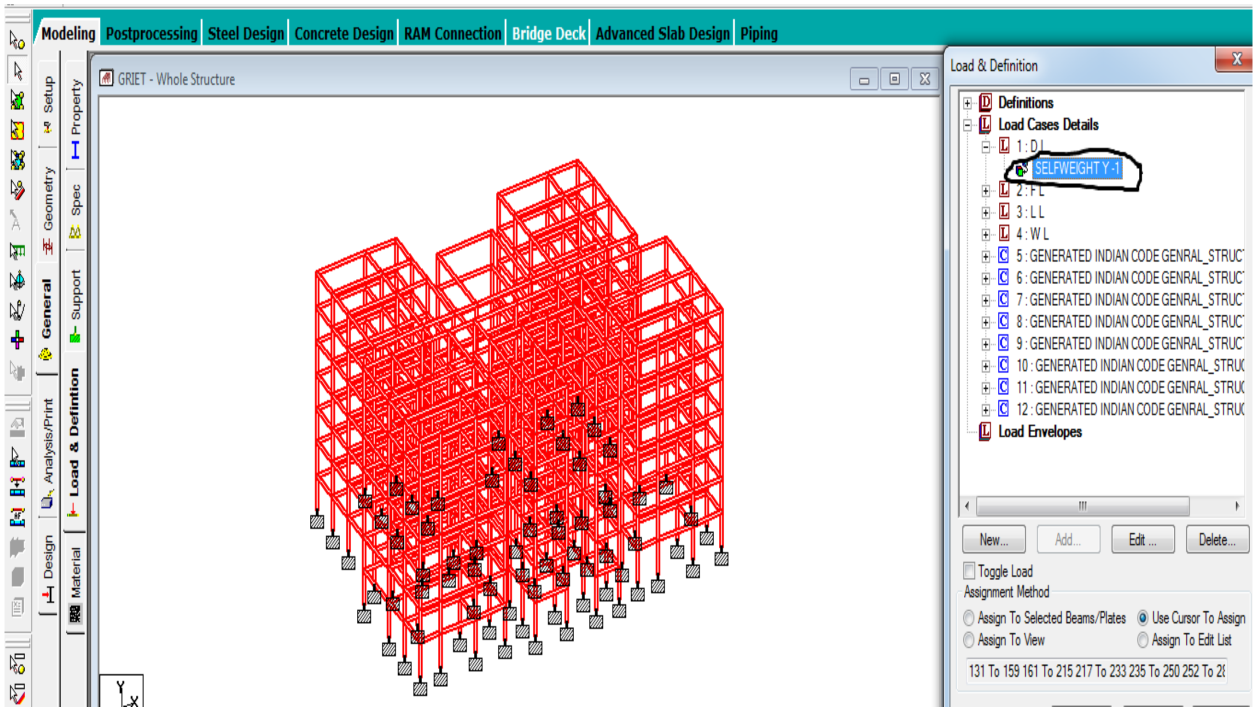


Fig 4.4.1a Example for calculation of dead load;

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 b e located or directed to give the maximum load effect possible in end-use conditions. For example. The stair load of 300 pounds should be applied to the center 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.

For our structure live load is taken as **25 N/mm** for design.

Live loads are calculated as per **IS 875 part 2**

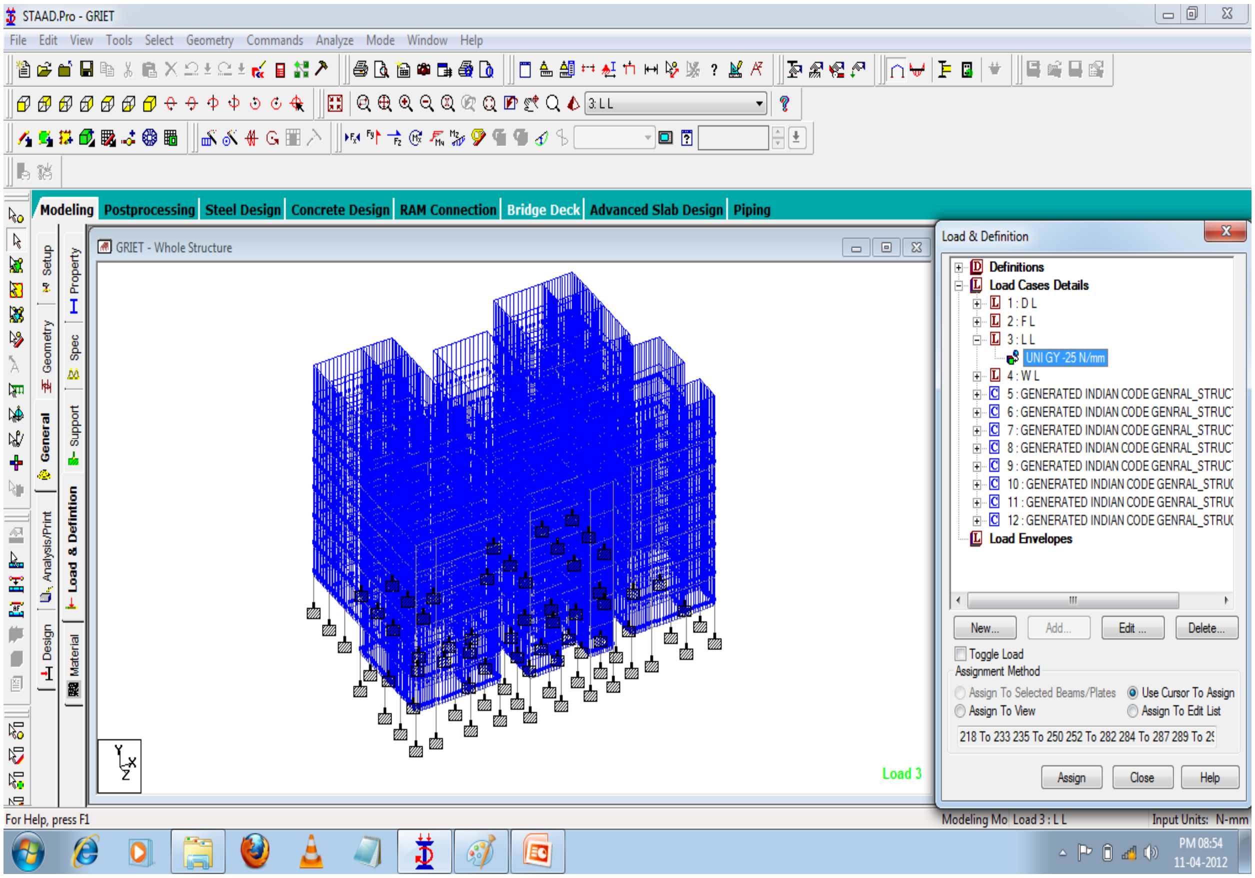


Fig 4.4.2a <u>diagram of live load</u>

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

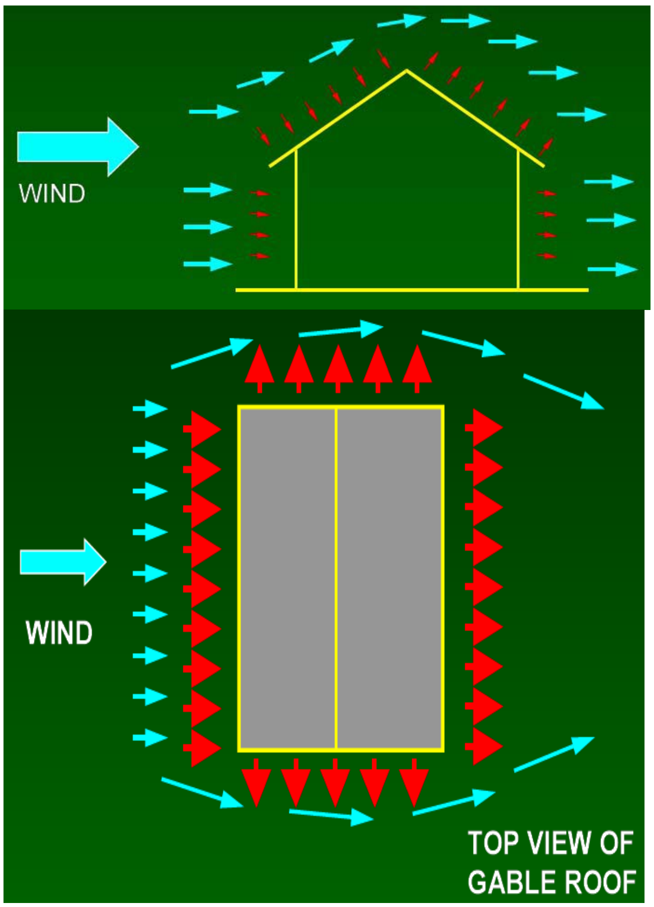


Fig 4.4.3a a diagram of wind load

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 in two ways

1. collecting the standard values of load intensities for a particular heights and assigning of the loads for respective height.
2. calculation of wind load as per **IS 875 part 3.**

We designed our structure using second method which involves the calculation of wind load using wind speed.

In Hyderabad we have a wind speed of 45 kmph for 10 m height and this value is used in calculation.

After the assignment of wind load the structure looks as shown in figure

4.4.3.1 Basic wind speed:

Gives 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.

The wind speed for some important cities/towns is given table below.

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.

a) Risk level
b) Terrain roughness, height and size of the structure and
c) 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

Table 4.4.3.3

Basic wind speed at 10 m for hight for some important cities/town:

CITIES SPEED	**BASIC WIND (m/s)**	**CITIES SPEED**	**BASIC WIND (m/s)**
Cuttack	50	Pune	39
Agra	47	Jhansi	47
Durbhanga	55	Raipur	39
Ahmadabad	39	Jodhpur	47
Darjeeling	47	Rajkot	39
Ajmer	47	Kanpur	47
Dehra dun	47	Ranchi	39
Alomar	47	Kohima	44
Delhi	47	Roorkee	39
Amritsar	47	Kurnool	39
Alanson	47	Rourkela	39
Gangtok	47	Lakshadweep	39
Auragabad	39	Simla	39

Gauhati	50	Srinagar	39
Bahraich	47	Ludhina	47
Gaya	39	Surat	44
Bangalore	33	Madras	50
Gorakhpur	47	Tiruchchirappalli	47
Varanasi	47	Madurai	39
Hyderabad	44	Trivandrum	39
Bareilly	47	Mandi	39
Impale	47	Udaipur	47
Bhatinda	47	Mangalore	39
Jabalpur	47	Vododara	44
Bhalali	39	Moradabad	47
Jaipur	47	Varanasi	33
Bhopal	39	Mysore	50
Jamshedpur	47	Vijayawada	50
Bhuvaneshwar	50	Nagpur	44
Bhuj	50	Vishakhapatnam	50
Bikaner	47	Naimital	47
Bikaro	47	Nasik	39
Bokaro	47	Nellore	50
Bombay	44	Panjim	39
Calcutta	50	Patiala	47

Calicut	47	Patna	47
Chandigarh	47	Pondicherry	50
Coimbatore	39	Por blair	44

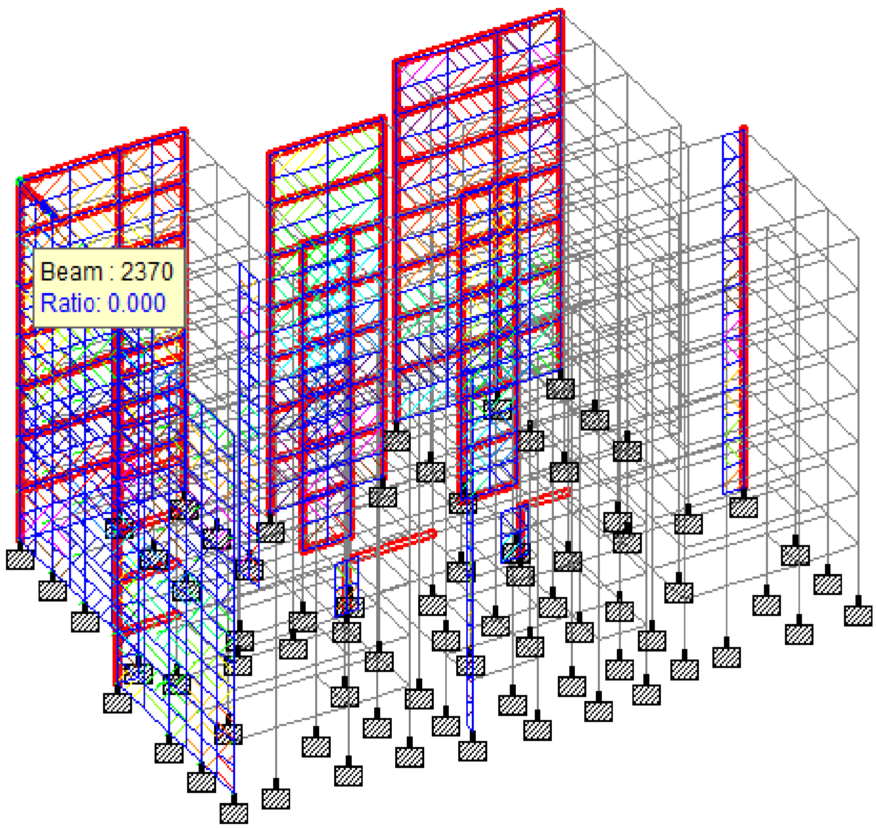


figure 4.4.3.3b Wind Load

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: **0.0035 N/mm²**

-ve sign indicates that floor load is acting downwards.

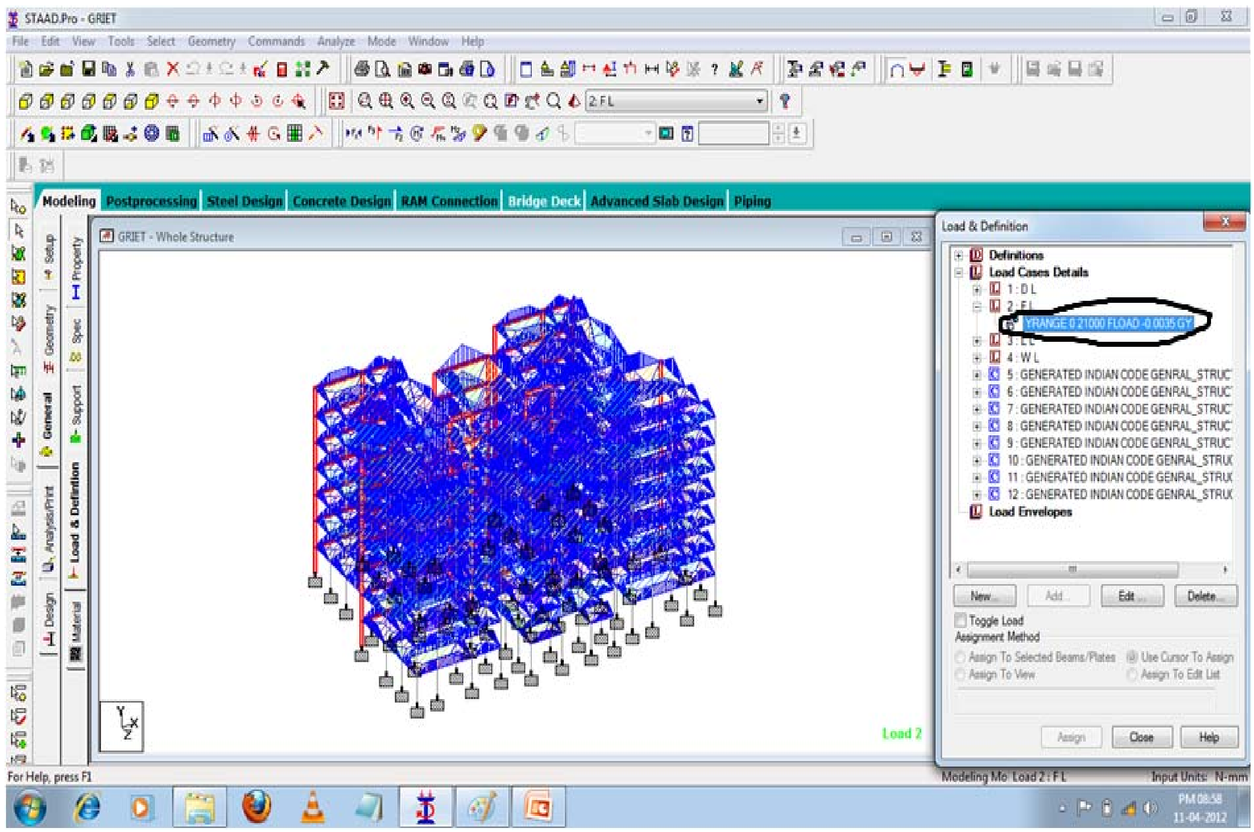


Fig 4.4.4.a **Diagram of floor load**

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 **IS456** 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**

Live load	**dead load**	**wind load**
1.5	1.5	0
1.2	1.2	1.2
0.9	0.9	0.9

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 analyzed by taking all the above combinations.

CHAPTER 5

BEAMS

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

In general we have two types of beam: single and double. 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 Beam design:

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 reinforeced concrete beams

1.) single reinforced beams
2.) double reinforced concrete
3.) 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. I 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.

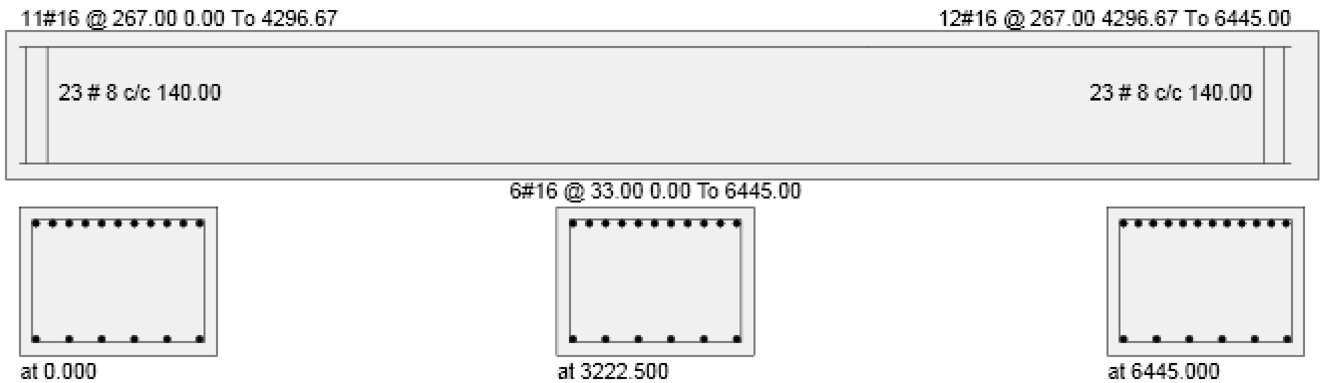
Figure shows the bottom and top reinforcement details at three different sections.

These calculations are interpreted manually.

STAAD.Pro Query   Concrete Design

Beam no. 218

Design Code: IS-456



Design Load

Mz(Kn Met)	Distet	Load
92.300003	3.200000	5
-162.130005	0.000000	5
-175.589996	6.400000	5

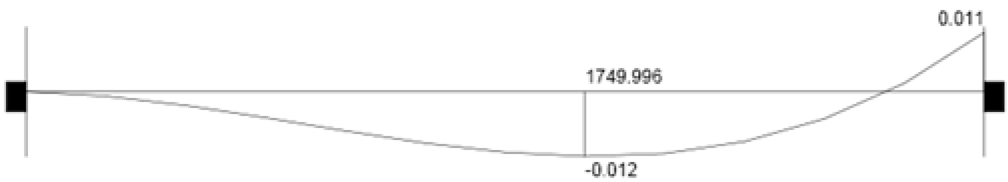
Design Parameter

Fy(Mpa)	415.000000
Fc(Mpa)	30.000000
Depth(mm)	299.999395
Width(mm)	399.999201
Length(mm)	6444.987183

Fig 5.2a   A_diagram of the reinforcement details of beam

The following figure shows the deflection of a column.

Deflection:



Distmm	X(in)	Y(in)	Z(in)
0.000000	0.0000	0.0000	0.0000
249.999491	-0.0008	-0.0049	0.0002
499.998983	-0.0025	-0.0099	0.0011
749.998474	-0.0048	-0.0148	0.0025
999.997965	-0.0072	-0.0198	0.0046
1249.997457	-0.0094	-0.0247	0.0074
1499.996948	-0.0110	-0.0297	0.0109
1749.996440	-0.0117	-0.0346	0.0153
1999.995931	-0.0112	-0.0396	0.0205
2249.995422	-0.0091	-0.0445	0.0266
2499.994914	-0.0049	-0.0494	0.0337
2749.994405	0.0016	-0.0544	0.0417
2999.993896	0.0107	-0.0593	0.0508

Fig 5.2b A diagram of the deflection of a column.

Due to huge output data, output of a sample beam is shown below.

Beam design

```
=========================================================================
======
                  B E A M  N O.     218   D E S I G N  R E S U L T S

         M30                     Fe415 (Main)              Fe415
(Sec.)

       LENGTH:  6445.0 mm      SIZE:   400.0 mm X  300.0 mm   COVER:
25.0 mm


                          DESIGN LOAD SUMMARY (KN MET)
   -------------------------------------------------------------------
---------
   SECTION |FLEXURE  (Maxm. Sagging/Hogging moments)|          SHEAR
   (in mm) |     P        MZ         MX   Load Case  |    VY       MX
Load Case
   -------------------------------------------------------------------
---------
       0.0 |     0.00     23.66     -1.39     4      |  154.56     0.78
5
           |     0.00   -162.13      0.78     5      |
     537.1 |     0.00     22.68     -1.98     9      |  131.59     0.78
5
           |     0.00    -91.95      2.30     7      |
    1074.2 |     0.00     22.24     -1.98     9      |  106.30     0.78
5
           |     0.00    -36.08      2.30     7      |
    1611.2 |     0.00     37.65     -1.05     6      |   80.61     0.78
5
           |     0.00    -15.45      2.21    10      |
    2148.3 |     0.00     64.93      0.78     5      |   51.11     2.30
7
           |     0.00     -6.69      2.21    10      |
    2685.4 |     0.00     86.02      0.78     5      |   29.06     2.30
7
           |     0.00      0.00      0.00     1      |
    3222.5 |     0.00     92.30      0.78     5      |   10.62     2.21
10
           |     0.00      0.00      0.00     1      |
    3759.6 |     0.00     83.77      0.78     5      |  -32.40    -1.05
6
           |     0.00     -3.53     -1.39     4      |
    4296.7 |     0.00     60.45      0.78     5      |  -57.22     0.78
5
           |     0.00     -7.41     -1.39     4      |
```

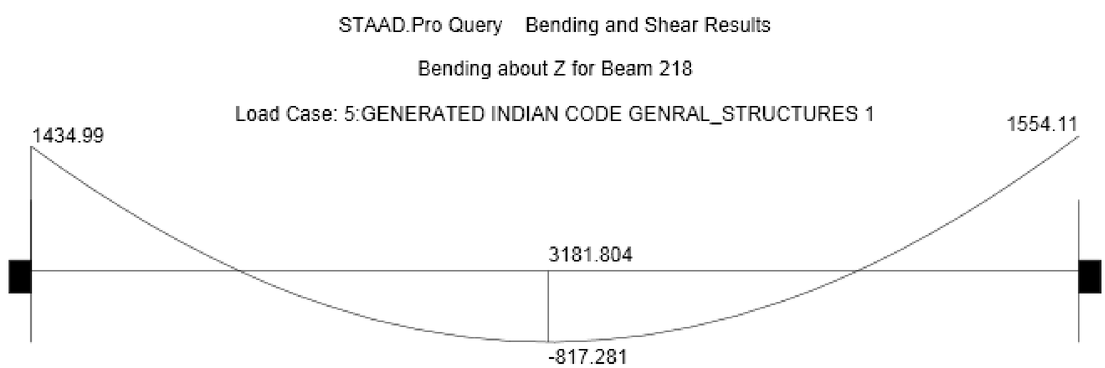
```
    4833.8 |     0.00     31.42      2.30     7     |  -84.78     0.78
5
           |     0.00    -15.12     -1.98     9     |
    5370.8 |     0.00     20.20      2.21    10     | -110.48     0.78
5
           |     0.00    -42.41     -1.05     6     |
    5907.9 |     0.00     20.40      2.21    10     | -135.77     0.78
5
           |     0.00   -100.07     -1.05     6     |
    6445.0 |     0.00     19.37      2.21    10     | -158.73     0.78
5
           |     0.00   -175.59      0.78     5     |
   ----------------------------------------------------------------------
---------
```

SUMMARY OF REINF. AREA (Sq.mm)

```
   ----------------------------------------------------------------------
---------
   SECTION |          TOP             |         BOTTOM          |
STIRRUPS
   (in mm) | Reqd./Provided reinf.    | Reqd./Provided reinf.   |   (2
legged)
   ----------------------------------------------------------------------
---------
       0.0 | 2102.75/2211.68(11-16í )|  625.79/ 804.25( 4-16í )|  8í
@ 140 mm
     537.1 | 1151.51/1206.37( 6-16í )|  265.73/ 603.19( 3-16í )|  8í
@ 140 mm
    1074.2 |  422.27/ 603.19( 3-16í )|  260.79/ 603.19( 3-16í )|  8í
@ 140 mm
    1611.2 |  218.75/ 603.19( 3-16í )|  425.58/ 603.19( 3-16í )|  8í
@ 140 mm
    2148.3 |  218.75/ 603.19( 3-16í )|  756.82/ 804.25( 4-16í )|  8í
@ 140 mm
    2685.4 |    0.00/ 402.12( 2-16í )| 1042.62/1206.37( 6-16í )|  8í
@ 140 mm
    3222.5 |    0.00/ 402.12( 2-16í )| 1133.58/1206.37( 6-16í )|  8í
@ 140 mm
    3759.6 |  218.75/ 603.19( 3-16í )| 1010.85/1206.37( 6-16í )|  8í
@ 140 mm
    4296.7 |  218.75/ 603.19( 3-16í )|  699.37/ 804.25( 4-16í )|  8í
@ 140 mm
    4833.8 |  218.75/ 603.19( 3-16í )|  368.27/ 603.19( 3-16í )|  8í
@ 140 mm
    5370.8 |  481.59/ 603.19( 3-16í )|  240.74/ 603.19( 3-16í )|  8í
@ 140 mm
    5907.9 | 1254.86/1407.43( 7-16í )|  242.95/ 603.19( 3-16í )|  8í
@ 140 mm
```

```
    6445.0 | 2284.09/2412.74(12-16í )|  826.67/1005.31( 5-16í )|  8í
@ 140 mm
   -------------------------------------------------------------------


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

   SHEAR DESIGN RESULTS AT   490.0 mm AWAY FROM START SUPPORT
     VY =   133.60 MX =     0.78 LD=    5
     Provide 2 Legged  8í  @ 140 mm c/c

   SHEAR DESIGN RESULTS AT   490.0 mm AWAY FROM END SUPPORT
     VY =  -137.98 MX =     0.78 LD=    5
     Provide 2 Legged  8í  @ 140 mm c/c
```

shear



Distmm	Fy(N)	Mz(kip-in)
0.000000	154555.0864	1434.9900
537.082265	131379.4330	754.7840
1074.164530	106689.3721	188.3447
1611.246796	80484.9035	-257.1290
2148.329061	53040.4566	-574.7001
2685.411326	25476.0760	-761.3173
3222.493591	-2088.3047	-816.9051
3759.575857	-29652.6853	-741.4635
4296.658122	-57217.0660	-534.9924
4833.740387	-84661.5129	-197.5675
5370.822652	-110865.9814	267.7601
5907.904918	-135556.0424	854.0532
6444.987183	-158731.6957	1554.1130

Fig 5.2c A diagram of the shear force of a column.

5.3 Check for the design of a beam (no. 230):

Given data:

Cross section of beam : b x d = 300mm x400 mm

Vertical shear force = v_u =145.93 KN

τ_c = 0.29 N/mm^2 (from table 19 of IS 456 200)

Minimum Shear Reinforcement:

When τ_v is less than τ_c , given in Table 19, minimum shear reinforcement shall -be provided

Design of Shear Reinforcement:

When τ_v exceeds τ_c, given in Table 19, **shear reinforcement shall be** provided in any of the following forms:

a) Vertical stirrups,

b) Bent-up bars along with stirrups, and

c) Inclined stirrups,

$\tau_v = v_u/(b \times d)$ (As per clause 40.1 of IS 456-2000)

$=145.93 \times 10^3/(400x300)$

$=1.216 \ N/mm^2$

$\tau_v \geq \tau_c$

design reinforcement Vus = Vu- $\tau_c$xbxd (As per clause 40.4 of IS 456-2000)

$= 145.93 \times 10^3 - 0.29x400x300$

= 111100 N

Shear reinforcement shall be provided to carry a shear equal to ***Vu*** **-** τ_c ***bd The*** strength of shear reinforcement ***Vus,*** shall be calculated as below:

For vertical stirrups:

Vus = 0.87 f_yAsvd/Sv (As per clause 40.4 of IS 456-2000)

Asv = total cross-sectional area of stirrup legs or bent-up bars within a distance Sv.

Sv = spacing of the stirrups or bent-up bars along the length of the member,

τ_v = nominal shear stress

τ_c = design shear strength of the concrete,

b = breadth of the member which for flanged beams, shall be taken as the breadth of the web *bw,*

fy = characteristic strength of the stirrup or bent-up reinforcement which shall notbe taken greater than 415 N/mm^2,

α = angle between the inclined stirrup or bent- up bar and the axis of the member, not less than 45", and

d = effective depth.

111130 N= $0.87x415x2x\pi x8^2x400/Sv$

Sv = 140 mm

Sv should not be more than the following

1. 0.75xd = 0.75 x 400 = 300 mm
2. 300 mm
3. Minimum shear reinforcement spacing = Svmin

Minimum shear reinforcement:

Minimum shear reinforcement in the form of stirrups shall be provided such that:

Asv/bSv ≥ 0.4/ 0.87fy (As per clause 26.5.1.6 of IS 456-2000)

Asv = total cross-sectional area of stirrup legs effective in shear,

Sv = stirrup spacing along the length of the member,
b = breadth of the beam or breadth of the web of flanged beam, and
fy = characteristic strength of the stirrup reinforcement in N/mm* which shall not be taken greater than 415 N/mn^2

S_v=2x(π/4)x8^2x0.87x415/(0.4x300)

=302 mm.

Provided 2 legged 8mm @140 mm strirrups .

Hence matched with staad output.

CHAPTER 6

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,R.C 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 multistoried 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:-

A) 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.
B) The spacing between the column is governed by the lamination on spans of supported beams, as the spanning of the column decides the 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 contraflexure 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 nonexistent. 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 200 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 fiber 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 fiber.

Design charts for combined axial compression and bending are in the form of intersection diagram in which curves for $P_u/f_{ck}\,bD$ verses $M_u/f_{ck}\,bD^2$ 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:

$(M_{ux}/ M_{uy})^{\alpha n} +(M_{uy}/ M_{uy1})^{\alpha n}<=1.0$

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

1.) shape of the section
2.) slenderness ratio(A=L+D)
3.) type of loading, land
4.) 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.

- Column with beams on two sides
- Columns with beams on three sides
- 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

1. Minimum reinforcement, max, bar sizes, maximum and minimum spicing.

2. Select the appropriate design code and input design column command to all the column.

3. 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

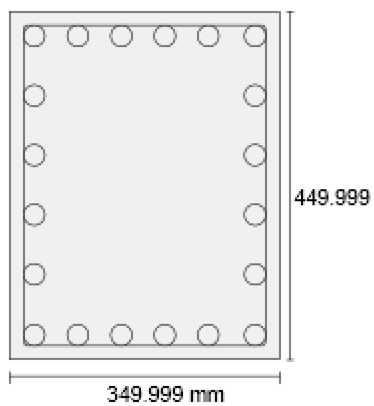
2. Longitudinal reinforcement

The type of bars to be used, amount of steel and loading on the column is represented in the below figure.

STAAD.Pro Query   Concrete Design

Beam no. 131

Design Code: IS-456



Design Load

Load	9
Location	End 1
Pu(Kns)	76.760002
Mz(Kns-Mt)	75.889999
My(Kns-Mt)	50.490002

Design Results

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	2041.000000
As (%)	1.436000
Bar Size	12
Bar No	20

Fig 6.3a   reinforcement details of a column

Output:

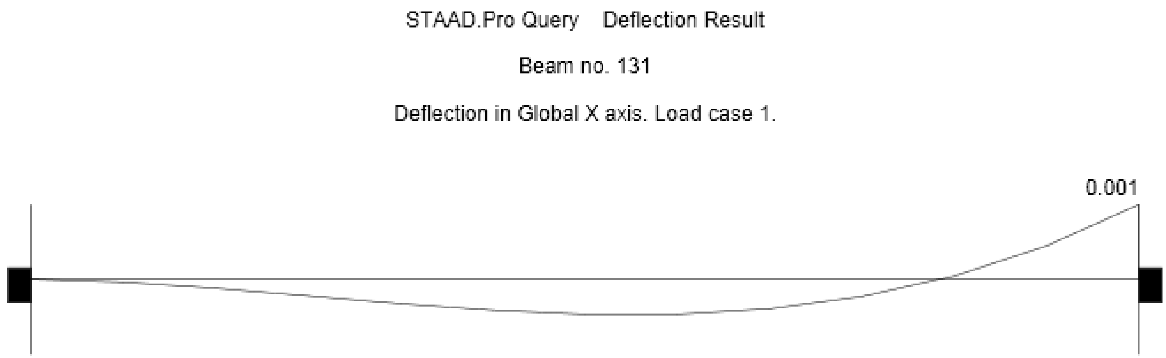
Due to very huge and detailed explanation of staad output for each and every coloumn we have shown a column design results below showing the amount of load,moments,amount of steel required,section adopted etc.

The main problem with staad is it takes all coloumns also as beams initially before design and continue the same.so here output of column 1 which os actually 131st beam as most of beams are used in drawing the plan.

Out put for coloumn 1(beam 131):

```
            C O L U M N   N O.   131  D E S I G N   R E S U L T S

         M30                     Fe415 (Main)              Fe415
(Sec.)

   LENGTH:  3000.0 mm   CROSS SECTION:  350.0 mm X  450.0 mm  COVER:
40.0 mm

   ** GUIDING LOAD CASE:    9 END JOINT:     1  SHORT COLUMN


   DESIGN FORCES (KNS-MET)
   -----------------------
   DESIGN AXIAL FORCE (Pu)             :    76.8

                                         About Z         About Y
   INITIAL MOMENTS                     :   75.89           50.49
   MOMENTS DUE TO MINIMUM ECC.         :    1.61            1.54

   SLENDERNESS RATIOS                  :     -               -
   MOMENTS DUE TO SLENDERNESS EFFECT   :     -               -
   MOMENT REDUCTION FACTORS            :     -               -
   ADDITION MOMENTS (Maz and May)      :     -               -

   TOTAL DESIGN MOMENTS                :   75.89           50.49

   REQD. STEEL AREA   :     2041.15 Sq.mm.
   REQD. CONCRETE AREA:   155458.86 Sq.mm.
   MAIN REINFORCEMENT : Provide  20 - 12 dia. (1.44%,   2261.95
Sq.mm.)
                        (Equally distributed)
   TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 190 mm
c/c

   SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
   ----------------------------------------------------------
   Puz :   2734.00   Muz1 :    144.59   Muy1 :    107.38

   INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

   SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
   ----------------------------------------------------------
   WORST LOAD CASE:     9
   END JOINT:     1 Puz :   2799.74   Muz :    157.05   Muy :
116.44   IR: 0.92
```

The following figure shows the deflection of same column.



Distmm	X(in)	Y(in)	Z(in)
0.000000	0.0000	0.0000	0.0000
249.999491	-0.0000	-0.0005	0.0001
499.998983	-0.0001	-0.0009	0.0002
749.998474	-0.0002	-0.0014	0.0005
999.997965	-0.0003	-0.0019	0.0008
1249.997457	-0.0004	-0.0023	0.0012
1499.996948	-0.0005	-0.0028	0.0017
1749.996440	-0.0005	-0.0033	0.0023
1999.995931	-0.0004	-0.0037	0.0030
2249.995422	-0.0002	-0.0042	0.0037
2499.994914	0.0000	-0.0047	0.0045
2749.994405	0.0005	-0.0051	0.0053
2999.993896	0.0010	-0.0056	0.0062

Fig 6.3 b deflection of column

Check for Column design :

Short axially Loaded columns:

Given data

fck =30 N/mm^2

fy =415N/mm^2

puz=2734 N

b=350 d=450

Design of reinforcement Area:

(As per clause 39.6 of IS 456 2000)

$Puz=0.45f_{ck}A_c+0.75f_yA_{sc}$

$2734=0.45*30*(350*450-Asc)+0.75*415*A_{sc}$

On solving the above equation we get

Asc=2041.15 Sq.mm.((Matched with Output)

Design of Main(Longitudinal) reinforcement:

(As per clause 26.5.3.1 of IS 456-2000)

1. The cross sectional area of longitudinal reinforcement shall not be less 0.8% , not more than 6% of the gross cross sectional area of the column.
2. The bars shall not be less than 12 mm in diameter.
3. Spacing of longitudinal bars measured along the periphery of the column shall not exceed 300 mm.

Provided main reinforcement : 20 - 12 dia
(1.44%, 2261.95 Sq.mm.)

Check for Transverse reinforcement :

(As per clause 26.5.3.2 of IS 456-2000)

A) pitch :
shall not be more than the least of the following
1) Least lateral dimension of the compression member (350mm).
2) 16 x diameter of longitudinal reinforcement bar
= 16x 12 = 192 mm
3) 300 mm

B) **Diameter :**
1) Shall not be less than one fourth of the diameter of main reinforcement.
2) Not less than 6 mm.

PROVIDED TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

CHAPTER 7

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 beam

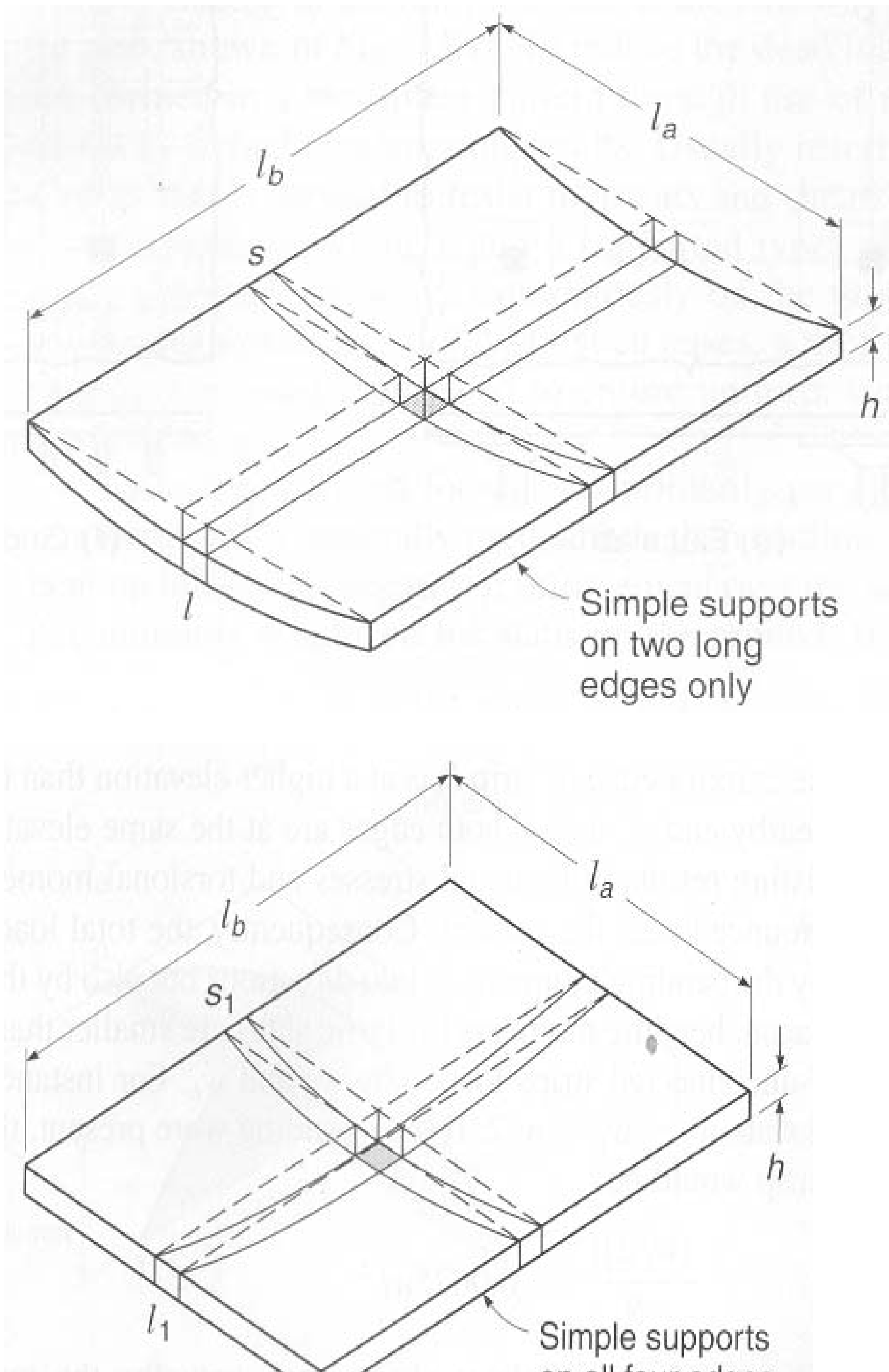
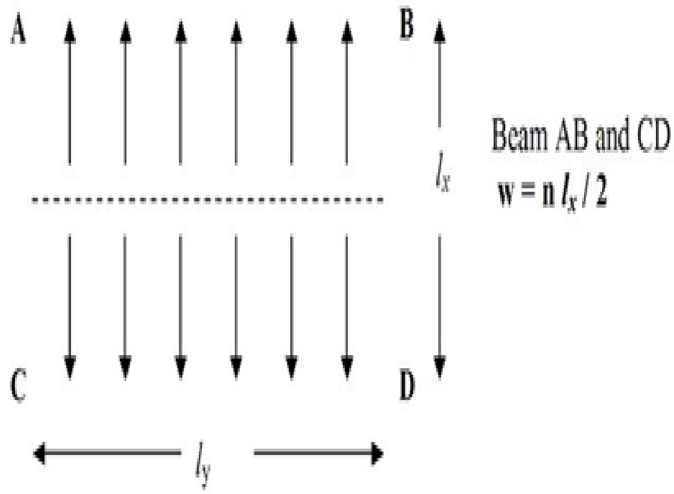


Fig 7.1. a Diagrams of slab deflection in one way and two way slabs

Following figures shows the load distributions in two slabs.

a) One-way slab



b) Two-way slab

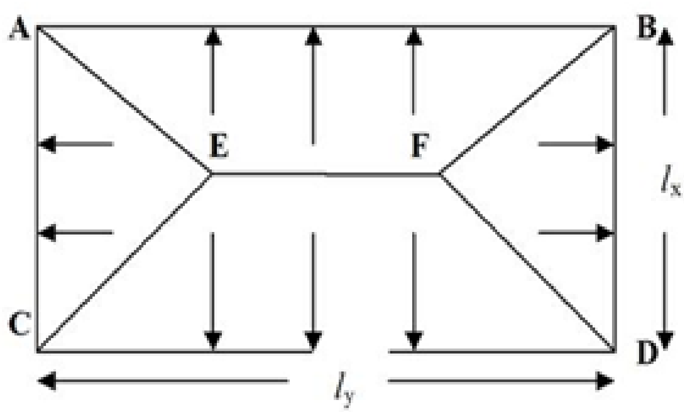


Fig 7.1.b A Diagram of load distribution of one way and two way slabs

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

This diagram shows the distribution of loads in two slabs.

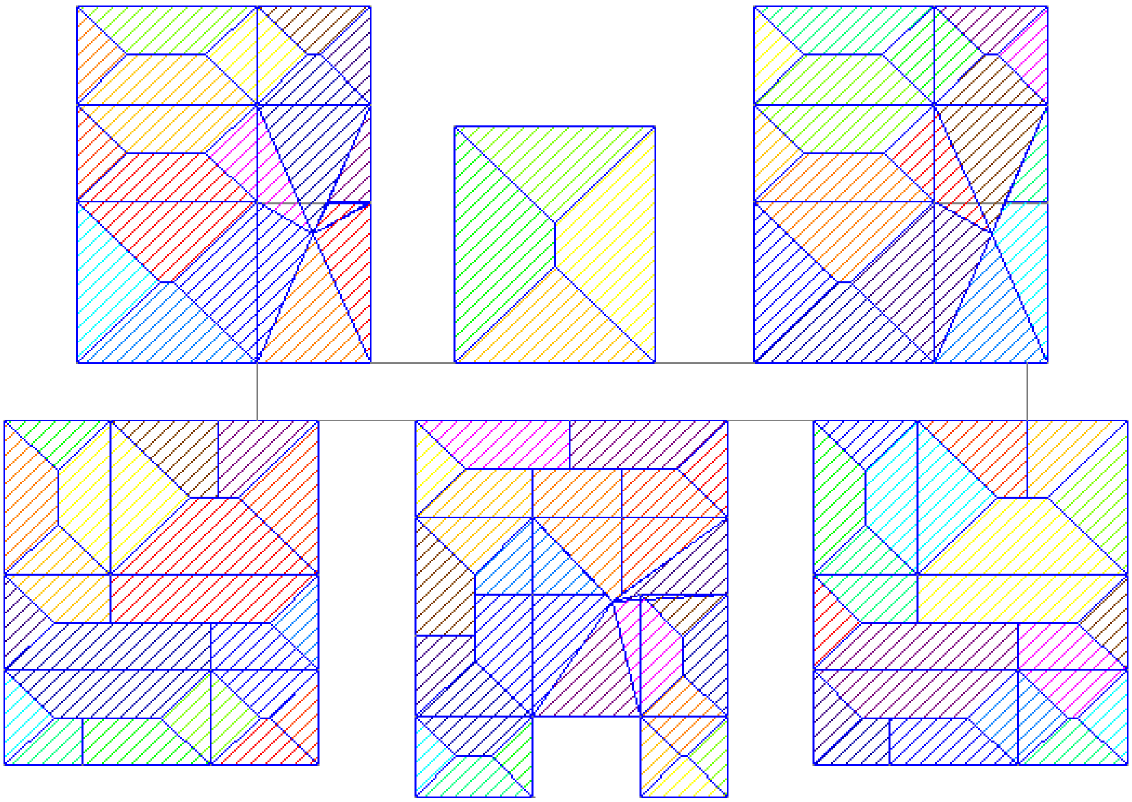


Figure 7.1.c Distribution of loads in two slabs.

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

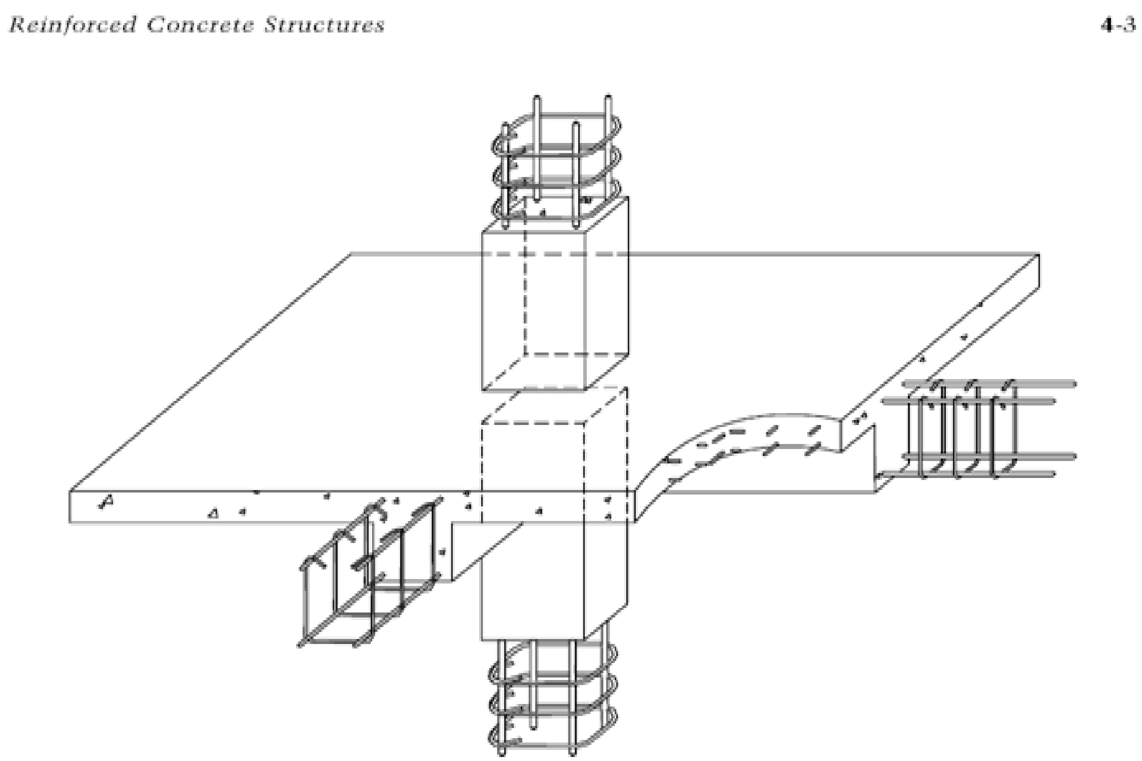


Figure 7.1.d monolithic connection between beam, column and slab

Design of slabs :

Size: 3.88m x 3.53m

End conditions for slab:

Adjacent long and short sides are continuous and other edges discontinuous.

Assuming the thickness of slab as 120 mm.

Calculation of loads:

Live load:

For residential building live load is usually taken as 2 kN/sq.m. (in accordance with 875 part II)

Dead load :

Self weight of slab = 1x1x0.12x25 = 3.0 KN/m^2

Weight of flooring (75mm thick) = 1x1x0.005x20 = 1.0 KN/m^2

Accidental loads = 1.0 KN/m^2 = 1.0 KN/m^2

5.0 KN/m^2

Live load:

Live load is taken = 2.0 KN/m^2

Total load = 2 + 5.0 KN/m^2

Factored load = 1.5x7.0 KN/m^2

Design load = 10.5 KN/m^2

Calculation of moments:

(As per Table 12 of IS 456-2000)

Bending moment coefficients for slab :

	Dead load and super imposed load
Near the middle	
End of span	+1/12
At support next to	
End support	-1/10

Positive bending moment at mid span = $wl^2/12$

Mu = $10.5x(3.88)^2/12$

= 13.17KNm

Negative bending moment at support = $-10.5x(3.88)^2/10$

= 15.8KNm

Design bending moment = 15.8KNm

Calculation of effective depth:

Adopting M30 concrete and Fe 415 steel

As per IS 456-2000(Annexure G)

Mu,limit $=0.36xXumax/d(1-0.42Xumax/d)bd^2f_{ck}$

$=0.36x0.46(1-0.42x0.48)bd^2x30$

Xumax/d =0.48

Mulimit $=4.13bd^2$

Assuming b =1000mm

Mu =Mulimit

d $=\sqrt{15.8x10^6/(4.13x1000)}$

=61.852mm

Adopting 8-mm dia bars as reinforcement

Effective cover = 15+10/2 =20mm

Over all depth = D =61.852+20=81.852

Therefore providing overall depth D = 120mm

Effective depth d = 120-20=100mm

Calculation of steel: (MAIN REINFORCEMENT)

Form IS 456-2000(Annexure G)

Mu $=0.87xf_yxAstxd(1-f_yxAst/bdf_{ck})$

15.8 =0.87x415x100xAst(1-415xAst/(1000x100x30)

Ast $=437.6mm^2$

Providing minimum steel of $=0.12\%xbxD=144mm^2$

Spacing of 10mm dia bars =(astx1000)/Ast

$=(\prod x10^2x1000)/(4x437.6)$

=179.47mm c/c

As per IS 456 2000, clause 26.3.3b,the spacing of Reinforcement should be not more than least of following

1. 3xeffective depth =3x100 =300mm
2. 300mm

   Provide 10 mm Φ bars @ 175 mm.

Distribution reinforcement:

As per IS 456-2000(clause:26.5.2.1)

Providing 0.12% of gross area as distribution reinforcement

Area of steel = (0.12x120x1000)/100 $=144mm^2$

Adopting 6mm Φ bars as distribution reinforcement

Spacing = (astx1000)/Ast

$= (\prod/4x6^2x1000)/144$

=196.35mm c/c

Provide 6mm Φ bars @ 180mm c/c

Check for development length:

As per IS 456-2000(clause 26.2.1)

The development length Ld is given by

Ld $= \Phi\sigma_{st}/4\ \tau_{bd}$

$= (10x0.87x415)/(4x1.2x1.6)$

= 470.11 mm (req.)

Ld(available) $= MI/V+L_0$

M1 $= 0.87xf_yxAstxd(1-f_yxAst/bdf_{ck})$

$= 0.87x415x437x100(1-437x415/(1000x100x30)$

$= 14.82x10^6$N-mm

Shear force at the section due to design loads

V = W1/2 = 10.5x3.88/2

= 20.37

$M1/V+L_0$ $= 14.82/20.37 +L_0$

$= 0.727m + L_0$

$=727mm +L_0$

Ld(available)>Ld(req'd) safe

CHAPTER 8

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.

<u>Shallow (D<B)</u>

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

<u>Deep (D>B)</u>

- 1.Pile Cap
- 2. Driller Pier

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

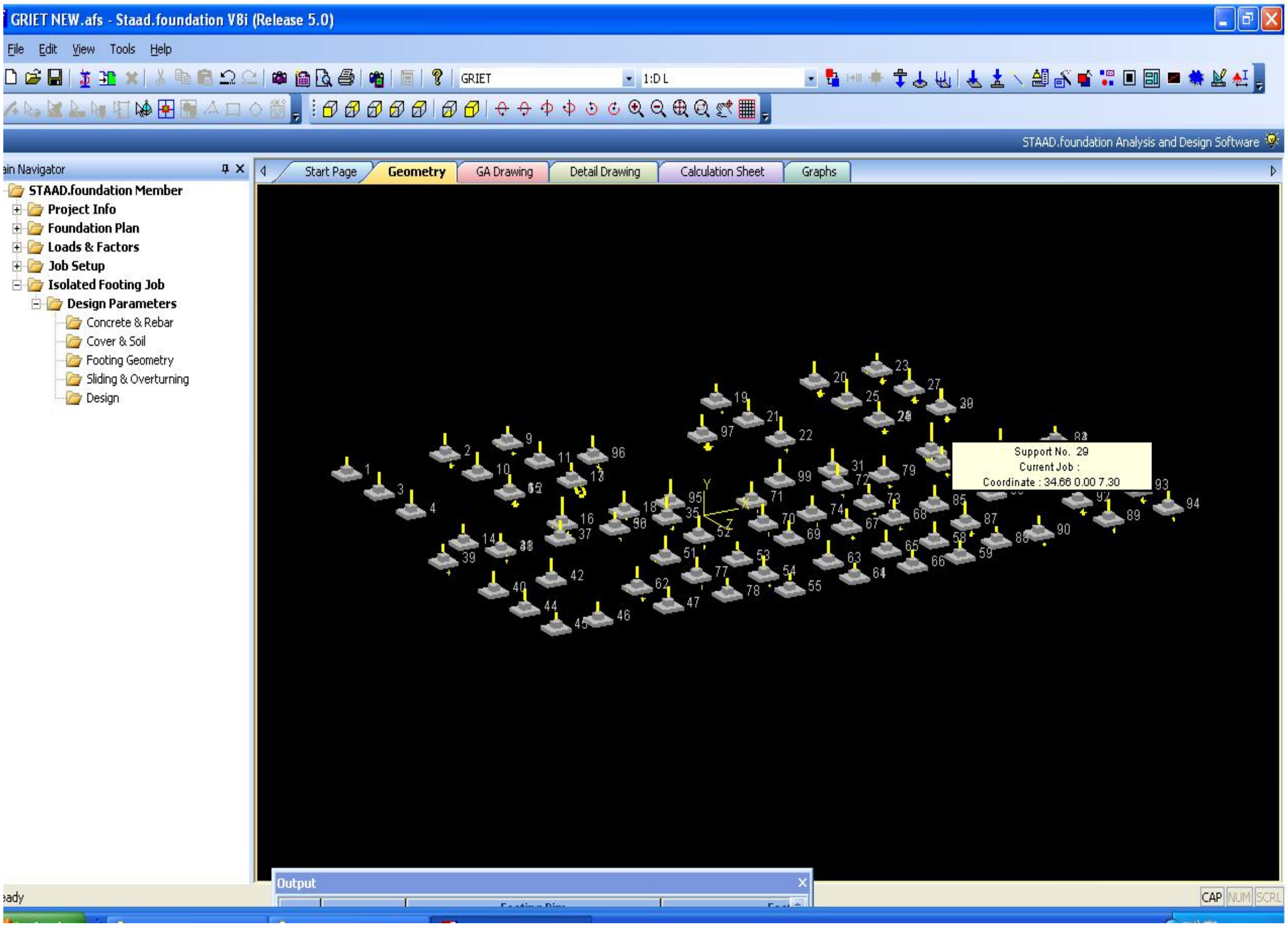


Fig 8.1a placement of columns

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
- Yield strength of steel:415 n/mm^2
- Minimum bar size:6mm

- Maximum bar size:40mm
- Bottom clear cover:50mm
- Unit weight of soil:22 kn/m^3
- Soil bearing capacity:300 kn/m^3
- Minimumlength:1000mm
- Minimum width:1000mm
- Minimum thichness:500mm
- 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.

Footing No.	Group ID	Foundation Geometry		
-	-	Length	Width	Thickness
1	1	3.800 m	3.800 m	0.502 m
2	2	4.750 m	4.750 m	0.553 m
3	3	3.200 m	3.200 m	0.702 m
4	4	3.350 m	3.350 m	0.752 m
6	5	2.650 m	2.650 m	0.551 m
9	6	2.900 m	2.900 m	0.501 m

10	7	3.500 m	3.500 m	0.802 m
11	8	2.900 m	2.900 m	0.601 m
12	9	3.250 m	3.250 m	0.501 m
13	10	2.450 m	2.450 m	0.501 m
14	11	2.950 m	2.950 m	0.652 m
15	12	2.650 m	2.650 m	0.551 m
16	13	3.650 m	3.650 m	0.852 m
17	14	2.600 m	2.600 m	0.551 m
18	15	3.050 m	3.050 m	0.702 m
19	16	4.100 m	4.100 m	0.502 m
20	17	3.750 m	3.750 m	0.652 m
21	18	3.500 m	3.500 m	0.652 m
22	19	3.350 m	3.350 m	0.752 m
23	20	3.200 m	3.200 m	0.501 m
24	21	2.650 m	2.650 m	0.501 m
25	22	3.500 m	3.500 m	0.802 m
26	23	2.650 m	2.650 m	0.501 m
27	24	2.850 m	2.850 m	0.651 m
28	25	2.250 m	2.250 m	0.501 m
29	26	2.550 m	2.550 m	0.551 m
30	27	2.550 m	2.550 m	0.551 m
31	28	3.300 m	3.300 m	0.752 m
32	29	4.150 m	4.150 m	0.952 m
35	30	2.800 m	2.800 m	0.602 m
36	31	2.100 m	2.100 m	0.501 m
37	32	2.350 m	2.350 m	0.501 m
38	33	2.300 m	2.300 m	0.551 m
39	34	2.500 m	2.500 m	0.551 m
40	35	3.100 m	3.100 m	0.652 m
41	36	2.300 m	2.300 m	0.551 m
42	37	3.600 m	3.600 m	0.852 m
44	38	3.150 m	3.150 m	0.702 m
45	39	3.150 m	3.150 m	0.501 m
46	40	2.350 m	2.350 m	0.501 m
47	41	2.850 m	2.850 m	0.651 m
50	42	2.100 m	2.100 m	0.501 m
51	43	3.200 m	3.200 m	0.702 m
52	44	2.850 m	2.850 m	0.651 m
53	45	2.400 m	2.400 m	0.551 m
54	46	2.600 m	2.600 m	0.601 m
55	47	2.150 m	2.150 m	0.501 m

58	48	2.650 m	2.650 m	0.601 m
59	49	2.000 m	2.000 m	0.501 m
61	50	1.750 m	1.750 m	0.501 m
62	51	3.300 m	3.300 m	0.752 m
63	52	3.100 m	3.100 m	0.702 m
64	53	1.750 m	1.750 m	0.501 m
65	54	3.000 m	3.000 m	0.702 m
66	55	2.050 m	2.050 m	0.501 m
67	56	2.400 m	2.400 m	0.551 m
68	57	2.650 m	2.650 m	0.601 m
69	58	2.600 m	2.600 m	0.601 m
70	59	2.750 m	2.750 m	0.601 m
71	60	2.750 m	2.750 m	0.602 m
72	61	2.850 m	2.850 m	0.651 m
73	62	2.650 m	2.650 m	0.601 m
74	63	2.500 m	2.500 m	0.551 m
77	64	2.450 m	2.450 m	0.551 m
78	65	2.200 m	2.200 m	0.501 m
79	66	2.750 m	2.750 m	0.651 m
80	67	2.300 m	2.300 m	0.501 m
81	68	2.350 m	2.350 m	0.501 m
82	69	2.900 m	2.900 m	0.652 m
83	70	1.950 m	1.950 m	0.501 m
84	71	1.950 m	1.950 m	0.501 m
85	72	2.950 m	2.950 m	0.702 m
86	73	3.600 m	3.600 m	0.802 m
87	74	3.150 m	3.150 m	0.702 m
88	75	2.050 m	2.050 m	0.501 m
89	76	2.800 m	2.800 m	0.602 m
90	77	2.350 m	2.350 m	0.501 m
91	78	3.200 m	3.200 m	0.702 m
92	79	3.350 m	3.350 m	0.752 m
93	80	2.500 m	2.500 m	0.551 m
94	81	2.200 m	2.200 m	0.501 m
95	82	3.650 m	3.650 m	0.852 m
96	83	3.350 m	3.350 m	0.752 m
97	84	3.450 m	3.450 m	0.802 m
99	85	3.600 m	3.600 m	0.852 m

Footing No.	Footing Reinforcement			
-	Bottom Reinforcement(M_z)	Bottom Reinforcement(M_x)	Top Reinforcement(M_z)	Top Reinforcement(M_x)

1	#10 @ 65 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
2	#12 @ 70 mm c/c	#12 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
3	#10 @ 70 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
4	#10 @ 60 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
6	#8 @ 65 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
9	#8 @ 60 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
10	#10 @ 65 mm c/c	#10 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
11	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
12	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
13	#8 @ 65 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
14	#10 @ 75 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
15	#8 @ 65 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
16	#10 @ 65 mm c/c	#10 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
17	#8 @ 65 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
18	#8 @ 50 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
19	#10 @ 70 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
20	#10 @ 60 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
21	#10 @ 65 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
22	#10 @ 60 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
23	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
24	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
25	#10 @ 65 mm c/c	#10 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
26	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
27	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
28	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
29	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
30	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
31	#10 @ 65 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
32	#10 @ 50 mm c/c	#10 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
35	#10 @ 75 mm c/c	#10 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
36	#8 @ 75 mm c/c	#8 @ 70 mm c/c	#8 @ 75 mm c/c	#8 @ 75 mm c/c
37	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
38	#8 @ 70 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
39	#8 @ 55 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
40	#10 @ 70 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
41	#8 @ 70 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
42	#10 @ 65 mm c/c	#10 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
44	#10 @ 65 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
45	#8 @ 70 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
46	#8 @ 60 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
47	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c

50	#8 @ 75 mm c/c	#8 @ 70 mm c/c	#8 @ 75 mm c/c	#8 @ 75 mm c/c
51	#10 @ 65 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
52	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
53	#8 @ 65 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
54	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
55	#8 @ 75 mm c/c	#8 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
58	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
59	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
61	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
62	#10 @ 75 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
63	#10 @ 70 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
64	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
65	#10 @ 75 mm c/c	#10 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
66	#8 @ 80 mm c/c	#8 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
67	#8 @ 65 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
68	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
69	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
70	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
71	#10 @ 75 mm c/c	#10 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
72	#8 @ 50 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
73	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
74	#8 @ 55 mm c/c	#8 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
77	#8 @ 60 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
78	#8 @ 70 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
79	#8 @ 55 mm c/c	#8 @ 50 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
80	#8 @ 65 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
81	#8 @ 65 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
82	#8 @ 50 mm c/c	#10 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
83	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
84	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
85	#8 @ 55 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
86	#10 @ 55 mm c/c	#10 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
87	#10 @ 65 mm c/c	#10 @ 70 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
88	#8 @ 80 mm c/c	#8 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
89	#10 @ 75 mm c/c	#10 @ 75 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
90	#8 @ 60 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
91	#10 @ 65 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
92	#10 @ 60 mm c/c	#10 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
93	#8 @ 60 mm c/c	#8 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
94	#8 @ 70 mm c/c	#8 @ 65 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
95	#10 @ 60 mm c/c	#10 @ 55 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c

96	#10 @ 65 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
97	#10 @ 65 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c
99	#10 @ 65 mm c/c	#10 @ 60 mm c/c	#8 @ 80 mm c/c	#8 @ 80 mm c/c

After the design is complete the calculations is obtained for each and every column and a sample column calculations is shown below.

Isolated Footing 1

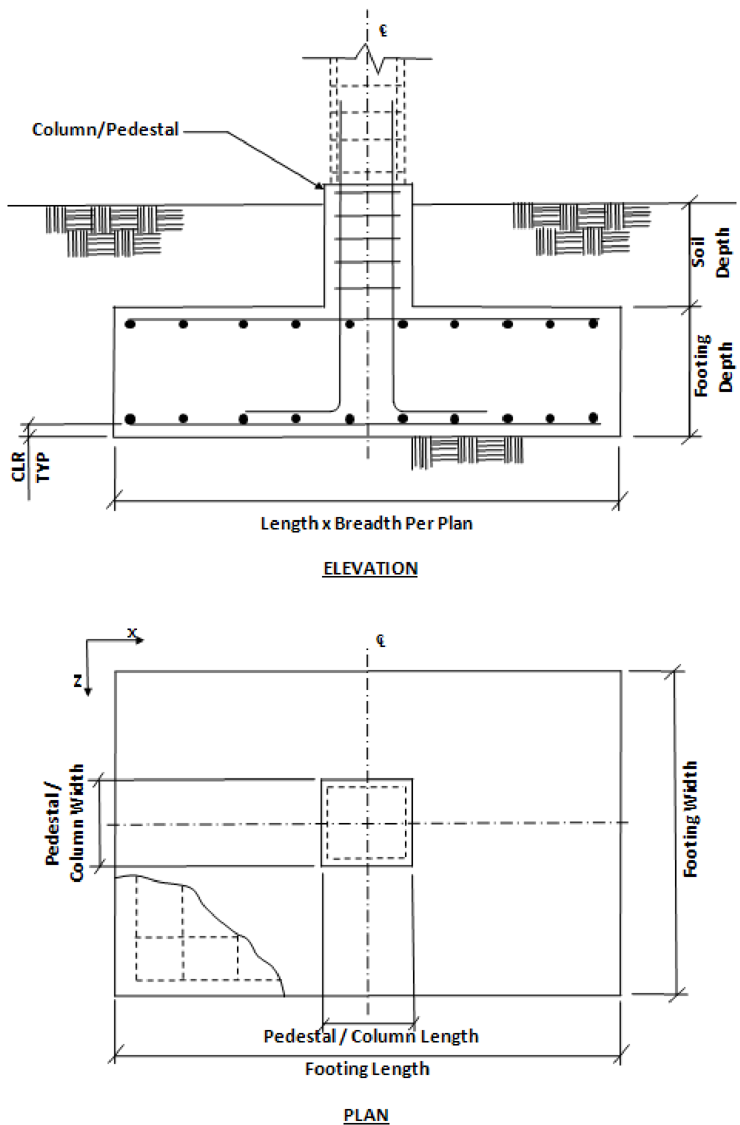


Fig 8.1.a Elevation and Plan of Isolated Footing

Footing Geometry

Footing Thickness (Ft) : 500.00 mm
Footing Length – X (Fl) : 1000.00 mm
Footing Width – Z (Fw) : 1000.00 mm

Column Dimensions

Column Shape :	Rectangular
Column Length – X (Pl) :	0.45 m
Column Width – Z (Pw) :	0.35 m

Pedestal

Pedestal Length – X : N/A
Pedestal Width – Z : N/A

Design Parameters

Concrete and Rebar Properties

Unit Weight of Concrete : 25.000 kN/m3
Strength of Concrete : 30.000 N/mm2
Yield Strength of Steel : 415.000 N/mm2
Minimum Bar Size : # 6
Maximum Bar Size : # 40
Minimum Bar Spacing : 50.00 mm

Maximum Bar Spacing : 500.00 mm
Footing Clear Cover (F, CL) : 50.00 mm

Soil Properties :

Soil Type : Un Drained
Unit Weight : 22.00 kN/m3
Soil Bearing Capacity : 300.00 kN/m2
Soil Surcharge : 0.00 kN/m2
Depth of Soil above Footing : 0.00 mm
Untrained Shear Strength : 0.00 N/mm2

Sliding and Overturning :

Coefficient of Friction : 0.50
Factor of Safety Against Sliding : 1.50
Factor of Safety Against Overturning : 1.50

Applied Loads – Allowable Stress Level					
LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
1	168.123	-1.837	0.275	1.491	1.441
2	140.638	-3.797	-0.289	0.593	3.370
3	842.201	-16.764	-1.784	2.831	14.560
4	-116.948	20.364	19.053	32.167	-52.030
5	1726.443	-33.597	-2.696	7.373	29.057
6	1240.817	-2.441	20.708	44.499	-39.191
7	1521.493	-51.314	-25.020	-32.702	85.682
8	1381.155	-26.878	-2.156	5.898	23.245
9	76.762	27.790	28.993	50.487	-75.884
10	427.606	-33.301	-28.168	-46.014	80.207
11	252.184	-2.755	0.413	2.237	2.162
12	151.310	-1.653	0.248	1.342	1.297

Applied Loads – Strength Level					
LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
1	168.123	-1.837	0.275	1.491	1.441
2	140.638	-3.797	-0.289	0.593	3.370
3	842.201	-16.764	-1.784	2.831	14.560

4	-116.948	20.364	19.053	32.167	-52.030
5	1726.443	-33.597	-2.696	7.373	29.057
6	1240.817	-2.441	20.708	44.499	-39.191
7	1521.493	-51.314	-25.020	-32.702	85.682
8	1381.155	-26.878	-2.156	5.898	23.245
9	76.762	27.790	28.993	50.487	-75.884
10	427.606	-33.301	-28.168	-46.014	80.207
11	252.184	-2.755	0.413	2.237	2.162
12	151.310	-1.653	0.248	1.342	1.297

Design Calculations :

Footing Size

Initial Length (L_o) = 1.00 m

Initial Width (W_o) = 1.00 m

Uplift force due to buoyancy = -0.00 kN

Effect due to adhesion = 0.00 kN

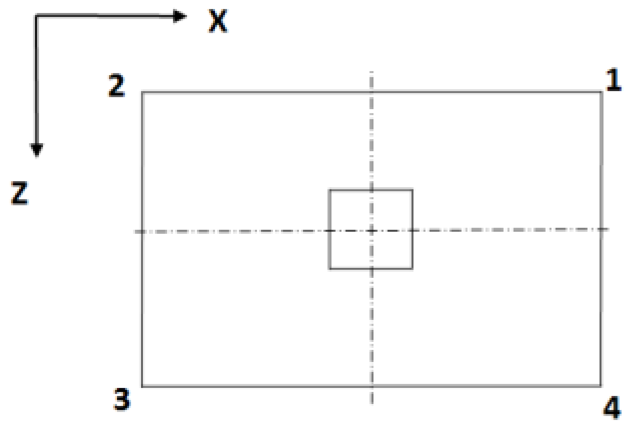
Min. footing area required from bearing pressure, A_{min} = P / q_{max} = 5.796 m^2

Footing area from initial length and width, A_o = $L_o \times W_o$ = 1.00 m^2

Final Footing Size

Length (L_2) =	3.80	M	Governing Load Case :	# 4
Width (W_2) =	3.80	M	Governing Load Case :	# 4
Depth (D_2) =	0.50	m	Governing Load Case :	# 4
Area (A_2) =	14.44	m^2		

Pressures at Four Corner



Load Case	Pressure at corner 1 (q_1) (kN/m^2)	Pressure at corner 2 (q_2) (kN/m^2)	Pressure at corner 3 (q_3) (kN/m^2)	Pressure at corner 4 (q_4) (kN/m^2)	Area of footing in uplift (A_u) (m^2)
5	**136.4151**	126.3869	127.7045	137.7327	0.00
5	136.4151	**126.3869**	127.7045	137.7327	0.00
5	136.4151	126.3869	**127.7045**	137.7327	0.00
5	136.4151	126.3869	127.7045	**137.7327**	0.00

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/m^2)	Pressure at corner 2 (q_2) (kN/m^2)	Pressure at corner 3 (q_3) (kN/m^2)	Pressure at corner 4 (q_4) (kN/m^2)
5	**136.4151**	126.3869	127.7045	137.7327
5	136.4151	**126.3869**	127.7045	137.7327
5	136.4151	126.3869	**127.7045**	137.7327
5	136.4151	126.3869	127.7045	**137.7327**

Adjust footing size if necessary.

Details of Out-of-Contact Area
(If Any)

Governing load case = N/A

Plan area of footing = 14.44 sq.m

Area not in contact with soil = 0.00 sq.m

% of total area not in contact = 0.00%

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	94.894	633.851	406.729	280.722
2	42.284	556.554	1358.999	115.812
3	30.503	286.709	1001.994	84.696
4	1.560	1.668	2.896	1.941
5	28.379	353.724	601.339	79.013
6	291.089	34.319	49.231	71.120
7	16.584	34.012	71.523	29.044
8	29.051	362.094	615.569	80.883
9	4.629	4.437	7.522	5.444
10	9.130	10.794	19.225	11.929
11	78.517	524.459	336.534	232.274
12	100.353	670.316	430.128	296.871

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

Critical Load Case for Sliding along X-Direction : 4

Governing Disturbing Force : 20.364 kN

Governing Restoring Force : 31.776 kN

Minimum Sliding Ratio for the Critical Load Case : 1.560

Critical Load Case for Overturning about X-Direction : 4

Governing Overturning Moment : 41.693 kNm

Governing Resisting Moment : 120.746 kNm

Minimum Overturning Ratio for the Critical Load Case : 2.896

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

Critical Load Case for Sliding along Z-Direction : 4

Governing Disturbing Force : 19.053 kN

Governing Restoring Force : 31.776 kN

Minimum Sliding Ratio for the Critical Load Case : 1.668

Critical Load Case for Overturning about Z-Direction : 4

Governing Overturning Moment : -62.212 kNm

Governing Resisting Moment : 120.746 kNm

Minimum Overturning Ratio for the Critical Load Case : 1.941

Moment Calculation :

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

Critical Load Case = #5

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.45 m

Governing moment (M_u) = 678.540753 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}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 4133.149375 kN/m^2

Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 3138.136379 kNm

$M_u <= M_{umax}$ hence, safe

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

Critical Load Case = #5

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.45 m

Governing moment (M_u) = 656.192207 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}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 4133.149375 kN/m^2

Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^2$ = 3138.136379 kNm

$M_u <= M_{umax}$ hence, safe

Shear Calculation

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

Critical Load Case = #5

Shear Force(S) = 582.75 kN

Shear Stress(T_v) = 343.078914 kN/m^2

Percentage Of Steel(P_t) = 0.2566

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 1005.98 kN/m^2

$T_v < T_c$ hence, **safe**

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

Critical Load Case = #5

Shear Force(S) = 573.75 kN

Shear Stress(T_v) = 337.778591 kN/m^2

Percentage Of Steel(P_t) = 0.2479

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 1005.98 kN/m^2

$T_v < T_c$ hence, safe

Check Trial Depth for two way shear

Critical Load Case = #5

Shear Force(S) = 1640.97 kN

Shear Stress(T_v) = 1083.55 kN/m^2

As Per IS 456 2000 Clause 31.6.3.1

$K_s = \min[(0.5 + \beta), 1] = 1.00$

Shear Strength(T_c)= $0.25 \times \sqrt{f_{ck}}$ = 1369.3064 kN/m^2

$K_s \times T_c$ = 1369.3064 kN/m^2

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

Reinforcement Calculation

Calculation of Maximum Bar Size

Along X Axis

Bar diameter corresponding to max bar size (d_b) = 25.000 mm

As Per IS 456 2000 Clause 26.2.1

Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}}$ = 1.47 m

Allowable Length(l_{db}) = $\left[\frac{(B - b)}{2} - cc\right]$ = 1.63 m

$l_{db} > l_d$ hence, **safe**

Along Z Axis

Bar diameter corresponding to max bar size(d_b) = 25.000 mm

As Per IS 456 2000 Clause 26.2.1

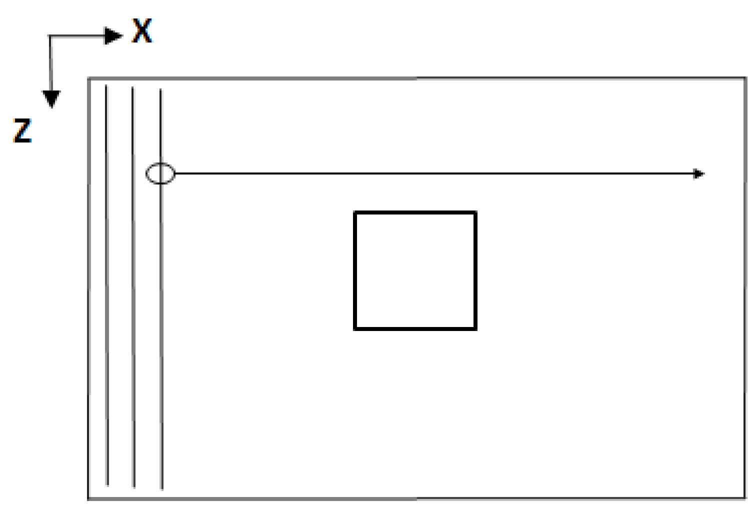
Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}}$ = 1.47 m

Allowable Length(l_{db}) = $\left[\frac{(H - h)}{2} - cc\right]$= 1.68 m

$l_{db} > l_d$ hence, safe

Bottom Reinforcement Design

Along Z Axis



PLAN

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

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case = #5

Minimum Area of Steel (A_{stmin}) = 2289.12 mm2

Calculated Area of Steel (A_{st}) = 4359.21 mm2

Provided Area of Steel ($A_{st,Provided}$) = 4359.205 mm2

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

Selected bar Dia = 10.000

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

Selected spacing (S) = 67.091 mm

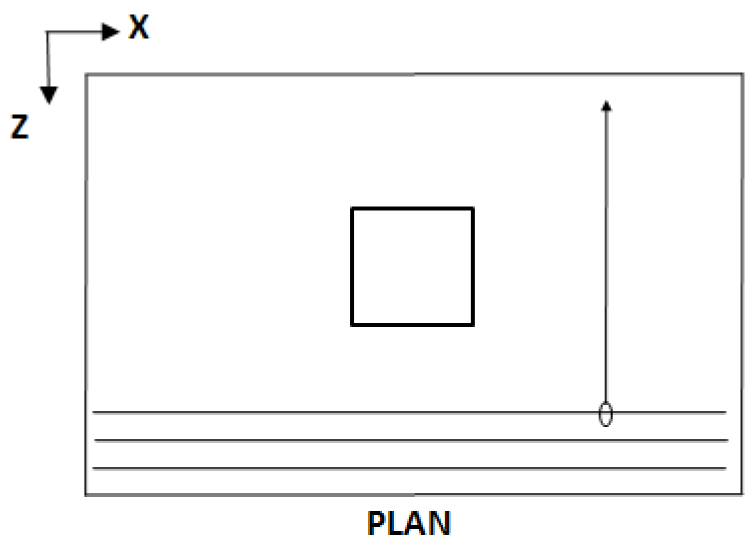
S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

#10 @ 65.000 mm o.c.

Along X Axis



For moment w.r.t. Z Axis (M_z)

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case = **#5**

Minimum Area of Steel (A_{stmin}) = 2289.12 mm2

Calculated Area of Steel (A_{st}) = 4210.337 mm2

Provided Area of Steel ($A_{st,Provided}$) = 4210.337 mm2

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

Selected bar Dia = 10.000

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

Selected spacing (S) = 69.62 mm

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

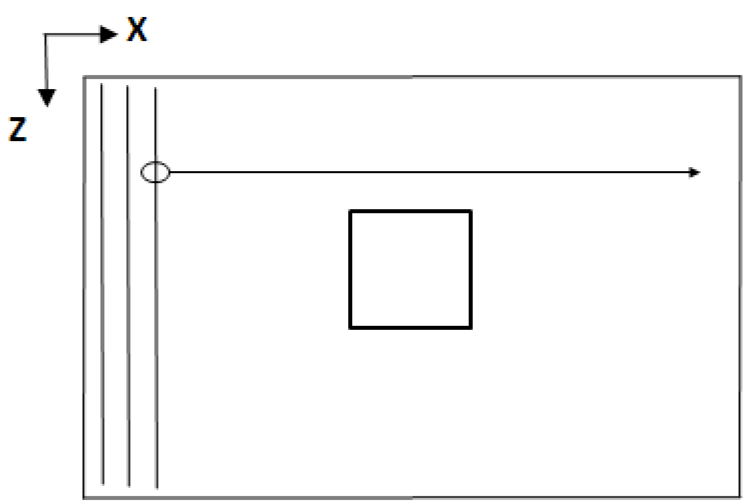
The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

#10 @ 65.000 mm o.c.

Top Reinforcement Design

Along Z Axis



PLAN

Minimum Area of Steel (A_{stmin}) = 2289.120 mm2

Calculated Area of Steel (A_{st}) = 2284.560 mm2

Provided Area of Steel ($A_{st,Provided}$) = 2289.120 mm2

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

Governing Moment = 0.000 kNm

Selected Bar Dia = 8.000

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

Selected spacing (S) = 82.044 mm

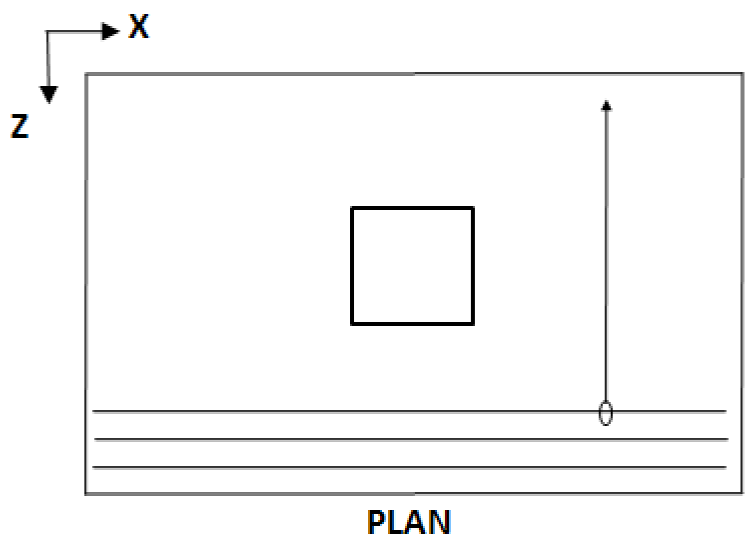
$S_{min} <= S <= S_{max}$ and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

#8 @ 80.000 mm o.c.

Along X Axis



Minimum Area of Steel (A_{stmin}) = 2289.120 mm2

Calculated Area of Steel (A_{st}) = 2284.560 mm2

Provided Area of Steel ($A_{st,Provided}$) = 2289.120 mm2

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

Governing Moment = 0.000 kNm

Selected Bar Dia = 8.000

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

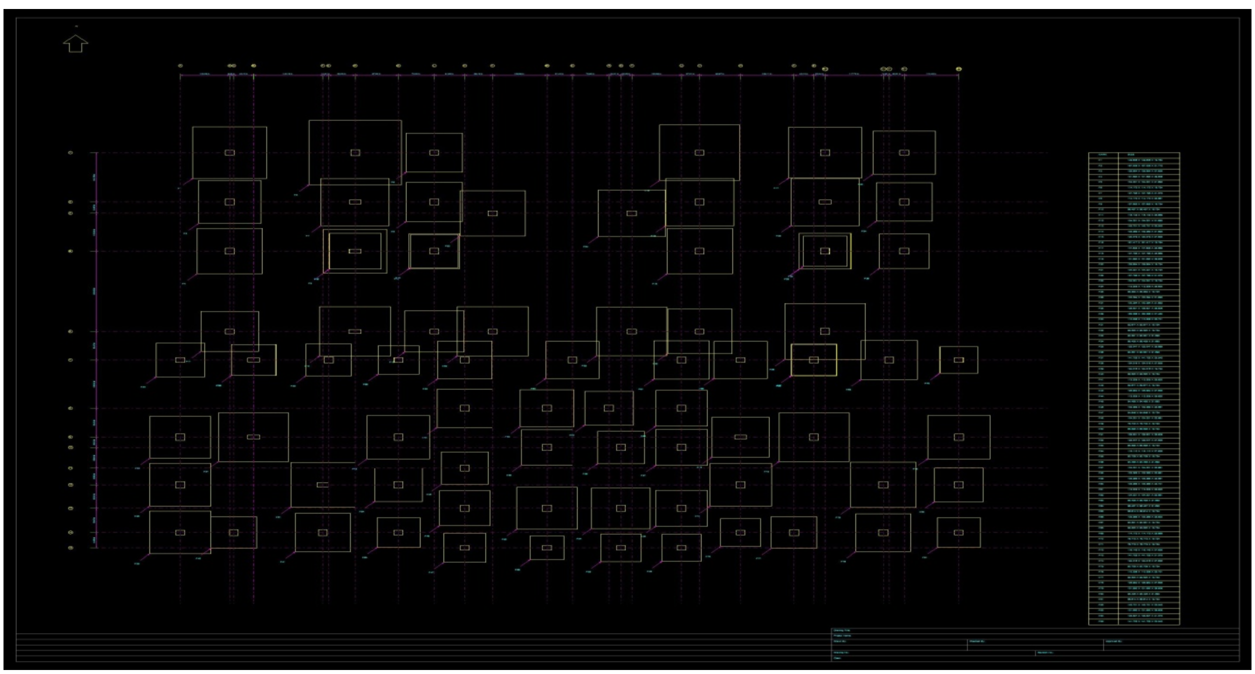
Selected spacing (S) = 82.044 mm

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

#8 @ 80.000 mm o.c.



The figure shows layout of foundations for each and every column.

Here we can observe that some of the footings coincide as they are very near, in such situations combined(strap or cantilever) is laid.

Reinforcement details of column is shown below

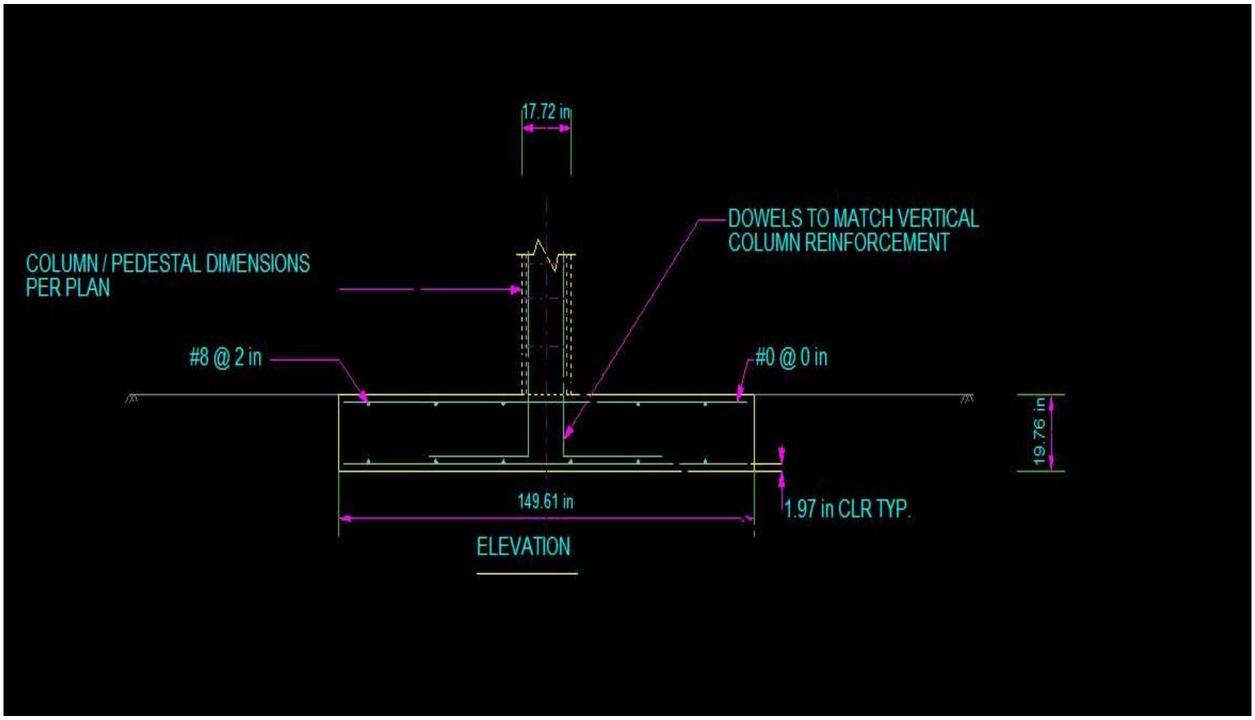


Fig 8.2.1 elevation of reinforcements

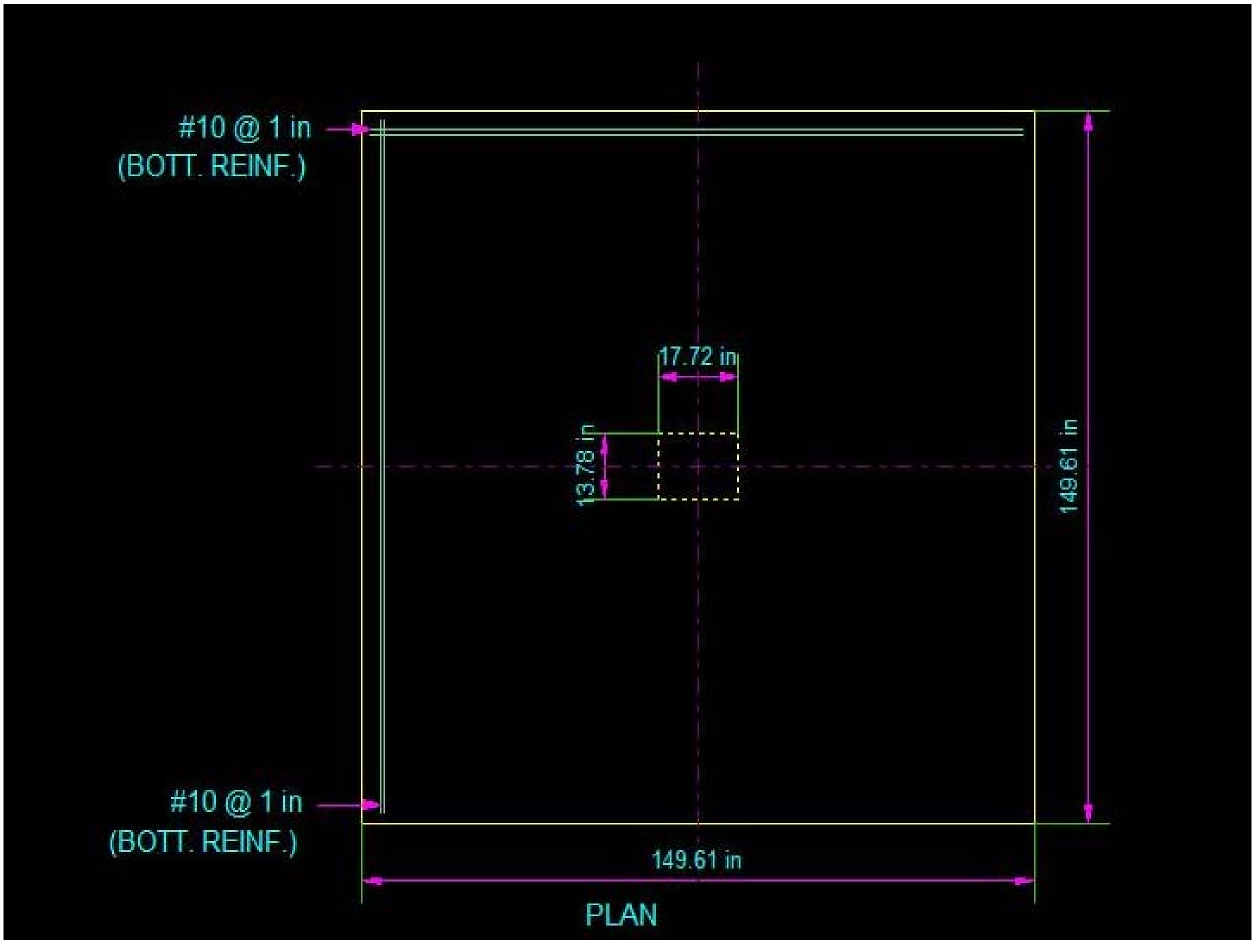


Fig 8.2.b plan of reinforcement

Staad Editor:

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 14-Apr-08

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 6.445 0 0; 3 0 0 3.65; 4 0 0 7.29; 6 6.445 0 7.29; 9 10.51 0 0;

10 6.445 0 3.65; 11 10.51 0 3.65; 12 6.445 0 7.3; 13 10.51 0 7.3;

14 0 0 13.235; 15 6.44 0 7.29; 16 6.44 0 13.235; 17 10.51 0 7.29;

18 10.51 0 13.235; 19 24.153 0 0; 20 30.598 0 0; 21 24.153 0 3.65;

22 24.153 0 7.29; 23 34.663 0 0; 24 30.593 0 7.29; 25 30.598 0 3.65;

26 30.598 0 7.29; 27 34.663 0 3.65; 28 30.598 0 7.3; 29 34.663 0 7.3;

30 34.663 0 7.29; 31 24.153 0 13.235; 32 30.593 0 13.235; 35 12.083 0 15.35;

36 8.668 0 15.35; 37 5.088 0 15.35; 38 1.223 0 15.35; 39 -2.542 0 15.35;

40 -2.542 0 21.06; 41 1.228 0 15.35; 42 1.228 0 21.06; 44 -2.542 0 24.59;

45 -2.542 0 28.12; 46 0.204 0 28.12; 47 4.788 0 28.12; 50 8.673 0 15.35;

51 8.673 0 21.06; 52 12.083 0 18.92; 53 12.083 0 23.35; 54 12.083 0 26.325;

55 12.083 0 29.255; 58 23.213 0 26.325; 59 23.213 0 29.255; 61 16.307 0 29.255;

62 4.788 0 24.59; 63 16.303 0 26.325; 64 16.303 0 29.255; 65 20.103 0 26.325;

66 20.103 0 29.255; 67 20.103 0 21.825; 68 23.213 0 21.825; 69 16.303 0 21.825;

70 16.303 0 18.92; 71 17.613 0 15.35; 72 23.213 0 15.35; 73 23.213 0 18.92;

74 19.488 0 18.92; 77 8.668 0 24.59; 78 8.668 0 28.12; 79 26.258 0 15.35;

80 30.023 0 15.35; 81 30.028 0 15.35; 82 33.888 0 15.35; 83 37.468 0 15.35;

84 37.473 0 15.35; 85 26.258 0 21.06; 86 30.028 0 21.06; 87 26.258 0 24.59;

88 26.258 0 28.12; 89 33.588 0 28.12; 90 29.004 0 28.12; 91 37.473 0 21.06;

92 33.588 0 24.59; 93 37.468 0 24.59; 94 37.468 0 28.12; 95 13.51 0 13.235;

96 13.51 0 4.49; 97 20.663 0 4.49; 99 20.663 0 13.235; 100 0 3 0;

101 6.445 3 0; 102 0 3 3.65; 103 0 3 7.29; 104 6.445 3 7.29; 105 10.51 3 0;

106 6.445 3 3.65; 107 10.51 3 3.65; 108 6.445 3 7.3; 109 10.51 3 7.3;

110 0 3 13.235; 111 6.44 3 7.29; 112 6.44 3 13.235; 113 10.51 3 7.29;

114 10.51 3 13.235; 115 24.153 3 0; 116 30.598 3 0; 117 24.153 3 3.65;

118 24.153 3 7.29; 119 34.663 3 0; 120 30.593 3 7.29; 121 30.598 3 3.65;

122 30.598 3 7.29; 123 34.663 3 3.65; 124 30.598 3 7.3; 125 34.663 3 7.3;

126 34.663 3 7.29; 127 24.153 3 13.235; 128 30.593 3 13.235;

129 34.663 3 13.235; 130 12.083 3 15.35; 131 8.668 3 15.35; 132 5.088 3 15.35;

133 1.223 3 15.35; 134 -2.542 3 15.35; 135 -2.542 3 21.06; 136 1.228 3 15.35;

137 1.228 3 21.06; 138 -2.542 3 24.59; 139 -2.542 3 28.12; 140 0.204 3 28.12;

141 4.788 3 28.12; 142 8.673 3 15.35; 143 8.673 3 21.06; 144 12.083 3 18.92;

145 12.083 3 23.35; 146 12.083 3 26.325; 147 12.083 3 29.255;

148 23.213 3 26.325; 149 23.213 3 29.255; 150 16.307 3 29.255;

151 4.788 3 24.59; 152 16.303 3 26.325; 153 16.303 3 29.255;

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157 23.213 3 21.825; 158 16.303 3 21.825; 159 16.303 3 18.92;

160 17.613 3 15.35; 161 23.213 3 15.35; 162 23.213 3 18.92; 163 19.488 3 18.92;

164 8.668 3 24.59; 165 8.668 3 28.12; 166 26.258 3 15.35; 167 30.023 3 15.35;

168 30.028 3 15.35; 169 33.888 3 15.35; 170 37.468 3 15.35; 171 37.473 3 15.35;

172 26.258 3 21.06; 173 30.028 3 21.06; 174 26.258 3 24.59; 175 26.258 3 28.12;

176 33.588 3 28.12; 177 29.004 3 28.12; 178 37.473 3 21.06; 179 33.588 3 24.59;

180 37.468 3 24.59; 181 37.468 3 28.12; 182 13.51 3 13.235; 183 13.51 3 4.49;

184 20.663 3 4.49; 186 20.663 3 13.235; 189 33.888 3 13.25; 190 6.44 3 15.335;

191 0 6 0; 192 6.445 6 0; 193 0 6 3.65; 194 0 6 7.29; 195 6.445 6 7.29;

196 10.51 6 0; 197 6.445 6 3.65; 198 10.51 6 3.65; 199 6.445 6 7.3;

200 10.51 6 7.3; 201 0 6 13.235; 202 6.44 6 7.29; 203 6.44 6 13.235;

204 10.51 6 7.29; 205 10.51 6 13.235; 206 24.153 6 0; 207 30.598 6 0;

208 24.153 6 3.65; 209 24.153 6 7.29; 210 34.663 6 0; 211 30.593 6 7.29;

212 30.598 6 3.65; 213 30.598 6 7.29; 214 34.663 6 3.65; 215 30.598 6 7.3;

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220 34.663 6 13.235; 221 12.083 6 15.35; 222 8.668 6 15.35; 223 5.088 6 15.35;

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228 1.228 6 21.06; 229 -2.542 6 24.59; 230 -2.542 6 28.12; 231 0.204 6 28.12;

232 4.788 6 28.12; 233 8.673 6 15.35; 234 8.673 6 21.06; 235 12.083 6 18.92;

236 12.083 6 23.35; 237 12.083 6 26.325; 238 12.083 6 29.255;

239 23.213 6 26.325; 240 23.213 6 29.255; 241 16.307 6 29.255;

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245 20.103 6 26.325; 246 20.103 6 29.255; 247 20.103 6 21.825;

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336 23.213 9 21.825; 337 16.303 9 21.825; 338 16.303 9 18.92;

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401 -2.542 12 15.35; 402 -2.542 12 21.06; 403 1.228 12 15.35;

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414 12.083 12 29.255; 415 23.213 12 26.325; 416 23.213 12 29.255;

417 16.307 12 29.255; 418 4.788 12 24.59; 419 16.303 12 26.325;

420 16.303 12 29.255; 421 20.103 12 26.325; 422 20.103 12 29.255;

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432 8.668 12 28.12; 433 26.258 12 15.35; 434 30.023 12 15.35;

435 30.028 12 15.35; 436 33.888 12 15.35; 437 37.468 12 15.35;

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487 5.088 15 15.35; 488 1.223 15 15.35; 489 -2.542 15 15.35;

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541 33.888 15 13.25; 542 6.44 15 15.335; 543 0 18 0; 544 6.445 18 0;

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657 34.663 21 7.29; 658 24.153 21 13.235; 659 30.593 21 13.235;

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DEFINE MATERIAL START

ISOTROPIC CONCRETE

E 2.17185e+007

POISSON 0.17

DENSITY 23.5616

ALPHA 1e-005

DAMP 0.05

END DEFINE MATERIAL

MEMBER PROPERTY

132 TO 134 138 140 144 147 TO 149 151 153 TO 157 159 161 163 166 169 171 172 -

174 TO 177 179 183 185 187 TO 195 198 TO 200 204 205 207 TO 211 1277 TO 1279 -

1283 1285 1289 1292 TO 1294 1296 1298 TO 1302 1304 1306 1308 1311 1314 1316 -

1317 1319 TO 1322 1324 1328 1330 1332 TO 1340 1343 TO 1345 1349 1350 1352 -

1353 TO 1356 1362 1478 TO 1480 1484 1486 1490 1493 TO 1495 1497 1499 TO 1503 -

1505 1507 1509 1512 1515 1517 1518 1520 TO 1523 1525 1529 1531 1533 TO 1541 -

1544 TO 1546 1550 1551 1553 TO 1557 1563 1679 TO 1681 1685 1687 1691 1694 -

1695 TO 1696 1698 1700 TO 1704 1706 1708 1710 1713 1716 1718 1719 -

1721 TO 1724 1726 1730 1732 1734 TO 1742 1745 TO 1747 1751 1752 1754 TO 1758 -

1764 1880 TO 1882 1886 1888 1892 1895 TO 1897 1899 1901 TO 1905 1907 1909 -
1911 1914 1917 1919 1920 1922 TO 1925 1927 1931 1933 1935 TO 1943 -
1946 TO 1948 1952 1953 1955 TO 1959 1965 2081 TO 2083 2087 2089 2093 2096 -
2097 TO 2098 2100 2102 TO 2106 2108 2110 2112 2115 2118 2120 2121 -
2123 TO 2126 2128 2132 2134 2136 TO 2144 2147 TO 2149 2153 2154 2156 TO 2160 -
2166 2282 TO 2284 2288 2290 2294 2297 TO 2299 2301 2303 TO 2307 2309 2311 -
2313 2316 2319 2321 2322 2324 TO 2327 2329 2333 2335 2337 TO 2345 -
2348 TO 2350 2354 2355 2357 TO 2361 2367 PRIS YD 0.45 ZD 0.45
135 137 139 142 143 152 164 167 168 182 203 1280 1282 1284 1287 1288 1297 -
1309 1312 1313 1327 1348 1481 1483 1485 1488 1489 1498 1510 1513 1514 1528 -
1549 1682 1684 1686 1689 1690 1699 1711 1714 1715 1729 1750 1883 1885 1887 -
1890 1891 1900 1912 1915 1916 1930 1951 2084 2086 2088 2091 2092 2101 2113 -
2116 2117 2131 2152 2285 2287 2289 2292 2293 2302 2314 2317 2318 2332 -
2353 PRIS YD 0.6 ZD 0.3
131 136 141 145 146 150 158 162 165 170 173 178 180 181 184 186 196 197 201 -
202 206 212 TO 215 217 1276 1281 1286 1290 1291 1295 1303 1305 1307 1310 -
1315 1318 1323 1325 1326 1329 1331 1341 1342 1346 1347 1351 1357 TO 1361 -
1363 1477 1482 1487 1491 1492 1496 1504 1506 1508 1511 1516 1519 1524 1526 -
1527 1530 1532 1542 1543 1547 1548 1552 1558 TO 1562 1564 1678 1683 1688 -
1692 1693 1697 1705 1707 1709 1712 1717 1720 1725 1727 1728 1731 1733 1743 -
1744 1748 1749 1753 1759 TO 1763 1765 1879 1884 1889 1893 1894 1898 1906 -
1908 1910 1913 1918 1921 1926 1928 1929 1932 1934 1944 1945 1949 1950 1954 -
1960 TO 1964 1966 2080 2085 2090 2094 2095 2099 2107 2109 2111 2114 2119 -
2122 2127 2129 2130 2133 2135 2145 2146 2150 2151 2155 2161 TO 2165 2167 -
2281 2286 2291 2295 2296 2300 2308 2310 2312 2315 2320 2323 2328 2330 2331 -

```
2334 2336 2346 2347 2351 2352 2356 2362 TO 2366 2368 PRIS YD 0.45 ZD 0.35
218 TO 233 235 TO 250 252 TO 282 284 TO 287 289 TO 294 297 TO 328 -
1263 TO 1265 1269 1271 TO 1275 1364 TO 1476 1565 TO 1677 1766 TO 1878 1967 -
1968 TO 2079 2168 TO 2280 2369 TO 2481 PRIS YD 0.3 ZD 0.4
CONSTANTS
MATERIAL CONCRETE ALL
SUPPORTS
1 TO 4 6 9 TO 32 35 TO 42 44 TO 47 50 TO 55 58 59 61 TO 74 77 TO 97 99 FIXED
DEFINE WIND LOAD
TYPE 1
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
ASCE-7-2002:PARAMS 50.000 kmph 0 1 1 0 0.000 ft 0.000 ft 0.000 ft 1 -
1 21.000 ft 40.000 ft 29.000 ft 2.000 0.010 0 -
0 0 0 0 0.633 1.000 1.000 0.850 0 -
0 0 0 0.874 0.800 0.550
!> END GENERATED DATA BLOCK
INT 0.478803 0.478803 0.478803 0.478803 0.478803 0.478803 0.478803 0.478803 -
 0.478803 0.478803 0.478803 0.478803 0.478803 0.478803 0.478803 HEIG  0  4.572 -
 4.71268  4.85335  4.99403  5.13471  5.27538  5.41606  5.55674  5.69742 -
 5.83809  5.97877  6.11945  6.26012  6.4008
EXP 1.5 JOINT 1 TO 4 6 9 TO 32 35 TO 42 44 TO 47 50 TO 55 58 59 61 TO 74 77 -
78 TO 97 99 TO 184 186 189 TO 718
LOAD 1 LOADTYPE Dead  TITLE D L
SELFWEIGHT Y -1 LIST 131 TO 159 161 TO 215 217 TO 233 235 TO 250 252 TO 282 -
284 TO 287 289 TO 294 297 TO 328 1263 TO 1265 1269 1271 TO 2481
```

LOAD 2 LOADTYPE Live TITLE F L

FLOOR LOAD

YRANGE 0 21 FLOAD -3.5 GY

LOAD 3 LOADTYPE Live TITLE L L

MEMBER LOAD

218 TO 233 235 TO 250 252 TO 282 284 TO 287 289 TO 294 297 TO 300 302 TO 320 -

322 TO 328 1263 TO 1265 1269 1271 TO 1275 1364 TO 1440 1442 TO 1460 1462 -

1463 TO 1476 1565 TO 1641 1643 TO 1661 1663 TO 1677 1766 TO 1842 1844 TO 1862 -

1864 TO 1878 1967 TO 2043 2045 TO 2063 2065 TO 2079 2168 TO 2244 -

2246 TO 2264 2266 TO 2280 2369 TO 2445 2447 TO 2465 2467 TO 2480 -

2481 UNI GY -25

LOAD 4 LOADTYPE Wind TITLE W L

WIND LOAD X 1.5 TYPE 1 YR 0 21

WIND LOAD Z 1.5 TYPE 1 YR 0 21

LOAD COMB 5 Generated Indian Code Genral_Structures 1

1 1.5 2 1.5 3 1.5

LOAD COMB 6 Generated Indian Code Genral_Structures 2

1 1.2 2 1.2 3 1.2 4 1.2

LOAD COMB 7 Generated Indian Code Genral_Structures 3

1 1.2 2 1.2 3 1.2 4 -1.2

LOAD COMB 8 Generated Indian Code Genral_Structures 4

1 1.2 2 1.2 3 1.2

LOAD COMB 9 Generated Indian Code Genral_Structures 5

1 1.5 4 1.5

LOAD COMB 10 Generated Indian Code Genral_Structures 6

1 1.5 4 -1.5

LOAD COMB 11 Generated Indian Code Genral_Structures 7

1 1.5

LOAD COMB 12 Generated Indian Code Genral_Structures 8

1 0.9

PERFORM ANALYSIS PRINT ALL

START CONCRETE DESIGN

CODE INDIAN

UNIT MMS NEWTON

CLEAR 25 MEMB 218 TO 233 235 TO 250 252 TO 282 284 TO 287 289 TO 294 -

297 TO 300 302 TO 320 322 TO 328 1263 TO 1265 1269 1271 TO 1275 1364 TO 1440 -

1442 TO 1460 1462 TO 1476 1565 TO 1641 1643 TO 1661 1663 TO 1677 -

1766 TO 1842 1844 TO 1862 1864 TO 1878 1967 TO 2043 2045 TO 2063 -

2065 TO 2079 2168 TO 2244 2246 TO 2264 2266 TO 2280 2369 TO 2445 -

2447 TO 2465 2467 TO 2481

CLEAR 40 MEMB 131 TO 159 161 TO 215 217 1276 TO 1363 1477 TO 1564 -

1678 TO 1765 1879 TO 1966 2080 TO 2167 2281 TO 2368

FC 30 ALL

FYMAIN 415 ALL

FYSEC 415 ALL

MAXMAIN 16 ALL

MAXSEC 10 ALL

MINMAIN 12 ALL

MINSEC 8 ALL

TRACK 2 ALL

```
DESIGN BEAM 218 TO 233 235 TO 250 252 TO 282 284 TO 287 289 TO 294 -
297 TO 328 1263 TO 1265 1269 1271 TO 1275 1364 TO 1476 1565 TO 1677 1766 -
1767 TO 1878 1967 TO 2079 2168 TO 2280 2369 TO 2481
DESIGN COLUMN 131 TO 159 161 TO 215 217 1276 TO 1363 1477 TO 1564 -
1678 TO 1765 1879 TO 1966 2080 TO 2167 2281 TO 2368
CONCRETE TAKE
END CONCRETE DESIGN
FINISH
```

Estimation:

Total volume of concrete = 661.74 CU.METER

BAR DIA (in mm)	WEIGHT (in Staad)
- 8	142796.00
10	340.00
12	289856.00
16	172675.47
TOTAL= 605667.50	

Bending Moment:

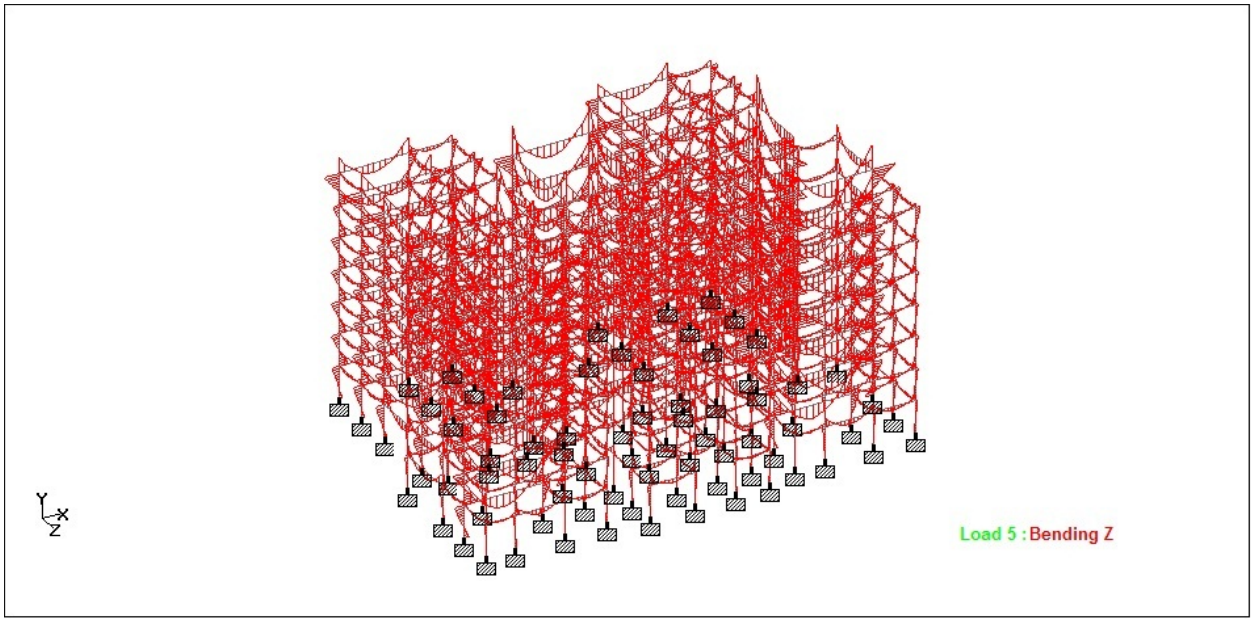

Fig 9.2 a showing bending moments of all the beams

Shear:

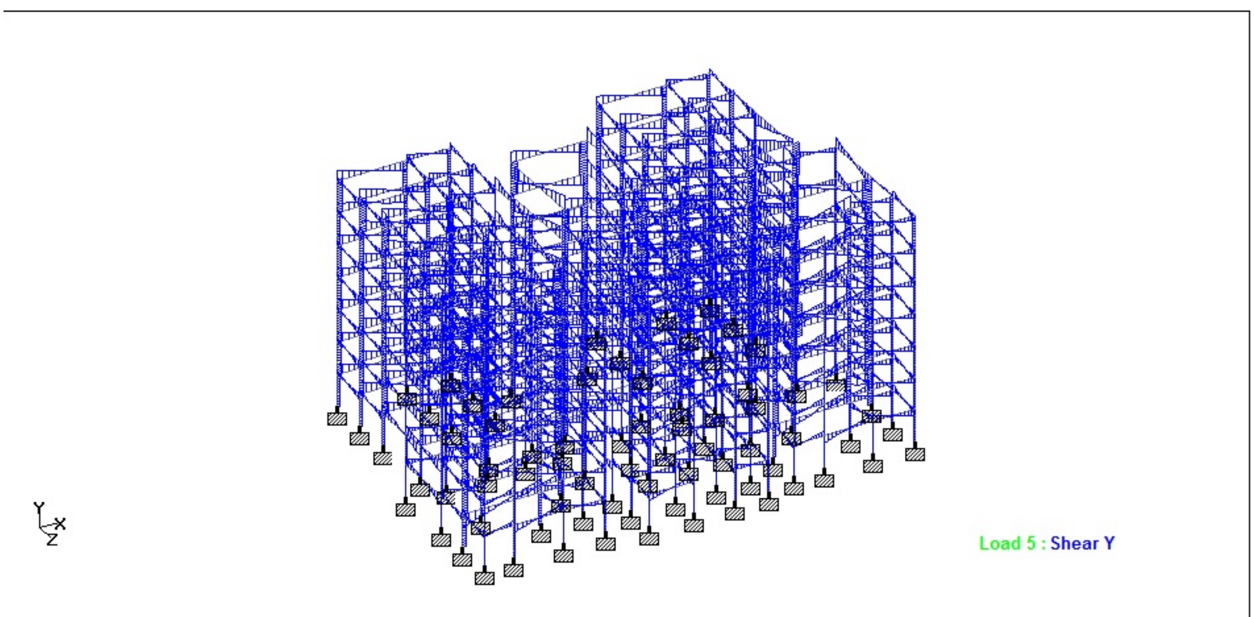

Fig 9.2 b Showing Shear Force of all the beams

Conclusions:

1.Designing 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.Accuracy is Improved by using software.

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

1.IS 456-2000 code book for design of beams, columns and slabs

2.SP-16 for design of columns.