ISSN: 0974-5823 Vol. 7 No. 4 April, 2022

International Journal of Mechanical Engineering

ANALYSIS AND DESIGN OF A (G + 12) MULTI STOREY RESIDENTIAL BUILDING USING STAAD PRO

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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 multi-storey 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 Kane's method, Cantilever method, Portal method, Matrix method. The present project deals with the analysis of a multi storied residential building of G+12 consisting of 3 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 multi storied building.

Assumptions in Design:

1. Using partial safety factor for loads in accordance with clause 36.4 of IS-456-2000 as ϒt =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 24.0 KN/m^3 ii) Reinforced 25.0KN/m^3 iii) Flooring material (cm) 20.0 KN/m^3 iv) Brick masonry 19.0 KN/m^3

v) Fly ash 5.0KN/m3

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 = 4.0 KN/m^2

DESIGN CONSTANTS:

Use M30 and Fe 415 grade of concrete and steel for beams, slabs, footings, columns. Therefore;

fck = Characteristic strength for M30-30 N/mm^2 fy = Characteristic strength of steel-415 N/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) M30 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.

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 of civic sense is 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 is 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, multipanelled 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 (39*25) consists of columns built monolithically forming a network. The size of building is 39X25m. The numbers of columns are 55. 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 frames and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per **IS456-2000**.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 Statement of project

Salient features:

Utility of building: Residential complex

No of stories: G+12

Shape of the building: 3 APARTMENTS

No of staircases: 2

No. of flats: 33

No of lifts: 2

Type of construction: R.C.C framed structure Types of walls: Brick wall, Blocks Geometric details:

Ground floor: 3.3m

Floor to floor height: 3.3m.

Height of plinth: 0.6m Depth of foundation: 3.3m Materials:

Concrete grade: M30 All steel grades: Fe415 grade

Bearing capacity of soil: 300KN/m^2

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 SFD and BMD 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 structure 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 lacs and so all engineers can't use it due to heavy cost.

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

SHALLOW (D<B)

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

DEEP (D>B)

1. Pile Cap
2. Driller Pier

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

1. Combined Footing or Strap footing is generally laid when two columns are very near to each other.
2. Mat foundation is generally laid at places where soil has less soil bearing capacity.
3. Pile foundation is laid at places with very loose soils and where deep excavations are required.

So depending on the soil at type we have 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

Geometry of footing

1. Reinforcement

2. Column layout
3. Graphs
4. 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.

CHAPTER 3
PLAN AND ELEVATION

PLAN

The Auto CAD plotting no.1 represents the plan of a G+12 building. The plan clearly shows that it is a combination of three apartments. We can observe there is a combination between each and every apartment.

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+12 proposed building, so for 3 blocks we have 3*11=33 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 three apartments have typical 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.

Elevation:

AutoCAD plot no.2 represents the proposed elevation of building. It shows the elevation of a G+12 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 33 apartments.

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.

Centre line plan

The above figure represents the centre line diagram of our building in staad pro. Each support represents the location of different columns in the structure. This structure is used in generating the entire structure using a tool called 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.

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. Classifications of loads are described in the following sections.

4.2 Building Loads Categorized by Orientation:

Types of loads on a hypothetical building are as follows.

1. Vertical Loads
2. Dead (gravity)
3. Live (gravity)
4. Snow(gravity)
5. Wind(uplift on roof)
6. Seismic and wind (overturning)
7. Seismic(vertical ground motion)

4.2.1 Horizontal (Lateral) Loads:

Direction of loads is horizontal with respect to the building.

1. Wind
2. Seismic(horizontal ground motion)
3. Flood(static and dynamic hydraulic forces
4. 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.

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.

4.4 Design loads for residential buildings:

General

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

Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. While the buildings considered in this guide are primarily single-family detached and attached dwellings, the principles and concepts related to building loads also apply to other similar types of construction, such as low-rise apartment buildings. In general, the design loads recommended in this guide are based on applicable provisions of the ASCE 7 standard-Minimum Design; loads for buildings and other structures

(ASCE, 1999).the ASCE 7 standard represents an acceptable practice for building loads in the United states and is recognized in virtually all U.S. building codes. For this reason, the reader is encouraged to become familiar with the provisions, commentary, and technical references contained in the ASCE 7 standard. In general structural design of housing has not been treated as a unique engineering discipline or subjected to a special effort to develop better, more efficient design practices. Therefore, this part of the guide focuses on those aspects of ASCE 7 and other technical resources that are particularly relevant to the determination of design loads for residential structures.

4.4.1 Dead Loads:

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

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

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

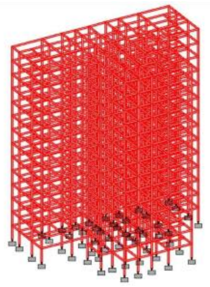


Fig 4.4.1a Example for calculation of dead load;

Dead load calculation

Weight = Volume x Density

Self weight floor finish = 0.12*25+1 = 3 kn/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 endues conditions. For example. The stair load of 300 pounds should be applied to the centre of the stair tread between supports.

In staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. After the assignment of the live load the structure appears as shown below.

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

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

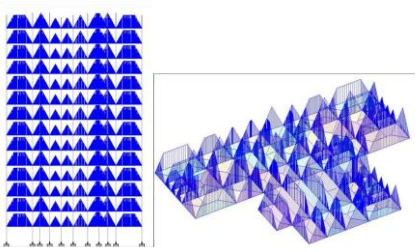


Fig 4.4.2a diagram of live load

4.4.3 Wind loads:

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

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

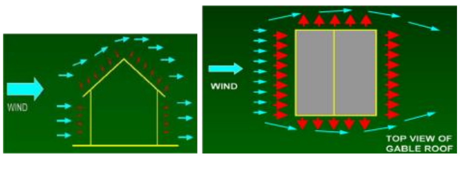


Fig 4.4.3a a diagram of wind load

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.

1. 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 Nasik we have a wind speed of 30 kmph for 10 m height and this value is used in calculation.

4.4.3.1 Basic wind speed:

Table 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.

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

It can be mathematically expressed as follows:

Vs.= Vb* K1* K2* K3

Where,

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

K1= probability factor (risk coefficient)

K2=terrain height and structure size factor and

K3=topography factor

Table 4.4.3.3

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

CITY	BASIC WIND SPEED(m/s)	CITY	BASIC WIND SPEED(m/s)
Agra	47	Bhopal	39
Ahmadabad	39	Delhi	47
Aurangabad	39	Nagpur	44
Chandigarh	47	Pune	39
Coimbatore	39	Mumbai	44
Nasik	39		

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.

4.4.5 Seismic loads (Earthquake Load):

Seismic forces are generated by the inertia of buildings as they dynamically respond to ground motion. The dynamic nature of response makes earthquake loading markedly different from other loads

Seismic loading is one of the basic concepts of earthquake engineering which means application of an earthquake generated agitation to a structure. It happens at contact surfaces of structure either with the ground or with adjacent structure.

Seismic loading depends upon:

1) Anticipated earthquake's parameters at the site known as seismic hazard.
2) Geotechnical parameters of the site
3) Structure's parameters
4) Characteristics of the anticipated gravity waves from tsunami (if applicable)

A good earthquake engineering design is one where designer takes control of building by dictating how building is to respond. This can be achieved by selection of the preferred response mode, selecting zone where inelastic deformations are acceptable and suppressing the development of undesirable response modes which could lead to building collapse.

We referred IS 1893 for Seismic loading.

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**

When the building is designed for both wind and seismic loads maximum of both is taken. Because of wind and seismic do not come at same time as per code. Structure is analyzed by taking all the above combinations.

Combination	**SL X+**	**SL X-**	**SL Z+**	**SL Z-**	**WL X+**	**WL X-**	**WL Z+**	**WL X-**	**DL**	**LL**
1									1.5	1.5
2					1.2				1.2	1.2
3						1.2			1.2	1.2
4							1.2		1.2	1.2
5								1.2	1.2	1.2
6					-1.2				1.2	1.2
7						-1.2			1.2	1.2
8							-1.2		1.2	1.2
9								-1.2	1.2	1.2
10	1.2								1.2	1.2
11		1.2							1.2	1.2
12			1.2						1.2	1.2
13				1.2					1.2	1.2
14	-1.2								1.2	1.2
15		-1.2							1.2	1.2
16			-1.2						1.2	1.2
17				-1.2					1.2	1.2
18					1.5				1.5	

19						1.5			1.5	
20							1.5		1.5	
21								1.5	1.5	
22					-1.5				1.5	
23						-1.5			1.5	
24							-1.5		1.5	
25								-1.5	1.5	
26	1.5								1.5	
27		1.5							1.5	
28			1.5						1.5	
29				1.5					1.5	
30	-1.5								1.5	
31		-1.5							1.5	
32			-1.5						1.5	
33				-1.5					1.5	
34	1.5								0.9	
35		1.5							0.9	
36			1.5						0.9	
37				1.5					0.9	
38	-1.5								0.9	
39		-1.5							0.9	
40			-1.5						0.9	
41				-1.5					0.9	

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 geometryand 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 reinforced 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.

Fig 5.2a a diagram of the reinforcement details of beam

The following figure shows the deflection of a column.

Beam design

B E A M N O. 173

D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 4602.0 mm SIZE: 230.0 mm X 300.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1150.5 mm	2301.0 mm	3451.5 mm	4602.0 mm
TOP REINF.	1297.84 (Sq. mm)	360.81 (Sq. mm)	127.19 (Sq. mm)	289.22 (Sq. mm)	1111.47 (Sq. mm)
BOTTOM REINF.	503.82 (Sq. mm)	339.64 (Sq. mm)	278.34 (Sq. mm)	468.19 (Sq. mm)	541.99 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1150.5 mm	2301.0 mm	3451.5 mm	4602.0 mm
TOP REINF.	7-16í 2 layer(s)	2-16í 1 layer(s)	2-16í 1 layer(s)	2-16í 1 layer(s)	6-16í 2 layer(s)

5.3 Check for the design of a beam

Given data:

Cross section of beam : b x d = 230mm x300 mm

Vertical shear force = vu =145.93 KN

τc = 0.29 N/mm2 (from table 19 of IS 456 200)

Minimum Shear Reinforcement:

When τv is less than τc, given in Table 19, minimum shear reinforcement shall be provided

Design of Shear Reinforcement:

When τv exceeds τc, 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)

$=145.93 \times 10^3/(300x230)$

$=2.11$ N/mm2 $\tau v \geq \tau c$

Design reinforcement

Vus = Vu- τc xbxd (As per clause 40.4 of IS 456-2000)

$= 145.93 \times 10^3 - 0.29x300x230$

= 125920 N

For vertical stirrups:

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

Minimum shear reinforcement:

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

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

$Sv= 2x (\pi/4)x8^2 \ x0.87x415/ (0.4x230) =110$ mm.

Provided 2 legged 8mm @110 mm stirrups.

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.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 multi-storeyed buildings.

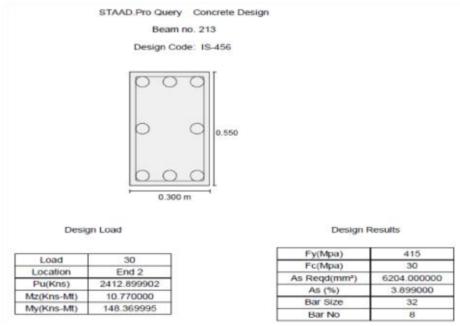


Fig 6.3a reinforcement details of a column

Output:

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

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

Output for column

C O L U M N N O. 213 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3300.0 mm CROSS SECTION: 300.0 mm X 550.0 mm COVER: 40.0 mm

GUIDING LOAD CASE: 30 END JOINT: 121 SHORT COLUMN

REQD. STEEL AREA : 6204.00 Sq.mm.

REQD. CONCRETE AREA: 158796.00 Sq.mm.

MAIN REINFORCEMENT: Provide 8-32 dia. (3.90%, 6433.98 Sq.mm. (Equally distributed) TIE REINFORCEMENT: Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 4074.74 Muz1 : 336.37 Muy1 : 156.52

INTERACTION RATIO: 0.97 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 11

END JOINT:121 Puz : 4143.22 Muz : 218.40 Muy 100.72 IR: 1.70

CHAPTER 7: SLABS

7.1 Slab design:

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

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

Design of slabs:

Size: 6.51m x 3.51m

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 IS 875 part 2)

Dead load:

Self weight of slab = 1x1x0.12x25 = 3.0 KN/m2

Weight of flooring (75mm thick) = 1x1x0.005x20 = 1.0 KN/m2

Accidental loads = 1.0 KN/m2 = 1.0 KN/m2

Total Dead Load = 5.0 KN/m2

Live load:

Live load is taken = 2.0 KN/m2

Total load = 2 + 5.0 KN/m2

Factored load = 1.5x7.0 KN/m2

Design load = 10.5 KN/m2

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		= $10.5x\ (6.51)^2/12$
		= 37.082 KNm
Negative bending moment at support		= $-10.5x\ (6.51)^2/10$
		= 44.499 KNm
Design bending moment **<u>Calculation of effective depth:</u>** Adopting M30 concrete and Fe 415 steel As per IS 456-2000(Annexure G)	= 44.5 KNm	
Mu,limit	=0.36xXumax/d(1-0.42Xumax/d)bd2fck	
	=$0.36x0.46\ (1-0.42x0.48)bd^2X30$	
Xumax/d	=0.48	
Mulimit	=$4.13\ bd^2$	
Assuming b	=1000mm	
Mu	=Mulimit	
d	=$\sqrt{44.5x10^6/(4.13x1000)}$	

Adopting 8-mm dia bars as reinforcement	=102.8mm
Effective cover	= 15+10/2 =20mm
Over all depth	= D =102.8+20=122.8

Therefore providing overall depth D = 120mm

Effective depth d = 120-20 =100mm

Calculation of steel: (MAIN REINFORCEMENT)

Form IS 456-2000(Annexure G)

Ast =0.5 fck/fy {1- √[1-(4.6Mu/fck.b.d^2}Xbd

$$= 0.5 \frac{\quad}{415} x\{1- \sqrt{[4.6X44.8X10^6/(30X1000X100^2)]}\}X1000X100 x\ 3\ 0$$

Ast =618.74 mm2

Providing minimum steel of =0.12%xbxD=144mm2

Spacing of 10mm dia bars =(astX1000)/Ast

= (ΠX10^2X1000)/(4X618.74)

=126.93mm 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 @ 125 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 =144mm2

Adopting 6mm Φ bars as distribution reinforcement

Spacing = (astx1000)/Ast

= (Π/4x6X6x1000)/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 = Φσst/4 ᵗbd

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

= 470.11 mm (req.)

Ld(available) = MI/V+L0

M1 = 0.87xfyxAstxd(1-fyxAst/bdfck)

= 0.87x415x618x100(1-618x415/(1000x100x30)

= 20.40X10^6 N-mm

Shear force at the section due to design loads

V = W1/2 = 10.5x6.51/2 = 34.17

M1/V+L0 = 20.40/34.17 +L0

= 0.597m + L0

=597mm + L0

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:

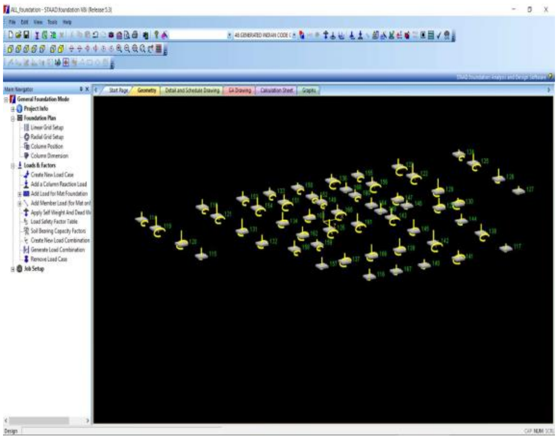
1.) Footing shall be designed to sustain the applied loads, moments and forces and the induced reactions and to assure that any settlements which may occur will be as nearly uniform as possible and the safe bearing capacity of soil is not exceeded.

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 or 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.

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



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

Minimum length: 1000mm

Minimum width: 1000mm

Minimum thickness: 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
114	1	2.500 m	2.500 m	0.655 m
115	2	2.500 m	2.500 m	0.655 m
116	3	2.300 m	2.300 m	0.555 m
117	4	2.450 m	2.450 m	0.605 m
118	5	2.700 m	2.700 m	0.705 m
119	6	3.200 m	3.200 m	0.805 m
120	7	3.350 m	3.350 m	0.806 m
121	8	3.500 m	3.500 m	0.857 m
122	9	3.500 m	3.500 m	0.857 m
123	10	2.800 m	2.800 m	0.705 m
124	11	2.500 m	2.500 m	0.655 m
125	12	3.200 m	3.200 m	0.805 m
126	13	3.350 m	3.350 m	0.807 m
127	14	2.500 m	2.500 m	0.655 m
128	15	2.800 m	2.800 m	0.705 m
129	16	3.550 m	3.550 m	0.906 m
130	17	2.750 m	2.750 m	0.705 m
131	18	3.700 m	3.700 m	0.907 m

132	19	2.950 m	2.950 m	0.705 m
133	20	2.350 m	2.350 m	0.605 m
134	21	3.050 m	3.050 m	0.805 m
135	22	3.300 m	3.300 m	0.857 m
136	23	2.550 m	2.550 m	0.655 m
137	24	2.750 m	2.750 m	0.705 m
138	25	3.200 m	3.200 m	0.805 m
139	26	3.600 m	3.600 m	0.907 m
140	27	2.450 m	2.450 m	0.655 m
141	28	2.800 m	2.800 m	0.705 m
142	29	3.600 m	3.600 m	0.907 m
143	30	3.000 m	3.000 m	0.755 m
144	31	2.850 m	2.850 m	0.705 m
145	32	3.250 m	3.250 m	0.805 m
146	33	2.500 m	2.500 m	0.655 m
147	34	2.850 m	2.850 m	0.705 m
148	35	2.300 m	2.300 m	0.605 m
149	36	2.400 m	2.400 m	0.605 m
150	37	2.400 m	2.400 m	0.605 m
151	38	2.700 m	2.700 m	0.655 m
152	39	2.250 m	2.250 m	0.605 m
153	40	2.450 m	2.450 m	0.655 m
154	41	2.900 m	2.900 m	0.755 m
155	42	2.400 m	2.400 m	0.605 m
156	43	2.800 m	2.800 m	0.705 m
157	44	2.400 m	2.400 m	0.555 m
158	45	2.350 m	2.350 m	0.555 m
159	46	2.500 m	2.500 m	0.655 m
160	47	2.350 m	2.350 m	0.605 m
161	48	3.450 m	3.450 m	0.857 m
162	49	2.650 m	2.650 m	0.655 m
163	50	2.850 m	2.850 m	0.705 m
164	51	2.450 m	2.450 m	0.655 m
165	52	2.750 m	2.750 m	0.705 m
166	53	3.400 m	3.400 m	0.857 m
167	54	2.300 m	2.300 m	0.605 m
168	55	2.250 m	2.250 m	0.605 m

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
-	Bottom Reinforcement(M_z)	Bottom Reinforcement(M_x)	Top Reinforcement(M_z)	Top Reinforcement(M_x)	Main Steel	Trans Steel
114	Ø8 @ 75 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
115	Ø8 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
116	Ø8 @ 80 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
117	Ø8 @ 65 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 65 mm c/c	Ø8 @ 65 mm c/c	N/A	N/A
118	Ø8 @ 70 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 135 mm c/c	Ø8 @ 135 mm c/c	N/A	N/A
119	Ø8 @ 50 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
120	Ø10 @ 75 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
121	Ø10 @ 70 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 75 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
122	Ø10 @ 75 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 75 mm c/c	Ø10 @ 75 mm c/c	N/A	N/A
123	Ø8 @ 70 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
124	Ø8 @ 65 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
125	Ø8 @ 50 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
126	Ø10 @ 75 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
127	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
128	Ø8 @ 55 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
129	Ø8 @ 60 mm c/c	Ø10 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
130	Ø8 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
131	Ø10 @ 65 mm c/c	Ø10 @ 55 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
132	Ø8 @ 55 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
133	Ø8 @ 80 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
134	Ø8 @ 80 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 80 mm c/c	Ø8 @ 85 mm c/c	N/A	N/A
135	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
136	Ø8 @ 70 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 135 mm c/c	Ø8 @ 135 mm c/c	N/A	N/A
137	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
138	Ø8 @ 50 mm c/c	Ø10 @ 70 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
139	Ø10 @ 70 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
140	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
141	Ø8 @ 55 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
142	Ø10 @ 70 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
143	Ø8 @ 50 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
144	Ø8 @ 90 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A

145	Ø8 @ 50 mm c/c	Ø10 @ 65 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	N/A	N/A
146	Ø8 @ 60 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
147	Ø8 @ 70 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 110 mm c/c	Ø8 @ 110 mm c/c	N/A	N/A
148	Ø8 @ 70 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
149	Ø8 @ 85 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 85 mm c/c	Ø8 @ 85 mm c/c	N/A	N/A
150	Ø8 @ 80 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
151	Ø8 @ 60 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 60 mm c/c	N/A	N/A
152	Ø8 @ 85 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 110 mm c/c	Ø8 @ 110 mm c/c	N/A	N/A
153	Ø8 @ 80 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 135 mm c/c	Ø8 @ 135 mm c/c	N/A	N/A
154	Ø8 @ 50 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
155	Ø8 @ 80 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
156	Ø8 @ 55 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
157	Ø8 @ 70 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 85 mm c/c	Ø8 @ 85 mm c/c	N/A	N/A
158	Ø8 @ 70 mm c/c	Ø8 @ 65 mm c/c	Ø8 @ 130 mm c/c	Ø8 @ 130 mm c/c	N/A	N/A
159	Ø8 @ 65 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 85 mm c/c	Ø8 @ 85 mm c/c	N/A	N/A
160	Ø8 @ 85 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 85 mm c/c	Ø8 @ 85 mm c/c	N/A	N/A
161	Ø10 @ 70 mm c/c	Ø10 @ 60 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
162	Ø8 @ 80 mm c/c	Ø8 @ 50 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
163	Ø8 @ 90 mm c/c	Ø10 @ 75 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
164	Ø8 @ 80 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 115 mm c/c	Ø8 @ 115 mm c/c	N/A	N/A
165	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	Ø8 @ 55 mm c/c	N/A	N/A
166	Ø10 @ 70 mm c/c	Ø10 @ 65 mm c/c	Ø10 @ 70 mm c/c	Ø10 @ 70 mm c/c	N/A	N/A
167	Ø8 @ 90 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 90 mm c/c	Ø8 @ 90 mm c/c	N/A	N/A
168	Ø8 @ 85 mm c/c	Ø8 @ 60 mm c/c	Ø8 @ 110 mm c/c	Ø8 @ 110 mm c/c	N/A	N/A

Footing Geometry

Design Type : Calculate Dimension

Footing Thickness (Ft) : 305.000 mm

Footing Length - X (Fl) : 1000.000 mm

Footing Width - Z (Fw) : 1000.000 mm

Eccentricity along X (Oxd) : 0.000 mm

Eccentricity along Z (Ozd) : 0.000 mm

Column Dimensions

Column Shape : Rectangular

Column Length - 0.500 m

X (Pl) :

Column Width - Z 0.230 m

(Pw) :

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 : Ø8

Maximum Bar Size : Ø32

Minimum Bar Spacing : 50.000 mm

Maximum Bar Spacing : 500.000 mm

Pedestal Clear Cover (P, CL) : 50.000 mm

Footing Clear Cover (F, CL) : 50.000 mm

Soil Properties

Soil Type : Drained

Unit Weight : 22.000 kN/m3

Soil Bearing Capacity : 300.000 kN/m2

Soil Surcharge : 0.000 kN/m2

Depth of Soil above Footing : 4.000 mm

Cohesion : 0.000 kN/m2

Min Percentage of Slab : 0.000

Sliding and Overturning

Coefficient of Friction : 0.500

Factor of Safety Against Sliding : 1.500

Factor of Safety Against Overturning : 1.500

Design Calculations

Footing Size

Initial Length (L_o) = 1.000 m

Initial Width (W_o) = 1.000 m

Uplift force due to buoyancy = 0.000 kN

Effect due to adhesion = 0.000 kN

Area from initial length and width, $A_o = L_o \times W_o$ = 1.000 m2

Min. area required from bearing pressure,

$A_{min} = P / q_{max} = 5.333\ m^2$ **Pressures at Four Corner**

Load Case	Pressure at corner 1 (q_1) (kN/m2)	Pressure at corner 2 (q_2) (kN/m2)	Pressure at corner 3 (q_3) (kN/m2)	Pressure at corner 4 (q_4) (kN/m2)	Area of footing in uplift (A_u) (m2)
34	**297.7729**	290.9585	227.1679	233.9824	0.000
34	297.7729	**290.9585**	227.1679	233.9824	0.000
34	297.7729	290.9585	**227.1679**	233.9824	0.000
34	297.7729	290.9585	227.1679	**233.9824**	0.000

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

Summary of adjusted Pressures at Four Corner

Load Case	**Pressure at corner 1 (q_1) (kN/m2)**	**Pressure at corner 2 (q_2) (kN/m2)**	**Pressure at corner 3 (q_3) (kN/m2)**	**Pressure at corner 4 (q_4) (kN/m2)**
34	**297.7729**	290.9585	227.1679	233.9824
34	297.7729	**290.9585**	227.1679	233.9824
34	297.7729	290.9585	**227.1679**	233.9824
34	297.7729	290.9585	227.1679	**233.9824**

Details of Out-of-Contact Area

(If Any)

Governing load case = N/A

Plan area of footing = 6.250 sq.m

Area not in contact with soil = 0.000 sq.m

% of total area not in contact = 0.000%

Check For Stability Against Overturning And Sliding

-	**Factor of safety against sliding**		**Factor of safety against overturning**	
Load Case No.	**Along X-Direction**	**Along Z-Direction**	**About X-Direction**	**About Z-Direction**
11	58.015	684.577	1289.129	107.393
12	102.142	152.466	142.060	31.023
13	27.345	145.940	165.366	25.448
14	33.355	12.957	13.381	56.875
15	81.877	29.368	31.165	153.584
16	27.211	136.908	154.332	25.279
17	107.088	169.968	156.441	31.688
18	87.032	28.076	29.779	178.434
19	35.769	14.051	14.495	65.379
20	95.181	1303.517	47395.027	30.132
21	26.086	506.887	725.961	23.874
22	39.720	27.253	27.509	72.675
23	77.632	46.926	49.753	145.443
24	26.086	506.887	725.961	23.874
25	95.181	1303.517	47395.027	30.132
26	77.632	46.926	49.753	145.443

27	39.720	27.253	27.509	72.675
28	44.453	100.581	97.456	19.989
29	24.625	121.744	134.608	21.401
30	28.036	7.672	7.958	46.318
31	97.900	24.407	25.789	184.745
32	24.497	113.879	125.451	21.264
33	45.911	111.440	107.149	20.422
34	106.816	23.371	24.687	231.101
35	31.129	8.440	8.747	56.586
36	43.514	2688.492	2625.287	19.748
37	23.279	493.758	663.127	19.917
38	36.777	17.253	17.561	66.949
39	91.634	38.829	40.871	172.608
40	23.279	493.758	663.127	19.917
41	43.514	2688.492	2625.287	19.748
42	91.634	38.829	40.871	172.608
43	36.777	17.253	17.561	66.949
44	17.628	1952.350	735.974	9.840
45	17.918	429.914	534.798	14.242
46	20.961	5.856	6.003	37.749
47	112.497	28.779	30.099	214.475
48	17.918	429.914	534.798	14.242
49	17.628	1952.350	735.974	9.840
50	112.497	28.779	30.099	214.475
51	20.961	5.856	6.003	37.749

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

Critical Load Case for Sliding along X-Direction : 44

Governing Disturbing Force : 13.637 kN

Governing Restoring Force : 240.399 kN

Minimum Sliding Ratio for the Critical Load Case 17.628

:

Critical Load Case for Overturning about X- 46 Direction :

Governing Overturning Moment : 45.161 kNm

Governing Resisting Moment : 271.099 kNm

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

Critical Load Case = #50

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.451 m

Governing moment (M_u) = 295.015 kNm

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

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

Critical Load Case = #34

Effective Depth = = 0.601 m

Governing moment (M_u) = 321.565 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/m2

Limit Moment Of Resistance (M_{umax}) =

= 3732.176064 kNm

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

Shear Calculation

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

D_X = 0.601 m

Shear Force(S) = 373.588 kN

Shear Stress(T_v) = 248.644539 kN/m2

Percentage Of Steel(P_t) = 0.1308

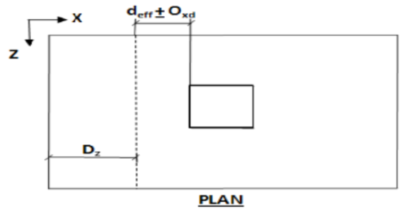
As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 275.772 kN/m2

$T_v < T_c$ hence, safe

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

(Shear Plane Parallel to Z Axis)



= #32

D_Z = 0.501 m

Shear Force(S) = 279.097 kN

Shear Stress(T_v) = 222.832062 kN/m2

Percentage Of Steel(P_t) = 0.1478

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 291.582 kN/m2

$T_v < T_c$ hence, safe

Shear Force(S) = 1359.157 kN

Shear Stress(T_v) = 585.272 kN/m2

As Per IS 456 2000 Clause 31.6.3.1

K_s = = 0.960

Shear Strength(T)= = 1369.3064 kN/m2

K_s x T_c = 1314.5341 kN/m2

T_v<= K_s x T_c hence, safe

Reinforcement Calculation

Calculation of Maximum Bar Size

Along X Axis

Bar diameter corresponding to max bar size = 25 mm

(d_b)

As Per IS 456 2000 Clause 26.2.1

Development Length(l_d) = = 0.920 m

Allowable Length(l_{db}) = = 0.950 m

l db >=l_d hence, safe

Along Z Axis

Bar diameter corresponding to max bar = 25 mm size(d_b)

As Per IS 456 2000 Clause 26.2.1

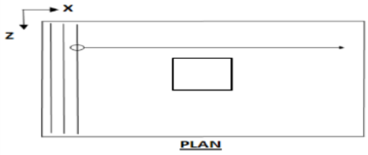
Development Length(l_d) = = 0.920 m

Allowable Length(l_{db}) = = 1.085 m

l db >=l_d hence, safe

Bottom Reinforcement Design

Along Z Axis



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

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case = #50

Minimum Area of Steel (A_{stmin}) = 1965.000 mm2

Calculated Area of Steel (A_{st}) = 2096.001 mm2

Provided Area of Steel ($A_{st,Provided}$) = 2096.001 mm2

Astmin<= Ast,Provided Steel area is accepted

Selected bar Size (d_b) = Ø8

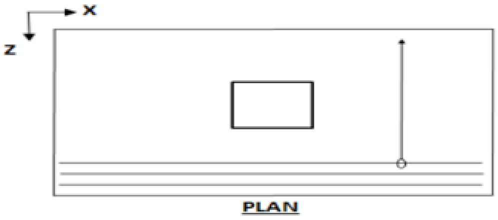
Minimum spacing allowed (S_{min}) = 48.000 mm

Selected spacing (S) = 58.341 mm

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

The reinforcement is accepted.

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 = #34

Minimum Area of Steel (A_{stmin}) = 1515.000 mm2

Calculated Area of Steel (A_{st}) = 1347.543 mm2

Provided Area of Steel ($A_{st,Provided}$) = 1515.000 mm2

Astmin<= Ast,Provided Steel area is accepted

Selected bar Size (d_b) = Ø8

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

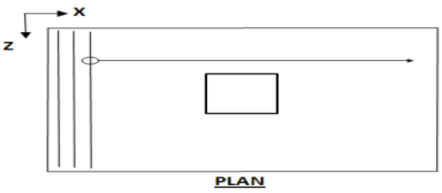
Selected spacing (S) = 79.733 mm

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

The reinforcement is accepted.

Top Reinforcement Design

Along Z Axis



Minimum Area of Steel (A_{stmin}) = 1965.000 mm2

Calculated Area of Steel (A_{st}) = 915.000 mm2

Provided Area of Steel ($A_{st,Provided}$) = 1965.000 mm2

Astmin<= Ast,Provided Steel area is accepted

Governing Moment = 13.800 kNm

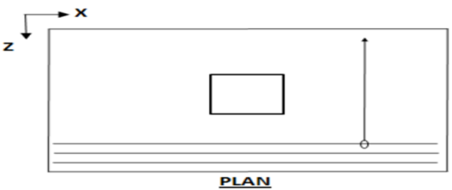
Selected bar Size (d_b) = Ø8

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

Selected spacing (S) = 132.889 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size... The reinforcement is accepted.

Along X Axis



Minimum Area of Steel (A_{stmin}) = 1515.000 mm2

Calculated Area of Steel (A_{st}) = 915.000 mm2

Provided Area of Steel ($A_{st,Provided}$) = 1515.000 mm2

Astmin<= Ast,Provided Steel area is accepted

Governing Moment = 10.712 kNm

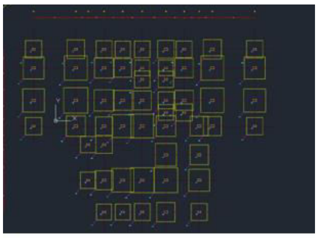
Selected bar Size (d_b) = Ø8

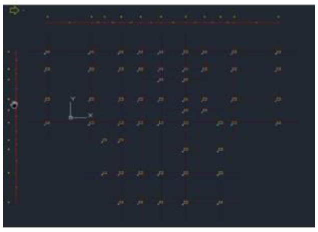
Minimum spacing allowed (S_{min}) = = 50.000 mm

Selected spacing (S) = 132.889 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 Ø8 @ 130 mm o.c.





The Above figures shows layot of foundations for each and every column

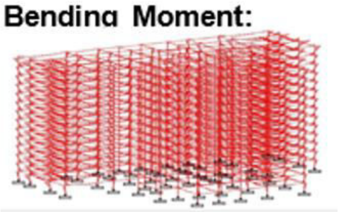
Estimation:

REINFORCING STEEL QUANTITY REPRESENTS REINFORCING STEEL IN BEAMS AND COLUMNS DESIGNED ABOVE. REINFORCING STEEL IN PLATES IS NOT INCLUDED IN THE REPORTED QUANTITY.

TOTAL VOLUME OF CONCRETE = 636.8 CU.METER

BAR DIA (in mm)	WEIGHT (in New)
8	200364
10	102058
12	186550
16	199896
20	97061
25	227531
32	6541
TOTAL=	1020000

Bending Moment:



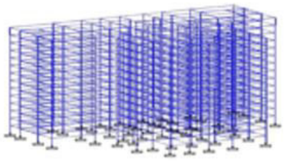


Fig .Showing Shear Force of all the beams

Conclusions:

1. Designing using Software's like STAAD.Pro 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.

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