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Analysis and Design of Multi-Storey (G+6) Building by Using STAAD Pro

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Abstract

This project is named "Analysis and design of multi-storey building by using STAAD Pro" which involves the analysis of 3D frames of varying floor heights and varying no. of bays using a highly successful software tool STAAD Pro. To compete in the ever-growing competent market, a structural engineer needs to save time as well as Cost. As a sequel to this, an attempt is made to analyze and design a multi-storied building by using the software package STAAD Pro. For analyzing a multi-storied building, one must consider all the possible load(s) and see that the structure is safe against all possible load conditions. There are several methods for the analysis of different frames like Kani's method, Cantilever method, Portal method, and Matrix method. The project deals with the design & analysis of a multi-storied residential building of G+6 consisting of 2 apartments on each floor. The Dead load & Live loads are applied and the design for Beams, Columns & Footing is obtained by utilizing STAAD Pro's new features which have surpassed its predecessors and compotators like AutoCAD, in data sharing capabilities. We conclude that STAAD Pro is a very powerful tool that can save much time and cost and is very accurate in Designs calculations and it is suitable for the design of a multistoried building.

Keywords: 3D (G+6), Auto CAD, STAAD

1. Introduction

Building construction involves engineering which deals with the construction of the buildings such as Residential houses, complexes, skyscrapers, etc. A simple building can be defined as an enclosed space with walls & roof along with basic amenities such as food, cloth, etc. In ancient times humans lived in caves, over trees, or under trees, to protect themselves from wild animals, rain, sun, etc. as time passed, humans evolved and started living in huts made of timber branches. The shelters of those old timber houses now have been developed nowadays into beautiful houses. Rich people live in sophisticated houses. Buildings are an important indicator of the social progress of the county. Every human has the desire to own a comfortable home, on average generally one spends two-thirds life in the house.

2. Literature Review

1. **A. Sivaji , N. Madhava Reddy , T. Yeswanth Kumar** : Analysis & Design of Multistory Building using Staad Pro and E-Tabs.This paper represents the 5-storey building using STAAD Pro and ETABS. The beams,columns and slabs are designed using software and by manual procedure and also reinforcement details also compared. The foundation is designed by using STAAD Foundation software. The load usedin the analysis are dead load (IS875-1987 part 3), seismic load (IS 1893-1984 part 1) and 25 load combination are considered as per 1987 code book.
2. **A. D. Bhosale , Archit Pradip Hatkhambhar** : Analysis and Design of multi-storey Building by using STAAD Pro-V8i.In this paper G+3 structure is consider and dead , live , combination , wind are applied. Then result are studied and compared by manual calculations. In the STAAD Pro the designing is done by better technique for creating geometry, defining the cross sections for columns and beams etc. After that the model is analyzed for 'run analyses.
3. **S.K. Saleen , B. Ravi Kumar** : Analysis and Design multistoried building by using STAAD Pro. In this paper the design involves load calculations manually and analyzing the structure by STAAD Pro. The design methods used in STAAD Pro analysis are limit state design conforming to Indian standard code of practice. The final work was the proper analysis and design of a G+5 3D RCC frame under various load combinations. STAAD Pro feature the state-of-the-art user interface, visualization tools , powerful analysis and design engines with advanced finite elements and dynamic analysis capabilities.
4. **B. Pradeep Kumar, Sk. Yusuf Basha** : Planning Analysis and Design of residential building, quantity survey.The primary objective of this project is to gain sufficient knowledge in planning, analysis and design of building and quantity surveying. It is reinforced concrete framed structure consist of G+6 using IS 456-200. The planning will be recognized by NBC. The ceiling height is provided as 3.2 m.
5. **Nasreen M. Khan** : Analysis and Design of Apartment Building.Practical knowledge is an important and essential skill required by every engineer. For obtaining this skill, an apartment building is analysed and designed , located at thrissure with B+G+8 storeys having a car parking facility provided at basement and ground floor. The building have a shear wall around the lift pit. The modelling and analysis of structure is done by using STAAD Pro 2007 and detailing is done using AutoCAD 2016 and designing was done manually.
6. **Aman, Manjunath Nalwadgi** :. Analysis and Design of multi-storey Building by using STAAD Pro.The main aim of structural engineer is to design the structures for safe technology in the computing field. This project belongs to the utility builders to be executed in the Gulbarga city. The name of the project is Bharat pride. The design consists of C+G+5 residential and commercial building. Residential flat consists of one 3BHK and three 2BHKHere in this project work based on software named "STAAD Pro" has been used.
7. **Anoop A, Fousiga Hussain, Neeraja R**. : Planning Analysis and Design of multi storied building by STAAD Pro V8i.The aim of this project is to design a multi storied building of G+6 floors, at Kalakoda about 4 km from Paravoor. The design is done by taking into account the requirements and standards recommended by IS code, Kerala building rules and national building rules. Planning is done using the 3D modelling software SketchUp 2011with the help of AutoCAD 2014. The structure analysis and

design is done using STAAD Pro V8i and a cross check is done for selected members using limit state method of design as per IS 456-2000.

3. Methodology

1.1 PLAN

The auto cad plotting no.1 represents the plan of a G+6 building. The Apartment is located opposite to Vijay Durga Temple near Vinayaka nagar in Kadapa. In each block, the floor consists of two, three bedroom houses that occupy an entire floor of a block. It represents a rich locality with huge areas for each house. As is a G+6 proposed building, so for 6 blocks we have 6*6=36 flats. The plan shows the details of the dimensions of every room and the type of room and orientation of the different rooms like bedroom, bathroom, kitchen, hall, etc., The entire plan area is about 540 sq.m. There is some space left around the building for parking cars. The plan gives details of the arrangement of various furniture like sofa etc. The plan also gives the details of the location of staircases in different blocks. We have 1 staircase for each block. So, these represent the plan of our building, and a detailed explanation of the remaining parts like elevations and design is carried out in the next sections.

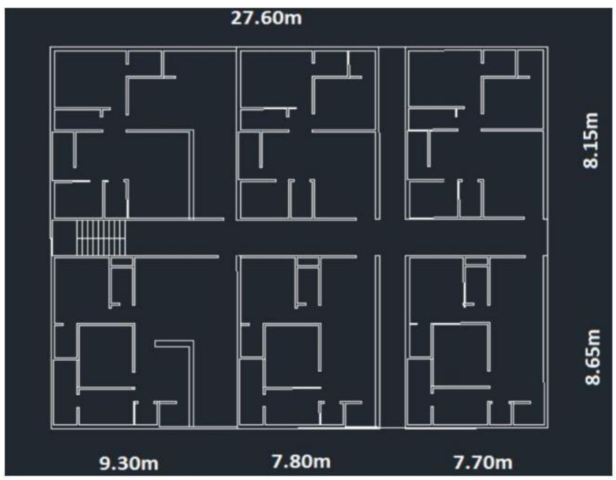


Figure 3.1: The plan in AutoCAD

1.2 Elevation:

AutoCAD plot no.2 represents the proposed elevation of a 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 is taken at the site. the building is actually under construction and all the analysis and design work is completed before the Beginning of the project. Each floor consists of a height of 3m which is taken as per KMC rules for residential buildings. The building is not designed for increasing the number of floors in the future. So, the number of floors is fixed for the future also for this building due to the unavailability of the permissions of respective authorities. The construction is going to complete in July 2013 and will also be ready for occupancy. This is regarding the plan and details of the site and the next section deals with the design part of the Building under various loads for which the building is designed.

1.3 Centerline plan

The above figure represents the central 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. The 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

3. DESIGN

Design of staircase:

Materials used M20 concrete Fe 415 steel
Height between two floors = 3m
Height of each flight = 3/2 = 1.5m
From NBC:
Rise = 150 to 200 mm:
Tread = 200 to 300 mm
Assuming a rise of 150mm and tread 300mm
Number of risers for in each flight = 1.5/0.15=10
Number of treads=10-1=9
Length of each flight =300x9 = 2700 mm 2.73m
Available length for landing = 5-2.73 = 2.27m

1.3.1 Loads:

Assuming the thickness of the waist slab=160mm=0.16m
Weight of each step = 0.3x0.15x25 = 1.125KN/m2
Total number of treads=9
Total weight of steps in one floor = 9x1.125=10.125kn/m2
Load distribution on each beam=10.125/2=5.0625kn/m2
Generally we are taking 3 kn/m2 as stair case load

1.3.2 Design of flight

Effective span = 5m
Assuming that the staircase is partially restrained Maximum bending moment= $wl^2/10$
=10.125x4.42/10=19.06KN.
Effective depth = d = $\sqrt{}$ (M/ (2.76Xb))
=$\sqrt{}$ (19.06/ (2.76x1000))
=70mm<160 D=160mm

1.3.3 Reinforcement:

M = 0.87fyAstd (1-Astx415/bdfck)

19.06x106 = 0.87x415xAstx160 (1-Astx415/1000x160x20)

Ast = 800.10mm2 Use 10mm dia bars

Spacing = ((π/4x102)/ (800.10)) x100=40mm Provide 10 mm dia @ spacing of 40 mm c/c

1.1.1 Distribution steel:

Ast = 0.15%bd

= (0.15/100) x2780x150

= 625mm2

Use 8mm dia bars

Spacing = ((π/4x82)/625) x1000

=320mm

Provide 8mm dia bars @ spacing of 320mm c/c

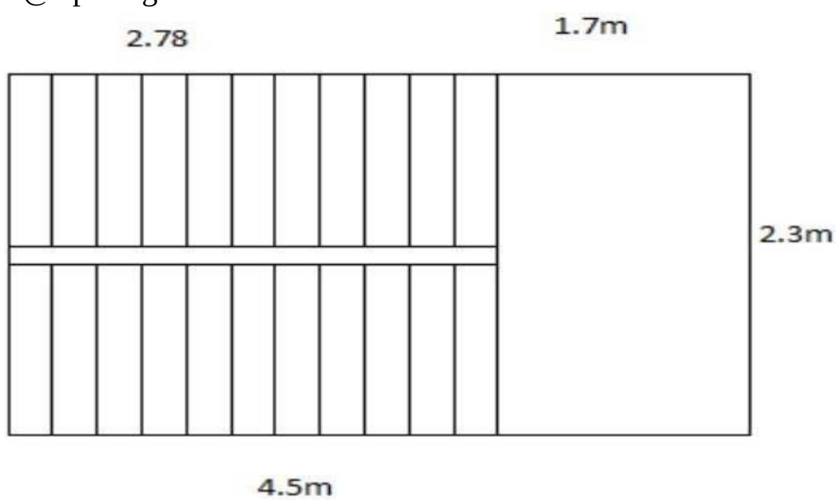


Figure5.1: Staircase plan

2. BEAMS

Beams transfer load from slabs to columns. Beams are designed for bending. In general, we have two types of beams: singly and doubly reinforced. 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.

2.1 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 Beam

3. Flanged beams

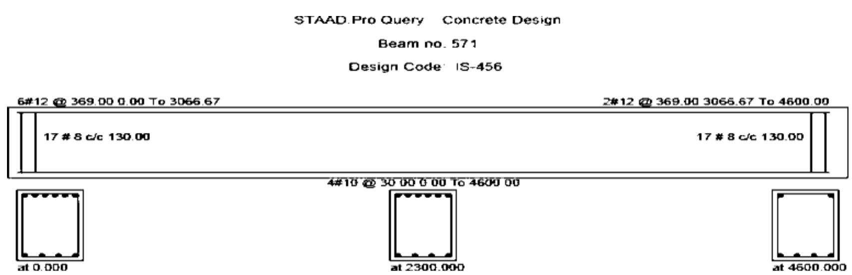
1. Singly reinforced beams:

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

2. Doubly reinforced concrete beams:

It is reinforced under compression tension regions. The necessity of steel for compression region arises due to two reasons. When the depth of the beam is restricted. The strength available for singly reinforced beams is inadequate. At support of a continuous beam where the bending moment changes sign (Point of Contra flexure) in such a situation may also arise in the design of a beam in plan

The figure shows the bottom and top reinforcement details at three different sections. These calculations are interpreted manually.



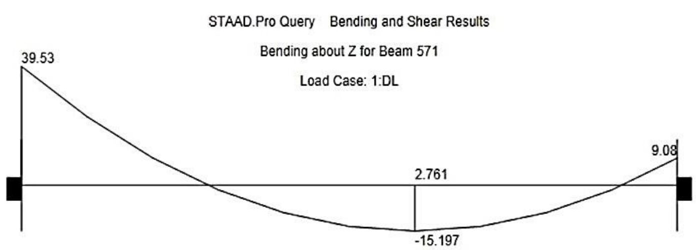
Design Load

Mz(Kn Met)	Distet	Load
28 030001	2 700000	4
-71.010002	0.000000	4
-21 680000	4 600000	5

Design Parameter

Fy(Mpa)	415 000000
Fc(Mpa)	20.000000
Depth(m)	0.400000
Width(m)	0.250000
Length(m)	4.600000

Figure 6.1: Reinforcement details of beam



Distm	Fy(kN)	Mz(kNm)
0.000000	39.6391	39.5271
0.383333	34.1359	25.3869
0.766667	28.6327	13.3563
1.150000	23.1295	3.4352
1.533333	17.6263	-4.3763
1.916667	12.1231	-10.0783
2.300000	6.6199	-13.6707
2.683334	1.1167	-15.1535
3.066667	-4.3865	-14.5268
3.450000	-9.8897	-11.7905
3.833334	-15.3929	-6.9447
4.216667	-20.8961	0.0107
4.600000	-26.3993	9.0756

Figure 6.2 : the sheer force of a column.

6.3 Check for the design of a beam (no. 571):

Given data:

Cross section of beam: b x d = 250mm x400 mm Length of the beam= 4.6m Load on the beam= 28.03kn/m

Factored load Wu=1.5x28.03=42.045N/mm

Factored Vertical shear force = vu =Wuxl/2= 42.045x4600/2=96.7x10^3N τc = 0.56 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, τv = vu/ (b x d) (As per clause 40.1 of IS 456-2000)

=96.7 x 103/ (250x400)

=0.96 N/mm2 τv ≥ τc

Shear carried by the concrete= τcxbxd= 0.56x250x400=56000N

Balance shear carried by stirrups Vus = Vu- τcxbxd (As per clause 40.4 of IS 456- 2000) =

96.7 x103 - 56000 = 40700N

Shear reinforcement shall be provided to carry a shear equal to Vu - τc bd The

Strength of shear reinforcement Vus, shall be calculated as below:

For vertical stirrups:

Vus = 0.87 fyAsvd/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,

τv = nominal shear stress

τc = design shear strength of the concrete,

b = breadth of the member FY = 415 N/mm2,

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

d = effective depth

40700 N= 0.87x415x3.14x82x400/Sv

Sv = 130 mm

Sv should not be more than the following 1. 0.75xd = 0.75 x 400 = 300 mm

2. 300 mm

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=2x (π/4) x82x0.87x415/ (0.4x250) =360 mm.

Provided 2 legged 8mm @130 mm stirrups. Hence matched with staad output.

3. COLUMNS

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

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

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 acting loads.

a. Positioning of columns:

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

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

a. Column design:

A column may be defined as an element used primarily to support axial compressive loads and with a height of a least three times its lateral dimension. The strength of a column.

Depends upon the strength of materials, shape and size of cross section, length and degree of proportion, and restraints at its ends.

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

In our structure, we have 3 types of columns.

- Ccolumn 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 them to the respective columns depending on the connection. But in these structures we adopted the same cross-section throughout the structure with a rectangular cross-section. In foundations, we generally do not have circular columns if a 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 the geometry page assigning the dimensions of the columns. Now analyze the column for loads to see the reactions and total loads on the column, by seeing the load design column and giving appropriate parameters like

1. Minimum reinforcement, max, bar sizes, maximum and minimum spicing.
2. Select the appropriate design code and input the design column command to the entire column.
3. Now run the analysis and select any column to collect the reinforcement details

The following figure shows the reinforcement details of a beam in STAAD Pro. The figure represents details regarding

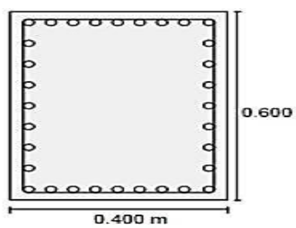
1. Transverse reinforcement
2. Longitudinal reinforcement

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

STAAD.Pro Query Concrete Design

Beam no. 55

Design Code: IS-456



Design Load

Load	4
Location	End 2
Pu(Kns)	2126.260010
Mz(Kns-Mt)	10.960000
My(Kns-Mt)	135.960007

Design Results

Fy(Mpa)	415
Fc(Mpa)	20
As Reqd(mm²)	3242.000000
As (%)	1.508000
Bar Size	12
Bar No	32

Figure7.1: Reinforcement details of a column

STAAD.Pro Query Deflection Result

column no.55

Deflection in Global X axis. Load case 1.

Distm	X(mm)	Y(mm)	Z(mm)
0.000000	0.0000	0.0000	0.0000
0.250000	-0.0039	-0.0447	-0.0154
0.500000	-0.0132	-0.0894	-0.0503
0.750000	-0.0271	-0.1341	-0.0987
1.000000	-0.0451	-0.1787	-0.1545
1.250000	-0.0663	-0.2234	-0.2116
1.500000	-0.0900	-0.2681	-0.2638
1.750000	-0.1156	-0.3128	-0.3052
2.000000	-0.1424	-0.3575	-0.3295
2.250000	-0.1695	-0.4022	-0.3308
2.500000	-0.1964	-0.4468	-0.3028
2.750000	-0.2223	-0.4915	-0.2396
3.000000	-0.2465	-0.5362	-0.1350

Figure 7.2: deflection of column

b. Check for Column design:

Given data

Fck =20 N/mm2

FY=415N/m2 puz=1.5x2126 =3189x10^3N b=400 d=600

Design of reinforcement area:

(As per clause 39.6 of IS 456 2000) Puz=0.45fckAc+0.75fyAsc Where Ac=area of concrete=A-Asc =400x600-Asc

Asc=area of longitudinal reinforcement

3189x10^3=0.45*20*(24*10^4-Asc) +311*Asc On solving the above equation we get Asc=3200 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 than 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.%of steel=100Asc/bd=100*3200/ (400*600) =1.33% Assume 12mm dia bars.

Number of bars=Asc/ (3.14d^2) =3200/ (0.785*144) = 30.6=31

Provided main reinforcement:

(1.33%, 3200 Sq.mm.)

Check for lateral ties:

(As per clause 26.5.3.2 of IS 456-2000)

A) Spacing:

Spacing will be the least of the following

1) Least lateral dimension of the compression member (300mm).
2) 16 x diameter of longitudinal reinforcement bar = 16x 12= 192 mm
3) 300 mm

B) Diameter:

The diameter shall be greater of the following

1) 1/4x12=3say 6mm
2) 6 mm.

3. FOOTINGS

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

a. General:

1. Footing shall be designed to sustain the applied loads, moments, forces, and induced reactions, and to assure that any settlements which may occur will be as nearly uniform as possible and also the safe bearing capacity of soil will not exceed its permissible limit.
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 neither soil nor less than 300mm above the tops of the pile for footing on piles.

i. Bearing capacity of soil:

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

b. Foundation design:

Foundations are structural elements that transfer loads from a building or individual columns to earth and to provide adequate safety isolated footings are provided for multi-story buildings. These may be square rectangle are circular in the plan, the choice of type of foundation to be used in a given situation depends on several 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. These are the 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

The following information was taken into consideration in the footing design

- Type of foundation: ISOLATED.
- Yield strength of steel:415 n/mm^2
- Minimum bar size:8mm
- Maximum bar size: 40mm
- Unit weight of soil: 22 kn/m^3

- Soil bearing capacity: 200 kn/m^3
- Minimum length: 1000mm
- Minimum width: 1000mm
- Minimum thickness: 500mm
- Maximum length: 12000mm
- Maximum width: 12000mm

c. Design of footing for column no.55:
Size of column=400x600mm Load=2126kn
Self-weight of footing=10% Total load w=p+0.1p=2338.6kn Bearing capacity of soil=200kn/m2

Area of footing=w/sbc=2338.6/200=11m2 Area=0.3x*0.45x=11 X=7

The short side of the footing=0.4x=2.8m Longer side of the footing=0.60x=4m Size of the footing=2.8mx4m
Area =11.2m2

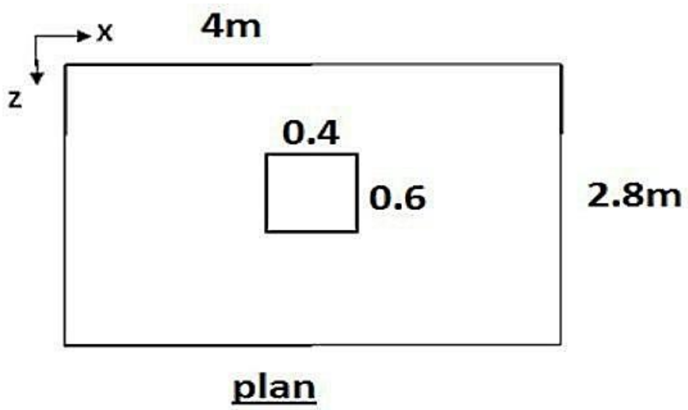


Fig9.1 The footing plan

Bending moment:
We know that pressure p=Pu/A=1.5*2126/11.2=284.7kn/m2

B.m about the axis x-x passing through the face of column Mu=pxBx ((L-D)/2) ^2/2
=284.7*2.8((4-0.6)/2)) ^2/2=1150.89kn-m

Effective depth required:
d = (Mu/ (0.138Fckb)) ^1/2

= (1150.89/ (0.138*20*2800)) 1/2=385mm
Increase the above depth to 1.75 to 2 times due to shear consideration Depth=770mm Area of tension reinforcement:
Mu = 0.87FyAstd (1-Astfy/bdFck) 1150.89=0.87*415*Ast*770(1-(415*Ast)/(2800*770*20)) By solving we get Ast=4318m2

Area of steel per meter=4318/3=1439mm2 Provide 10mm dia bars ast=3.14/4x10^2=78.55mm^2 Spacing of reinforcement in both ways S=1000xast/Ast=1000*78.5/1439=56.5=60mm

Provide 10mm dia bars @60mm c/c

1.1 Check for footing:

1.1.1 Check for one-way shear: Shear force Vu=PxB (((L-D)/2)-d)
=284.7*2.8(((4-0.6)/2)-0.77) =741.35kn
Shear stress TV=Vu/Bd=741.35*10^3/ (2800*770) = 0.34n/mm2
%steel=100xAst/Bd=100*1439/ (2800*770) = 6% From table no.19, IS456 Tc=0.56 >TV Design is safe against one-way shear

1.1.1 Check for two-way shear:
Shear force Vu=p (A-(D+d) ^2) =284.7(11.2-(0.6+0.77) ^2
=2654.28kn

Shear stress TV=Vu/b'd=2654.28/ (5480*770) =0.62n/mm2 Where b'=perimeter=4(D+d) =4(600+770) =5480mm
Max shear permitted Tc=0.25(Fck) ^1/2= 1.11>TV Design is safe against 2-way shear

1. Result and Discussion

Design for Flexure: Maximum sagging (creating tensile stress at the bottom face of the beam) and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above-mentioned sections. Each of these sections is designed to resist both these critical sagging and hogging moments. Where ever the rectangular section is inadequate as singly reinforced section, doubly reinforced section is tried.

Design for Shear: Shear reinforcement is calculated to resist both shear forces and torsional moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by STAAD Pro program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections. Beam Design Output: The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.

Column Design: Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yields maximum reinforcement is called the critical load. Column design is done for the square section. Square columns are designed with reinforcement distribution.

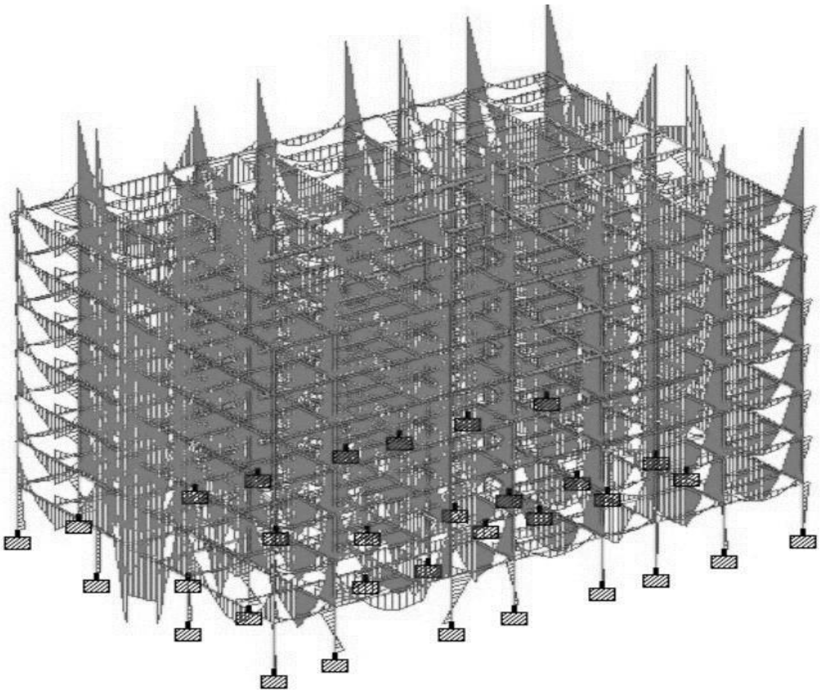


Fig 10.1 Shear force diagram:

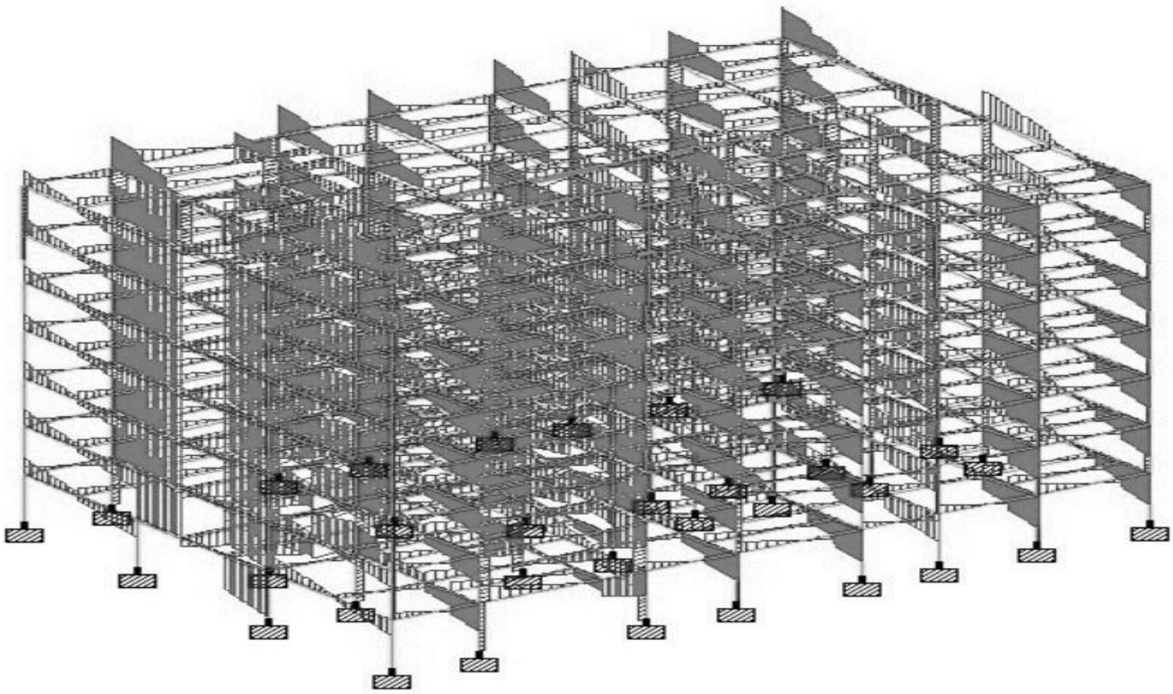


Fig 10.2 Bending moment diagram:

2. Conclusion

- Storey drift in Equivalent Static Analysis in X-direction is more for Steel frame as compared to Composite and RCC frames.
- RCC frame has the lowest values of storey drift because of its high stiffness.
- The differences in storey drift for different stories along X and Y direction are owing to orientation of column sections. Moment of inertia of column sections are different in both directions.

- Same storey drift patterns are obtained by using Response Spectrum method validating the results obtained by the Equivalent Static method.
- Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the steel and the composite frame. Base shear gets reduced by 40% for Composite frame and 45% for Steel frame in comparison to the RCC frame.

Reduction in cost of Composite frame is 33% and Steel frame is 27% compared with cost of RCC frame. This involves material cost only and doesn't include fabrication cost, transportation cost, labour cost etc

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