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Computerised Analysis, Design & Estimation of A G+1 Villa in Vijayawada City

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Abstract- Engineering drawings were made on sheets of paper using drawing boards before the launch of design software. Multiple pieces of equipment were required to complete a drawing and if any kind of mistakes is happened in plan it was difficult to correct them. But after launching of designing Software, it improves the speed of production, the quality of drawing and reduce development costs. Generation of visualization during the design process to help the decision making. From early years, the structures are constructed with basic requirements but, now a day's lifestyle has been changed as every person needs a luxurious life. So, to see such various views in the detailed planning is necessary. Normally all buildings are constructed according to the drawings and specifications prepared by architects, each city has prescribed building byelaws to which buildings must conform. The design communication is gradually being changed from 2D based to integrated 3D digital interface. REVIT is a model-based design concept, in which buildings will be built virtually before they get built out in the field, where data models organized for complete integration of all relevant factors in the building lifecycle which also manages the information exchange between the AEC (Architects, Engineers, Contractors) professionals, to strengthen the interaction between the design team. In this project the planning of residential building (G+1) is done by Revit software. The 2D and 3D planning of proposed building is done by using Revit Architecture Software. The principal objective of this project is planning, analysis and Design of a Residential Building.

Keys Words: Shear Force, Bending Moment, Deflection, Slabs, Beams, Columns, Footings ,2D plan in AutoCAD, 3D modelling in Revit, Estimate, Standard Schedule, Abstract Estimate, Carpet Area, Quotations.

1. INTRODUCTION

1.1 GENERAL

The basic requirements of human presences are food, apparels and shelter. From times immemorial man has been attempting endeavors in enhancing their way of life. The purpose of his endeavors has been to give a monetary and productive sanctuary. The ownership of safe house other than being a fundamental, utilized, gives a sentiment security, obligation and demonstrated the societal position of man. Each individual has an inborn enjoying for a quiet domain required for his charming living, this item is accomplished by having a position of living arranged at the safe and advantageous area, such a spot for agreeable and wonderful living requires considered and kept in stand point.

The aim of the project is to know and understand the various aspects like planning and we have planned a residential building of two floors (G+1). The planning is done as per the requirements and regulations. Residential building is a building that comes with sleeping accommodation for normal residential purposes, with or without cooking or dining facilities, and includes one or more family dwellings, lodging or boarding houses, hostels, dormitories, apartment houses, flats and private garages of such buildings. The Residential Building Plan was drafting by AutoCAD software which is useful to easily draw a column layout and followed as per limit state method. Any construction project is to begin with the layout of building or followed by design of structure which is succeeded by planning for the said project. This project involves the layout, design, planning and cost estimation of g+1 residential building. The aim of our project is used to design prepare drawing of residential building. The methodology used in this project is easy and less time consuming it mainly depends on the software AutoCAD and Revit.

1.2 PLANNING CONSIDERATIONS

The plan and detailing were drawn using Auto CAD. The building is rectangular in shape. The building consists of ground floor, first floor and terrace floor. Enough parking space is provided around the building and staircase is also provided with enough safety in the building.

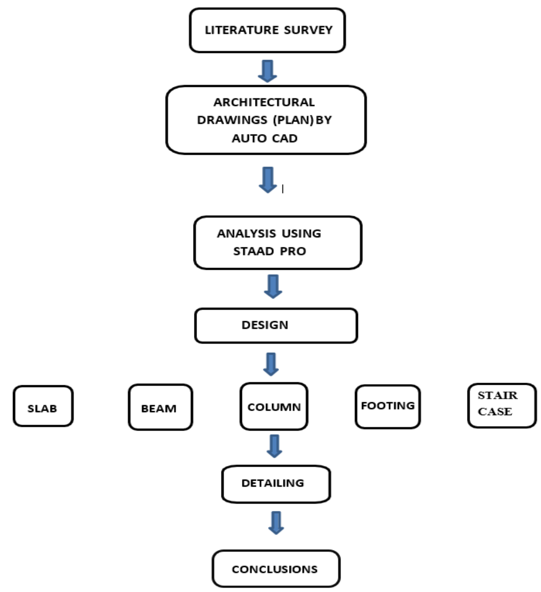
1.3 OBJECTIVES OF THE PROJECT

- To draw the plan of a G+1 Residential building (Villa) by using Auto Cad software
- To draw the 3D view of the same building by using Revit software
- To analyze & design the G+1 Villa
- To estimate the quantities of all elements

2. LITERATURE REVIEW

- J Vinoth Kumar: In India 49% of the respondent use owners, Architects, Engineers & Builders. AUTOCAD AND REVIT is in field to better communicate & integrate construction information. which is gradually gaining acceptance by the Revit as measure Revit tool. The AUTOCAD AND EVIT is new & promising approaching India,
- Mehmet F Hergunsel: The project studied six AUTOCAD AND REVIT utilization activities: visualization, 3D coordination, cost estimation, prefabrication, construction planning and monitoring, and record model. The visualization is generally the simplest use of a Building Information Model such as renderings. As soon as the Building Information Model are produced, the quantity takeoffs can be generated to provide costestimations on a construction project.
- Saeed Reza Mohandas: Due to numerous steps of construction industry and its complicated and extensive structure, errors and reworks often might happen in this section. As such, AUTOCAD AND REVIT (Building Information Modeling) is regarded as a beneficial tool in minimizing the waste and improving the efficiency ofbuilding construction. It has discussed the concept, explained the history, planning and implementation process and the benefits of using AUTOCAD AND REVIT in construction industry. Furthermore, the application of AUTOCAD AND REVIT in construction process of two specific projects has been explained.

3.METHDOLOGY



4. PLANNING

This is a north facing G+1 Residential Building plan that means a duplex house plan. This plan has 2 floors ground floor and first floor. The plans for both the floors are same as shown in the drawing. The residential building consists of two storeys. First storey is referred as ground floor and second is referred as first floor. The respective plan for ground floor, first floor upto top floor which are drafted in AUTOCAD software are shown as individually as below.

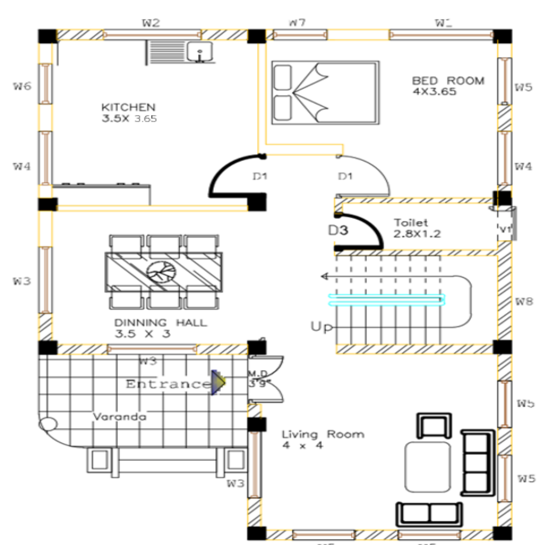


Figure 4.1. Ground floor plan

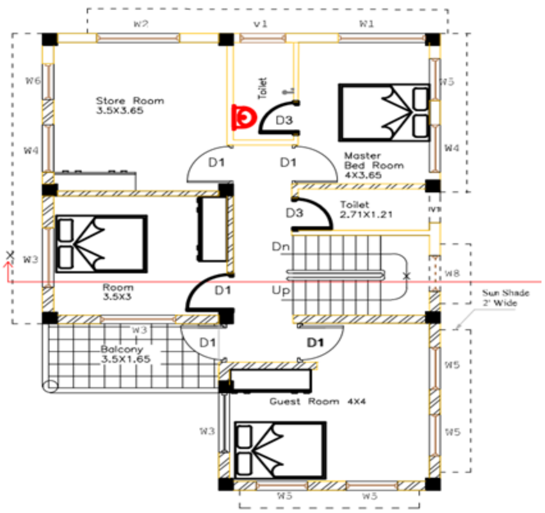


Figure 4.2. First floor plan

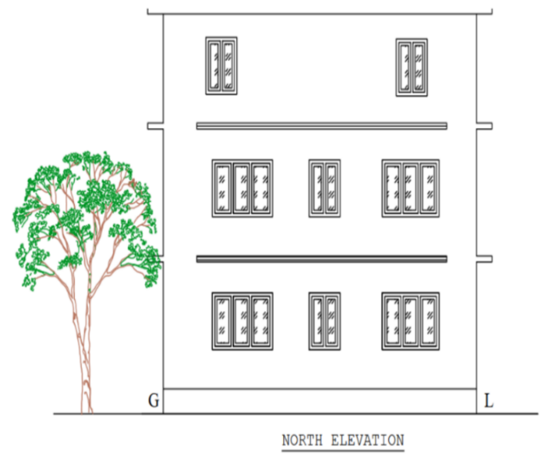


Figure 4.6. North Elevation

Figure4.3. West Elevation

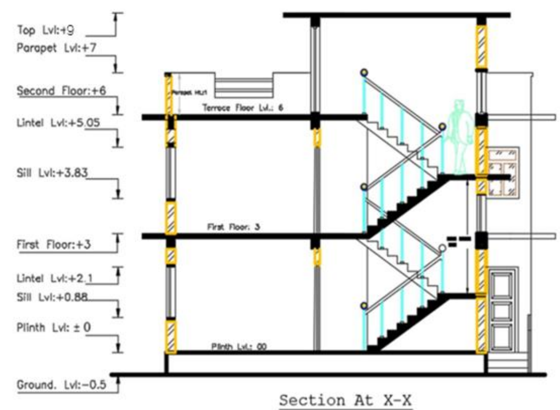


Figure4.7. Cross section at X-X

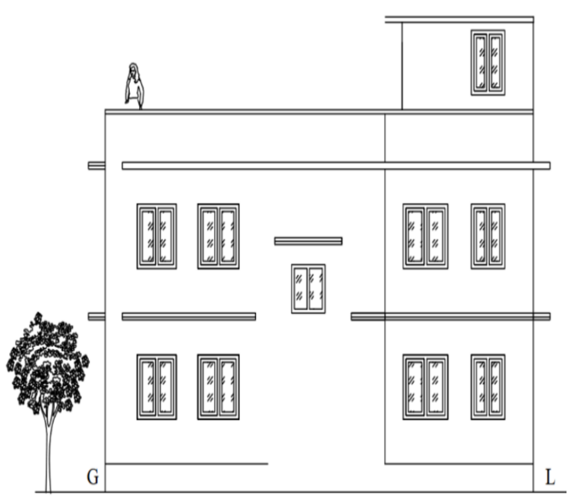


Figure 4.4. East Elevation

Figure 4.8. 3Dview in Revit mode

5. ANALYSIS

5.1 GENERAL

STAAD Pro V8i has a very user-friendly interface and very useful for designing complex structures and analyzing them. STAAD Pro V8i is a design and structural analysis program developed by Research

Engineers International, CA. It was acquired by Bentley Systems in 2005. It is one of the most widely used design and structural analysis software's for concrete, steel and timber design codes.

STAAD pro allows designers and structural engineers to design and analyse virtually any type of structure through its very flexible modeling environment, fluent data collection and advanced features.

5.2 POST PROCESSING RESULTS

The combined load (dead load & live load) is applied with load factor 1.5 and the model isanalyzed and post processing displacement & shear force diagram are given below.

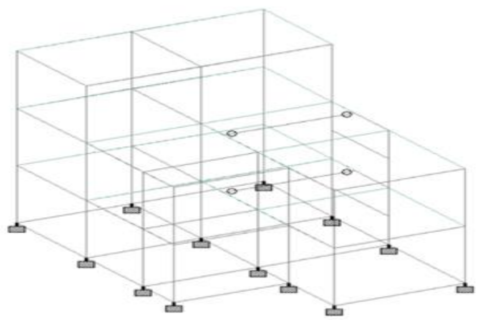


Figure 5.1 Model of the structure

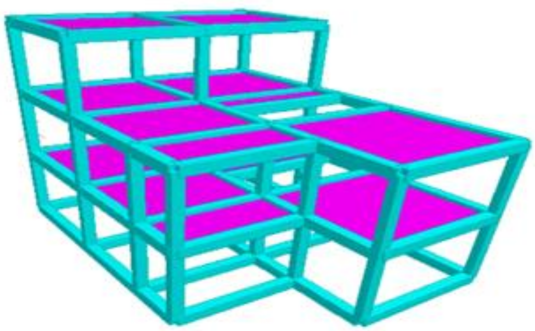


Figure 5.2 3D view of the structure

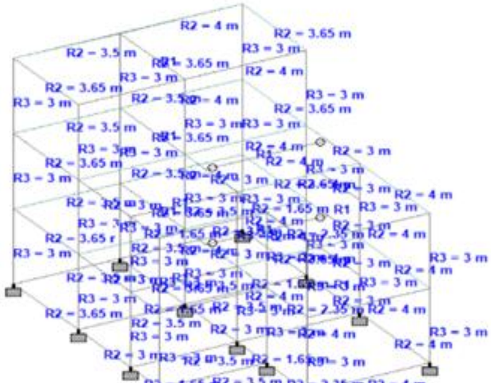


Figure 5.3 Sectional Properties

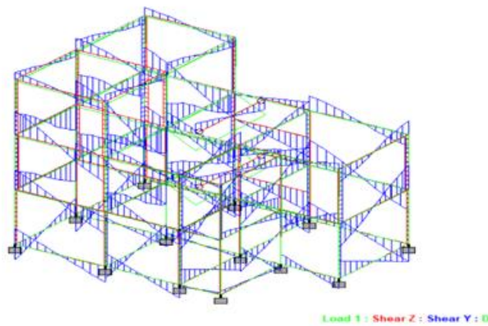


Figure 5.4 Shear Force Diagram

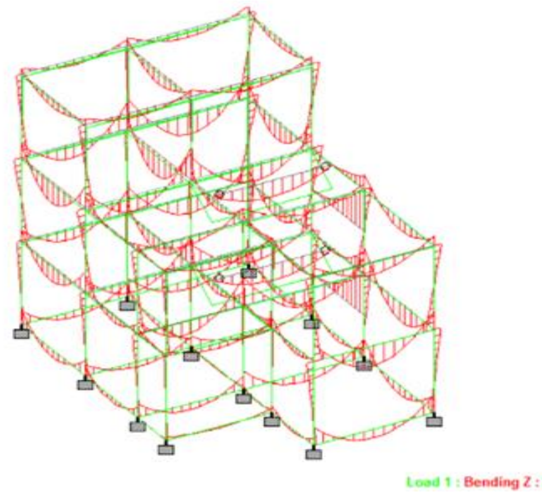


Figure 5.5 Bending Moment Diagram

6.DESIGN

6.1DESIGN OF SLAB

As per clause 26.5.2.2 of IS 456:2000, the diameter of reinforcing bars shall not exceed 1/8 of the totalthickness of the slab.

Here the model for the design of slab is mentioned, like this need to do for every slabs in thebuilding.

Floor finish =1kN/m²

Fck =20N/mm²

Fy =415N/mm²

STEP 1: Check for Slab

L_y / L_x =1.4<2

Hence it is Two Way Slab.

STEP 2: Thickness of slab

Modification factor

fs = 0.58*fy

fs = 0.58*415

= 240.7 N/mm^2

Percentage of steel (Pt) = 0.4 to 0.6 for slabs

Pt = 0.4

MF = 1.3

Lx/d = 20*1.3

∴ d = 120mm

Overall depth D = d+d'

Assume d' = 20mm

D = 140mm

STEP 3: Effective span

Lx = 3+0.12

= 5.12m

Ly = 3.5+0.12

=3.62m

Ly/Lx = 3.62/3.12

= 1.16>2

∴ It is designed as two way slab

STEP 4: Loads

Self weight = D*b*γ

= 0.14*1*25

= 3.5 KN/m^2

Floor finish = 1 KN/m^2

Live load = 3KN/m^2

Total load P = 7.5 KN/m^2

Design load Pu = 7.5*1.5

= 11.25KN/m^2

Bending moment

Mx = αx*w*lx^2

αx = 0.084

αy = 0.059

Mx = 0.084*11.25*3.12^2

Mx = 9.19 KN-m

My = αy*W*lx^2

My = 0.059*11.25*3.12^2

= 6.46KN-m

STEP 5

Check for depth required

D_{req} = ✓Mu/0.138*fck*b

=✓9.19*10^6/0.138*20*1000

= 57.7mm <d

Hence safe

STEP 6

Ast calculation (shorter span)

Mx = 0.87*fy*Ast*d{1-(fyAst/fck*bd)}

9.19*10^6 = 0.87*415*Ast*120{1-(415*Ast/20*1000*120)}

Ast x = 220.52mm^2

Provide 10mm bars

ast = π/4*d^2

= 78.53mm^2

Spacing(shorter span)

S = ast/Ast*1000

= 78.53/220.52*1000

S = 350mm

∴ provide 10mm bars@350mm @ c/c

No.of bars N = 220.52/(π/4*10^2)

N = 3 bars

Provided (Ast)x = 3*π/4*10^2

Ast pro = 235.61mm^2

Longer span

My = 0.87*fy*Ast*dy{1-(fy*Ast/fck*b*d)}

6.46*10^6 = 0.87*415*Ast*110{1-(415*Ast*/20*1000*110)}

∵dy = 120-10

dy = 110mm

Ast = 167.9mm^2

Assume 10mm bars

ast = π/4*d^2

= 78.53mm^2

Spacing

S = ast/Ast*1000

= 78.53/235.61*1000

= 500mm

Provide 10mm ϕ bars @ 500mm c/c

No. of bars N = 167.9/(π/4)10^2

N = 3 bars

Provided (Ast)y = 3*π/4*10^2

= 235.61mm^2

Check for shear

Vux = Wulx/2

= 11.25 x 3.12/2

Vux = 17.55 KN

Vuy = 11.25*3.62/2

= 20.36 KN

τv x = Vux/b*d

= 17.55*10^3/1000*120

τv x = 0.146N/mm^2

τv y = Vuy/b*d

= 20.36*10^3/1000*120

= 0.18 N/mm^2

τc = 0.304 N/mm^2

$\tau_{vx} < \tau_{vy} < \tau_c$

∴ slab is safe in shear

STEP 7: Reinforcement Detailing

1. Effective Depth = 120 mm

2. Effective Span Shorter= 3.725 m
3. Effective Span Longer
   = 3.830 m
4. 12mmΦ bar @200mm C/C for Shorter
5. 12mmΦ bar @200mm C/C for Longer

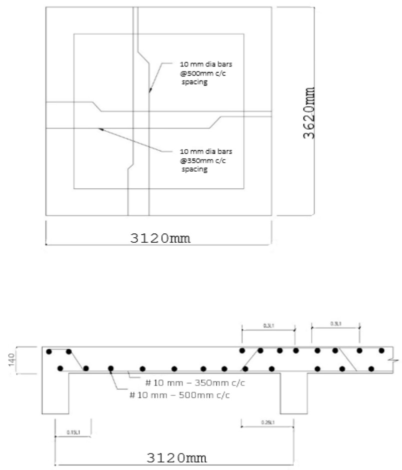


Figure 6.1. Reinforcement details of Slab

6.2 DESIGN OF BEAM FOR FLEXURE

A beam is generally designed by considering bending moments, shear – forces and twisting moments developed by the lateral load.IS 456: 2000 recommends the minimum grade ofconcrete shall not be less than M_{20} in R.C. works.

BEAM WITH MOMENT DISTRIBUTION METHOD:

Size of the beam = 400 x 300 mm

Fck = 20 N/mm^2

Fy = 415 N/mm^2

M_u from STAAD pro = 10.464 N/mm^2

= 1.5*10.464

= 15.69 KN-m

Provide 25mm clear cover

Effective depth = 400-25-12/2

= 380mm

Ast calculation

Mu limit = 0.138*fck*b*d^2

= 0.138*20*300*200

= 119.56KN-m

$M_u < M_{ulim}$

Check for depth required

D_{req} = ✓Mu/0.138*fck*b

= ✓15.69*10^6/0.138*20*300

= 137mm

$D_{req} < D_{pro}$

Hence safe

Mu = 0.87*fy*Ast*d(1-fy*Ast/fck*b*d)

15.696*10^6 = 0.87*415*Ast*380{1-415*Ast/20*300*380}

Ast = 200mm^2

No. of bars

N = Ast/πd^2/4

= 200/*π*12^2/4

n = 3 bars

provide 3 no 12mm dia in tension zone and 3 no of 10mm dia in compression zone.

check for shear

Vu = 40.5 KN

τ_v = Vu/bd

= 40.5*10^3/300*380

= 0.35 N/mm^2

% of steel (Pt) = Ast_{pro}/bd*100

Ast pro = πd^2/4*n

= π*12^2/4*3

= 339.29 mm^2

Pt = 339.39/300*380*100

= 0.29 %

τ_c = 0.33 N/mm^2

τ_{cma} = 2.8 N/mm^2

Spacing Sv = Ast*087*fy/0.4*b

= (π/4*8^2*0.87*415)/0.4*300

= 150mm

Sv < 0.75*d< 0.75*380

∴ Provide 8mm dia of stirrups @ 150mm c/c

CHECK FOR DEFLECTION:

(l/d) max>(l/d) pro

(l/d) max = (l/d) basic x Kf × Kc× Kt

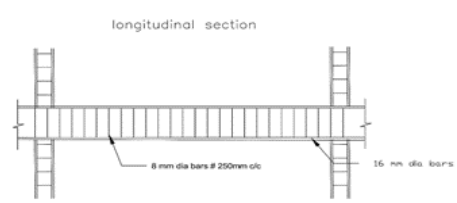
= 20×1×1×1.2

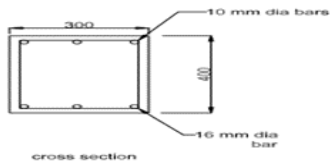
(l/d) = 24

(l/d) pro = 8.85

As (l /d) max>(l/d) pro

Hence safe





6.3 DESIGN OF A COLUMN

A column is a Structural member used to transfer the load from beam to footing. The area of reinforcement should not be less than 0.8% and not more than 6% of the cross-sectional area of the column. The purpose of providing minimum reinforcement is to prevent the buckling of column due to accidental eccentricity of load on it. Generally, a cover of 40 mm is provided. The main reinforcement is provided with transverse of main reinforcements in the form of the lateralties to prevent the dislocation of main reinforcements, buckling, etc.

Design process

Design Load = 583.61 KN

Fck = 20 N/mm^2

Fy = 415 N/mm^2

Gross area of column = Ag

Assuming 1% of steel

Asc = 0.8% of gross area

Ag = b*d

= 230*300

= 6900 mm^2

Asc = 0.8*69000 ÷100

= 552mm^2

Assume 12 mm Diameter bar

552 = n*π/4*12^2

n = 4 bars

Ac = Ag – Asc

= 69000 – 552

= 68448mm^2

Ac = 68448mm^2

Lateral ties

Diameter of lateral ties not less than

a) ¼*16 = 4
b) 6 mm

Hence, adopt 6mm dia bars

Pitch of the ties shall be minimum of

a) Least lateral dimension of column = 300mm
b) 16 times the dia of longitudinal bar = 16*16 = 256mm
c) 300mm

Provide 6mm lateral ties at 250mm c/c.

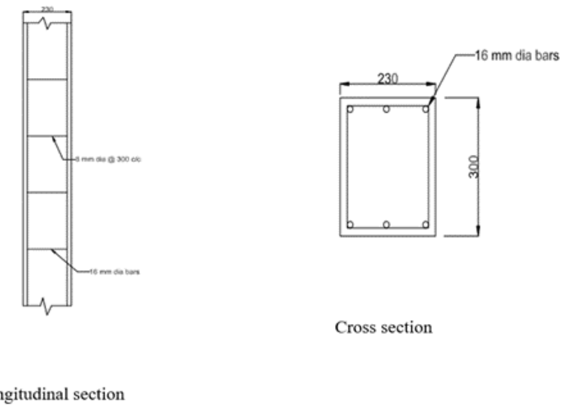


Figure no 6.3. Reinforcement details of Column

6.3DESIGN OF FOOTINGS

Footings are the bases laid on the soil on top of which a structure is erected. Thus, it is the foundation on which a building or any such structure stands upon. They are made of concrete having reinforcements inside them and are poured into an excavated ditch or conduit. Before thefoundation is built, a test is done to assess the strength of the soil bearing capacity to ascertain the type of foundation to be built.

Given below are the types of footing and the situation under which they are applied is defined for better understanding-

A.Isolated Footing
B.Combined Footing
C.Raft Footing
D.Pile Footing

Size of Column = 230mm × 300mm

Bearing Capacity of Soil = 150 kN/m^2

Fy = 500 N/mm^2

Fck = 20 N/mm^2

Total load on column (Wc) = 583.61KN

STEP 1

Calculation of load

Self weight of footing = 10% of column load

Ws = 58.31KN

W = Wc + Ws

W = 641.92KN

STEP 2

SIZE OF FOOTING

Area (A) = load/SBC

= 641.92/150

= 4.27m^2

Let :

L/B = 40/60

= 2/3

L = 2B/3

A = L*B

= 2B/3*B

$2B^2$ = 12.81

B^2 = 6.405

B = 2.5m

L = 2B/3 = 2*2.5/3

L = 1.6m

Size of footing = 1.6*2.5m

STEP 3

Calculation of footing soil pressure

Qu = factored load/Area of footing

= 1.5*Wc/1.6*2.50

= 1.5*583.61/4

= 218.85 KN/m^2

= 0.218N/mm^2

STEP 4

Calculation of depth of footing using bending moment

Mu = qu*L{$(B-b)^{2/8}$}

= 218.85*2.5{$(1.6-0.23)^{2/8}$}

Mu =128.36 KNm

Moment of resistance

Mu = 0.138*fack*Bd^2

211.84*10^6 = 0.138*20*1600*d^2

D = 220mm

increase the depth of footing by1.5 to 2 times

hence d = 2*220

d = 440mm

Overall depth (D) = d + effective covers

= 440 + 60

D = 500mm

STEP 5

Calculation of area of steel

Mu = 0.87*fy*Ast{d – (fy*Ast/fck*B)}

218.84*10^6 = 0.87*fy*Ast[500 – (415*Ast/20*1600)]

Ast = 1211.51mm^2

Using 16mm dia bars

Spacing = ast*B/Ast

= {(π/4*16^2*1600)/1211.51}

= 265.53mm

Hence provide 16mm bars at 260mm c/c in both directions

STEP 6

CHECK FOR ONE WAY SHEAR

The critical section for one way shear is at a distance d from the face of the column

Factored shear force, Vu = qu*L{(B-b/2)-d}

= 0.218*2500{(2500-300/2)-440}

Vu = 359700N

Tv = Vu/Bd

= 359700/2500*440

= 0.37N/mm^2

Percentage of steel (Pt) = (ast/s*d)*100

= {(π/4*16^2)/265.53*440}

= 0.172%

From IS 456 code of table 19

τc = 0.29N/mm^2

∴ $\tau c < \tau v$

Hence, the slab is safe in one way shear

CHECK FOR TWO WAY SHEAR

The critical section is at a distance of d/2 from the face of the column

Perimeter of the critical section = 2(730+800)

= 3060mm

Area of critical section A = 3060*D

= 3060*500

Two way shear , Vu_2 = qu*area of shaded portion

= 0.218{(2500*1600)-(7300*800)}

Vu_2 = 744688N

Two way shear stress = Vu_2/A

= 744688/3060*500

= 0.48N/mm^2

Permissible punching stress τp = 0.25*✓fck

= 0.25*✓20

= 1.12

∴ $\tau p > \tau v$

Hence, it is safe in two way shear

STEP 7

CHECK FOR DEVELOPMENT LENGTH

τbd = 1.6*1.2 =1.92 N/mm^2

Ld = 0.87*fy*ϕ/4*τbd

= 0.87*415*16/4*1.92

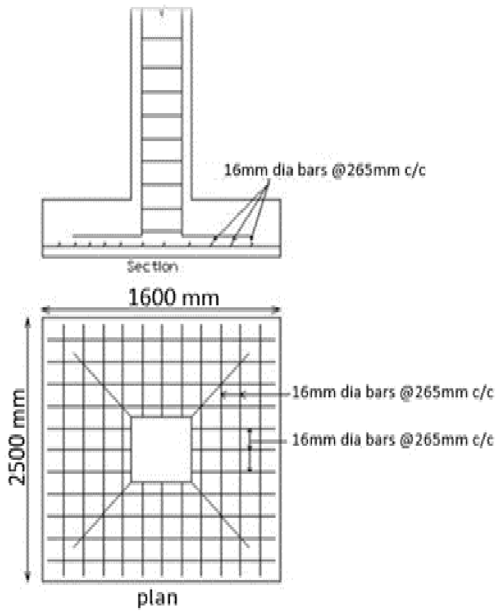
= 752.2mm

Length available at beyond the column face

= 2500-300/2

= 1100 >Ld

Hence ok.



6.4DOG LEGGED STAIRCASE

In this type of staircase, the first newel should pass through the lower floor, and toensure solidity should be secured by bolts to a joist as shown in the plan. The rail is attached to the newels in the usual manner, with handrail bolts or another suitable device. The upper newelshould be made fast to the joints as shown, either by bolts or in some other efficient manner. The intermediate newels are left square on the shank below the stairs, and may be fastened in the floor below either by mortise and tenon or by making use of joint bolts.

DESIGN OF STAIRCASE

Floor to Floor Height = 3+0.125 = 3.125m
Dimensions of stair hall = 4m×1.8m
Height of the floor = 3/2
= 1.5m
Rise (R) = 150mm
Tread (T) = 225mm
No.of rises = 1500/150
= 10
No.of treads = 10-1
= 9
Adopt width of stair = 0.85m
For 9 treads the length required = 9×0.225
= 2.025m
Width of landing = (4-2.025)/2
= 0.99m

2.Effective span

As the stair is spanning longitudinally

Span = 4+0.23
= 4.23m

3.thickness of slab

Effective depth (d) = span/25
= 4230/25
= 169.2mm
d ≈ 170mm
D = 200mm

4.loads

Weight of waist slab = $D\sqrt{1+(R/T)}\times 25$
= $0.2\sqrt{1+(0.15/0.225)^2}\times 25$
= 6.01KN/m
Weight of steps = R×25/2
= 0.15×25/2
= 1.875KN/m
Live load = 3KN/m
Floor finish = 1KN/m
Total load = 6.01+3+1.875+1
W = 11.88KN
Factored load (Wu) = 1.5×11.88
Wu = 17.83KN

5.Bending moment

$Mu = Wul^2/8$
$= 17.83\times 4.23^2/8$
$Mu = 39.88$KN-m

6.Minimum depth required

$Mu = 0.138\times fck\times b\times d^2$
$39.88\times 10^6 = 0.138\times 20\times 1000\times d^2$
$D = 120.2 < 170$mm

Hence provided depth is adequate

7.Tension reinforcement

Mu = 0.87fyAstd{1-[fy*Ast / fck*bd]}
39.88×10^6 = 0.87×415×Ast×170{1-(415×Ast/20×1000×170)}

Therefore, A_{st}= 712mm^2

Assume12mm dia bars

$a_{st} = \pi/4\times 12^2$
$a_{st} = 113.09$ mm^2
spacing $S = a_{st}/A_{st}\times 1000$
= 158.84mm

Hence provide 12mm dia bars @ 150mm c/c

8.Distribution reinforcement

Ast = 0.12% of gross area

= (0.12/100)×1000×200

Ast = $240mm^2$

Assume 8mm dia bars

ast = $\pi/4\times8^2$

= $50.26mm^2$

Spacing (S) = ast/Ast×1000

= 209.43mm

Hence provide 8mm dia bars @ 200mm c/c.

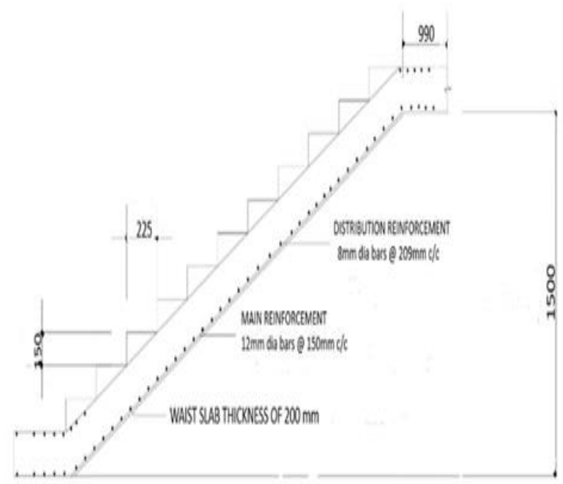
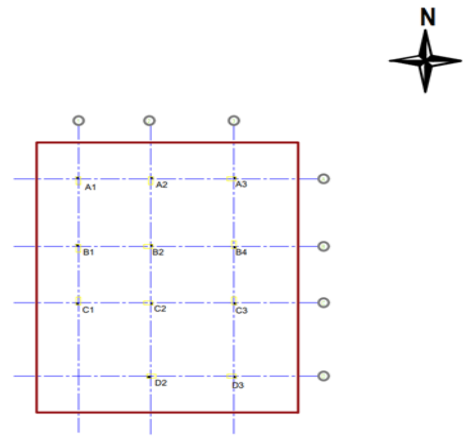


Figure 6.5. Reinforcement details of Stair Case

Table 6.1 TOTAL QUANTITIES FOR G+1 VILLA

SI.NO	DESCRIPTION OF THE WORK	QUANTITIES	TOTAL QUANTITIES
1	EARTH WORK EXCAVATION	63.21 m^3	63.21 m^3
2	P.C.C BED WORK FOOTING @ THICK OF 0.1M	5.75 m^3	31.75 m^3
	R.C.C BED WORK FOOTING @THICK OF 0.5M	26 m^3	
3	CEMENT CONCRETE @ COLUMN UPTO PLINTH LEVEL	0.9 m3	7.525 m^3
	CEMENT CONCRETE @ COLUMN UPON PLINTH LEVEL	6.625 m^3	
4	EARTH (OR) SAND FILLING IN PLINTH LEVEL	26.35 m^3	26.35 m^3
5	CEMENT MORTAR ON SAND FILLING AREA	6.59 m^3	6.59 m^3
6	BRICK WORK		
	GROUND FLOOR	34.98 m^3	85.76 m^3
	FIRST FLOOR	26.72 m^3	
	PENT HOUSE	24.06 m^3	
7	CONCRETE WORK OF SLAB		
	GROUND FLOOR	9.76 m^3	23.54 m^3
	FIRST FLOOR	9.06 m^3	
	PENT HOUSE	4.72 m^3	
8	PLASTERING ON BUILDING		
	INNER TO INNER	697 m^2	935.32 m^2
	OUTER TO OUTER	238.32 m^2	



Column centre line drawing

7.CONCLUSIONS

A Residential building of G+1 with terrace is designed and analyzed. The quantities of materials are also estimated. The size of the beams and slabs are assumed according to bending moment and shear force obtained. The sizes of column and footing are assumed according to the type of loading. The details ofReinforcement for various elements are drawn by using AutoCAD.

- The designed single storey building will effectively resist and survive the wind load.
- Maximum bending moment occurs in Beam (b/w B2 & B4) & maximum shear force occurs in intermediate column (B2) taking these values by using of STAAD PRO software.
- The total quantity of steel used is 19,203 newton's
- The total volume of concrete is 62.82 cu.m

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