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Planning, Designing and Estimation of High Ceiling Residential Building(G+1)

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ABSTRACT
The principle objective of this project is to Planning, Designing and Estimation of HighCeiling Residential Building (G+1). The design involves load calculations manually and the design methods used are LIMIT STATE DESIGN conforming to Indian Standard Code of practice. The 2D planning of proposed building is done by using AutoCAD Software and 3D planning of proposed building is done by using Revit Architecture Software. The final work was the proper plan, design and estimate of HIGH CEILING RESIDENTIAL BUILDING RCC frame under dead load and live load combinations.

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I. INTRODUCTION

Advantages of HighCeilings

There's the immediate sense of **space**, air, and light. High ceilings are interesting, appealing, and have definite **advantages**.

- They are elegant, fascinating, and luxurious– and open up the room.
- In warmer climates, it's easier to cool homes with high ceilings – making the residence more **energy-efficient**.
- No one ever feels cramped or cooped up in a room with highceilings.
- They add to the resale value of ahome.
- They provide **versatility** for a variety of décor ideas.
- Aside from aesthetics and the overallattraction of high ceilings, there's also scientific data that shows high ceilings stimulate the brain and encourage **creative thinking**.

II. EXPERIMENTALSETUP

The main aim of this project is to design a high ceiling residential building with appropriate reinforcement as per Indian standards with limit state analysis. The design of high ceiling residential building takes generation of plan which is done with the help of AUTOCAD software. Before going through this software the respective positions of rooms (like living room, kitchen, dining hall, master bedrooms, etc.). The arrangement of rooms is done with respect to aspects of building.

A. Arrangements of Rooms

***1)* Aspects**

Aspect means particular arrangement of doors and windows in external walls of residential building while environment to pass through it. The important aspect in planning is not only providing the sunshine but also hygiene and eco-friendly environment. The room is based upon the allowance of air and light and referred to such particular aspect. As per the plan the different arrangements of room are shownbelow.

Table 1. Aspects of room

Room (In both floors)	Aspect
Entrance	North
Car parking	North east
Living room	East
Kitchen	South east
Dining hall	East
Prayer Room	East
Master Bedroom	South west
Bed room	North west
Bathroom/Toilet	West
Staircase	West
Balcony	North east ,South east

***2)* Size**

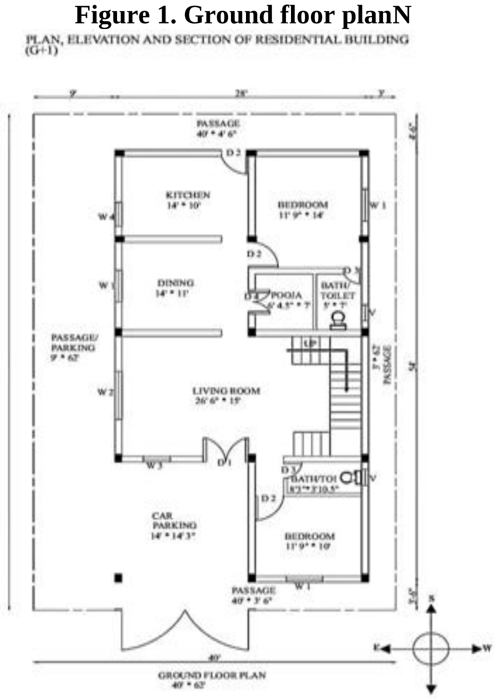
The total area of residential building is

140.65 Sq. m (1512 Sq.ft). The area is divided into number of rooms as per requirement. In keeping the view of health and ventilation, the sizes of room are provided keeping in view of National Building code, the different dimensions of rooms are providedas.

Table 2. Dimensions of room

Room Dimensions(in meters) Ground floor	
Car parking	4.26×4.35
Living room	7.92×4.57
Kitchen	4.26×3.04
Dining hall	4.26×3.35
Prayer Room	1.82×2.13
Master Bedroom	3.62×4.26
Bedroom	3.62×3.04
Bathroom/Toilet(common)	2.51×1.18
Bathroom/Toilet(attached)	1.52×2.13
First Floor	
Balcony (common)	4.26×3.04
Guest room	4.26×3.35
Master bedroom 1	3.62×3.35
Master bedroom 2	3.62×4.07
Walk in closets	2.24×3.04
Bathroom/Toilet(guest room)	1.21×3.04
Bathroom/Toilet(Master bedroom 1)	1.21×3.04
Bathroom/Toilet(Master bedroom 2)	2.51×1.21
Balcony (Guest room)	2.93×3.04

Figure 1. Ground floor planN



5) First Floor plan

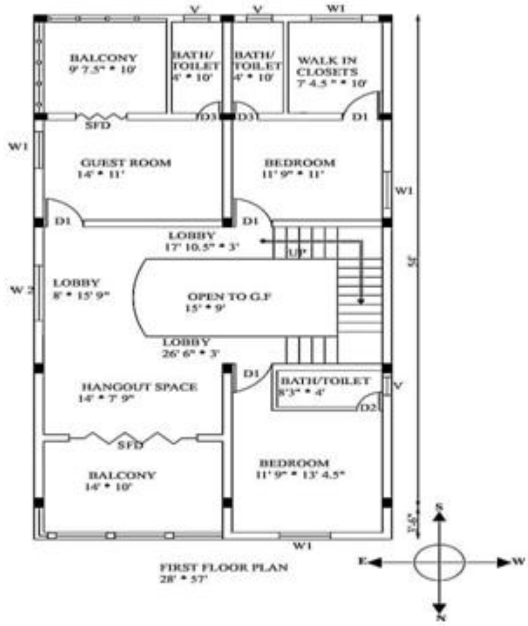


figure.2 First floor plan

3) **Planning**

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 and first floor which are drafted in AUTOCAD software are shown as individually as below.

6) Section

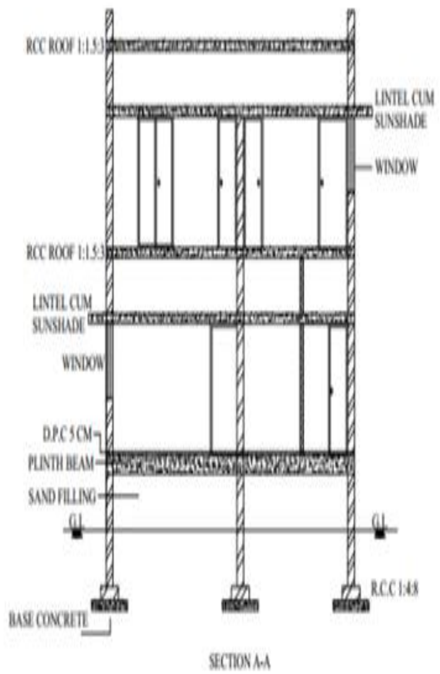


Figure 3. Section A-A

7) Rectangular footingplan9) Plinth beam plan

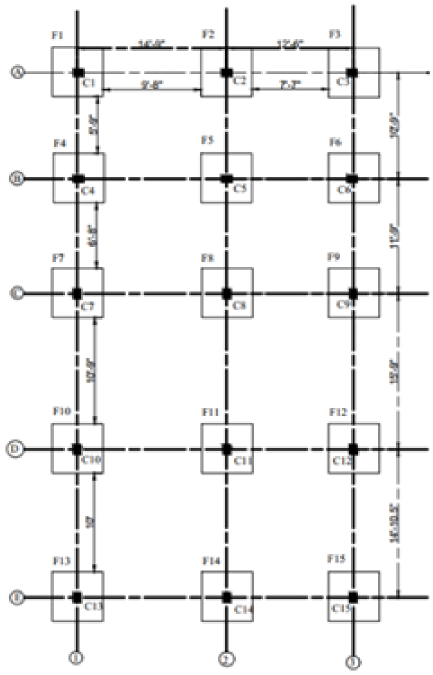


Figure 4. Rectangular footing plan

8) Rectangular column plan

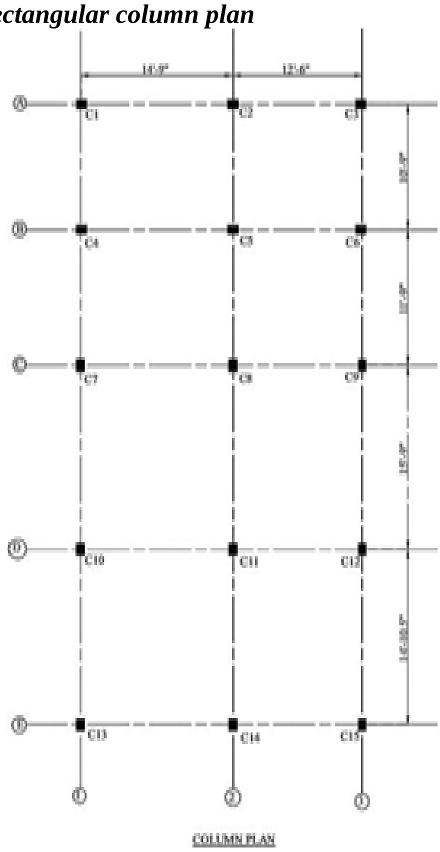


Figure 5. Rectangular column plan

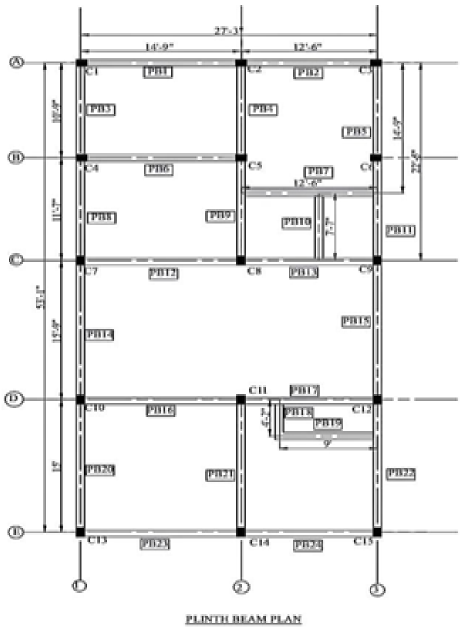


Figure 6. Plinth beam plan

10) **Ground floor roof beamplan**

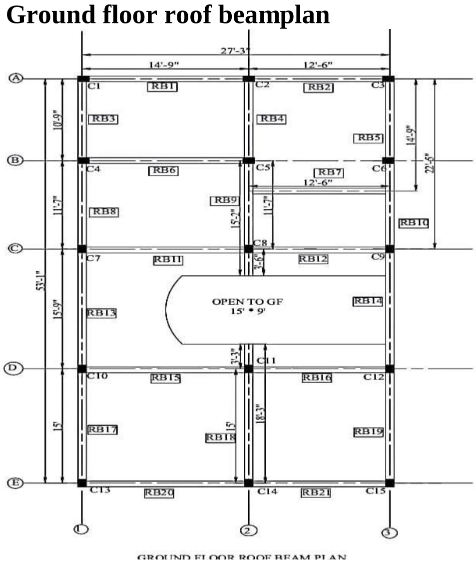


Figure 7. Ground floor roof beam plan

11) **First floor roof beamplan**

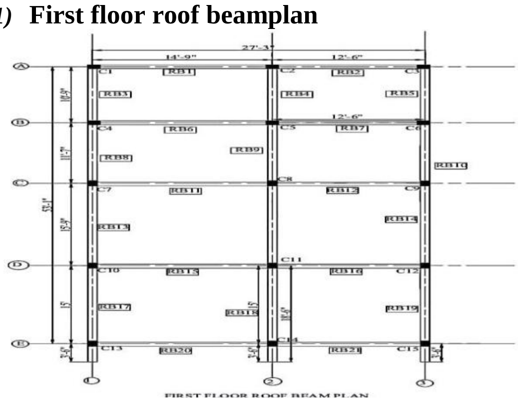


Figure 8. First floor roof beam plan

12)3D View

Figure 9. 3D view

Figure 10. Front view

Figure 11. Sideview

III. DESIGN OF RESIDENTIALBUILDING

The design of residential building is carried out as per Limit state analysis. The codes used in the design are
IS: 456 2000 and IS: 875 1980

A. Design ofslab

The foremost important point in design of slab is analysis of loads. The loads are directly taken as provided in Indian Standard IS: 875 1980 (Part 1 for dead load; Part 2forliveload;Part3forwindload)AsperIS:8751 980part II, the live loads for different types of rooms rested on ground floor is selected as.

Data Assumed:-

Typeofslab =Continuous one wayslab
Clearsize =3m×1.2m
Wallthickness =230mm
Floorfinish =1kN/m² **(ReferIS875-1987)**
F_{ck} =M20
F_y =Fe415
ØOf bar =10mm
Nominal cover=15mm

Step-1:- Type of Slab

ly/lx>2
=3/1.2
=2.5>2

Hence the slab is to be designed as one way continuous slab

Step-2:- Effective depth

Effective depth =Span/(Basic value Modification factor)
=1200/ (26×1.5)
=30.76mm-80mm

Overall depth =Effective depth +Nominal $\emptyset/2$
=80+15+5 **(ReferIS 456-2000)**
=100mm

Step-3:- Effective span

Forend span =Clear span + effectivedepth/2
=1200+80/2
=1200+40
=1240mm

Step-4:- Calculation of load

Self-weight of slab =D× γc
=0.1×25
=2.5 m²

Floor finish=1 m^2 **(Refer IS875-1987)**

Access to provided =1.5 kN/m² **(Refer IS875-1987)**

Total dead load, W_d =5.0 kN/m² Load on /m length, W_d=5.0kN/m²

Total design dead load, W_{ud}=5.0×1.5 =7.5 kN/m²

Imposed load, W_l =5.0 kN/m²

Load on /mlength, W_l=5.0 kN/m²

Total design deadload, W_{ud}=5.0×1.5
=7.5 kN/m²

Step-5:- Calculation of Bending moment

B.M@near middle ofendspan
=+Wudl^2/12+ Wul l^2/10
=(7.5(1.2)²/12) +(7.5(1.2)²/10)
M_{u1} =1.98kNm

B.M @near middle of mid span=Wudl^2/16+ Wul l^2/12
= (7.5(1.2)²/16) + (7.5(1.2)²/12)
Mu_2=1.575kNm

B.M @ support nextto end Support =-Wud l^2/10- Wul l^2/9

$=-(7.5(1.2)^2/10)-(7.5(1.2))^2/9$

Mu_3 =-2.28kNm

B.M @ other interior supports =-Wud l^2/12- Wud l^2/9

$=-(7.5(1.2)^2/12)+(7.5(1.2)^2/10)$

Mu4 =-1.98kNm

Take max.moment **Mu=2.28kNm**

Step-6:- Check for depth required

Mu $=M_{u,lim}$ $=Q_{ub}\,b\,d^2$

2.28× 10^6 = Qub b (Refer IS456-2000)

$d_{req}=\sqrt{(Mu/Q_{ub}\,b)}$

$=\sqrt{(2.28\times10^6/2.76\times1000)}$

=41.66mm

$d_{req}< d_{pro}$ Hence the provided depth is ok.

Step-7:- Calculation of Ast

Mu =0.87 f_y A_{st} d [1- $\frac{Ast fy}{bdfck}$]

$2.28\times10^6=0.87\times415\times A_{st}\times80$ [1-(415Ast) / (20×1000×80)]

2.28×10^6 =28884Ast-7.49Ast^2

7.49Ast^2-28884Ast+2.28×10^6=0

A_{st}=173 mm^2

A_{stmin} =0.12/100(bD)

=0.12/100(1000×100)=120 mm^2

Ast min< Ast_{req} Hence the required A_{st} is ok

S =ast /Ast(1000)

A_{st} $=\pi d^2/4$

$=\pi(10)^2/4$ =78.5

S =78.5/173(1000)

=453~450mm

Spacing should not exceed

- 3×d=3×80=240mm
- 300mm
- 450mm

Adopt lesser one

Provide Øbar as main reinforcement @ 240mm c/c Actual

$A_{st}=a_{st}$ / S(1000)

=78.5/240(1000)= 327.25mm²

Step-8:- Distribution steel

Assume Ø bar

A_{st}=0.12/100(bD)

=0.12/100(1000×100)=120mm²

S $=a_{st}/A_{st}(1000)$

$A_{st}=\pi d^2/4$

$=\pi(8)^2/4$ =50.24 mm²

S =50.24/120(1000)

=418.88~250mm

Spacing should not exceed

- 5×d=5×80=400mm
- 500mm
- 250mm

Adopt lesserone

Therefore provide 8mm Øbar as main reinforcement @ 250mmc/c

Step-9:- Check for shear

Maximum S.F@support next to end support = 0.6Wudl+0.6Wull

=0.6(7.5)(1.2)+0.6(7.5)(1.2)=10.8kN

Therefore Nominal ShearForce,Vu=10.8kN

Nominal shearstress,τ_v=Vu/bd

$=10.8\times10^3/(1000)(80)$

τ_v=0.135 N/mm^2

Permissible shear stress, Kτc **(Refer IS 456-2000)**

Where K=1.3

%of steel =100Ast/bd

=100(327.25)/1000(80)=0.41%

0.25=0.36 $=0.36+\frac{(0.48-0.36)(0.41-0.25)}{(0.50-0.25)}$

0.41=?

0.50=0.48 **(Refer IS 456-2000)**

=0.44

Permissible shear stress, Kτc =1.3(0.44)=0.57N/mm^2

Maximum shear stress, τc Max =2.8N/mm^2

(Refer IS 456-2000)

Hence the slab is safe against shear.

Step-10:- Check for Deflection

Where, d=Span/(Basic value × Modification factor)

f_s=0.58fy Ast_{req} / As_{pro}

=0.58(415)(173)/(327.25)

f_s =127.24N/mm^2

% of steel=0.41%

M.F=1.4 **(Refer IS 456-2000)**

B.V=26

d =1200/(26×2)

d_{req}=23.07mm

$d_{req}< d_{pro}$ Hence the Slab is safe against Deflection.

B. Design ofBeam

Data Assumed:-

Type ofBeam =singly reinforced continuousbeam

F_{ck}=M20

F_{ym}=Fe415

Ø of bar =20mm

Nominalcoverm=25mm **Step-1:- Size of the beam** Effective depth =L/10 toL/15

=3000/10 to 3000/15

=300mm to 200mm

Assume overalldepth, D =350mm

=Overall depth-Nominal cover- Ø/2

=350-25-20/2

Effective depth, d =315mm

Breadth,b =D/2 to2/3D

=350/2 to 2/3(350)

=175mmto 233.33mm

Say breadth, b =230mm

Overall size of the beam =230mm X 350mm

Step-2:- Effective span

Effective span =wall thickness/2+clear span +wall thickness/2

SpanAB =230/2+3000+230/2

=3230mm

Step-3:- Load calculation

Span AB:-

Slab load on beam, W_{sl} =1m²×15kN/m² (for per m²)
=15kN

Load on/2mlength =15/2
=7.5kN/m

Self-weight ofbeam,W_d =l X B X D Xγc
=2 x0.23x0.35x25
=4.025kN/m

Load on/2mlength =4.025/2
=2.0125kN/m

Design deadload, W_{ud} =2.0125x1.5

W_{ud} =3.018kN/m

Total designload, W_u =10.51kN/m

Step-4:- Calculation of bending moments

Bendingmoment M_u $=W_u l_{eff}/24$
$=10.51(2)^2/24$
=1.751kN/m

Step-5:- Type of section

$M_{u\ lim}$ $=2.76bd^2$ **(Refer IS 456-2000)**
$=2.76(230)(315)^2$
$=62.98\times10^6$

$M_u<M_{u,lim}$ Hence it is a under reinforced section

Step-6:- Check for depth required

D_{req} =√M_u/Q_{sb}
=√ $(1.751x10^6/2.76\ (230)$
=52.51mm

Hence $d_{req}<d_{pro}$ the depth is ok

Step-7:- Calculation of A_{st}

Mu =0.87 F_y A_{st} d (1- (F_y A_{st})/ (f_{ck} b d))
$1.751x10^6=0.87(415)A_{st}(315)(1-(415A_{st})/(20*230*31))$
$1.751x10^6=113730.75\ A_{st}-32.57A_{st}^2$

A_{st} =15.46mm²

A_{stmin} $=0.85bd/F_y$
=0.85(230)(315)/415
=148.39mm

A_{stmax} =0.04bd
=0.04(230)(315)
=2898mm²

$A_{stmin}> A_{st}< A_{stmax}$ Hence provide A_{stmin}

Numbers $=A_{st}/a_{st}$

a_{st} $=\pi d^2/4$
$=\pi 20^2/4$
=314.16mm²

Numbers=148.39/314.16
=0.47~3nos

Act $A_{st}=3(20^2/4)$
=942.48mm²

% of steel=100 Act A_{st}/ (b) (d)
=100(942.48)/ (230)(315)
=1.3%

f_s $=0.58\ F_y\ (A_{streq})/(A_{stpro})$
=0.58(415) (148.39) / (942.48)
=37.89mm²

Step-8:- Check for deflection

d =Span/ (Basic value x modificationfactor)
=3000/ (26x2)
=57.69mm

Hence $d_{req}<d_{pro}$ the beam is safe againstdeflection

Step-9:- Check for shear

Nomal shear force, $V_u=W_u l_{eff/2}$
=10.51(2)/2
=10.51kN

Nominal shearstress,τ_v =Vu/ b d
$=10.51x10^3/(230)(315)$
=0.415N/mm²

Permissible shear stress, τ_c=0.70N/mm²

Maximum shear stress, τ_{cmax}=2.8N/mm²

$\tau_v<\tau_c<\tau_{cmax}$ Hence provide minimum shear reinforcement

$(A_{sv}/S_v)_{min}$ =0.4b/0.87 F_y **(Refer IS 456-2000)**
=0.4(230)/0.87(415) =0.25

Assume 8mmØ 2 legged vertical stirrups

A_{sv} $=2(\pi 8^2/4)$
=100.53mm²

S_v $=A_{sv}/0.33$
=100.53/0.33
=304.64mm say 300mm

Spacing should not exceed

- 0.75xd=0.75x315=236.25mm say250mm
- 300mm
- 300mm

Hence provide 8mmØ 2 legged vertical stirrups @ 250mm C/c

C.Design of column

Data assumed:-

Type of column =Double loadedrectangular column
Size of column =230×300
F_{ck} =M20
F_y =Fe415
Heightofroof =3m
Nominalcover =50mm
Øofbar =20mm

Step-1:-Effective Length

l_{eff} =0.65L
=0.65(3)
=1.95m

Step-2:-Calculation of slenderness ratio

S.R $=l_{eff}/D$
=1950/300
= 6.5<12

Hence it is a short column

Step-3:-Calculation of Eccentricity

- e_{min} =L/500+D/30
= (3000/500) + (300/30)
=16<20
- e_{min} =0.5D
=0.5×300
=15mm<20mm

Hence the Loadis assumed **axial**

Step-4:-Load Calculation

Self-weight of column, W_d=L×B×D× unit weight

W_d=0.3×0.23×3×25

W_d=5.175kN

Total design load,W_{ud}=5.175×1.5

W_{ud}=7.76kN

Loadfrombeam,W_{ud}=(10.51×(4.27/2))+(10.42×(3/2))

W_{ul}=38.06kN

Total design load, P_u=7.76+38.06

=45.82kN

Assume, A_{sc} =2% ofA_g

A_c=A_g-A_{sc}

=A_g-

0.02$A_g$$A_c$

=0.98A_g

P_u=0.4$f_{ck}$$A_c$+0.67$F_y$$A_{sc}$**(Refer IS 456:2000)**

45.85×10³ =0.4×20×0.98A_g+0.67×415×0.02A_g

45.85×10³ =7.84A_g+5.56A_g

45.85×10³ =13.4A_g

A_g =45.85×10³/13.4

A_g =3421.64mm²

Assume, it is a rectangular column

L×B =A_g

L×B =3421.64mm²

~230mm×300mm

Hence size of column=230mm×300mm

A_{sc} =0.02×A_g

=0.02×69000

A_{sc} =1380mm²

Step-5:-Numbers of bars

Nos =A_{sc}/a_{sc}

A_{sc} =(π20²/4)

=314.15mm²

Nos =1380/314.15

Nos =4.3~6nos

$A_{st}$$A_{st}$ =6(π(20²)/4)

=1884.9mm²

Step-6:-Calculation of lateralties

Minimumdiameter:-

- 6mm
- ¼ Largest longitudinalbar
- ¼× (20) =5mm~6mm

Minimum pitch:-

- The least lateral dimension=300mm
  16×Ø of longitudinal bar
- 16×20=320mm
- 300mm

Hence provide 6mmØ lateral ties @ 300mm c/c

D.Design of plinth beam

Data Assumed:-

Type ofBeam = Continuous beam

F_{ck} =M20

F_y=Fe 415

Øofbar =20mm

Nominalcover =25mm

Step-1:- Size of the beam

Effectivedepth =L/10 toL15

=3000/10 to 3000/15

=300mm to 200mm

Assume overall depth,D=Overall depth-Nominal cover- Ø/2

=300-25-20/2

Effective depth, d=265mm

Breadth,b =D/2 to2/3D

=450/2 to 2/3(450)

=225mmto 300mm

Saybreadth,b =230mm

Overall size of the beam =230mm X 300mm

Step-2:- Effective span

Effective span =wall thickness/2+clear span +wall thickness/2

SpanAB =230/2+3000+230/2

=3230mm

Step-3:- Load calculation

Self-weight of plinth beam =1 X B X D X γc

=1 x0.23x0.3x25

=1.725kN/m

Load on/1mlength =3.375/1

=1.725kN/m

Design deadload, W_d =1.725x1.5

W_{ud} =2.5875kN/m

Self-weight ofwall,W_1 =1x B x D xγm

=1x0.23x3x20

=13.8kN

Load on/1mlength =13.8/1

=13.8kN/m

Design live load, W_{ul}=13.8x1.5

=20.7kN/m

Total designload, W_u=23.28kN/m

Step-4:- Calculation of support moments

M_u =W_ul²/24

= (23.28×3²)/24

=8.73kNm

Step-5:- Calculation of span moments

Span AB:-

=W udl²/12 + W ul²/10

=2.5875(3)²/12+13.8(3)²/10

=14.36kNm

=W udl²/16 + W ull²/12

=2.5875(3)²/16+13.8(3)²/12

=11.805kNm

M_{ulim}=2.76bd²**(Refer IS 456-2000)**

=2.76(300) (265)²

=84.57 kNm

Hence M_u< M_{ulim} moment is ok

Step-6:- Check for depth required

d_{req}=√Mu/Qub

=√ (14.36x10⁶/2.76(230))

Hence d_{req}<d_{pro} the depth is ok

Step-7:- Calculation of A_{st}

M_u =0.87 F_y A_{st} d (1- (F_y A_{st})/ (f_{ck} b d))

$14.36x10^6$=0.87(415)A_{st}(265)(1-(415A_{st})/(20*230*26)

$14.36x10^6$ =95678.25 A_{st}-32.572A_{st}^2

A_{st} =290mm²

A_{stmin} =0.85bd/F_y

=0.85(230)(265)/415

=255mm

A_{stmax} =0.04bd

=0.04(230)(265)

=540mm²

A_{stmin}< A_{st}< A_{st} max Hence provide A_{st}

Numbers= A_{st}/a_{st}

a_{st} =$\pi d^2/4$

= $\pi 20^2/4$

=314.16mm²

Numbers=290.24/314.16=0.92~3nos

A_ct A_{st} =3(20^2/4)=942.48mm²

%of steel =100 A_{ct} A_{st}/ (b)(d)

=100(942.48)/(230)(265)=0.75%

f_s =0.58 F_y(A_{streq})/(A_{stpro})

=0.58(415)(290.24)/(942.48)

=74.12mm²

Step-8:- Check for deflection

d=Span/ (Basic value x modification factor)

=3000/ (26x2) **(Refer IS 456-2000)**

=57.69mm

Hence d_{req}<d_{pro} the beam is safe against deflection

Step-9:- Check for shear

Normal shear force, V_u=W_{u}/2

= (25.76×3)/2

=38.64kN

Nominal shear stress, τ_v =Vu/ b d

=38.64x10³/(230)(265)

=0.31N/mm²

Permissible shear stress, τ_c =0.4N/mm²

Maximum shear stress, τ_{cmax} =2.8N/mm²

τ_v≤τ_c<τ_{cmax} Hence shear reinforcement is safe

Hence provide minimum shear reinforcement

$(A_{sv}/s_v)_{min}$ =0.4b/0.87 F_y

=0.4(230)/0.87(415)

=0.33

Assume 8mm Ø 2 legged vertical stirrups

A_{sv} =2($\pi 8^2/4$)

=100.53mm²

s_v =A_{sv}/0.33

=100.53/0.33

=304.64mm

Say 300mm

Spacing should not exceed

- 0.75xd=0.75x415=311.25mm
- 300mm

Hence provide 8mm Ø 2 legged vertical stirrups @ 300mm

E.Design of footing

Data Assumed:-

Size of column =300×230

Soil bearing capacity=200kN/m²

F_{ck} =M20

F_y =415

Ø of bar=25mm

Nominal cover=50mm

Load calculation:-

Load from column =45.82kN×2=91.64kN

Load from plinth beam =25.76kN

Total load =(25.76(3/2))+(25.76(3.35/2))+91.64

Total load, W =173.428kN

Step-1:-Calculate the size of footing

Axial load, P=173.428kN

Total load on column footing=Total load+Self-Weight of column

Assume 10% of self-weight of footing

Self-weight of footing =(10/100)×173.428

=17.34kN

Total load on column footing

=173.428+17.34

W_u=190.77kN

Area of footing required, A_f = $\frac{\text{Total load on soil}}{\text{Safe bearing capacity of soil}}$

=$\frac{190.77}{200}$

=0.95m²

$B_x \times D_x = A_f$

Where,

D_x=Depth of column

B_x=width of column

Hence 2.3x×3x=0.95

6.9x²=0.95

x =0.37

Short side of footing

=2.3x=2.3×0.37=0.851m~1.5m

Long side of footing =3x

=3×0.37 =1.11~2m

Side of footing is proportional to side of column

Soil pressure, q_u= W_u/ b_x×D_x (per meter)

q_u= 190.77/(1×2)(per meter)

q_u=95.385kN/m²~100kN/m²<200kN/m²

Hence the footing area is adequate. Since the soil pressure developed at the base is less than the safe bearing capacity of soil.

Step-2:-Factored bending moment

Cantilever projection

from short face(longer direction)(L_y)=0.5(D_x-D)

=0.5(2-0.3)

=0.85m

Cantilever projection

from long face(shorter direction)(L_x)=0.5(B_x-B)

=0.5(1.5-0.23)

=0.385m

B.M(short face)(M_{ux}) = q_u×L^2/2

=100×0.85²/2=36.125kNm

B.M(long face)(M_{uy}) = q_u×L^2/2

=100×0.385²/2=7.411kNm

Step-3:-Depth of footing

(a)From moment consideration

M_u =0.138f_{ck}.b.d^2

36.125×10^6=0.138×20×1000×d^2

d =114.40mm

(b)From shear stress consideration

V_{uL} =q_u[(ly/2)-(300/2)-d]

V_{uL} =100[(2000/2)-(300/2)-d]

V_{uL} =100(850-d)

For M20 concrete, P=0.25%

τ_c =0.36N/mm²

τ_c =V_{uL}/bd

0.36=100(850-d)/(1000×d)

d =184.7mm

Adopt effective depth as 330mm and overall depth as 350mm

Step-4:-Reinforcement

(a)Longer direction

M_{ux} =0.87 f_y A_{st} d [1-($A_{st}f_y$/bdf_{ck})]]

36.125x10^6=0.87(415)A_{st}(330)(1-(415A_{st})/(20*1000*330))

36.125x10^6 =119146.5 A_{st}-7.49A_{st}^2

A_{st} =309.20mm²

Use 16mm bars,

a_{st} =(π(16²)/4=201.06mm²

No of bars=309.20/201.06=1.53~6 bars

A_{stp} =5(π(16²)/4=1005.3mm²

Spacing=a_{st}/A_{st}×1000

=(201.06/309.20)×1000

=650mm~300mm c/c

(a)Shorter direction

M_{ux} =0.87 f_y A_{st} d [1-($A_{st}f_y$/bdf_{ck})]]

7.411x10^6=0.87(415)A_{st}(330)(1-(415A_{st})/(20*1000*330))

7.411x10^6 =119146.5 A_{st}-7.49A_{st}^2

A_{st} =62.44mm²~100mm²

Use 12mm bars,

A_{st} =(π(12²)/4=113.09mm²

No of bars =100/113.09=0.88~4bars

A_{stp} =4(π(12²)/4=452.3mm²

Spacing =a_{st}/A_{st}×1000

=(100/113.09)×1000

=884mm~300mm c/c

Step5:-Central band

Central band width=width of footing=1.5m

Reinforcement in central band(A_{cb})=2/ β +1

Total reinforcement in short direction

β=D_x /d_x

D_x=long side of footing

d_x=short side of footing

β=2/1=2

A_{st}($_{cb}$) =(2/(2+1))*100*1

A_{st}($_{cb}$) =66.66~100mm²

Minimum reinforcement=0.12% b×D

=0.12/100×1000×380=456mm²

Use 16mm bars,A_{stp} =201.10mm²

Use 10mm bars,A_{stp} =113.09mm²

V_{uL} =100(850-d)

V_{uL}=100(850-330)/10³=52kN

τ_v =V_{uL}/bd

τ_v =52*10³/1000*330=0.15N/mm²

100A_{stp}/bd=100×1005/(1000*330)=0.304N/mm²

Step6:-Check for shear stress

Table 19, **(Refer IS 456-2000)**

τ_c =0.4

Ks×τ_c =1×0.4=0.4N/mm²

τ_v<Ks× τ_c, Hence safe

Nominal shear stress,τ_v =V_u/bd

0.4=52×10³/(1000×d)

d=135mm~330mm

Adopt a revised effective depth of 330mm and overall depth of 380mm

F.Design of lintel beam

Data Assumed:-

Lintel type=Through lintel

Lintel above=Main Door, MD

F_{ck} =M20

F_y =Fe415

Ø of bar=10mm

Nominal cover =15mm

Step-1:- Size of Lintel

Breadth of the lintel=230mm

Depth of the lintel=150mm

Step-2:- Effective length

Effective length(l_{eff}) =L+ d

Where, Effective depth, d=D-N.C-Ø/2

d=150-15-10/2=130mm

Effective length(l_{eff}) =L+d

=1600+130=1730mm

Adopt whichever is less

Step-3:- Height of Equilateral Triangle

Height of Equilateral Triangle =0.8661

=0.866x1.730=1.49m

Height of wall =3-0.46-0.115-2.2=0.225m

0.8661>h

Hence the load distribution is in the form of rectangular.

Step-4:- Load calculation

Weight of masonry, W1 =1 x B x h x γ_c

=1.73x0.23x0.75x20=5.96kN

Self-weight of lintel, W2=1 x B x D x γ_c

=1.75x0.23x0.15x25=1.50kN

Total weight, W=W1+W2

=5.96+1.50=7.46kN

Total design load, W_u =7.46x1.5=11.19kN

Step-5:- Moment calculation

M_u =$W_u l_{eff}/8$

=(11.19x1.73)/8=2.41kNm

Step-6:- Check for depth required

M_u =$Q_u bd^2$

d =√$M_u/Q_u b$

=√(2.41x10^6)/(2.76x230)=61.61mm

61.61<150mm

dreq<dpro Hence the depth is ok

Step-7:- Calculation of Ast

Mu =0.87 $F_y A_{st}$ d(1-($F_y A_{st}$)/ (f_{ck} bd))

2.41x10^6=0.87(415)A_{st}(130)(1-(415A_{st})/(20x230x130))

2.41x10^6 =46936.5A_{st}-24.97A_{st}^2

32.57 A_{st}^2 – 46936.5 A_{st}+2.41x10^6=0

A_{st} =53.31mm^2

A_{stmin} =0.85bd/F_y

=0.85(230)(130)/415=61.24mm

A_{stmax} =0.04bd=0.04(230)(150)=1380mm^2

A_{st} min> A_{st}< A_{stmax} Hence provide minimum A_{st}

Step-8:- Number of bars

Nos =A_{st}/a_{st}=61.24/ (π(10^2)/4)=0.77-4nos

Hence, Provided 4nos of 10mm Ø main bar

Provided 2nos of 10mm Ø hanger bar

Assume, 8mm Ø 2legged vertical stirrups

A_{sv}=π(8^2)/4=50.27mm^2

A_{sv} / s_v =0.4b/0.87F_y

=0.4(230)/0.87(415)=0.25

s_v =50.27/0.25=197.28-200mm

Provide 8mm Ø 2legged vertical stirrups@200mm C/c

G.Design of tread riser staircase Data Assumed:

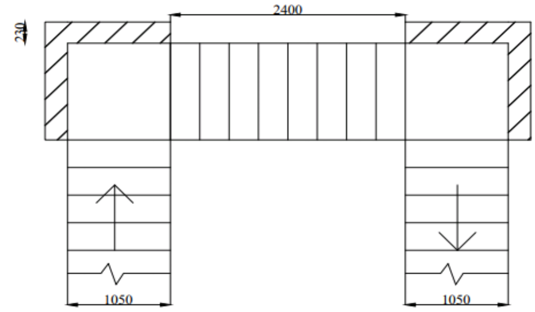


Figure12. Tread riser staircase plan

Riser(R) =150mm

Tread(D) =275mm

Width of flight= Landing width=1050mm

Material M_{20}, Fe_{415}

Step-1:- Effective span and thickness of slab

Effective span =1050+2400+1050+230=4730mm

=4.73m

Thickness of Tread riser slab= Span/25=4730/25

=189.2 ~ 190mm

D =200mm

Cover(d')=25mmd

=165mm

Step-2:- Loads on Going

Self cut of Tread riser slab per step =(0.12+0.275x0.19x25)

=2.018kN

Dead load of step per m

=2.018x1000/275=7.33kN/m^2 Floor finishes =0.6kN/m^2

Live load =4kN/m^2

Total load =11.3kN/m^2

Factored load =1.5x11.93=17.89kN/m^2

Step-3:- Loads on loading slab

Self-weight of the slab=0.19x1x25=4.75kN/m^2

Floor finishes =0.6kN/m^2

Live load =4kN/m^2

Total load =9.35kN/m^2

Factored load =1.5x9.35=14.025kN/m^2

(50% may be assured)=0.5x14.025=7.0125 KN/m^2

Step-4:- Design of Step riser:

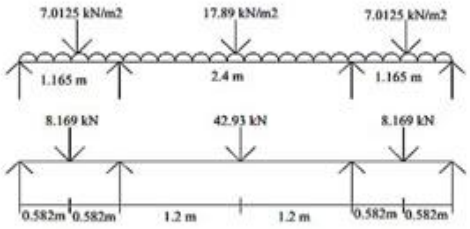


Figure 13. Loads on tread riser staircase

Taking moment about D,

$(R_A x 4.73)=(8.169x4.1475)+(42.93x2.365)+(8.169x0.5825)$,

$R_A = 29.634$ kN

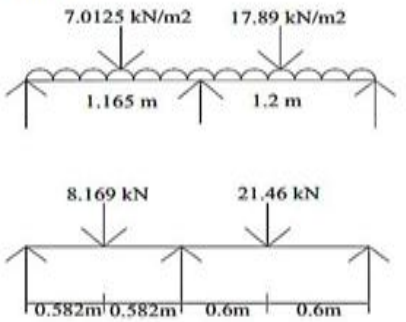


Figure 14. Loads on tread riser stair

Bending moment=$(R_A x2.365)-(8.169x0.5825)$
=29.765kN.m

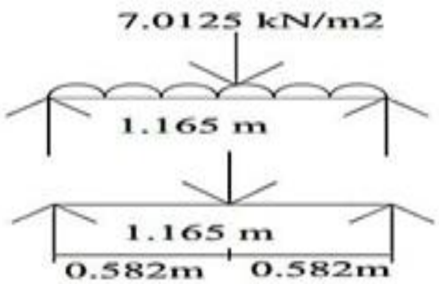


Figure 15. Loads

Step-5:- Check fordepth

$d=\sqrt{(M_u / f_{ck}\, b)}$

$d=\sqrt{(42.64x10^6/0.138x20x1000))}$

$d=124.29< 165$mm

Hence the depth is safe

Step-6:- Reinforcement:

$M_u=0.87\, F_y\, A_{st}\, d\, (1- (F_y\, A_{st})/ (f_{ck}\, b\, d))$

$42.64x10=0.87(415)A_{st}(165)(1-(415A_{st})/(20x1000x16)$

$42.64x10^6=59573.25\, A_{st} -7.49\, A_{st}^2\ A_{st}=795.2mm^2$

Provide 12mm Ø , $a_{st} =(\pi/4)x12^2=113.09mm^2$

Spacing $= (ast/ A_{st})x1000$

= (113.09/795.2)x1000 =142mm~150mm

Use 12mm Ø bass @ 150mm C/c

Distribution load:

Use 8mm Ø bass @ 150mm c/c spacing

Reinforcement in Landing slab

$M_u =0.87\, F_y\, A_{st}\, d\, (1- (F_y\, A_{st})/ (f_{ck}\, b\, d))$

$29.765x10^6=59573.25\, A_{st} -7.49A_{st}^2 A_{st} =478mm^2$

Use 12mm Ø , a_{st}=

$(\pi/4)x12^2=113.09mm^2 S=(a_{st}/A_{st})x1000=(113.09/478)x1000=236mm~230mm$ Provide 12mm Ø bass @ 230mm C/c

14) Reinforcement sketches
a) Continuous one wayslab

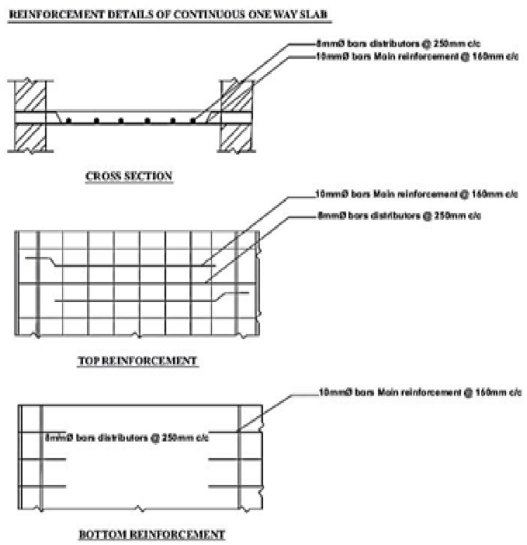


Figure 16.Continuous one way slab

b)Singly reinforced continuousbeamd) Rectangular footing

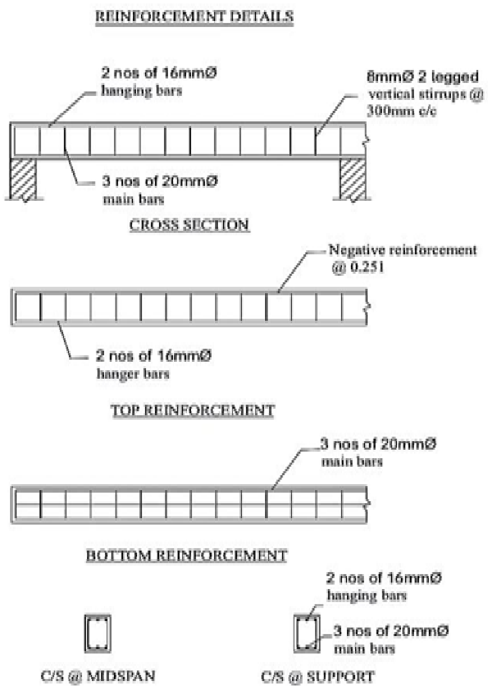


Figure 17. singlyRCB

c)Rectangular column

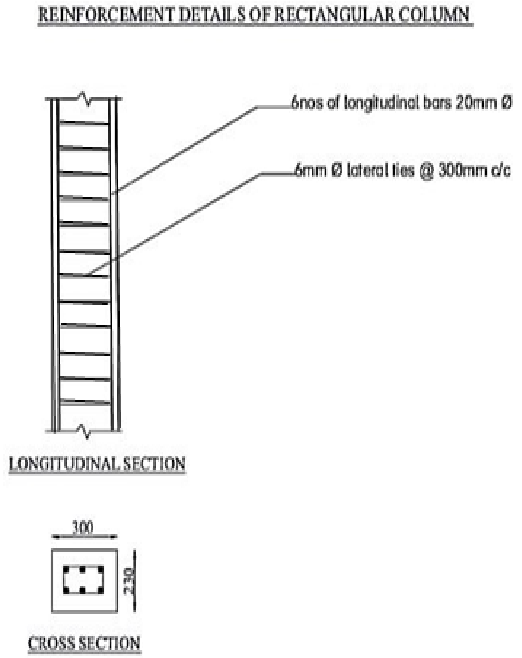


Figure 18. Rectangular column

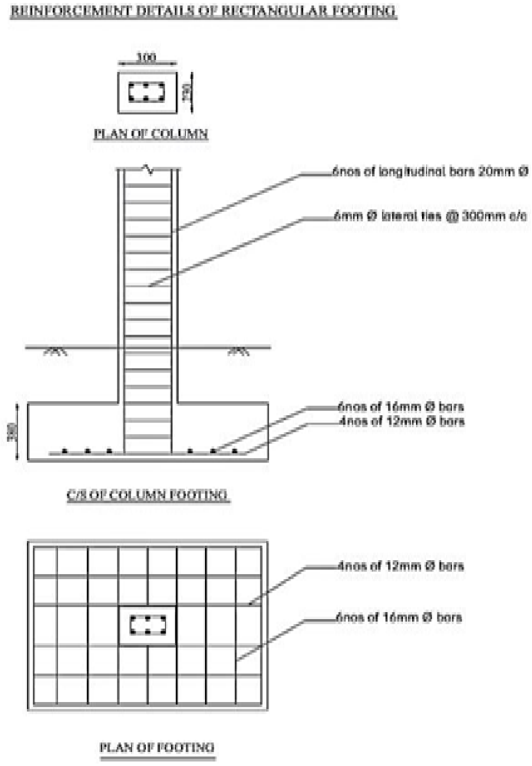


Figure 19. Rectangular footing

e) Plinth beam

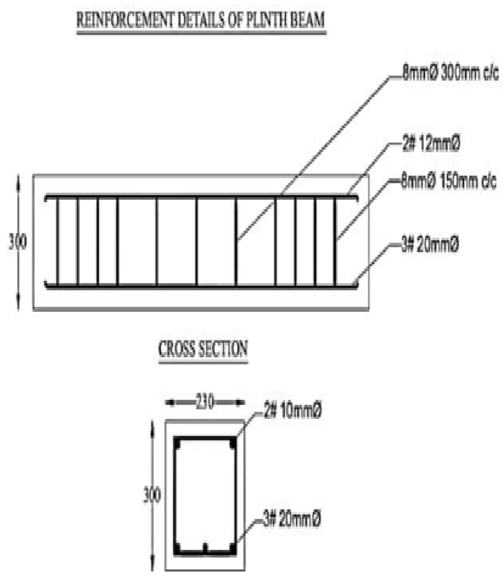
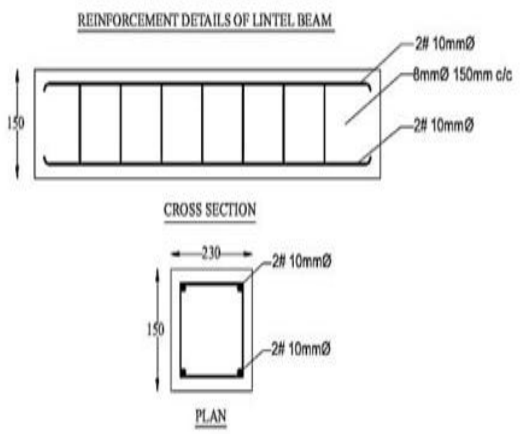


Figure 20. Plinth beam reinforcement

f) Lintel beam



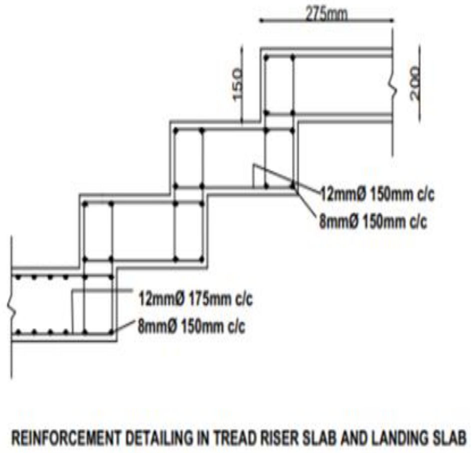


Figure 21. Lintel beam reinforcement detailsFigure 23. I)Detailed Estimation

g) Tread riserstaircase

Figure 22. Reinforcement details of tread riser staircase

IV. DETAILED ESTIMATE

DETAILED ESTIMATE:

S.NO	DESCRIPTION	NO	LENGTH	BREADTH	DEPTH	QUANTITY	UNIT
1	Earthwork						
	Excavation	15	2.4	1.9	2.1	143.64	(cube.m)
2	Sand filling	15	2	1.5	0.05	2.25	(cube.m)
3	Plain cement concrete (1:4:8)	15	2	1.5	0.1	4.5	(cube.m)
4	Raft concrete and concrete for column up to ground level						
	Raft concrete	15	1.8	1.3	0.38	13.338	(cube.m)
	Column up to ground level	15	0.3	0.23	1.62	1.6767	(cube.m)
5	Plinth beam details						
	Plinth beam	1	101.64	0.23	0.3	7.013	
	Deduction						
	Column	15	0.23	0.23	0.3	0.238	
					Total	6.775	(cube.m)
6	Column up to roof						
	Column	15	0.3	0.23	6.915	7.15	(cube.m)

7	Lintel cum sunshade					
	Through lintel	2	101.64	0.23	0.15	7.013	(cube.m)
	Deduction						
	Column	15	0.23	0.23	0.15	0.119	(cube.m)
			Total	6.89	(cube.m)		
8	Sunshade						
	Window(W1)	6	1.66	0.0525	0.5229	(cube.m)	
	Window(W2)	2	2.26	0.0525	0.237	(cube.m)	
	Window(W4)	1	1.36	0.0525	0.0714	(cube.m)	
					Total	7.7213	(cube.m)
9	Roof & Roof beam concrete quantity						
	Roof 1	1	8.84	7.165	0.15	9.747	(cube.m)
	Roof 2	1	8.84	5.03	0.15	6.843	(cube.m)
	Roof 3	1	3.965	2.59	0.15	5.368	(cube.m)
					Total	21.958	(cube.m)
	Roof beam1	2	16.47	0.23	0.15	1.136	(cube.m)
	Roof beam2	5	8.54	0.23	0.15	1.473	(cube.m)
					Total	2.609	(cube.m)
			Total roof concrete			24.567	(cube.m)

10	Brick masonry in GF						
	Horizontal	5	8.38	0.23	3	28.911	(cube.m)
	Vertical	3	16.385	0.23	3	33.916	(cube.m)
					Total	62.82	(cube.m)
	Deduction						
	Ventilator(V)	2	0.455	0.61	0.23	0.127	(cube.m)
	Window(W1)	3	1.2	1.2	0.23	0.993	(cube.m)
	Window(W2)	1	1.8	1.8	0.23	0.7452	(cube.m)
	Window(W3)	1	0.76	1.2	0.23	0.209	(cube.m)
	Window(W4)	1	0.9	0.9	0.23	0.186	(cube.m)
	Main door(MD)	1	1.5	2.1	0.23	0.724	(cube.m)
	Door(D1)	1	1.5	2.1	0.23	0.7245	(cube.m)
	Door(D2)	3	0.9	2.1	0.23	1.3041	(cube.m)
	Door(D3)	2	0.61	2.1	0.23	0.5892	(cube.m)
	Door(D4)	1	1.2	2.1	0.23	0.5796	(cube.m)
					Total	6.1819	
					Actual total	56.6381	(cube.m)
	Brick masonry in FF						
	Horizontal	5	8.38	0.23	3	28.911	(cube.m)
	Vertical	3	16.385	0.23	3	33.916	(cube.m)
	Horizontal 1	1	4.5	0.23	3	3.105	(cube.m)

Figure 23.ii) Detailed Estimation ***Figure 23.ii) Detailed Estimation***

	Vertical 1	2	3.1625	0.1125	3	2.134	(cube.m)
	Vertical 2	2	1.065	0.23	3	2.9394	(cube.m)
					Total	71.0054	(cube.m)
	Deduction						
	Ventilator(V)	3	0.455	0.61	0.23	0.191	(cube.m)
	Window(W1)	4	1.2	1.2	0.23	1.3248	(cube.m)
	Window(W2)	1	1.8	1.8	0.23	0.7452	(cube.m)
	Door(D1)	4	1.5	2.1	0.23	2.898	(cube.m)
	Door(D2)	1	0.9	2.1	0.23	0.4349	(cube.m)
	Door(D3)	2	0.61	2.1	0.23	0.5892	(cube.m)
	SFD	1	3.05	2.1	0.23	1.497	(cube.m)
	SFD	1	1.71	2.1	0.23	0.827	(cube.m)
					Total	8.507	(cube.m)
					Actual total	62.498	(cube.m)
					Total Brick masonry in GF & FF	122.539	(cube.m)
6	Outer Plastering						
	Front side	1	8.54		7.015	59.9081	(Sq.m)
	Back side	1	8.54		7.015	59.9081	(Sq.m)
	Left side	1	16.47		7.015	115.53	(Sq.m)
	Right side	1	16.47		7.015	115.53	(Sq.m)
	Projection	1	50.02		0.15	7.503	(Sq.m)
					Total	358.393	(Sq.m)

Figure 23.iv) Detailed Estimation

	Deduction						
	Ventilator(V)	2	0.455		0.61	0.277	(Sq.m)
	Window(W1)	3	1.2		1.2	4.32	(Sq.m)
	Window(W2)	1	1.8		1.8	3.24	(Sq.m)
	Window(W3)	1	0.760.9		1.2	0.912	(Sq.m)
	Window(W4)	1	1.5		0.9	0.81	(Sq.m)
	Main door(MD)	1	0.9		2.1	3.15	(Sq.m)
	Door(D2)	1			2.1	1.89	(Sq.m)
					Total	14.599	(Sq.m)
	Actual total	343.793	(Sq.m)				
7	Inner Plastering						
	Living Room	1	25.01		3.05	76.2805	(Sq.m)
	Kitchen	1	14.64		3.05	44.652	(Sq.m)
	Car parking	1	8.615		3.05	26.275	(Sq.m)
	Bedroom 1	1	13.26		3.05	40.443	(Sq.m)
	Bath/Toilet 1	1	7.42		3.05	22.631	(Sq.m)
	Bedroom 2	1	15.7		3.05	47.885	(Sq.m)
	Bath/toilet 2	1	7.32		3.05	22.326	(Sq.m)
	Dining room	1	15.25		3.05	46.5125	(Sq.m)
	Pooja room	1	8.155		3.05	24.872	(Sq.m)
					Total	351.937	(Sq.m)
	Deduction						

Figure 23. V) Detailed Estimation

	Ventilator(V)	2	0.455		0.61	0.277	(Sq.m)
	Window(W1)	3	1.2		1.2	4.32	(Sq.m)
	Window(W2)	1	1.8		1.8	3.24	(Sq.m)
	Window(W3)	1	0.760.9		1.2	0.912	(Sq.m)
	Window(W4)	1	1.5		0.9	0.81	(Sq.m)
	Door(D1)	1	1.5		2.1	3.15	(Sq.m)
	Door(D2)	3	0.9		2.1	5.67	(Sq.m)
	Door(D3)	2	0.61		2.1	2.562	(Sq.m)
	Door(D4)	1	1.2		2.1	2.562	(Sq.m)
					Total	23.503	(Sq.m)
					Actual total	328.43	(Sq.m)
8	Ceiling Plastering						
	Living Room	1	8.08	4.575		36.966	(Sq.m)
	Kitchen	1	4.27	3.05		13.023	(Sq.m)
	Car parking	1	4.27	4.345		18.553	(Sq.m)
	Bedroom 1	1	3.58	4.27		15.286	(Sq.m)
	Bath/Toilet 1	1	1.525	2.135		3.255	(Sq.m)
	Bedroom 2	1	3.58	3.05		10.919	(Sq.m)
	Bath/toilet 2	1	2.515	1.22		3.068	(Sq.m)
	Dining room	1	4.27	3.35		14.304	(Sq.m)
	Pooja room	1	1.94	2.135		4.141	(Sq.m)
					Total	119.5186	(Sq.m)

Figure 23. vi) Detailed Estimation

V. ABSTRACT ESTIMATE

S.NO	DESCRIPTION	REQUIRED QUANTITY	RATE	PER	AMOUNT
1	Earthwork	143.64	300	Cubic metre	43092
2	Sand Filling	2.25	220	Cubic metre	495
3	PCC	4.5	2116.3	Cubic metre	9523.35
4	RCC	61.228	3437.54	Cubic metre	210473.699
5	Brick masonry	122.539	4054	Cubic metre	496773.106
6	Plastering Outer Inner Ceiling	791.741	448.35	Square metre	355066.74
7	White washing	672.223	15.7	Square metre	10553.90
8	Distemper	672.223	15.7	Square metre	10553.90
9	Paint	672.223	30.0	Square metre	20166.69
10	Doors	14	6500	Numbers	91000
	SFD1	1	20000	Numbers	20000
	SFD2	1	10000	Numbers	10000
11	Windows	16	3000	Numbers	48000
				Total	13,25,697.686
	Contingencies	3%			39,770.93
	Work charged establishment	2%			26,513.95
	Add 60% for water supply,sanitary,electrical fitting,equipment charges	60%			7,95,418.61
	Interior designing				200000
	Total cost of proposed building				Rs.44,74,802.352/-
	Plinth Area of the building				140.65m²
	Plinth Area rate				Rs. 16000/m²
	Approximate cost of the Building				Rs.45,00,800/-

Figure 24.Abstract Estimate

VI. CONCLUSION

The method used is limit state analysis, the factor of safety for concrete is 1.5 and steel is 1.1 it means 50% more concrete and 10% more steel is consider. Where as in working state method which is widely followed in our country has factor of safety of 3 for concrete and 1.7 for steel it means 200% more concrete and 70% more steel. As amount of more concrete and steel, bigger areas can be seen in working stress method. As we can reduce out area by following limit state method and hence also proved as economical. The design follow the study of AUTOCAD and manual design and found out the structure is safe in deflections, stresses, loads and moments. The 3D view of the building by REVIT ARCHITECTURE software gives clear view of the building model. The aspects andprospectsaremadeaccordingtoNBCofIndia,whic hgivesvarious

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