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Analysis and Design of Multistorey Building G+4

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Abstract: A multi-storey is a building that has multiple floors above the ground. It can be a residential or commercial building. In this project the analysis and design of multi-storey building G+4. In general, the analysis of multi-storey is elaborate and rigorous because those are statically indeterminate structures. Shears and moments due to different loading conditions are determined by many methods such as portal method, moment distribution method and matrix method.

The present project deals with the analysis of a G+4 building.The dead load & live loads are applied and the design for beams, columns, the footing is obtained manually. The Analysis part of the structure is done using Kani's Method and the values are taken for design.

Keywords: Multi-storey, Load Bearing Masonry Buildings.

INTRODUCTION

The procedure for analysis and design of a given building will depend on the type of building, its complexity, the number of stories etc. First, the architectural drawings of the building are studied, structural system is finalized sizes of structural members are decided and brought to the knowledge of the concerned architect. The procedure for structural design will involve some steps which will depend on the type of building and also its complexity and the time available for structural design. Often, the work is required to start soon, so the steps in design are to be arranged in such a way the foundation drawings can be taken up in hand within a reasonable period of time.

Further, before starting the structural design, the following information of data are required:
(i) A set of architectural drawings;
(ii) Soil Investigation report (SIR) of soil data;
(iii) Location of the place or type of building in order to decide loadings;
(iv) Data for lifts, water tank capacities on top, special roof features or loadings, etc. Choice of an appropriate structural system for a given building is vital for its economy and safety. There are two type of building systems:-
(a) Load Bearing Masonry Buildings.
(b) Framed Buildings.

(a) Load Bearing Masonry Buildings

Small buildings like houses with small spans of beams, slabs generally constructed as load bearing brick walls with reinforced concrete slab beams. This system is suitable for building up to four or fewer stories. (As shown in fig. below). In such buildings crushing strength of bricks shall be 100 kg/cm2 minimum for four stories. This system is adequate for vertical loads it also serves to resists horizontal loads like wind & earthquake by box action. Further, to ensure its action against earthquake, it is necessary to provide RCC Bands in horizontal & vertical reinforcement in brick wall as per IS: 4326-1967(Indian Standards Code of Practice for Earthquake Resistant Construction of Buildings.)**.** In some Buildings, 115mm thick brick walls are provided since these walls are incapable of supporting vertical loads, beams have to be provided along their lengths to support adjoining slab & the weight of 115mm thick brick wall of the upper storey. These beams are to rest on 230 mm thick brick walls or reinforced concrete columns if required. The design of Load Bearing Masonry Buildings are done as per IS 1905-1980 (Indian Standards Code of Practice for Structural Safety of Buildings: Masonry Walls (Second Revision). Load bearing brick wall.

(b) Framed Buildings

In these types of buildings, reinforced concrete frames are provided in both principal directions to resist vertical loads and the vertical loads are transmitted to vertical framing system i.e., columns and Foundations. This type of system is effective in resisting both vertical & horizontal loads. The brick walls are to be regarded as non-load bearing filler walls only. This system is suitable for the multi-storied building which is also effective in resisting horizontal loads due to the earthquake. In this system the floor slabs, generally 100-150 mm thick with spans ranging from 3.0 m to 7.0 m. In certain earthquake prone areas, even single or double storey buildings are made framed structures for safety reasons. Also the single storey buildings of large storey heights (5.0m or more) , like electric substation etc. are made the framed structure as brick walls of large heights are slender and load carrying capacity of such walls reduces due to slenderness.

1.1 BASIC CODES FOR DESIGN

The design should be carried so as to conform to the following Indian code for reinforced concrete design, published by the Bureau of Indian Standards, New Delhi:
Purpose of Codes - National building codes have been formulated in different countries to lay down guidelines for the design and construction of the structure. The codes have evolved from the collective wisdom of expert structural engineers, gained over the years. These codes are periodically revised to bring them in line with current research, and often, current trends. Firstly, they ensure adequate structural safety, by specifying a certain essential minimum requirement for design. Secondly, they render the task of the designer relatively simple; often, the result of sophisticate analyses is made available in the form of a simple formula or chart. Thirdly, the codes ensure a measure of consistency among different designers. Finally, they have some legal validity in that they protect the structural designer from any liability due to structural failures that are caused by inadequate supervision and/or faulty material and construction.

(i) IS 456: 2000 – Plain and Reinforced Concrete – Code of Practice (Fourth Revision)

(ii) Loading Standards

These loads to be considered for structural design are specified in the following loading standards:

IS 875 (Part 1-5): 1987 – Code of practice for design loads (other than earthquake) for buildings and structures (second revision)

Part 1: Dead loads

Part 2: Imposed (live) loads

Part 3: Wind loads

Part 4: Snow loads

Part 5: Special loads and load combinations

Design Handbooks

The Bureau of Indian standards has also published the following handbooks, which serve as a useful supplement to the 1978 version of the codes. Although the handbooks need to be updated to bring them in line with the recently revised (2000 version) of the Code, many of the provisions continue to be valid (especially with regard to structural design provisions).

SP 16: 1980 – Design Aids (for Reinforced Concrete) to IS 456: 1978

SP 24: 1983 – Explanatory handbook on IS 456: 1978

SP 34: 1987 – Handbooks on Concrete Reinforced and Detailing.

General Design Consideration of IS: 456-2000.

The general design and construction of reinforced concrete buildings shall be governed by the provisions of IS 456 –2000

1.2 AIM OF DESIGN

The aim of design is achievement of an acceptable probability that structures being designed shall, with an appropriate degree of safety –

1.3 METHOD OF DESIGN

- Structure and structural elements shall normally be designed by Limit State Method.
- Where the Limit State Method cannot be conveniently adopted, Working Stress Method may be used.

MINIMUM GRADE OF CONCRETE

The minimum grade of concrete for plain & reinforced concrete shall be as per table below:

PLAN FLOOR For G+4

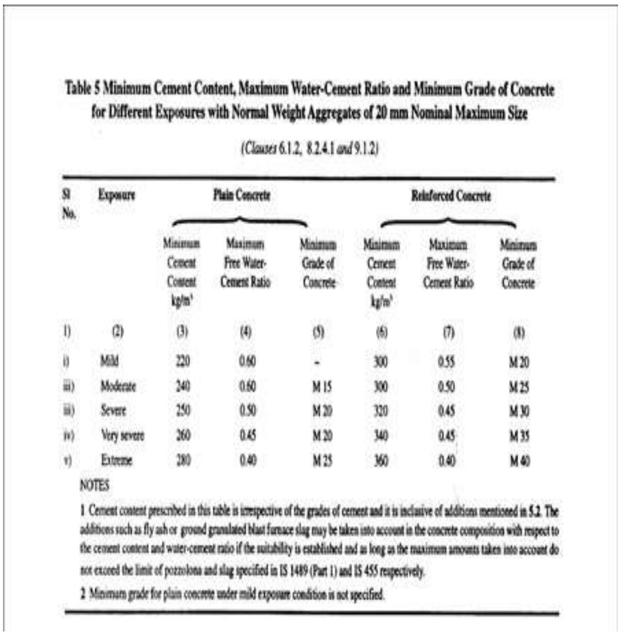


Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	-	300	0.55	M 20
ii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

BUILDING DESIGN

2.1 G+4 BUILDING DESIGN

2.1.1 DESIGN OF SLAB:

I: kitchen room size: 4.83m×4.83m fe 415, M20, Clear cover =20mm

Assuming the depth of the slab as 120mm effective depth = $120-20-\frac{10}{2}$ =100 mm

Load calculation:

Dead Load = 0.1X25 = 2.5kn/m^2
Live Load = 3kn/m^2
Floor Finish = 1kn/m^2
Total load = 6.5kn/m^2
Factored total load = 6.5*1.5 = 9.75kn/m2
ly/lx = 4.83/4.83 = 1<2

Design as two way slab.
Two adjacent edges discontinuous

αx for = 1 = 0.047 (For –Ve moment)
= 0.035 (For +Ve moment)
αyfor = 1 = 0.047 (For –Ve moment)
= 0.035 (For +Ve moment)
Mx = αxwlx2

For –ve moment in x direction
Mx=-0.047x9.75x4.83 = -10.69KN*m*

The +ve moment in x direction
Mx = 0.035×9.75×4.83= 7.96KN*m*.
For -Ve moment in y direction
My = α y2 = -0.047×9.75x4.82
My = -10.69KN*m*
The +ve moment in y direction
My = 0.035×9.75×4.83×4.83 = 7.96KNm
Checking for depth
Taking max moment & checking depth
Mu = 0.138 *fckbd ^{2}
10.69×106 = 0.138×20×1000×d ^{2}
d = 62.23mm<100mm safe

Calculation of Ast:
Along shorter span:

Mu = 0.87
Taking –Ve moment
Ast 10.69×106 = 0.87×415×Ast
Ast = 316.916mm
Spacing of bars 10mm ø bars is
= 247.825mm = 240 mm

Hence proved 10mm ø bars @ 240mm *c/c* spacing @ edge strip
Provide 10mm ø bars @ 300mm c/c spacing at @ middle strip.

2.1.3. DESIGN OF LIVING ROOM

Living room size: 7.56m×4.83m fe 415, M20, Clear cover =20mm

Assuming the depth of the slab as 120mm effective depth
= $120-20-\frac{10}{2}$ =100 mm

Load calculation:

Dead Load = 0.1X25 = 2.5kn/m^2

Live Load = 3kn/m^2

Floor Finish = 1kn/m^2

Total load = 6.5kn/m^2

Factored total load = 6.5*1.5 = 9.75kn/m^2

ly/lx = 4.83/2.53 = 1.9<2

Design as two way slab.
One short edge continuous

αx for = 1 = 0.053 (For –Ve moment)
= 0.041 (For +Ve moment)
αyfor = 1 = 0.032(For –Ve moment)
= 0.024 (For +Ve moment)
Mx = αxwlx^2

For –ve moment in x direction
Mx=-0.050x9.75x4.83 = -12.05KN*m*
αx for =1.5 =0.53 (For –Ve moment)
=0.41 (For +Ve moment)
αy for =1.5 =0.32 (For –Ve moment)
=0.024 (For +Ve moment)
Mx= αxwlx^2
For –ve moment in x direction
Mx= 0.050x9.75x4.83x4.83 = -12.05KN*m*
Mx =0.041×9.75×4.83x4.83 = 9.32KN*m*
For -Ve moment in y direction
My= αywly^2
=-0.032x9.75x4.83x4.83
Checking for depth

Taking max moment &checking depth
Mu =0.138fckbd^2
4.11×10^6 = 0.138×20×1000×d^2
d=66.075mm <100mm hence safe

Calculation of Ast:
Along shorter span:
Mu = 0.87 Ast Taking –Ve moment
$12.05\times10^6 = 0.87\times415\times$Ast
Ast = 360.745mm^2
Spacing of bars 10mm ø bars is
= 217.715mm = 300 mm
Hence proved 10mm ø bars @ 200mm *c/c*spacing @ edge strip Taking +Ve moment
9.32×10^6 = 36105 Ast-7.49 Ast^2
Ast = 273.673mm2
Spacingof 10 mm ø bars
=286.98mm S
Provide 10mm ø bars @ 280mm *c/c* spacing at @ middle strip
Hence safe

ALONG LONGER SPAN
Calculation of Ast:

Along longer span;
Mu = 0.87 Ast Taking –Ve moment
$7.27\times10^6 = 0.87\times415\times$Ast
Ast= 210.55mm^2
Spacing of bars 10mm ø bars is
= 373.02mm > 300 mm
Hence proved 10mmøbars@300mm *c/c*spacing @ edge

strip

Taking +Vemoment

5.45×10^6 = 36105 Ast-7.49 Ast^2
Ast = 155.99mm2
Spacingof 10 mm ø bars = 503.49 mm
Provide 10mm ø bars @ 300mm *c/c* spacing at @ middle strip

Chapter-3 KANI'S METHOD ANALYSIS FOR G+4 BUILDING

3.1. SIZE OF BEAM

D = $\frac{l}{12}=\frac{5030}{12}$=419mm~420 mm
B= $\frac{2xD}{3}=\frac{2x420}{3}$= 280 mm
BxD = 420x280 mm
I=$\frac{BD^3}{12}=\frac{280X420^3}{12}$=1.7x10^6 mm^4

3.2. SIZE OF COLUMN

BxD = 300X400
I= $\frac{BD^3}{12}=\frac{300X400^3}{12}$ = 1.6x10^{9}mm4
If I = 1.7x10^{6}mm^4
$\frac{1.6X10^3}{1.7X10^3}$=0.9I

3.3. CALCULATION OF SLAB LOAD ON BEAMS:

AB LOAD =9.75 KN/M^2
lx= 4.83m ly =4.83m
$\{ 3-(\frac{lx}{ly})^2\}$x $\frac{wl_x}{6}$
$\{ 3-(\frac{4.83}{4.83})^2\}$x $\frac{9.75X4.83}{6}$ =15.96kn/m
Weight of parapet wall
= 19x1.3x0.125= 3.08kN/m
Total load on AB = 9.34+3.1 =19.49kN/m
BC Load = 9.75kN/mm^2
lx= 2.53m ly=4.83m
$\{ 3-(\frac{lx}{ly})^2\}$x $\frac{wl_x}{3}$
$\{ 3-(\frac{2.53}{4.83})^2\}$x $\frac{9.75X2.53}{3}$ =22.41kn/m

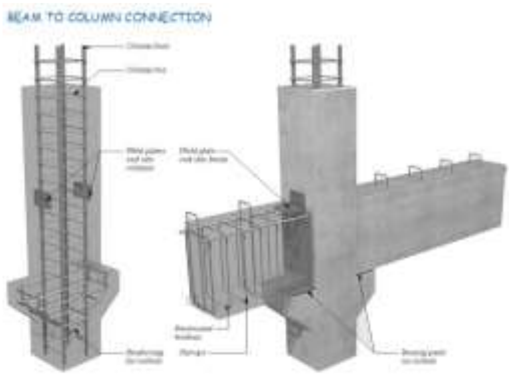
Weight of papa pet wall
= 19x1.3x0.125= 3.08kN/m

CD Load = 9.75kN/mm2

.lx = 4.83m ly=5.03m
$\{ 3-(\frac{lx}{ly})^2\}$x $\frac{wl_x}{6}$
$\{ 3-(\frac{4.83}{5.03})^2\}$x $\frac{9.75X4.83}{6}$ =16.30kn/m
Weight of wall = 19x1.3x0.125 =3.08 KN/m
Total load on AB = 15.69+3.08 =1877 KN/m
Total load on BC = 23+3.09 =26.1 KN/m
Total load on CD =16.30+3.09 = 19.38 KN/m
Total Load on A1B1 =15.69+11.39=27.08 KN/m
Total Load on B1C1 =23+11.39=34.39 KN/m
Total Load on C1D1 =16.3+11.39=27.69 KN/m
A1B1=A2B2=A3B3=A4B4
B1C1=B2C2=B3C3=B4C4
C1D1=C2D2=C3D3=C4D4
Deflection factor for all the column is taken as -0.3

Fixed end Moments:
$\bar{M}$AB = - $\frac{wl^2}{12}$= -36.49kNm
$\bar{M}$BA= +$\frac{wl^2}{12}$= 36.49kNm
$\bar{M}$BC = - $\frac{wl^2}{12}$= -13.61kNm
$\bar{M}$CB = +$\frac{wl^2}{12}$ = 13.61kNm
$\bar{M}$CD = -$\frac{wl^2}{12}$= -40.86kNm
$\bar{M}$DC = +$\frac{wl^2}{12}$= +40.86kNm
$\bar{M}$A1B1 =$\bar{M}$A2B2=$\bar{M}$A1B1 =$\bar{M}$A2B2= -$\frac{wl^2}{12}$=-52.64kNm
$\bar{M}$B1A1=$\bar{M}$B2A2 =$\bar{M}$A1B1 =$\bar{M}$A2B2= +$\frac{wl^2}{12}$= 52.64kNm
$\bar{M}$B1C1=$\bar{M}$B2C2=$\bar{M}$A1B1 =$\bar{M}$A2B2=- $\frac{wl^2}{12}$= 18.02kNm
$\bar{M}$C1B1 =$\bar{M}$C2B2=$\bar{M}$A1B1 =$\bar{M}$A2B2= + $\frac{wl^2}{12}$= +18.02kNm
$\bar{M}$C1D1=$\bar{M}$C2D2$\bar{M}$A1B1 =$\bar{M}$A2B2= - $\frac{wl^2}{12}$= -58.38kNm
$\bar{M}$D1C1=$\bar{M}$D2C2=$\bar{M}$A1B1 =$\bar{M}$A2B2= +$\frac{wl^2}{12}$ = +58.38kNm

3.4. DESIGN OF BEAMS
3.4.1. FOR BEAM AB



Mab = M'ab+2 Mab+Mba = -36.49+2x7.80-2.01 = -22.9kNm
Mba =M'ba +2Mba +Mab
=36.49+(2x-2.01)+7.80 = 40.27kNm

Final moment = 20.9+40.272=30.58kNm
$\frac{wl^2}{8}$ =18.77x4.83²/8 =54.73kNm
$\frac{wl^2}{8}$–final moment = 54.73-30.58 = 24.15kNm
Mu limit = 0.138fckbd² = 0.138X20X280X3842
= 113.95X10⁶KNm

Calculation of Ast

Ast $=\frac{f_{ck}}{2fy}[1-\sqrt{1-\frac{4.59x24.15x10^6}{20x280x384^4}}]$x280x384 =180.47m
Spacing of 16mm ø bars.
S=$\frac{\frac{\pi}{4}xx12x12x1000}{180.47}$=626.68 mm
No of bars =$\frac{626.68}{\frac{\pi}{4}x12x12}$=1.59 = 2 bars/m Provide 12 mm ø bars @ 300mm c/c spacing.
Provide 8mm ø 2 legged stirrups
Shear force = $\frac{wl}{2}=\frac{12.44x3.5}{2}$ = 21.77kNm
Spacing Sv =$\frac{0.87fyAsvd}{s.f}$ =$\frac{0.87x415x\frac{\pi}{4}x8x8x2x300}{21.77x10^3}$ =500mm
Provide 8mm ø 2 legged stirrups @ 300 mm c/c spacing.

COLUMN DESIGN FOR G+4 BUILDING

AXIAL COLUMNS:
COLUMN 3:

Pu = 23715KN P_u = 0.4FckAc+0.67FyAac

AnAs= A_{sc} **=I% of A_g**

Ag =Asc+Ac

Ac=Ag-0.01Ag

Ag = 0.099A_g

23715 x10³ = 0.4 X 20 x 0.099A_g+0.67 x 415 x 0.01 A_g

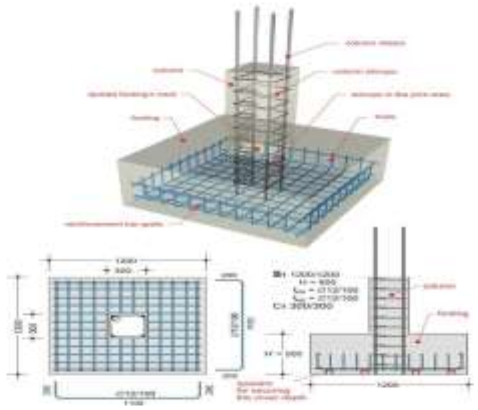
237.15x10³ = 7.92 Ag+2.78 A_g
237.15x10³ = 10.7 A_g

Ag= 22.16 X 10³

A_c= 0.01 X 22.163 X 10³

Ac=221.63ffunᶻ
Number of bars = $\frac{22216x4}{\pi x16x16}$ =2 Number

DESIGN OF FOOTING FOR G+4 BUILDING



Column load =237.15kN
Column size =300x400
Column Ast=16mm ø bars
Soil bearing capacity=100kN/mm2
Base of footing @ 1 m below ground level
r=20kN/
fck=20N/mm2 f y=415N/ mm2
Approximate area of footing=column load/s.b.c
=237.17/100 =2.37mm2 Total weight on Earth= 20x1x 2.37= 47.43kN
Total weight on column including Earth is =237.15+47.43 =284.58kN
Area of footing = 284.58/100=2.84 $\sqrt{2.84}$=1.68m =1.7m
Size of footing =1.7mx1.7m

Bending Moment:
A critical section is at the face of the column.
Net pressure =$\frac{237.15x1.5}{1.7x1.7}$ =123.08kN/mm2
B.m = 123.08x1.7x0.7²/2 =51.26kNm

Effective depth:
M=0.138fckbd²
23x 10⁶=0.138x20x1700xd²
D=104.52mm

Provide 200mm depth for taking shear into consideration (104.52x2=210=260mm)
D=260mm
d=260-40=220mm

Calculation of Ast:

Ast $=\frac{f_{ck}}{2fy}[1-\sqrt{1-\frac{4.59xm_u}{20xbxd^4}}]$xbd
Ast $=\frac{f_{ck}}{2fy}[1-\sqrt{1-\frac{4.59xm_u}{20x1700x220^4}}]$x1700x220

=670.22mm2

Spacing of 10mm ø bars

$\frac{\frac{\pi}{4}x10^2}{670.22x670.22}$x1000 =117.184 mm
No of bars = 670.2224x102=8.53 = 9 number of bars

Check:
One way shear:
A critical section is at a distance d from the face of the column.

Tv=Vu/bd
Vu=123.08x1.7x0.48 =100.43kN
Tv= bd
Tc =% of steel ,Pt =Astx100/bd
= $\frac{670.22x100}{1700x220}$=0.2%
For M20 and 0.2% STEEL
Tc =0.24 KN/mm2
kx. = 1.2x0.24 =0.288N/mm2
Tv<kSafe against one way shear

Two way shear:
Considering two- way shear @ A distance of d/2 from the face of the column.
Periphery of column = (300+d+400+d)×2
Tv=Vu/bd

Vu=Net pressure + [BXL-(b+d)(l+d) =123.08+[1.7x1.7-(0.3+0.22)x(0.4+0.22)]
Vu=125Kn B'=(0.3+0.22)x2 +(0.4+0.22)x2 =2.28m
Tv=125x10^3/2280x220=0.24n/mm2
The limiting stress in concrete ,Tc = Ks×0.25$\sqrt{fck}$
Ks = 0.50 +β_o =0.50+0.30.4 = 1.25>1
Ks = 1
Tc = 1×0.25×$\sqrt{20}$ = 1.1N/mm2
Tv<KTc
Hence safe against two way shear

Transfer of load from column to footing:
0.45fck$\sqrt{\frac{A1}{A2}}$From page 65 IS 456
A1=0.4+4D = 0.4+4x0.26
A2=0.3x0.4
=0.121.440.12
=3.45>2

$\sqrt{\frac{A1}{A2}}$= 2
0.45x20x2 =18 n/mm2
Actual bearing capacity =column load/ area of column
=237.15x10^2 /300x400= 1.97 N/mm2
18>1.97 N/mm2
> Actual bearing capacity
>safe against bearing

STAIRCASE DESIGN FOR G+4 BUILDING

5.1. DOG – LEGGED STAIR-CASE
Hight b/w floor = 3m
Live load = 3kN/mm2 , Floor finish = 1kN/mm2
M20,Fe 415 grade steel
Width of flight = 32 = 1.5m
Let riser be 200mm
Number of rises = 1.5/0.2 =7.5≈8 Numbers
Number of threads = 8-1 =7m
Let Thread = 400mm
Going = 7×0.4 =2.8m
Span in m = G + X +Y = 2.8 + 0.75 + 0.75 = 4.3m
Over length of stair = 4.3 + 1.5 + 0.25 = 6.05m
D = l/20 = 6.05/20 = 0.3025≈0.3mm = 300mm
Using 20mmΦ and using 8mmΦ ties d = 300- 20 -8 = 272mm
Slope of thread and rise = $\sqrt{R^2+T^2}$ =447.2mm
Self weight = 25×0.3$\frac{0.4472}{0.3}$= 11.18kN/ m^2
Self weight of steps = $\frac{1}{2}$×0.2×25 = 2.5kN/m^2
Live load = 3kN/mm^2
Floor finish = 1kN/mm^2
Total load = 17.68kN/mm^2
Factored load = 17.68×1.5 = 26.52kN/mm^2

LOADS ON LANDING:

Self weight = 0.4×25 = 10kN/mm^2
Live load = 3kN/mm^2
Floor finish = 1kN/mm^2
Total load = 14kN/mm^2
Factored load = 14×1.5 = 21kN/mm^2
Mu= wl^2/8=217.41KN/m2

Ast $=\frac{f_{ck}}{2fy}[1-\sqrt{1-\frac{4.59xm_u}{20xbxd^4}}]$xbd
Ast $=\frac{20}{2x415}[1-\sqrt{1-\frac{4.59x128.27x10^6}{20x1500x272^2}}]$x1500x272

=2542.21mm2
Using 16mmΦ bars
Number of bars =1406.68x4/πx162 = 12.64 ≈ 13 bars

DISTRIBUTION STEEL
Ast = 0.12BD = $\frac{0.12}{100}$×1500×300 = 540mm2

Using 12 mm Φ bars

Spacing $= \frac{1000 x 12^2 x \frac{\pi}{2}}{540}$ = 209 ≈ 200mm

CONCLUSION

- In this report, a design of multi-story Building G+4 is presented.
- The durability of a building depends mainly on proper construction and proper use of construction materials.

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