Analysis and Design of Primary School building

A.V. Deepanchakaravarthi[1], S. Nivetha[2], S. Rajalakshmi[3]

[1]Assistant professor, Civil Department, velammal college of Engineering and Technology, Madurai, Tamilnadu, India.
[2,3]Bachelor of Engineering Student, velammal college of Engineering and Technology, Madurai, Tamilnadu, India

---***---

Abstract-*Our project is to design a primary school building that can hold a total strength of 500 students, with proper infrastructure provided. Our project is designed to be located at Othakadai village, at the foot hills of anaimalai. This primary school building is designed to benefit the children dwelling in and around Othakdai. The total area of the school building is 6000 sq.meter. It comprises a class rooms, hygienic restrooms for both male and female, lobby, parent's lounge, library, staff room, indoor play area, art room, interactive digital learning room and office room, principal's room, splash area. The design thus obtained is analyzed using STAAD Pro, an analysis software, to check for the shear, bending and tensile conditions .Slab designing is done depending upon the type of slab, end conditions and the loading. From the slabs the loads are transferred to the beams, thereafter the loads from the beams are taken up by the columns and then to footing.*

I. INTRODUCTION

My project involves analysis and design of PRIMARY SCHOOL BUILDING using very popular designing software STAAD Pro v8i. The total area of the building is 6000 m2 .The detailed assessment of the primary school building needs and associated capital and operational funding requirements for primary school facility to service. It takes into account the following principles of planning:

The management of play school building, in particular new effective

Management options and their implications, financial modeling and forecasting, and usage/occupancy patterns.

Recommended size and priority components of play school building facility. They relate to financial and other operating outcomes (e.g. social, environmental).

Design and layout of recommended facilities to optimize management and operational benefits.

Integration of building design and location on a major recreation reserve.

Making arrangement: Making arrangements in an industrial chocolate making Layout will be identified as "multiple-aisle". These terms are commonly found in design standards manuals, building codes, and similar architectural reference documents. Each size is unique, with specific guidelines governing various size various spacing, and exit way.

II. LITERATURE REVIEW

1. DINESH RANJAN.S,AISHWARYALAKSHMI.V "Design and Analysis of an Institutional Building" Volume 1,Issue 2,M ar 2017.The aim of the project is to analyze and design of an institutional building. A lay out plan of the proposed building is drawn by using AUTO CADD 2010.Using this so many standard books analysis of bending moment, shear force, deflection, end moments and foundation reactions are calculated. The structure was analyzed using STAAD.ProV8i.The method we are design the entire structure is limit state Method. The R.C.C.detailing in general shall be as per SP 34 and as per ductile detailing codeI.S. 13920.1993. The design was carried as per IS 456:2000 for the above load combinations. As a result, the training, taken through a period of one month allowed to have sample exposure to various field practices in the analysis and design of multi-storeyed buildings and also in various construction techniques used in the school.

2. Natasha Khalil on design and analysis of a building. The aim of the project is to analyze and design of an institutional building. A lay out plan of the proposed building is drawn by using AUTO CADD 2010.Using this so many standard books analysis of bending moment, shear force, deflection, end moments and foundation reactions are calculated. The structure wasanalyzed using STAAD.ProV8i. The method we are design the entire structure is limit state Method. The R.C.C. detailing in general shall be as per SP 34 and as per ductile detailing code I.S. 13920.1993. The design was carried as per IS 456:2000 for the above load combinations. As a result, the training, taken through a period of one month allowed to have sample exposure to various field practices in the analysis and design of multistoried buildings and also in various construction techniques used in the school.

3. Arjunsahu, AnuragVerma, Aryanpaul "Design and analysis of framed structure .There are several methods for analysis of different frames like cantilever method, portal method, and Matrix method. The present project deals with the design & analysis of an institutional building. The dead load&live loads are applied and the design for beams, columns, footing is obtained STAAD Pro with its new features surpassed its predecessors and compotators with its data sharing capabilities with other major software like AUTOCAD.

III. WORK PROGRESS

3.1 BASIC DATA

Type of construction: Concrete structure

No of stories: 2

Types of walls: brick wall

Floor to floor height: 3m

Walls: 230 mm thick brick masonry walls for both external and internal wall

Materials: Concrete grade:

M20 Steel grades:

HYSD bars of Fe415 grade.

Bearing capacity of soil: 450 k N/m2

Details of play school building:

Total area of the building = 6000 sq m

Class Room Size 40 m2

Office Room 50 m2

Parents longue 50 m2

Canteen 40 m2

Library 150 m2

Computer Lab 100 m2

Craft Room 100 m2

Medical Inspection Room 25 m2

PET Room 50 m2

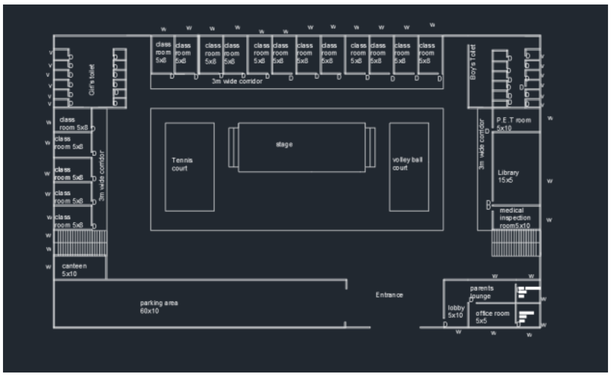
Toilet 225 m2

Art Room 100 m2

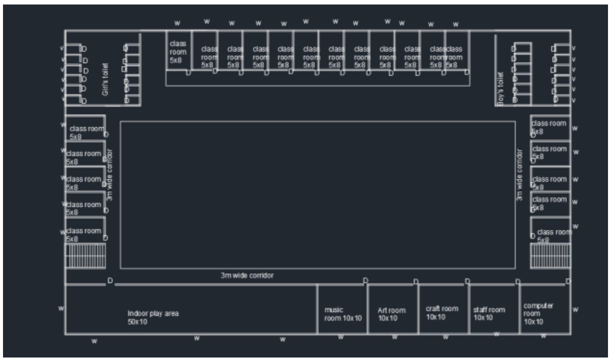
Music Room 100 m2

Parking Area 650 m2

3.2 PLAN OF THE BUILDING



Ground floor plan



First Floor Plan

IV. DESIGN OF BUILDING COMPONENTS

4.1 DESIGN OF SLAB

Data
Concrete grade (fck) = 25 N/mm2
Grade of steel (fy) = 415 N/mm2
Unit weight of concrete = 25 N/mm2
Edge condition = Two Short Edges Discontinuous
Assume
Dia of rod used = 10 mm
Clear cover = 20 mm (as per IS 456:2000 table: 16)
Type of Slab
Short span Lx = 5 m
Longer span Ly = 8 m
Lx/ Ly =8/5
= 1.6≤2
It is two way slab
Depth of Slab
Span/overall depth = 40 x 0.8
5230/D = 40 X 0.8
D = 156.44 mm
= 165 mm
Effective depth = D –c.c– Φ/2
= 165 – 20 – 10/2
d = 140 mm
Effective Span
Effective span = clear span + effective depth
= 5 + 0.14

= 5.14 mm

Calculation of Load

Self weight = b x D x unit weight of concrete
= 1 x 0.165 x 25
= 4.125 Kn/m2
Live load = 3 Kn/m2
Floor finish = 1 Kn/m2
Total load = 8.125 Kn/m2
Design load = 1.5 x 8.125
w = 12.188 Kn/m2

Ultimate Design Moment and Shear Forces

As per table 26 in IS 456:2000,
Mx = αx w lx
My = αy w ly
From the boundary conditions panel type is considered and the negative
and positive moment are calculated by using above formula.
Ly/Lx = 1
Type of panel is two adjacent edges discontinuous
Negative moment at continuous edge
αx= 0.063
αy= 0
Positive moment at mid span
αx= 0.047
αy= 0.035
Positive Moment
Mx = αx w lx
= 0.047 x 12.18 x 5.142
= 15.12 kNm
My = αy w ly
= 0.035 x 12.18 x5.142
= 11.26 kNm
Negative Moment
Mx = αx w lx
= 0.047 X 12.18 X5.142
= 20.27 kNm
My = αy w ly
= 0.0 X 12.18 X5.142
= 0 kNm

Shear force

Vu = 0.5wuLx
= 0.5 x 12.18 x 5.14
= 31.85 Kn

Check for Depth

Mu limit = 0.138fckbd2
= 15.13x106
= 0.138 x 25 x1000 x d2
= √ (14.689x106
/ (0.138 x 25 x 1000))
= 66.22 mm < 140 mm
Provide a depth of 110mm < 140mm
d = 110mm; D = 135mm
Hence the effective depth selected is sufficient to resist the design ultimate moment.

Reinforcement

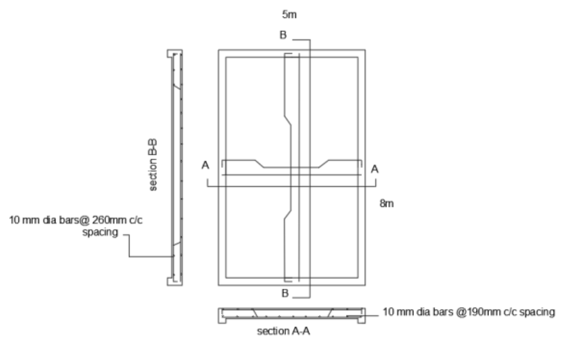
From IS 456:2000
Mu = 0.87fyAstd (1- Astfy/bdfck)
15.12 x106 = 0.87 x 415 x Astx 110 x (1-Ast x 415/1000 x 110 x25)
15.13 x106
= 39715.5 Ast – 7.49 Ast
(1- Astfy/bdfck)
11.26 x 106 = 0.87 x 415 x Astx 110 x (1-Ast x 415/1000 x 110 x25)
11.27 x 106
= 39715.5 Ast – 7.49 Ast2
Ast= 300.5 mm2
Minimum reinforcement = 0.12%Bd (as per 26.5.2.1)
= 0.12/100 x 1000 x 135
= 162 mm2
Adopt 10mm diameter bars,
Spacing = (π/4 X 102
/412) X 1000
= 190 mm
Provide,
10 mm bars at 190 mm center's (Ast= 341.484 mm2) in short span direction.
10 mm bars at 260 mm center's (Ast= 246.87 mm2) in longer spandirection.

sCHECK FOR SHEAR

Considering the short span and unit width of slab.
Ʈv = Vu/bd (as per clause 40.1 page no.72)
= 31.32x103
/1000x110
= 0.285 N/mm2
Pt = 100Ast/bd
= 100 x 412/1000 x 110
= 0.3
Refer table 19 in IS 456:2000 for pt=0.31
= 0.384
From IS 456:200 clause 40.2.1.1
Ʈck = 1.30 x 0.384
= 0.499 > 0.296
KƮc>Ʈv
Hence the shear stresses are with in safe permissible limits.

Check for Deflection Control

Considering unit width of slab
(L/d) basic = 26
(L/d) max = (L/d) basic x kt
fs = 0.58 fyAst(req)/Astprov
= 231.70
From SP16 table 3 page no: 49
pt = 0.3%
As per IS 456:2000 pg.38 fig 4
Kt = 1.5
From fig 4 IS 456:2000 page no: 38, Kt= 1.5
(L/d) max = (L/d) basic x Kt
= 40 x 1.5= 60
(L/d) actual = 5140/110 = 46.82 < 60
Hence the limit state of deflection is satisfied



Slab Reinforcement

4.2 DESIGN OF BEAM

Size of beam = 250 x 450 mm

Span(effective) = 5.23 m

L.L = 3KN/m

D.L = 2.82 + 4.375 = 7.195KN/m

DIMENSION:

Cover depth d’ = 50 mm

Effective depth = d = D – d’

= 450 – 50 = 400 mm

MOMENT CALCULATION:

Mu(-ve) = 1.5((Wd l2/ 10)+(Wd l2/ 9))

= 1.5 ((7.195x52/ 9)+(3x52/ 10))

= 45.09 KNm

Mu(-ve) = 1.5((Wd l2/ 12)+(Wd l2/ 10))

= 1.5 ((7.195x52/ 10)+(3x52/ 12))

= 39.78 KNm

Mu lim = 0.138 fck b d2

= 0.138x20x250x4002

= 110KNm

Mu < Mu lim

Main Reinforcement:

Mu = 0.87 x fy x Ast x d(1-(Astfy/bdfck))

45.09 x106

= 144420Ast(1-2.075x10-4Ast)

45.09 x106

= 144420Ast – 29.96Ast2

Ast = 335 mm2

No of bars required = 335 x 4/ 3.14 x 162

= 2

Provide 2 nos of 16 mm dia bar

Ast(prov) = 402.12 mm2

Minimum Reinforcement :

As per IS 456:2000 Cl.no 26.5.1.1\

Ast min = 0.85/fy x b x d

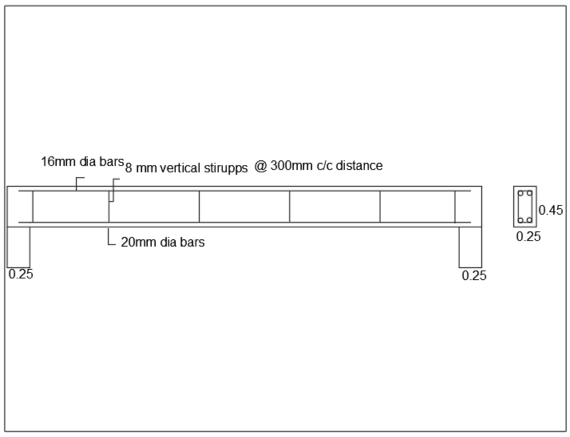
= 0.85/415 x 230 x 400

= 188 mm2

<Astprov

Hence Safe

Adopt 8 mm dia vertical stirrups @ 300 mm c/c spacing.



Beam Reinforcement

4.3 DESIGN OF COLUMN

Column (Column under Axial Compression)

DATA

Size of column = 250 mm x 250 mm

Length of column, L = 3 m

Eff. Length, Leff= 0.65 x 3 (as per IS 456:2000 table 28)

= 1.95 m

Grade of concrete fck= 20 N/mm2

Grade of steel fy = 415 N/mm2

Diameter of rod used = 12 mm

Clear cover = 40 mm

Effective cover d´ = 50 mm

Type of column

Leff/d = 1950/250= 7.8

Leff/D = 1950/250= 7.8 (as per IS 456:2000 clause 25.1.2)

Since Leff/d and Leff/D are less than 12. It is a short column.

Data taken from STAAD Pro analysis,

Fy= 294.28 Kn

Longitudinal Reinforcement

Axial load, Pu = 294.28 kN

Pu = 0.4fckng+ (0.67fy – 0.4fck) ASC

294.28 x 103 = 0.4 X 20 X (250 X 250) + (0.67 X 415 – 0.4 X 20)ASC

294.28 x 103= 500000 + (278.05 – 8) ASC

ASC = 761.9 mm2

No. of bars = 761.9/ (π/4 x 122

)

= 6.7 = 8 bars

Lateral Ties

As per IS 456:2000 clause 26.5.3.1 (c)

Pitch

 300 mm

 16 x 12 = 192 mm

 300 mm

Provide spacing of 300 mm.

Tie Diameter

 1/4 x 12 = 3 mm

 Not less than 6 mm

Provide 8 mm ties.

Column (Column under Uni Axial Compression)

Size of column = 250 mm x 250 mm

Length of column, L = 3 m

Eff. Length, Leff = 0.65 x 3 (as per table 28, IS 456:2000) = 1.95 m

Grade of concrete fck= 20 N/mm2

Grade of steel fy = 415 N/mm2

Diameter of rod used = 12 mm

Pu = 294.28 kN

Mu = 10.2 kNm

Type of column

Leff/d = 1950/250 = 7.8

Leff/ d = 1950/250 = 7.8 (refer clause 25.1.2, IS 456:2000)

42

Since Leff/d and Leff/D are less than 12. It is a short column.

Data taken from STAAD Pro analysis,

Fy= 294.28 kN

Non Dimensional Parameters

Pu/fckbd = 294.28 x103

/ (20 x 2502)

= 0.24

Mu/fckbd2

= 6.7 x106

/ (20 x 2503)= 0.03

Longitudinal Reinforcement

Refer chart 34 of SP:16 (d´/D = 0.2 and fy = 415 N/mm2)

P/fck = 0.18

P = 0.18 x 20

= 3.6

Asc = pbD/100

= (3.6 x 2502

)/100

= 2250 mm2

No. of bars = 2250/ (π/4 x 122)

= 19.89

= 19 bars

Lateral Ties

Tie diameter

(i) 1/4 x 12= 3 mm

(ii) Not less than 6 mm

Provide two legged 8 mm ties.

Pitch

(i) 300 mm

(ii) 16 x 12 = 192 mm

(iii) 300 mm

Provide spacing of 300 mm

Column (Column under Biaxial Compression)

Size of column = 250 mm x 250 mm

Length of column, L = 3 m

Eff. Length Leff = 0.65 x 3

= 1.95 m (As per table 28, IS 456:2000)

Grade of concrete fck= 20 N/mm2

Grade of steel fy = 415 N/mm2

Diameter of rod used = 12 mm

Clear cover = 40 mm

Effective cover d′ = 50 mm

Type of Column

Leff/d = 1950/250= 6.5

Leff/D = 1950/250 (As per clause 25.1.2, IS 456:2000)= 3.9

Since Leff/d and Leff/D are less than 12. It is a short column.

Data taken from STAAD pro analysis,

Fy= 294.28 kN

Design of Compression Member Subjected To Biaxial Bending

Axial load Pu= 294.28 KN

Moment Mz= 6.37kNm

Moment My= 3.28kNm

Assume Pu= 4%

Pt/fck= 4/20= 0.2

Uniaxial moment capacity of the section about XX axis

d′ = 40 + 20/2= 50

D = 250 mm

d′/ D = 50/250= 0.2

Pu/fckb = (294.28 x103)/ (20 x 2502)

= 0.23

Referring chart No. 44,

Mu/fckbD2

= 0.03

Uniaxial moment capacity of the section about X-X axis

Mux1 = 0.03 X 20 X 250 x 2502

= 9.375 kNm

Uniaxial moment capacity of the section about Y-Y axis

d′/ D = 50/250 = 0.175

Chart for d′/D = 0.018 will be used

Referring chart,

Mu/fckbd2

= 0.018

Muy1 = 0.018 x 20 x 250 x 2502

= 5.625 kNm

Calculation of Puz

From chart 63 corresponding to,

Pt = 4%

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 01 | Jan 2021 www.irjet.net p-ISSN: 2395-0072

fy = 415 N/mm2

fck = 20 N/mm2

Puz /Ag = 24 N/mm2

Puz= 24 x 250 x 250

Puz = 1500 kN

Pu/ Pux = 294.28/1500= 0.196

Mux/Mux1 = 6.37 /9.375 = 0.68

Muy/ Muy1 = 3.28/5.625

= 0.58

Referring to chart 64, the permissible value of Mux/Mux1 corresponding to the above

values of Muy/Muy1 and Pu/Pux is equal to 1

Corresponding to the above values of Muy/Muy1 and Pu/Pux, the permissible value of Mux/Mux1 is 1.Hence the section is O.K.

As = (px b x D)/100

= (4 x 250x 250)/100

= 2500 mm2

Use 12 mm dia bars,

No. of bars required = Ast/area of 1 bar

= 2500/ ((π/4) x 122)

= 18

The diameter,

(i) 1/4 x 12 = 3 mm

(ii) Not less than 6 mm

Provide two legged 8 mm ties.

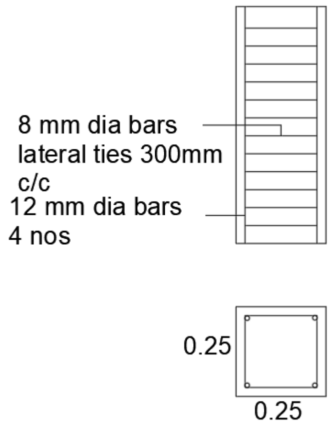
Pitch

(i) 300 mm

(ii) 16 x 12 = 192 mm

(iii) 300 mm

Provide spacing of 300 mm.



Column Reinforcement

4.4 DESIGN OF STAIRCASE

Height between floors = 3 m

Tread = 270 mm

Rise = 160 mm

Landing width = 1.25 m

Live load = 3 KN/m

F.F = 1 KN/m

Wall thickness = 250 mm

DIMENSIONS:

R=160 mm

T=270 mm

No. of steps = 3/0.16 = 18 steps

In case of dog legged staircase, 9 nos of steps for 1st flight and other 9nos of steps

for2ndflight.

Effective span = 0.25/2 + 1.25+(8x0.27)+1.25+0.25/2

=4.91 m

Slab thickness = leff/20 = 4.91/20 =245 mm

Assume cover 20mm & 12mm dia bars

deff(landing) = 245-20-12/2 = 219 mm

LOAD CALCULATION:

Dead load of slab on slope Ws= 0.245x1x25

= 6.125 KN/m

Dead load of slab on horizontal span

W = WsSQRT(R2+ T2) / T

W = 6.125SQRT(0.162 + 0.272) / 0.27= 0.70 KN/m

Dead load on one step = 0.5x0.16x0.27x25

= 0.54KN/m

Loads of steps per metre length = 0.54 x 1000 / 220 = 2KN/m

F.F = 1KN/m

Total load = 9.7KN/m

L.L = 3KN/m

Factored load = 19.05 KN/m

MOMENT CALCULATION:

M= 0.125 Wl2

= 0.125 x 19.05 x 4.912

= 57.40 KNm

CHECK FOR DEPTH:

d = ((Mu / (0.138 fck b))1/2

= 144.21 < 219 mm

Hence Safe

MAIN REINFORCEMENT:

Mu = 0.87 x fy x Ast x d (1- Astfy / bdfck)

57.40 x 106

= 0.87 x 415 x Ast x 144.21(1-(Ast415/1000x147x20))

57.40 x 106

= 53334.30 Ast – 7.49 Ast

Mu = 1310Nmm

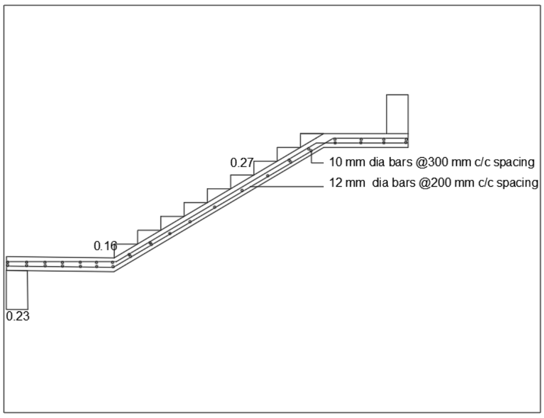
Provide 12 mm dia @200mm c/c

DISTRIBUTION REINFORCEMENT:

= 0.12% cross section

= 0.0012x1000x2 = 294 mm2

Provide 10 mm dia bars @ 300 mm c/c



Staircase Reinforcement

4.5 DESIGN OF FOOTING

Load on column = 249.28 KN

Extra load at 10% of load due to self wt of soil = 300KN

Therefore total load P = 549.28 KN

Area = P/SBC = 549.28/450 = 7.33 mm2

Area of footing = 7.5 m2

Upward soil Pressure = 249.28/(2.75x2.75) = 436.36vKN/m2

Two Way Shear:

Uniform overall thickness of footing D = 500mm

Assuming 16mm dia bars for main steel, effective depth of footing

d= 500-50-8 =452 mm

punching shear occurs at a distance of d/2 from the face of the column,

where a and are the dimensions of the column

Hence, punching area of footing =(a+d)2

=(0.25+0.452) = 0.702 m2

Punching shear force = factored load – (factored average pressure x

punching area of footing)

= 4500 –(654.54 x 0.702)

= 4040 KN

Perimeter along the section = 4(a+d)

= 4(250+452) =2808mm

Punching shear force

Nominal shear stress = perimeter x effective thickness

= 4040x103 / 2808x452 = 3.18 N/mm2

Allowable shear stress = Ks x Tc

Tc = 0.25 SQRT(fck)

= 1.1 N/mm2

Ks = 0.5 + 0.25/0.25 = 1.5

Allowable shear stress = 1.1 x 1.5 = 1.65N/mm2

1.1< 1.65 N/mm2

Hence assumed thickness of footing is sufficient.

S

Pu max = 436.36 KN

= 2750 – 450 / 2

= 1150 mm

Mu = total force x distance from the sectin

= 180 KN/m2

Mu / bd2

= Pt =0.625% (from sp-16)

Ast = Pt x b x d

= 0.625x2.75x2.75

= 1171.1mm2/m width

CHECK FOR ONE WAY SHEAR:

Vu = total force x (1-d)x B

= 436.36 x (1.5 – 0.452) x 2.75

= 1259 KN

Nominal shear stress =Vu / (B x d) = 1257/(2.75 x2.75)

= 0.16N/mm2

CHECK FOR DEVELOPMENT LENGTH:

The development length for 16 mm dia bars is given by

Ld = 47 x d = 47 x 16 = 752 mm

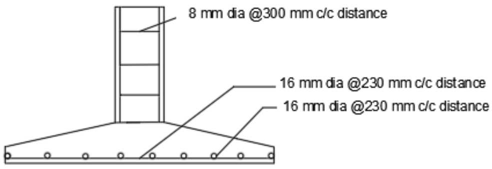
Providing 60 mm side cover, the total length available from the section is

0.5 x (l-a)-60

= 0.5 x (2750-250)-60

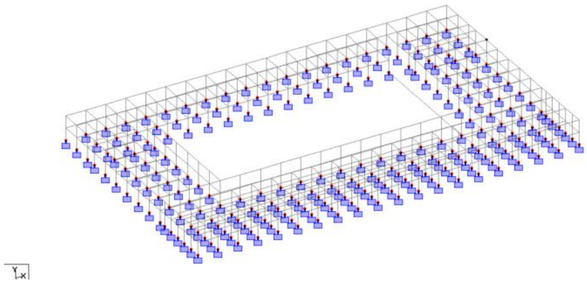
= 1190 >Ld

Hence Ok.

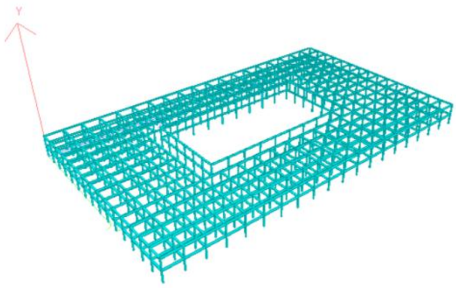


Footing Reinforcement

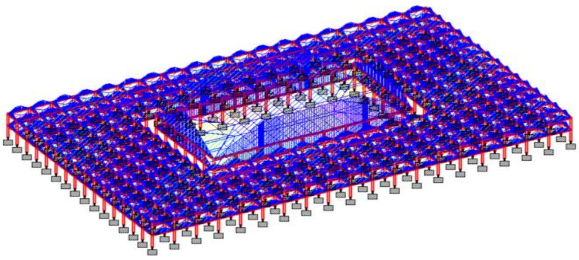
V. ANALYSIS USING STAAD-PRO:



Structural View of the building



3D view of the building



Load Distribution diagram

VI. CONCLUSION

We have learnt the methodology of constructing a high rise building by following all the codal provisions and to know the method of application of specification concepts for the design. We can conclude that there is difference between the theoretical and practical work done. As the scope of understanding will be much more when practical work is done. As we get more knowledge in such a situation where we have great experience doing the practical work. Knowing the loads we have designed the slabs depending upon the ratio of longer to shorter span of panel. In this project we have designed slabs as two way slabs depending upon the end condition, corresponding bending moment. The coefficients have been calculated as per I.S. code methods for corresponding lx/ly ratio. The calculations have been done for loads on beams and columns and designed frame analysis by moment distribution method. Here we have a very low bearing capacity, hard soil and isolated footing done.

REFERENCES

1. Bijaya Nepal1 & Prof. Dr. Ramkrishna Maharjan(2015) , "Effect ofSchool's Physical Facilities on Learning and Outcomes of Students inNepal"Volume 01, Issue 06.

2. Mohsen Ghasemi Ariani,& Fatemeh Mirdad,(2016)"The Effect ofSchool Design on Student Performance" Vol. 9, No. 1.

3. Georgios Mylonas, Christos Triantafyllis, Dimitrios Amaxilatis, "An Augmented Reality Prototype for supporting IoT-based Educational Activities for Energy-efficient School Buildings," Research Unit 1Patras,26504, Greece.

4. Anisha Goswami, Dr. Tushar ,Analysis of school building energy consumption in Tianjin, China , 10th International Conference on Applied Energy (ICAE2018), 22-25 August 2018, Hong Kong.

5. Dinesh Ranjan.S, Aishwarya Lakshmi.V(2017) "Design and Analysis of an Institutional Building" Volume 1,Issue 2.

6. Natasha Khalil(2015) on"design and analysis of a school building"Volume 1,Issue 2.

7. Krishna Raju, N. (2004), 'Structural Design and Drawing Reinforced Concrete and Steel', CBS Publisher & Distributors Pvt.Ltd., New Delhi.

8. Punmia.B.C(1980), 'Reinforced Concrete Structures', Laxmi Publications, New Delhi.

9. IS 456 – 2000, 'Plain and Reinforced Concrete Code of Practice ', Bureau of Indian Standards, New Delhi

10.IS (parts l,ll,lv)- 1987, 'Code of Practice for Design Loads for Building Structures:Part l – Dead Loads; Part ll – Imposed Loads; Part lv – SpecialLoads and Load Combinations', Bureau of Indian Standards, New Delhi.