A Project on

Planning and Designing of a School building

Submitted in partial fulfillment of the Degree of

Bachelor of Technology

विद्या तत्त्व ज्योतिसमः

May 2014

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WAKNAGHAT

Certificate

This is to certify that project report entitled "PLANNING AND DESIGNING OF SCHOOL BUILDING ", submitted by JAIVARDHAN CHAND in fulfilment for the award of degree of Bachelor of Technology in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date:

Supervisor's Name

Mr. Lav Singh

Assistant Professor

Department of Civil Engineering

Acknowledgement

We take this opportunity to express my profound gratitude and deep regards to my guide Mr Lav Singh for his exemplary guidance, monitoring and constant encouragement throughout the course of this thesis. The blessing, help and guidance given by him time to time shall carry me a long way in the journey of life on which we are about to embark.

We also take this opportunity to express a deep sense of gratitude to Dr Ashok Kumar Gupta, Head of Department of Civil Engineering, JUIT Waknaghat for his cordial support, valuable information and guidance, which helped me in completing this task through various stages.

Abstract:

The planning and design of school building encompasses our project that is planning of the school according to NBC 2005 norms, designing of the proposed plan of school building. Then checking whether the designed school is stable or not using STAADPRO software and finding out the cost using cost estimation software (Estimator).

Anyone managing the construction process needs a basic understanding of the engineer’s environment and the basic understanding of how a structure behaves. Constructors must be able to address a number of technical questions at the project site including structural issues that sometimes are not addressed by the design professionals. Since the safety of construction workers as well as the strength and stability of structures during the construction phase is of paramount importance, construction managers need this knowledge.

There are a variety of software programs which are available for the different specialized disciplines of civil engineering. Most civil engineers practice in specialized subsets of civil engineering, such as geotechnical engineering, structural engineering, transportation engineering, hydraulic engineering, environmental engineering, project and construction management. STAAD or (STAAD.Pro) is the structural engineering professional’s choice for steel, concrete, timber, aluminum, and cold-formed steel design of virtually any structure including culverts, petrochemical plants, tunnels, bridges, piles, and much more through its flexible modeling environment, advanced features, and fluent data collaboration. STAAD.Pro allows structural engineers to analyze and design virtually any type of structure through its flexible modeling environment, advanced features and fluent data collaboration. Its wide use in the field of civil engineering makes it of an utter importance to learn.

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CHAPTER 1: INTRODUCTION

1.1 Planning

When thinking about planning of school from a constructors point of view certain factors need to be considered environmental factors,social factors and economical factors etc.

1.Goal setting: Plans are the means to achieve certain ends or objectives. Therefore, establishment of organizational or overall objectives is the first step in planning. Objectives provide the guidelines (what to do) for the preparation of strategic and procedural plans. One cannot make plans unless one knows what is to be accomplished. Objectives constitute the mission of an organisation.

2. Developing the planning premises: Before plans are prepared, the assumptions and conditions underlying them must be clearly defined these assumptions are called planning premises and they can be identified through accurate forecasting of likely future events.

3. Reviewing Limitations: The key areas of Imitations are finance," human resources, materials, power and machinery. The strong and weak points of the enterprise should be correctly assessed.

4.Deciding the planning period: The planning period should be long enough to permit the fulfilment of the commitments involved in a decision. This is known as the principle of commitment. The planning period depends on several factors e.g., future that can be reasonably anticipated, time required to receive capital investments, expected future availability of raw materials, lead time in development and commercialization of a new product, etc.

5.Preparing operating plans: These plans consist of procedures, programmers, schedules, budgets and rules. Such plans are required for the implementation of basic plans. These plans are helpful in the implementation of long range plans. Along with the supporting, plans, the timing and sequence of activities is determined to ensure continuity in operations.

CHAPTER 2 : LITERATURE REVIEW

2.1 Research

For planning and designing of school building. A constructive survey was conducted thus helped us to know various technical and other essential norms that are generally considered from architects point of view ,investors point of view and society view this helped us to build a perception about various terms and conditions that are needed to be kept in mind for such a construction process.

2.2 Process

- The survey which was made it included interaction and getting feedback from the management of a school situated in Bhatinda (Punjab) and Jammu (J&K).
- The principle of the school expressed his ideas and also shared the need importance and problems faced throughout existence of any school.
- After this we went for a detail inspection of the school building and this helped us to get into insight of an school foundation and layout. We went through each an every unit of school and gave a thorough look at the construction point of views.

Conclusion:

- After the research process got over many observation were made.

- In Des Raj school which is a goverement based school upto class 10^{th} which had total number of student 796.Number of teacher were 35. Total number of classroom were 19.Area of the school was 3500sq ft. Average number of sections were 3.Number of washrooms were 3 (both for boys and girls).Average classroom size was 13x26 ft and height of the classroom was 10 ft. student teacher ratio was 1:23.

- In Lord Rama Public school which is a private school it has a total number of students 3000. Number of teachers 110. Average student in each class were 40.average number of section were 4. Area of the school was 11,500sq ft.Number of classrooms were 56 Average classroom size was 15x20 ft. Height of the classroom was 12ft. student teacher ratio was 1:27.

2.3 Failures

1.This picture depicts failure due to seepage .

Fig(2.1) Seepage Failure

2.Failure due to settlement

Fig(2.2)Settlement Failure

3. Cracks developed in slab

Fig(2.3) Cracking Of slabs

These are the samples used of the school building which was inspected and examined during research process. From the above research we got an idea and technical base of elements of construction and finishing process involved in building.

CHAPTER 3 : PROJECT WORK

We are planning a school which will be made according to the NBC 2005 having total area of 2 acres in plan region which will located 10 -15 km radius from the centre of the city. The school is easily accessible. School will be constructed on plan terrain which will be well compacted

1. We plan to Provide an interior environment that is visually comfortable and stimulating by providing ample natural light and incorporating colors that stimulate or soothe, depending on the space function.
2. Avoid glare and direct-beam sunlight.
3. Design for diffuse, uniform daylight throughout classrooms.
4. Use day lighting analysis tools to model the interaction of lighting and materials that reflect or absorb light.
5. Select building elements on the basis of life-cycle cost analysis—Mirror the lifespan of projects and systems with the expected lifespan of the facility.
6. Consider the recyclability of materials
7. Specify materials and products that are easy to maintain (balance this with their impact on children's health and the environment).
8. Use energy simulation and analysis tools to optimize energy performance (integrate day lighting systems, high-performance HVAC, energy-efficient building shell, and high-performance electric lighting)
9. Cluster classrooms around common areas.
10. Provide platform spaces for gathering, sitting, and presenting and alcoves for reading and studying.
11. Use operable walls to increase the efficiency of large, multipurpose spaces.
12. Accommodate technology upgrades.
13. Make day lighting a priority, especially in classrooms. Day lighting is the controlled admission of natural light into a space
14. Use natural ventilation when possible. (This and day lighting also provide a connection to the outdoors.)
15. Ensure superior indoor air quality

16. Connect the indoor environment to the outdoors by providing operable view windows in classrooms and easy access from classrooms to gardens and other outdoor areas that can be utilized in the curriculum.
17. Maximize visual access to corridors and school grounds
18. Increase occupants' sense of ownership and "territoriality" by providing comfortable, not institutional, rooms and by clearly defining the school boundaries.
19. Control access to the building and grounds by individuals and vehicles.
20. Use durable, non-toxic building materials
21. Use energy, water, and other resources efficiently.
22. Use of solar panels .
23. Integrate high-performance mechanical and lighting systems.
24. Provide opportunities for safe walking and bicycling to school.
25. Use the Green Building Concept.

We plan a school which will have 20 class room ,1 library ,3 labs ,Administrative block, Principal room, 1 Multipurpose hall ,1 games room , 2 boys and 2 girls toilet on each floor , 2 staff rooms 1 on each floor, 1 games room which will be made according to CBSE norms which are :

- School should have a min. area of 2 acres including academic block & playground.
- The pupil teacher ratio should not exceed 30:1 and section teacher ratio must be 1:1.5.
- The minimum floor space should be at least 1 sq. mtr. per student.

The number of student in the class should not be very large. The optimum number in a section of a class is 40

- Class rooms-minimum size should be 500 sq. ft.
- There should be seperate labs for Maths,Physics,Chemistry,Bio & Computer with min. area of 600 sq. ft.
- Library – minimum size should be 14m*8m fully equipped and with reading room facility.
- The school should have adequate facilities for providing recreation activities and physical education.
- Computer Lab and Math Lab. No minimum size is prescribed, however the school should have separate provision for each. The computer lab should have 10 computers or computer student ratio of 1:20.

- Rooms for extracurricular activities-either separate rooms for music, dance, arts & sports or one multi-purpose hall for all these activities should be available.

Auto cad drawings

Auto cad drawings Proposed plan of a School

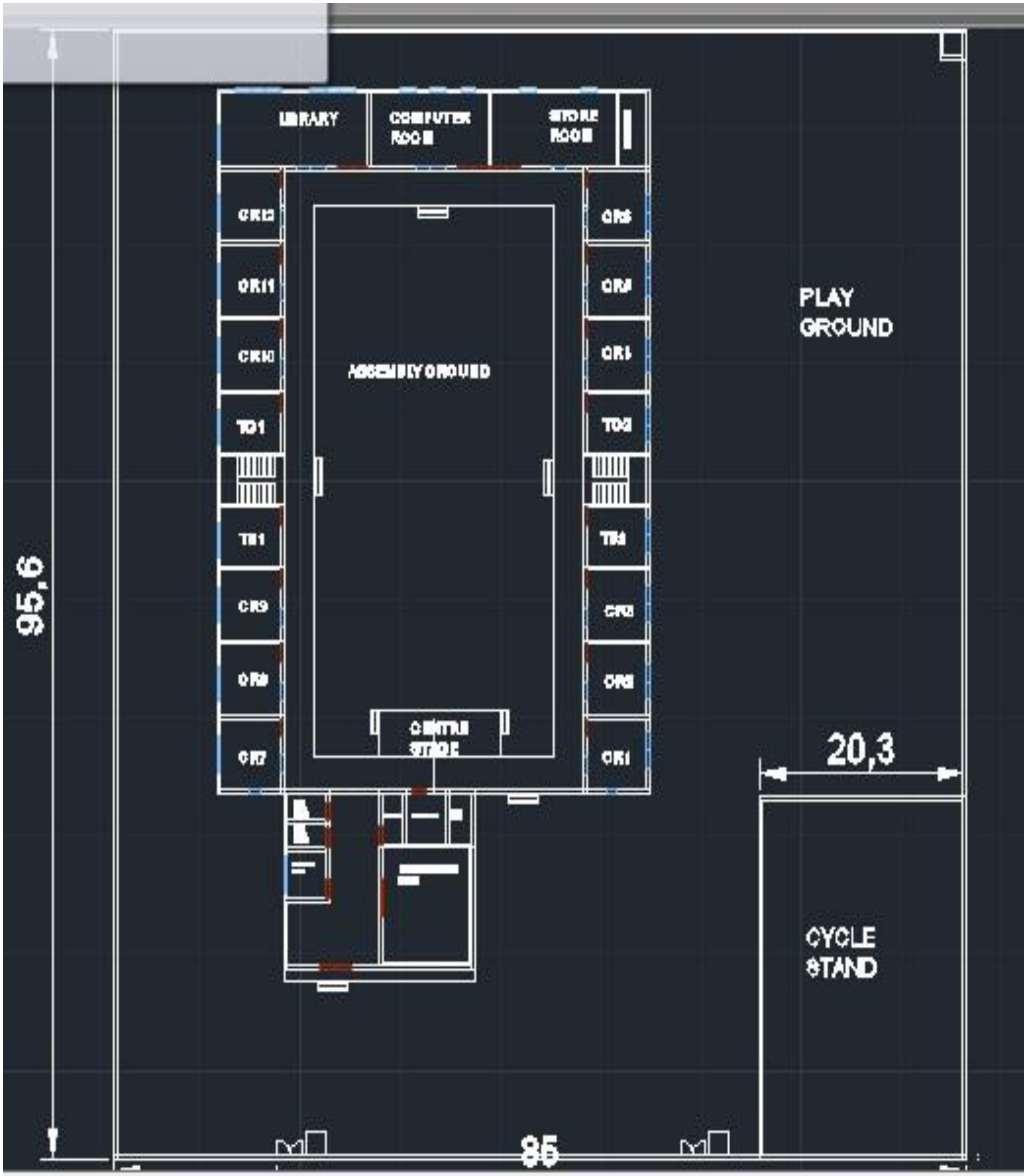


Fig (3.1) Autocad drawing of the planned school

2.First floor plan

Fig (3.2) Autocad drawing of 1st floor

3.Plan of a classroom

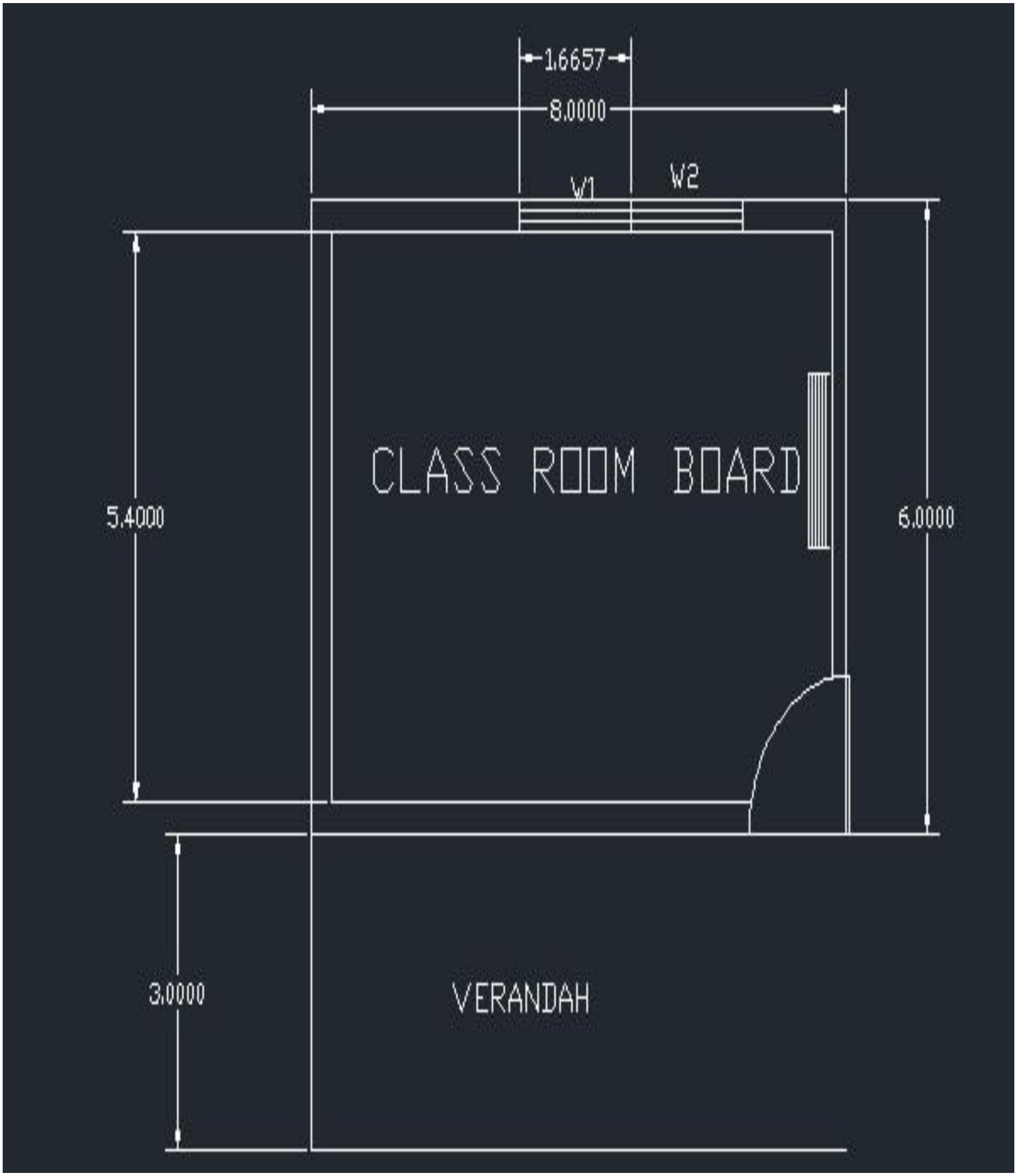


Fig (3.3) Autocad drawing of a class room

5. 3D plan of 1^{st} floor

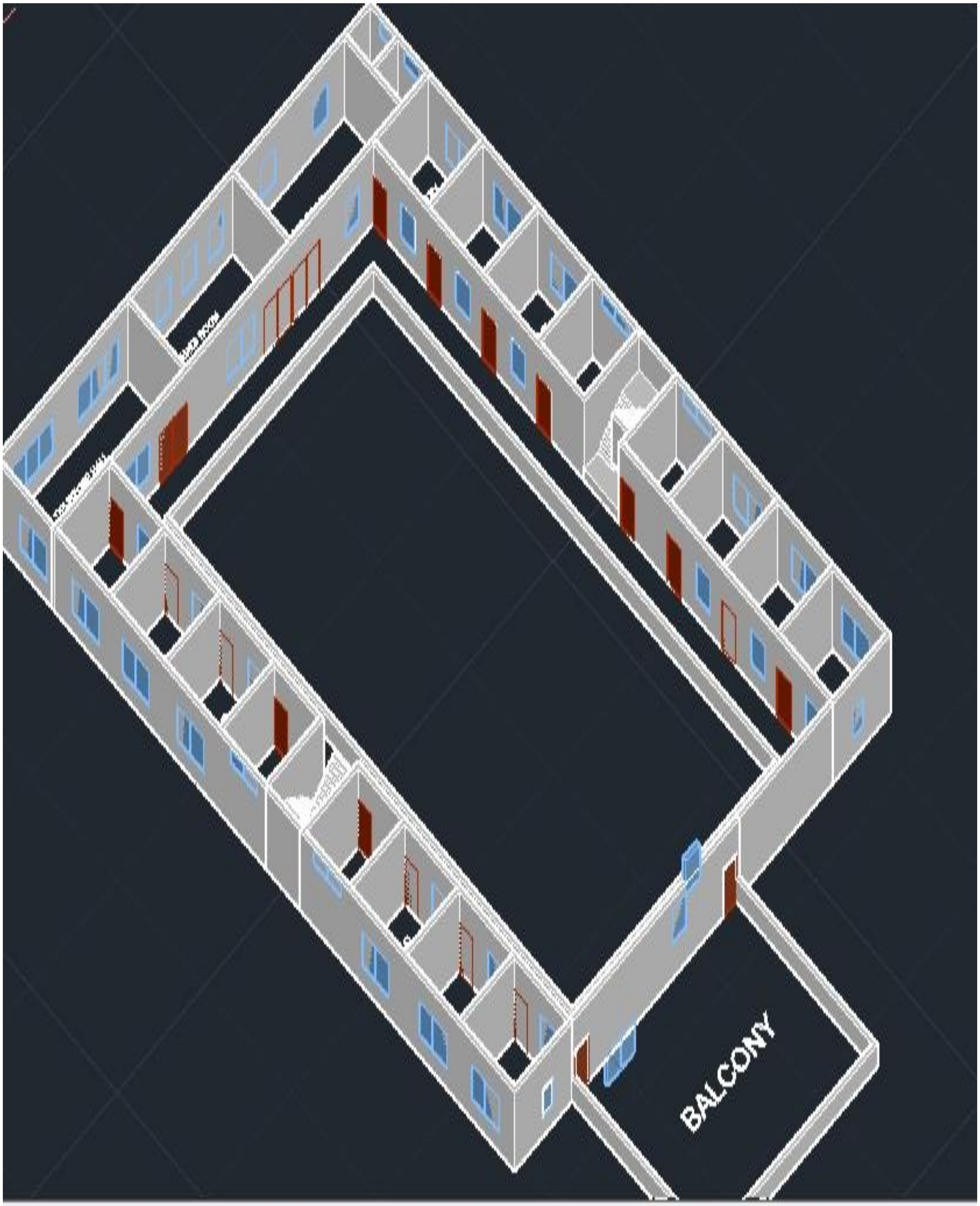


Fig (3.5)Autocad 3D modelling of the 1st floor

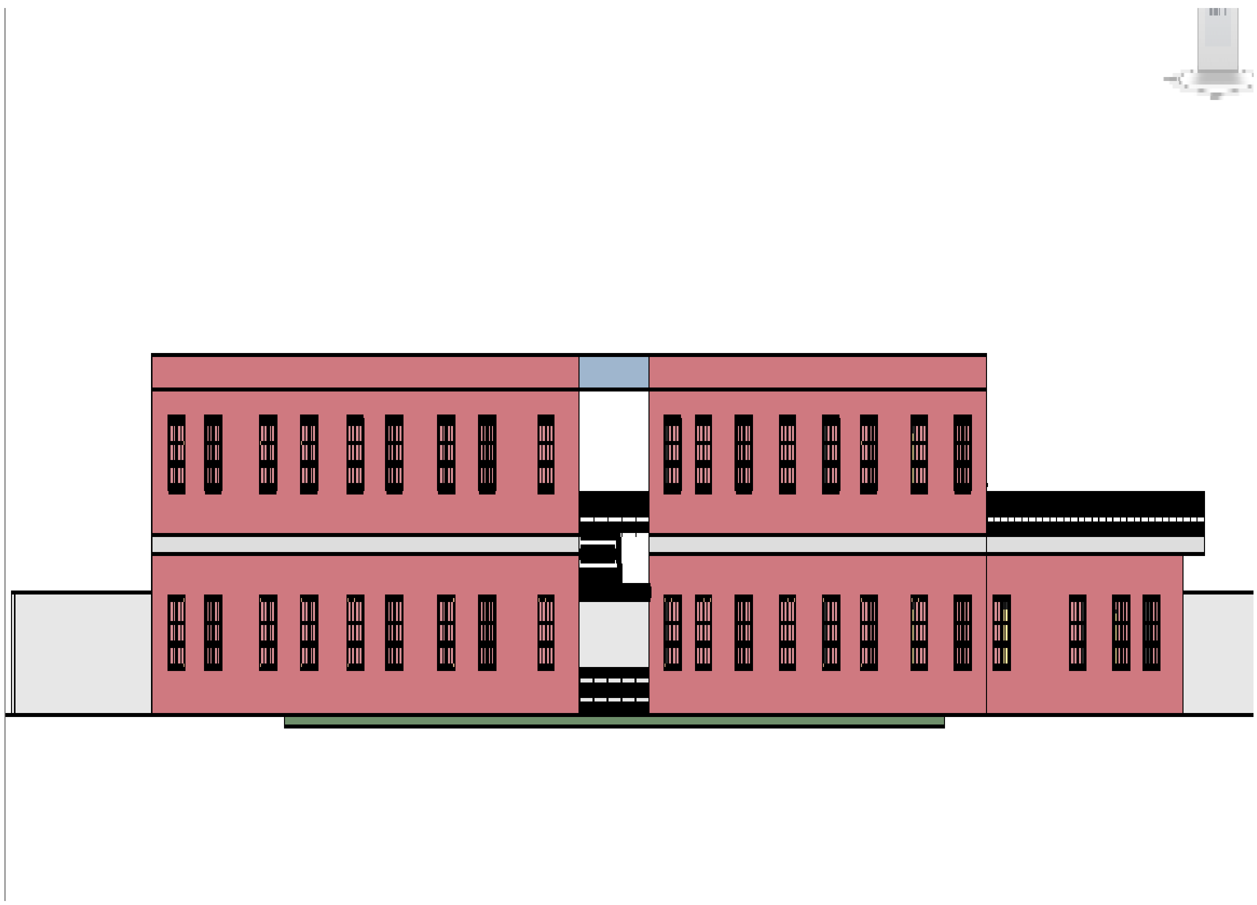
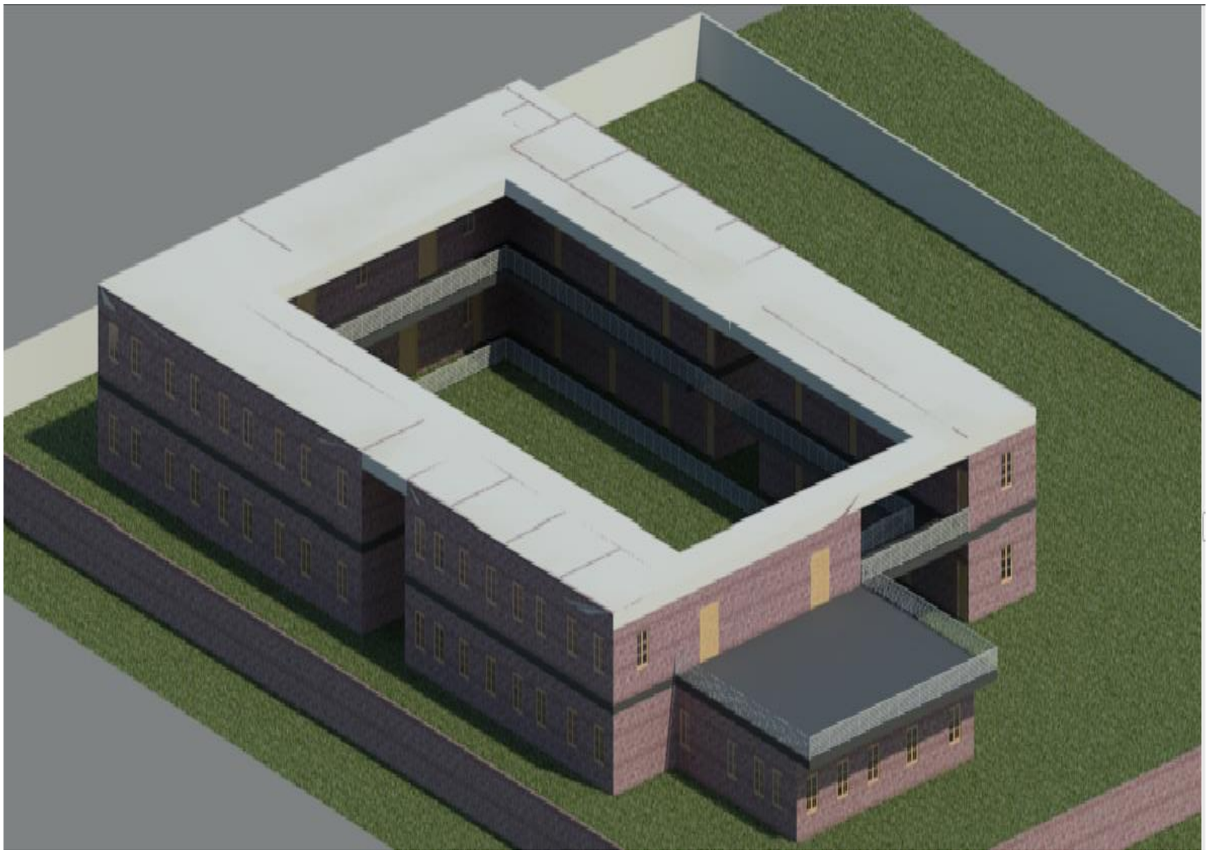


Fig (3.6) 3D side view of the school on Revit



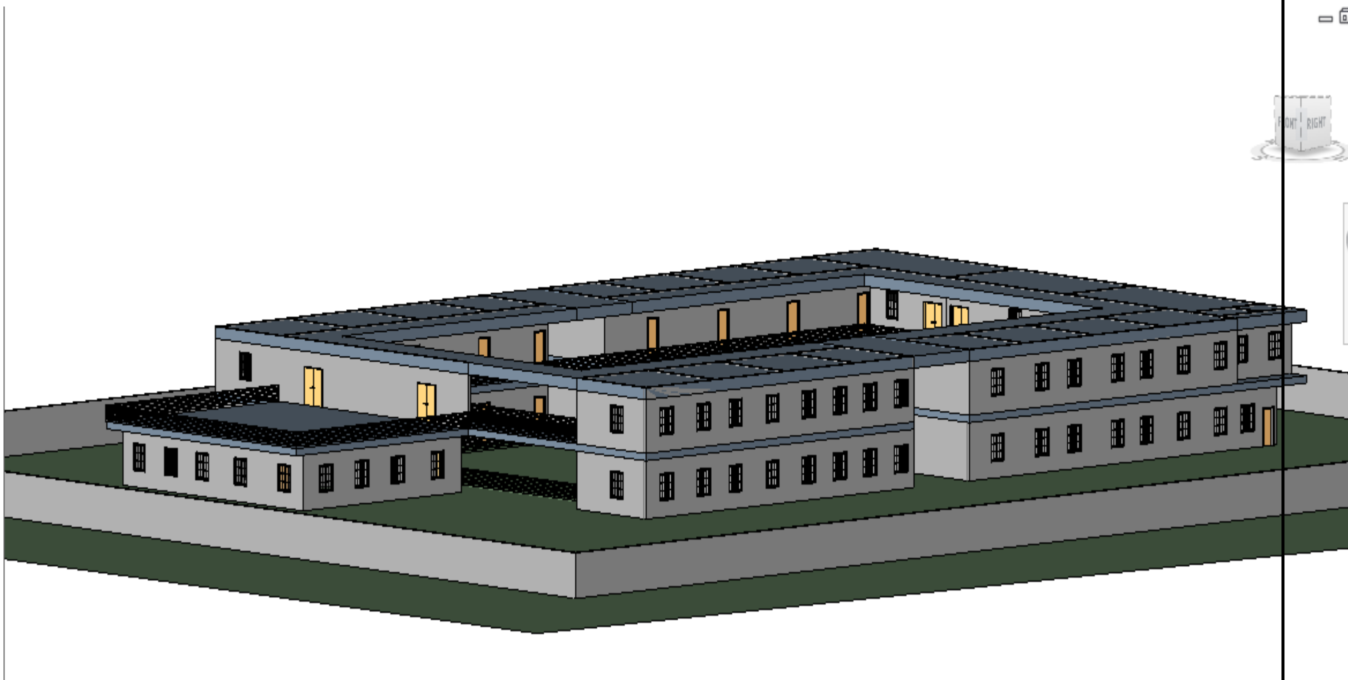


Fig (3.7) 3D   view of the school on Revit

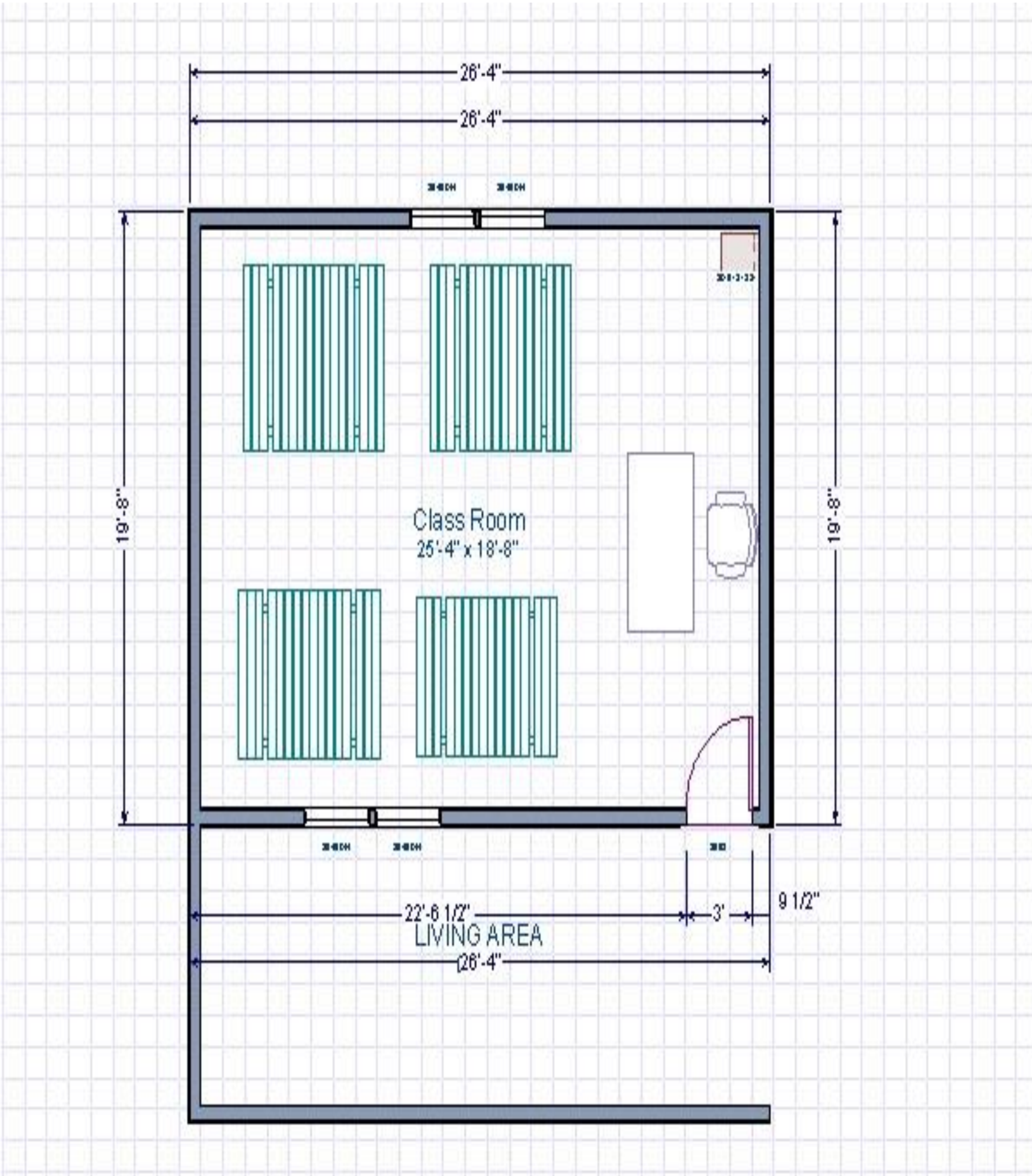


Fig (3.8) Drawing of a classroom On Chief Architect

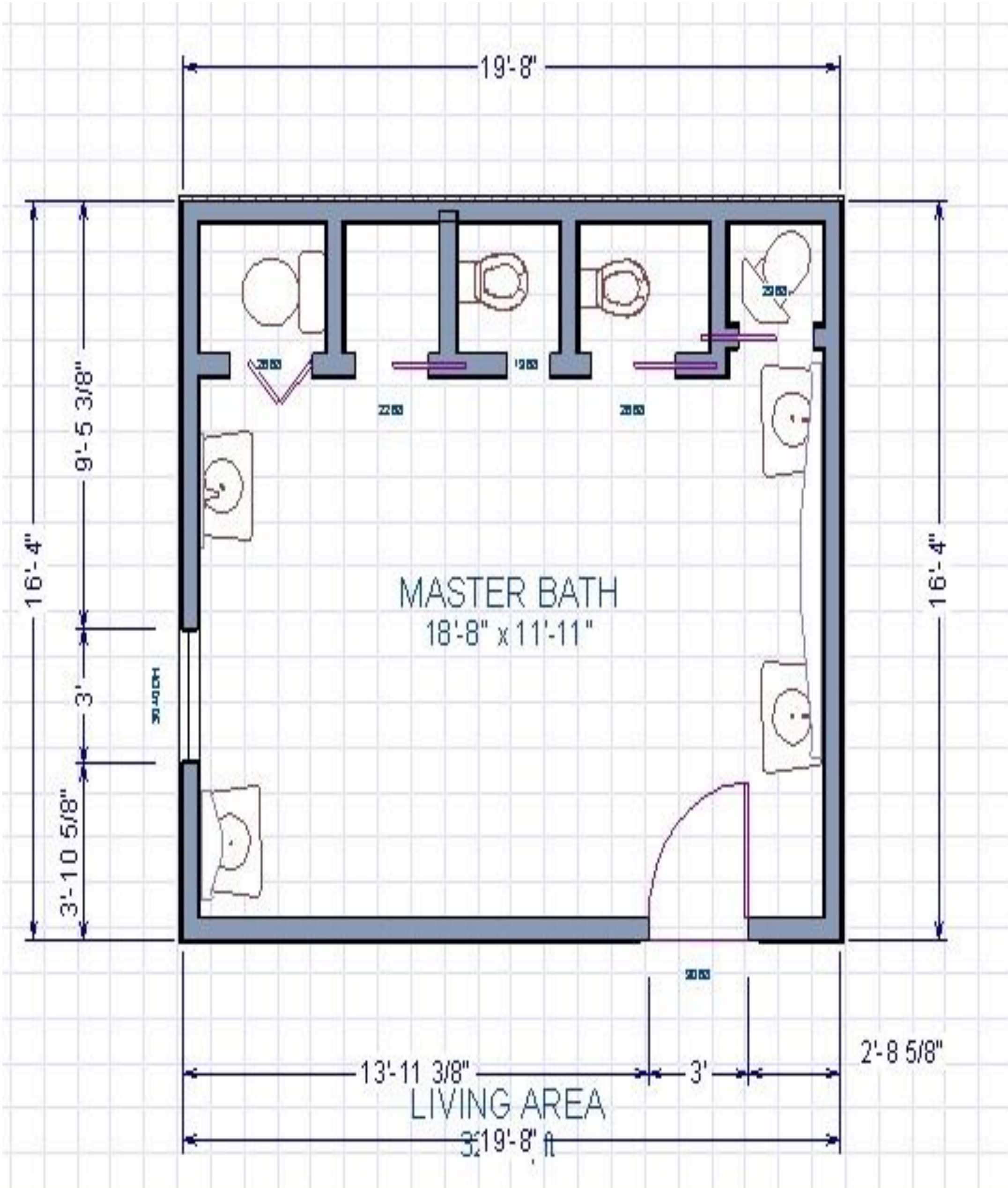


Fig (3.9) Drawing of a Toilet On Chief Architect

CHAPTER 2 : DESIGNING OF STRUCTURE

Salient Features:

The proposed school is to be constructed with G+ 1 Floor.
The class room size is 6m x8 m. Total no of classes are 20.

An expansion joint is provided between these buildings. The building is designed as aframed structure having a framework of R.C.C Beams and Columns with help of STAAD PRO. The design is based on the provisions as laid down in IS 456:2000 using Limit State Method .

No. of Storeys. = G + 1 FLOOR

Type of Structure: R.C.C Framed Structure

Section Sizes:

Column Sizes: - 450x 450 mm

Beam Sizes: - 300 x 600 mm

Slab Thickness = 150 mm

Concrete Grade = M20

Steel Grade = Fe415 (TMT/TOR)

4.1 LOADING

4.1 Dead Load

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m” and 25 kN/m” respectively. The dead load of steel sections are obtained according to SP-6.

4.2 Imposed Loads

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

4.3 Wind Load

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth’s rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term ‘wind’ denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 metres above ground.

4.3.1 Design Wind Speed (V)

The basic wind speed (V) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure:

a) Risk level;

b) Terrain roughness, height and size of structure; and

c) Local topography.

It can be mathematically expressed as follows:

Where:

$V = Vb * k_1 * k_2 * k_3$

V_b = design wind speed at any height z in m/s;

k_l = probability factor (risk coefficient)

k = terrain, height and structure size factor and

k_3 = topography factor

Risk Coefficient (k_I Factor) gives basic wind speeds for terrain Category 2 as applicable at10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.

Terrain, Height and Structure Size Factor (k, Factor)

Terrain - Selection of terrain categories shall be made with due regard to the effect ofobstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration.Wherever sufficient meteorological information is available about the nature of wind direction, the orientation of any building or structure may be suitably planned.

Topography (k_s Factor) - The basic wind speed Vb takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpments, or ridges.

BASIC LOADS:

1. Dead Load :

a) Wall Load

9” thick wall load = 0.23 x 20 x 3.05 = 14.03 kN/m

4.5” thick Partition wall load = 0.115 x 20 x 3.05 = 7.01 kN/m

1m high parapet wall = 0.115 x 20 x 1 = 2.3 kN/m

Stair load = 25 kN/m

b) Slab Load :

i) Self weight of slab = 0.15 x 25 = 3.75 kN/m^2

ii) 3”thick. Floor finishes = 0.075 x 20 = 1.5 kN/m^2

iii) 1” thick. Flooring = 0.025 x 25 = 0.625 kN/m^2

iv) Incidental wall load (partition) = 1 kN/m^2

Total = 6.875 KN/sqm ~ 7 kN/m^2

2. Live Load : as per IS 875 (Part-2)

a) Class Rooms = 3.0 kN/m^2	a) Corridor = 3.0 kN/m^2
b)Toilets = 2 kN/m^2	b) Lab = 3kN/m^2
c) Multipurpose hall =5kN/m^2	d) Games room =5kN/m^2
e) Staff room = 2.5 kN/m^2	f) Cafeteria = 3kN/m^2
g) Staircase = 4kN/m^2	h) Store room = 5kN/m^2
i) Library =6 kN/m^2	j) Roof load =1.5kN/m^2
k) Class Rooms = 3.0 kN/m^2	l) Corridor = 3.0 kN/m^2

WIND LOAD

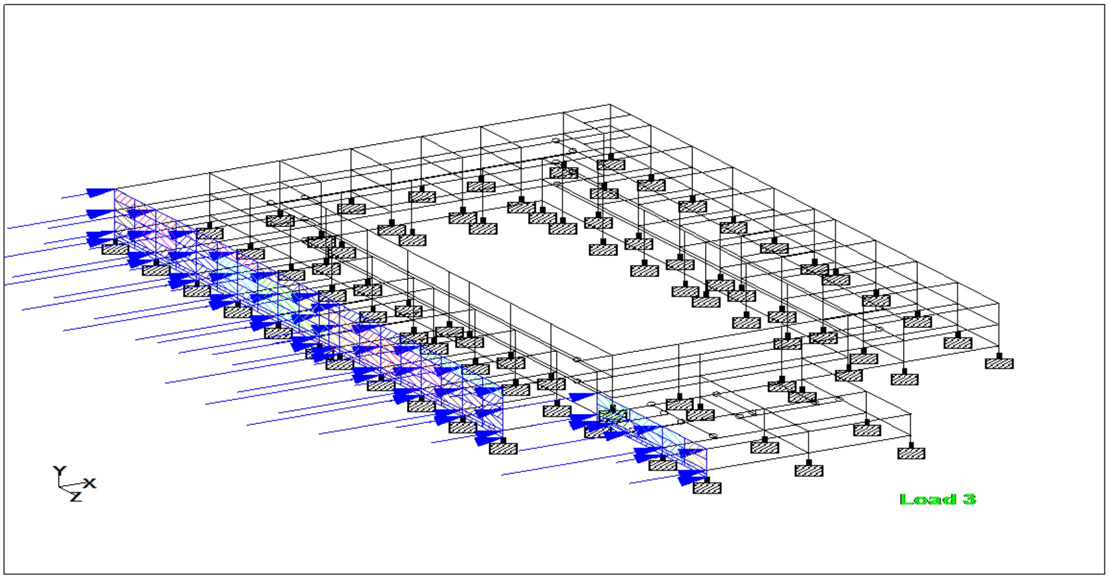


FIG (4.1) WIND LOAD IN X DIRECTION

Wind Load Calculations(as per IS 875 part-III)

a)	Basic Wind speed (at 10.0m above MGL)	39m/s
b)	Probability / Risk Factor (k1)	1.07
c)	Terrain Category	Category-III
d)	Topography Factor (k3)	1
Wind load calculations for Category-II & Class-A(size < 20m)		
e)	Terrain factor (k2)	1.06
	Design wind speed (Vz)= (Vbxk1xk2xk3)	39m/s
	Design wind Pressure (pz) = 0.6Vz2	912.6 N/m² ~ 1kN/m^2

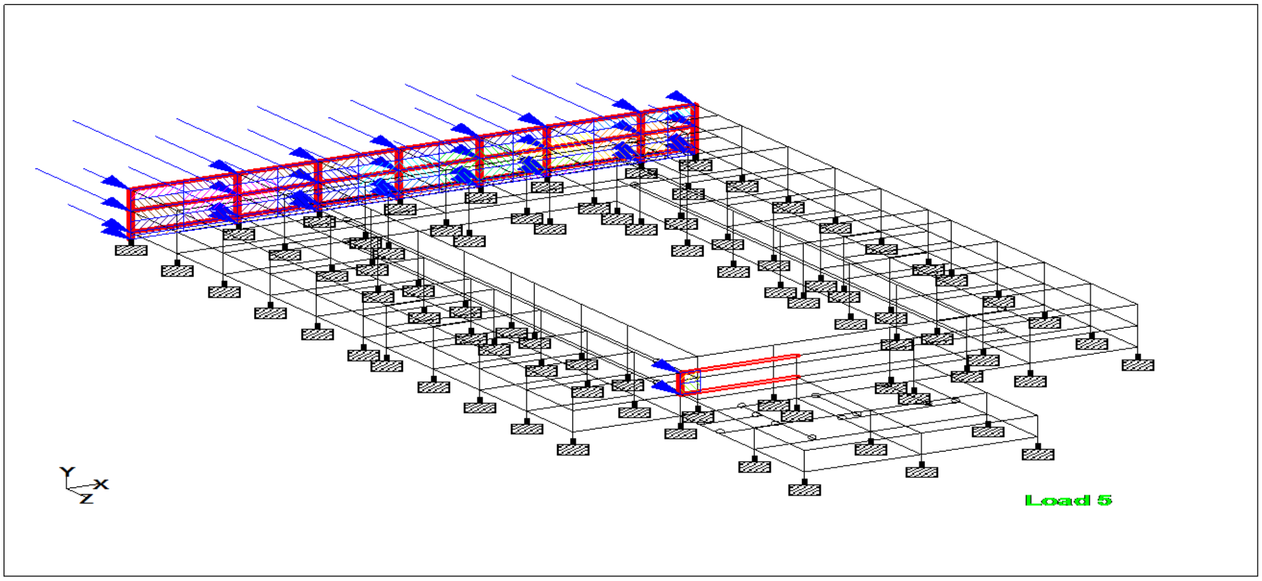


FIG (4.2) WIND LOAD IN Z DIRECTION

COLUMN DETAILS

STAAD OUTPUT

C O L U M N N O. 1051 D E S I G N R E S U L T S

M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 1000.0 mm CROSS SECTION: 450.0 mm X 450.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 31 END JOINT: 51 SHORT COLUMN

STAAD SPACE -- PAGE NO. 421

REQD. STEEL AREA : 1690.08 Sq.mm.

REQD. CONCRETE AREA: 200809.92 Sq.mm.

MAIN REINFORCEMENT : Provide 16 - 12 dia. (0.89%, 1809.56 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 2333.33 Muz1 : 140.59 Muy1 : 140.59

INTERACTION RATIO: 0.96 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 31

END JOINT: 51 Puz : 2369.44 Muz : 145.54 Muy : 145.54 IR: 0.91

C O L U M N N O. 1071 D E S I G N R E S U L T S

M20 Fe415 (Main) Fe415 (Sec.)

LENGTH: 1000.0 mm CROSS SECTION: 450.0 mm X 450.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 30 END JOINT: 71 SHORT COLUMN

REQD. STEEL AREA : 1733.52 Sq.mm.

REQD. CONCRETE AREA: 200766.48 Sq.mm.

MAIN REINFORCEMENT : Provide 16 - 12 dia. (0.89%, 1809.56 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 2346.46 Muz1 : 157.75 Muy1 : 157.75

INTERACTION RATIO: 0.96 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)

WORST LOAD CASE: 30

END JOINT: 71 Puz : 2369.44 Muz : 161.23 Muy : 161.23 IR: 0.93

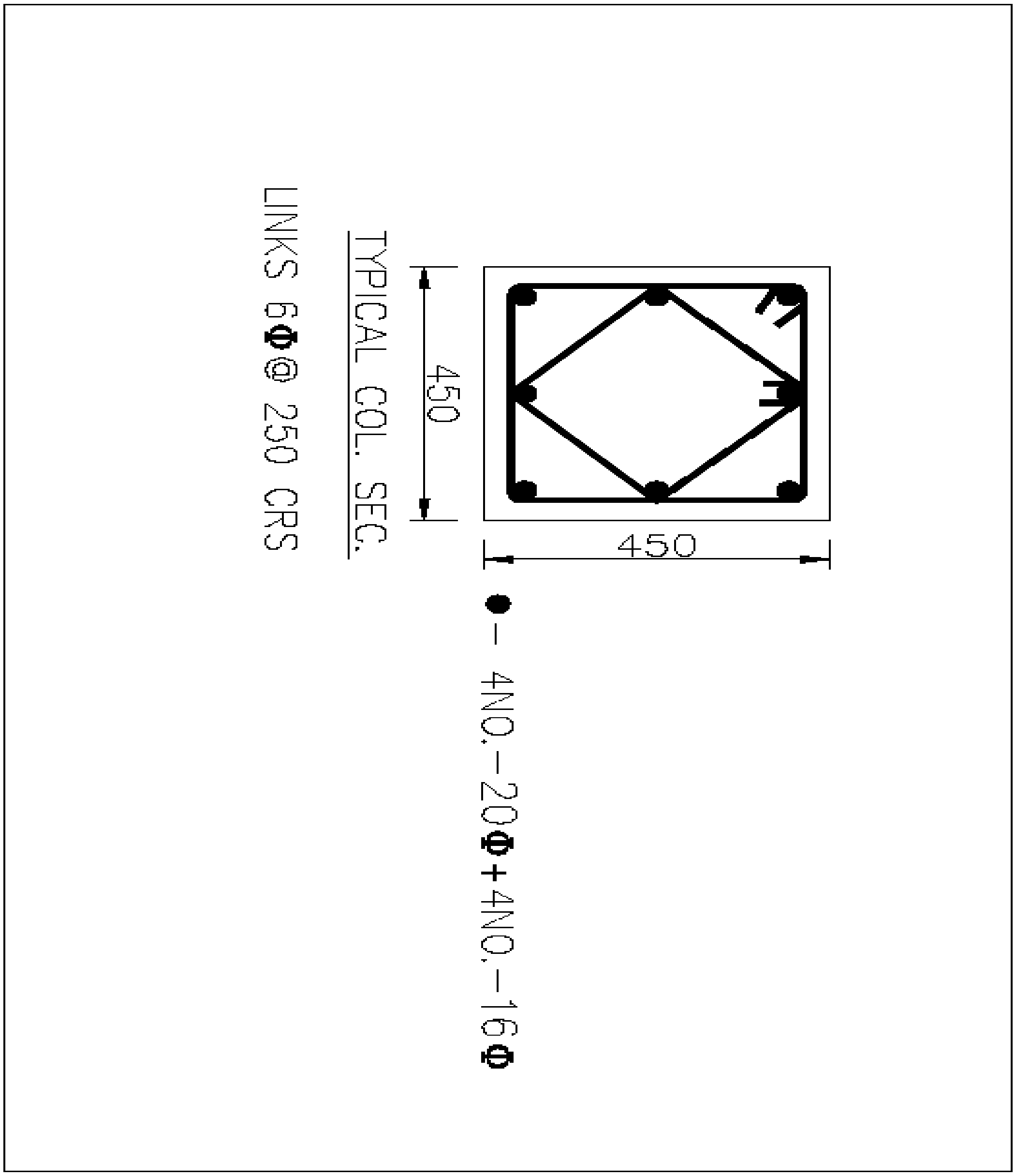


FIG (4.3) COLUMN SEC.

Factored load(Pu)	218	Fck(mpa)	20
Mux	136.4	Fy(mpa)	415
Muy	139.4		
d'	60		
Ex	625.6881		
Ey	639.4495		

both value are greater then 20 therefore
column is short

Dimensions of column

B	450		
D	450		
d'/D	0.133333		
Pu/fckbd	0.053827		
Mu/fckbd2	0.074842		
Mu/fckbd2	0.007649		

higher of above Mu i.e .076 is adopted

from SP-16

p/fck	0.04		
p/fck	0.8		
Ast	1620		
using 16 dia bars	16		
N	8.112981		
	8	Provide 4no.-16mm + 4no.-20mm	
Total no. of bars to be provided	8		
Lateral Ties			
d' (mm)	8	Using 8mm dia bars	

Spacing of lateral ties

Least of the following

According to IS Code

Least Lateral Dimension (s)	450
spacing (s)	256
spacing (s)	384

Using 6mm dia bars at 250mm C/C

EXCEL SHEET FOR COLUMN

BEAM DETAILS

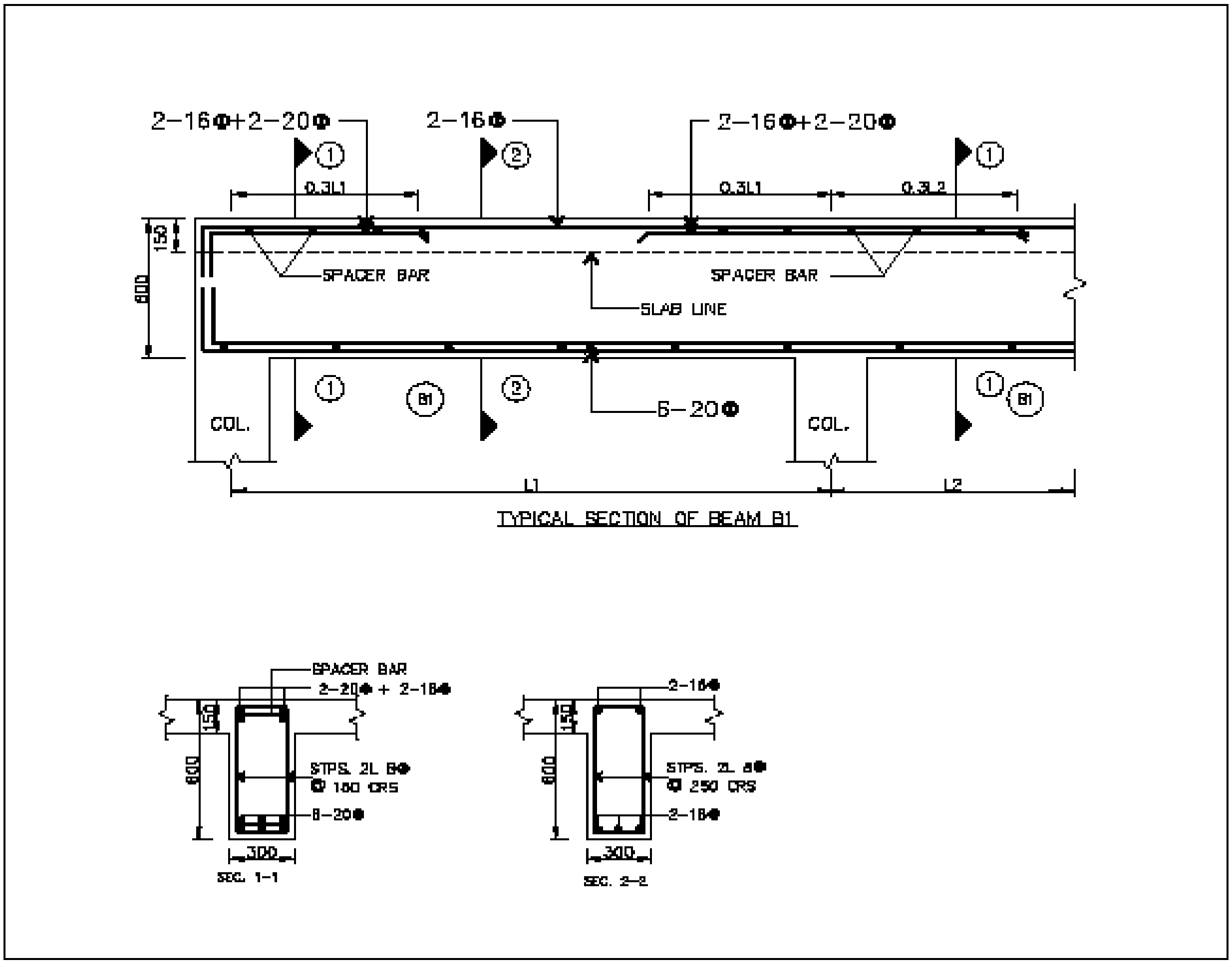
STAAD OUTPUT

```
============================================================================
=======
                B E A M   N O.    212   D E S I G N   R E S U L T S

        M20                 Fe415 (Main)              Fe415 (Sec.)

   LENGTH:   6000.0 mm      SIZE:    300.0 mm X   600.0 mm     COVER: 25.0 mm
  STAAD SPACE                                             -- PAGE NO.   175

                     SUMMARY OF REINF. AREA (Sq.mm)
            -----------------------------------------------------------------
 SECTION      0.0 mm      1500.0 mm     3000.0 mm     4500.0 mm     6000.0 mm
            -----------------------------------------------------------------
    TOP        1041.02        349.63          0.00         349.63       1084.80
```

REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)
BOTTOM	0.00	348.40	348.40	348.40	0.00
REINF.	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)	(Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1500.0 mm	3000.0 mm	4500.0 mm	6000.0 mm
TOP REINF.	10-12í 2 layer(s)	4-12í 1 layer(s)	2-12í 1 layer(s)	4-12í 1 layer(s)	10-12í 2 layer(s)
BOTTOM REINF.	2-16í 1 layer(s)	3-16í 1 layer(s)	3-16í 1 layer(s)	3-16í 1 layer(s)	2-16í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 190 mm c/c	2 legged 8í @ 190 mm c/c	2 legged 8í @ 190 mm c/c	2 legged 8í @ 190 mm c/c	2 legged 8í @ 190 mm c/c



2-16Φ+2-20Φ
2-16Φ
2-16Φ+2-20Φ
0.3L1
0.3L1
0.3L2
150
600
SPACER BAR
SPACER BAR
SLAB LINE
6-20Φ
COL.
COL.
B1
B1
L1
L2
TYPICAL SECTION OF BEAM B1
SPACER BAR
2-20Φ + 2-16Φ
STPS. 2L 8Φ
@ 150 CRS
6-20Φ
300
SEC. 1-1
2-16Φ
STPS. 2L 8Φ
@ 250 CRS
2-16Φ
300
SEC. 2-2

Fck(mpa)	20	
SPAN(L ,m)	8	assumption
DEPTH(D,m)	0.6	L/12
BREADTH(b,m)	0.3	assumption
Fy(mpa)	415	
	CALCULATION OF LOADS.	
DEAD LOAD(KN/m)	4.5	D*b*25
wall load	14	.23*3.05*20
LIVE LOAD(KN/m2)	9.375	5kn/sqm*area of trap
TOTAL LOAD	27.875	
FACTORED LOAD	41.8125	
MAX.BENDING MOMENT,Mu(KNm)	223	
MAX.SHEAR FORCE,Vu(KN)	167.25	
FOR BALANCED SECTION.		
	CHECK FOR DEPTH	
Mu=.138Fckbd2		
d(m)	0.518964037	
	D>d therefore OK.	
COVER(m)	0.04	
EFFECTIVE DEPTH,d(mm)	0.56	
	Xu=Xulim	
Xulim=.48*d	0.2688	
Xu=(2.42FyAst)/bFck		

Ast(m^2)	0.001605895	
	1606mm^2	Provide 6 no-20mm bars

DESIGN FOR SHEAR REINFORCEMENT

ACTUAL SHEAR FORCE(mpa)	1074.255556	
% STEEL	1.031474591	
from the table given τc	0.64	
τv	1074.255556	
	0.23	

since $\tau v<\tau c$ no need for shear r/f

provide minimum shear r/f	2 legged 8mm dia bars	
Asv(mm^2)	100.48	
Sv(mm)	302.3192	clause 26.5.1.6 IS 456

provide minimum as specified value of Sv above.

BEAM EXCEL SHEET

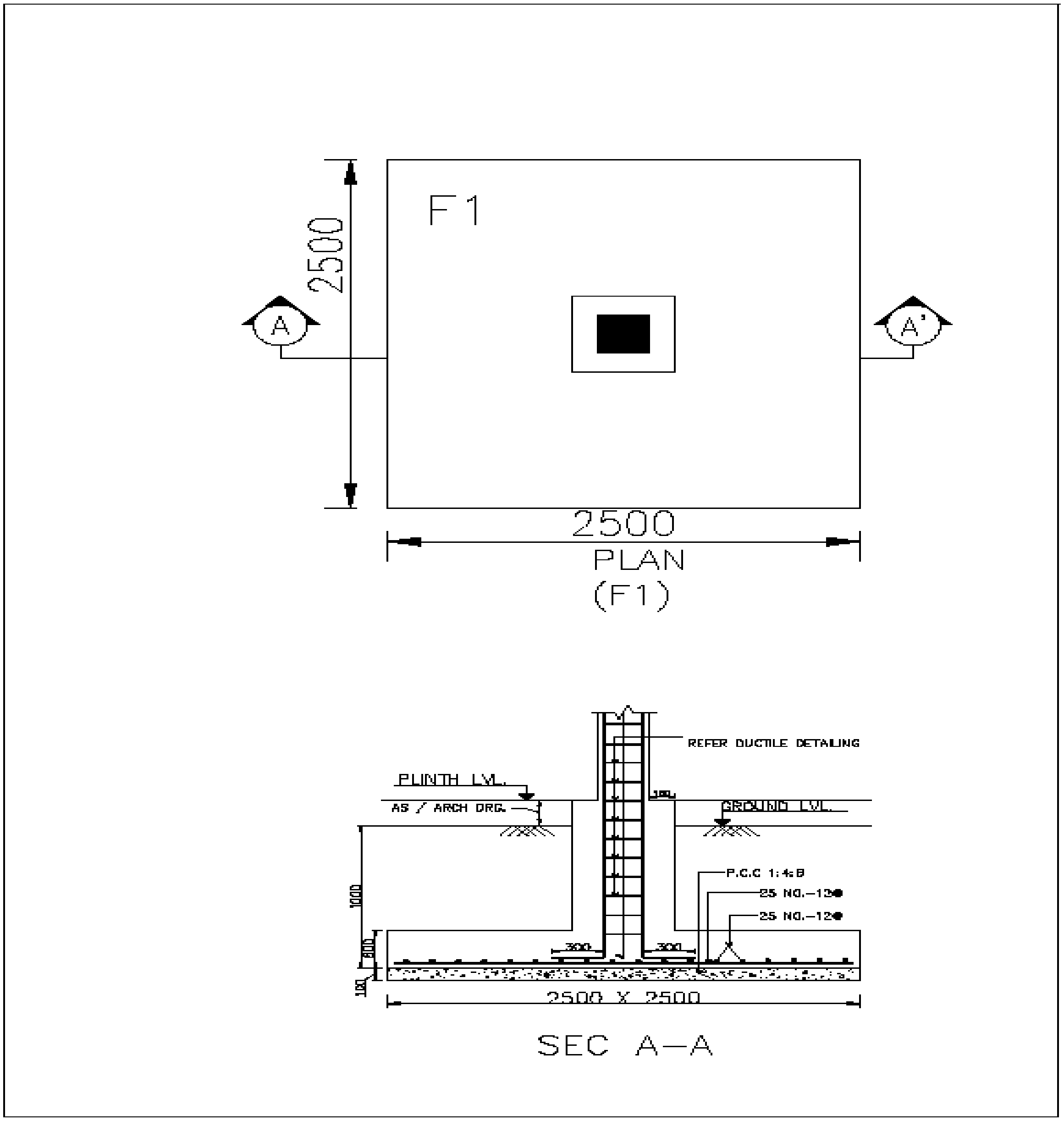


FIG (4.4) FOOTING DETAILS

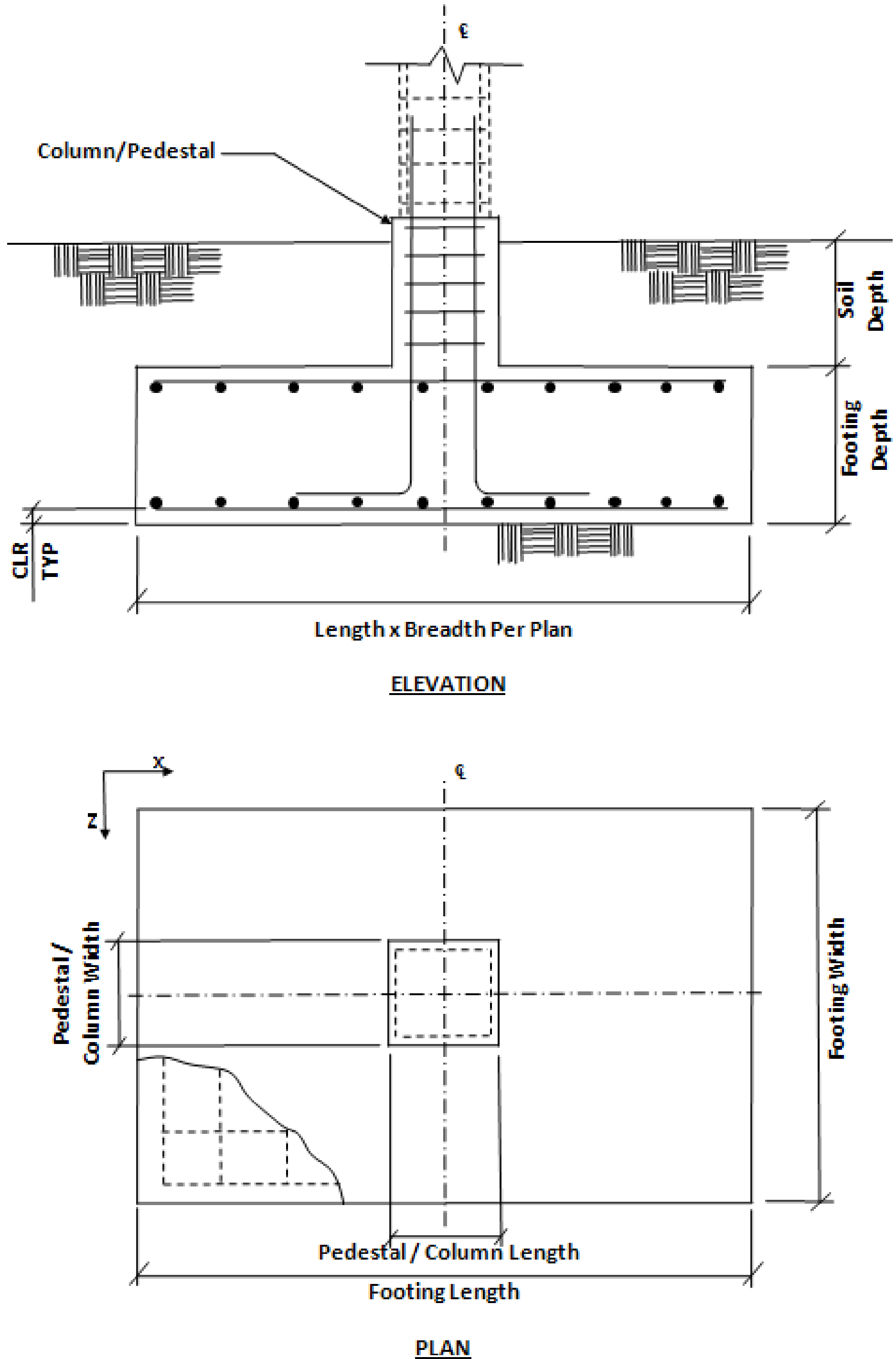
FOOTING EXCEL SHEET

ISOLATED FOOTING

Input				
P (Axial Load)		728	kN	
S.B.C		150	kN/sqm	
Unit wt. of soil		18	kN/cum	
Calculations				
Wt of Footing including earth		873.6	kN	
Area of footing		5.824	sqm	
Side of footing		2.413296501	m	
	say	2.5	m	1.05
Net upward pressure due to factored load		174.72	kN/sqm	
BM about face of column		240.786	kNm	
Effective depth required		186.8061073	mm	
Provide overall depth		600	mm	
Effective depth		560	mm	
Area of steel	Mu/bd2	0.31	0.143	
		2802.8	sqmm	
No of 12 dia bars		25		
Percentage		0.14	%	
One way Shear Check				490
Shear force		214.032	kN	
Nominal shear stress		0.15288	N/sqmm	
Shear strength of M20.		0.2002		
		0.28	N/sqmm	

Two way shear		960
Area	6250000	
Shear force	930.978048	kN
Nominal shear stress	0.4329325	kN/sqmm
	1.118033989	kN/sqmm

4.2 ISOLATED FOOTING (STAAD FOUNDATION SOFTWARE)



Input Values

Footing Geomtery

Design Type :	Calculate Dimension
Footing Thickness (Ft) :	200.000 mm
Footing Length - X (Fl) :	1000.000 mm
Footing Width - Z (Fw) :	1000.000 mm
Eccentricity along X (Oxd) :	0.000 mm
Eccentricity along Z (Ozd) :	0.000 mm

Column Dimensions

Column Shape	Rectangle
Column Length - X (Pl) :	0.450 m
Column Width - Z (Pw) :	0.450 m

Design Parameters

Concrete and Rebar Properties

Unit Weight of Concrete :	25.000 kN/m3
Strength of Concrete :	20.000 N/mm2
Yield Strength of Steel :	415.000 N/mm2
Minimum Bar Size :	Ø12
Maximum Bar Size :	Ø12

Minimum Bar Spacing :	50.000 mm
Maximum Bar Spacing :	500.000 mm
Pedestal Clear Cover (P, CL) :	50.000 mm
Footing Clear Cover (F, CL) :	50.000 mm

Soil Properties

Soil Type :	Drained
Unit Weight :	18.000 kN/m3
Soil Bearing Capacity :	150.000 kN/m2
Soil Surcharge :	10.000 kN/m2
Depth of Soil above Footing :	750.000 mm
Cohesion :	0.000 kN/m2
Min Percentage of Slab :	0.000

Sliding and Overturning

Coefficient of Friction :	0.500
Factor of Safety Against Sliding :	1.500
Factor of Safety Against Overturning :	1.500

Load Combination/s- Service Stress Level					
LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
9	728.182	-70.665	-37.975	-6.035	11.638
10	582.398	-55.838	-30.374	-4.821	8.780
11	582.667	-56.662	-30.381	-4.830	9.527
12	582.358	-56.554	-29.518	-4.255	9.347
13	582.695	-56.534	-30.492	-4.991	9.313
14	582.692	-57.226	-30.386	-4.835	9.841
15	582.424	-56.402	-30.379	-4.826	9.093
16	582.733	-56.510	-31.242	-5.400	9.274
17	582.396	-56.530	-30.268	-4.665	9.307
18	535.371	-14.175	-29.972	-4.279	-64.239
19	502.092	-56.948	22.279	74.812	9.991
20	629.720	-98.889	-30.788	-5.377	82.860
21	662.999	-56.116	-83.039	-84.468	8.630
22	727.998	-69.797	-37.968	-6.026	10.975
23	728.334	-70.828	-37.977	-6.037	11.909
24	727.947	-70.693	-36.898	-5.319	11.684
25	728.368	-70.668	-38.115	-6.238	11.642
26	728.365	-71.533	-37.982	-6.044	12.301
27	728.030	-70.502	-37.973	-6.032	11.367
28	728.416	-70.637	-39.052	-6.750	11.592
29	727.995	-70.663	-37.835	-5.831	11.634
30	669.214	-17.719	-37.465	-5.348	-80.299
31	627.615	-71.185	27.848	93.515	12.488
32	787.150	-123.612	-38.485	-6.721	103.575
33	828.749	-70.145	-103.798	-105.585	10.788

34	377.941	10.547	-22.275	-2.934	-84.954
35	336.342	-42.919	43.038	95.929	7.833
36	495.877	-95.345	-23.295	-4.307	98.920
37	537.476	-41.879	-88.608	-103.171	6.132

Applied Loads - Strength Level					
LC	Axial (kN)	Shear X (kN)	Shear Z (kN)	Moment X (kNm)	Moment Z (kNm)
9	728.182	-70.665	-37.975	-6.035	11.638
10	582.398	-55.838	-30.374	-4.821	8.780
11	582.667	-56.662	-30.381	-4.830	9.527
12	582.358	-56.554	-29.518	-4.255	9.347
13	582.695	-56.534	-30.492	-4.991	9.313
14	582.692	-57.226	-30.386	-4.835	9.841
15	582.424	-56.402	-30.379	-4.826	9.093
16	582.733	-56.510	-31.242	-5.400	9.274
17	582.396	-56.530	-30.268	-4.665	9.307
18	535.371	-14.175	-29.972	-4.279	-64.239
19	502.092	-56.948	22.279	74.812	9.991
20	629.720	-98.889	-30.788	-5.377	82.860
21	662.999	-56.116	-83.039	-84.468	8.630
22	727.998	-69.797	-37.968	-6.026	10.975
23	728.334	-70.828	-37.977	-6.037	11.909
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25	728.368	-70.668	-38.115	-6.238	11.642
26	728.365	-71.533	-37.982	-6.044	12.301
27	728.030	-70.502	-37.973	-6.032	11.367
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29	727.995	-70.663	-37.835	-5.831	11.634

30	669.214	-17.719	-37.465	-5.348	-80.299
31	627.615	-71.185	27.848	93.515	12.488
32	787.150	-123.612	-38.485	-6.721	103.575
33	828.749	-70.145	-103.798	-105.585	10.788
34	377.941	10.547	-22.275	-2.934	-84.954
35	336.342	-42.919	43.038	95.929	7.833
36	495.877	-95.345	-23.295	-4.307	98.920
37	537.476	-41.879	-88.608	-103.171	6.132

Design Calculations

Footing Size

Initial Length (L_o) = 1.000 m

Initial Width (W_o) = 1.000 m

Uplift force due to buoyancy = 0.000 kN

Effect due to adhesion = 0.000 kN

Area from initial length and width, A_o = L_o X W_o = 1.000 m^2

Min. area required from bearing pressure, A_{min} = P / q_{max} = 5.630 m^2

Note: A_{min} is an initial estimation.

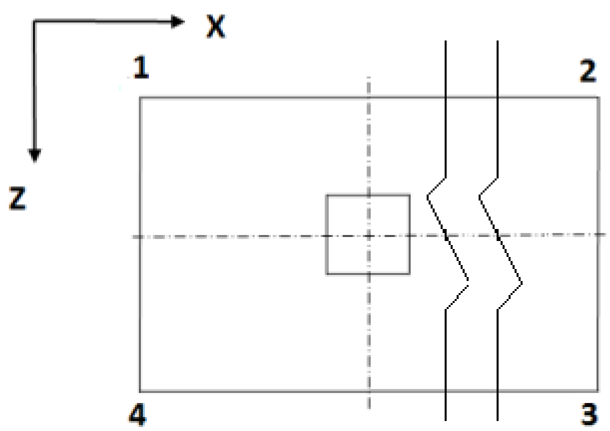
P = Critical Factored Axial Load(without self weight/buoyancy/soil).

q_{max} = Respective Factored Bearing Capacity.

Final Footing Size

Length (L_2) =	2.950	m	Governing Load Case :	# 33
Width (W_2) =	2.950	m	Governing Load Case :	# 33
Depth (D_2) =	0.370	m	Governing Load Case :	# 33
Area (A_2) =	8.703	m^2		

Pressures at Four Corner



Load Case	Pressure at corner 1 (q_1) (kN/m2)	Pressure at corner 2 (q_2) (kN/m2)	Pressure at corner 3 (q_3) (kN/m2)	Pressure at corner 4 (q_4) (kN/m2)	Area of footing in uplift (A_u) (m^2)
33	148.7460	137.1458	78.0880	89.6882	0.000
33	148.7460	137.1458	78.0880	89.6882	0.000
30	80.1470	116.0252	110.0228	74.1446	0.000
32	141.9919	82.0213	75.2818	135.2525	0.000

If A_u is zero, there is no uplift and no pressure adjustment is necessary. Otherwise, to account for uplift, areas of negative pressure will be set to zero and the pressure will be redistributed to remaining corners.

Summary of adjusted Pressures at Four Corner

Load Case	Pressure at corner 1 (q_1) (kN/m2)	Pressure at corner 2 (q_2) (kN/m2)	Pressure at corner 3 (q_3) (kN/m2)	Pressure at corner 4 (q_4) (kN/m2)
33	148.7460	137.1458	78.0880	89.6882
33	148.7460	137.1458	78.0880	89.6882
30	80.1470	116.0252	110.0228	74.1446
32	141.9919	82.0213	75.2818	135.2525

Details of Out-of-Contact Area
(If Any)

Governing load case = N/A

Plan area of footing = 8.703 sq.m

Area not in contact with soil = 0.000 sq.m

% of total area not in contact = 0.000%

Check For Stability Against Overturning And Sliding

-	Factor of safety against sliding		Factor of safety against overturning	
Load Case No.	Along X-Direction	Along Z-Direction	About X-Direction	About Z-Direction
9	6.272	11.671	95.930	50.735
10	6.632	12.192	100.268	54.767
11	6.538	12.194	100.209	52.390
12	6.548	12.545	107.532	52.881
13	6.553	12.150	98.556	53.001
14	6.474	12.193	100.156	51.343
15	6.566	12.191	100.215	53.623
16	6.556	11.859	93.828	53.118
17	6.551	12.235	101.925	52.998
18	24.467	11.571	99.591	16.662
19	5.798	14.820	12.288	45.557
20	3.984	12.797	100.765	11.324
21	7.317	4.945	11.985	61.015
22	6.349	11.671	95.983	52.427

23	6.259	11.673	95.928	50.152
24	6.268	12.009	102.937	50.621
25	6.273	11.631	94.346	50.737
26	6.197	11.672	95.877	49.150
27	6.286	11.670	95.932	51.332
28	6.276	11.353	89.820	50.849
29	6.271	11.712	97.570	50.733
30	23.350	11.043	95.047	15.901
31	5.520	14.110	11.699	43.373
32	3.824	12.283	96.717	10.869
33	7.035	4.754	11.523	58.663
34	25.419	12.036	107.031	9.084
35	5.762	5.746	6.979	44.438
36	3.430	14.040	107.610	8.177
37	8.306	3.926	8.489	70.732

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding X Direction

Critical Load Case for Sliding along X-Direction : 36

Governing Disturbing Force : -95.345 kN

Governing Restoring Force : 327.070 kN

Minimum Sliding Ratio for the Critical Load Case : 3.430

Critical Load Case for Overturning about X-Direction : 35

Governing Overturning Moment : 104.537 kNm

Governing Resisting Moment : 729.528 kNm

Minimum Overturning Ratio for the Critical Load Case : 6.979

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding Z Direction

Critical Load Case for Sliding along Z-Direction :	37
Governing Disturbing Force :	-88.608 kN
Governing Restoring Force :	347.869 kN
Minimum Sliding Ratio for the Critical Load Case :	3.926
Critical Load Case for Overturning about Z-Direction :	36
Governing Overturning Moment :	117.988 kNm
Governing Resisting Moment :	964.838 kNm
Minimum Overturning Ratio for the Critical Load Case :	8.177

Moment Calculation

Check Trial Depth against moment (w.r.t. X Axis)

Critical Load Case = #37

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.194 m

Governing moment (M_u) = 189.045 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 (K_{umax}) = $\frac{700}{(1100 + 0.87 \times f_y)}$ = 0.479107

Limiting Factor2 (R_{umax}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 2755.432917 kN/m2

Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^{\,2}$ = 305.919649 kNm

$M_u <= M_{umax}$ hence, safe

Check Trial Depth against moment (w.r.t. Z Axis)

Critical Load Case = #37

Effective Depth = $D - \left(cc + 0.5 \times d_b\right)$ = 0.194 m

Governing moment (M_u) = 147.943 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 (K_{umax}) = $\frac{700}{\left(1100 + 0.87 \times f_y\right)}$ = 0.479107

Limiting Factor2 (R_{umax}) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 2755.432917 kN/m2

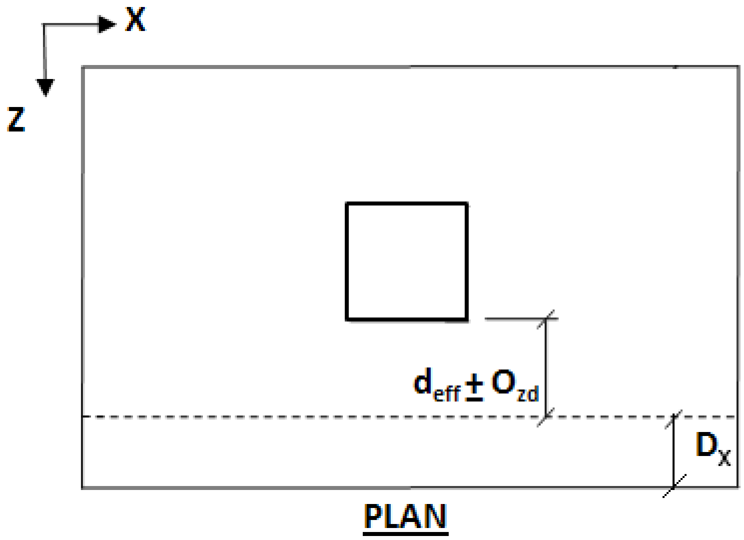
Limit Moment Of Resistance (M_{umax}) = $R_{umax} \times B \times d_e^{\,2}$ = 305.919649 kNm

$M_u <= M_{umax}$ hence, safe

Shear Calculation

Check Trial Depth for one way shear (Along X Axis)

(Shear Plane Parallel to X Axis)



Critical Load Case = #33

D_X = 0.314 m

Shear Force(S) = 318.617 kN

Shear Stress(T_v) = 343.967821 kN/m2

Percentage Of Steel(P_t) = 0.2290

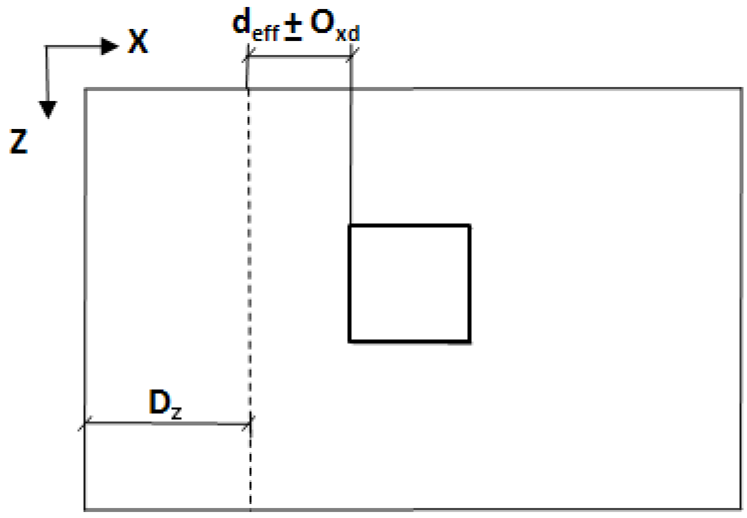
As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 345.937 kN/m2

$T_v < T_c$ hence, safe

Check Trial Depth for one way shear (Along Z Axis)

(Shear Plane Parallel to Z Axis)



PLAN

Critical Load Case = #32

D_Z = 0.304 m

Shear Force(S) = 309.267 kN

Shear Stress(T_v) = 344.856653 kN/m2

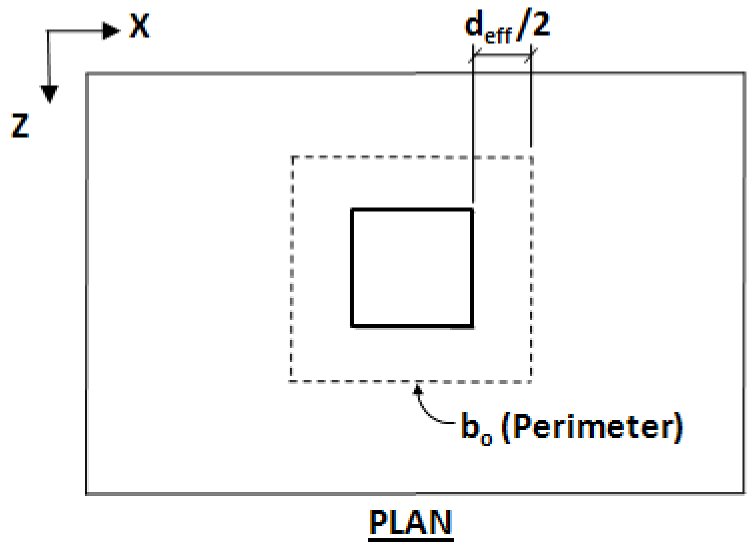
Percentage Of Steel(P_t) = 0.2283

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 345.443 kN/m2

$T_v < T_c$ hence, safe

Check Trial Depth for two way shear



Critical Load Case = #33

Shear Force(S) = 773.163 kN

Shear Stress(T_v) = 805.728 kN/m2

As Per IS 456 2000 Clause 31.6.3.1

K_s = $\min[(0.5 + \beta), 1]$= 1.000

Shear Strength(T_c)= $0.25 \times \sqrt{f_{ck}}$= 1118.0340 kN/m2

K_s x T_c = 1118.0340 kN/m2

T_v<= K_s x T_c hence, safe

Reinforcement Calculation

Calculation of Maximum Bar Size

Along X Axis

Bar diameter corresponding to max bar size (d_b) = 12 mm

As Per IS 456 2000 Clause 26.2.1

Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}}$ = 0.541 m

Allowable Length(l_{db}) = $\left[\frac{(B - b)}{2} - cc\right]$ = 1.200 m

l_{db} >=l_d hence, safe

Along Z Axis

Bar diameter corresponding to max bar size(d_b) = 12 mm

As Per IS 456 2000 Clause 26.2.1

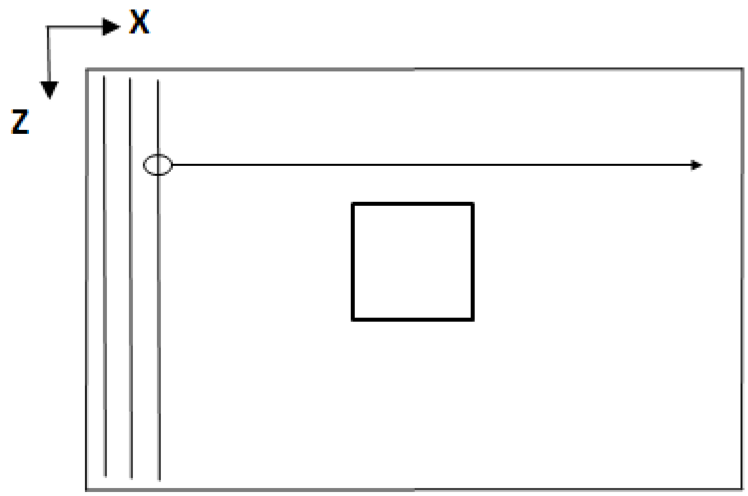
Development Length(l_d) = $\frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}}$ = 0.541 m

Allowable Length(l_{db}) = $\left[\frac{(H - h)}{2} - cc\right]$ = 1.200 m

l_{db} >=l_d hence, safe

Bottom Reinforcement Design

Along Z Axis



PLAN

For moment w.r.t. X Axis (M_x)

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case	= #37
Minimum Area of Steel (A_{stmin})	= 885.000 mm2
Calculated Area of Steel (A_{st})	= 3032.417 mm2
Provided Area of Steel ($A_{st,Provided}$)	= 3032.417 mm2
A_{stmin}<= $A_{st,Provided}$	Steel area is accepted

Selected bar Size (d_b)	= Ø12
Minimum spacing allowed (S_{min})	= 52.000 mm
Selected spacing (S)	= 109.154 mm

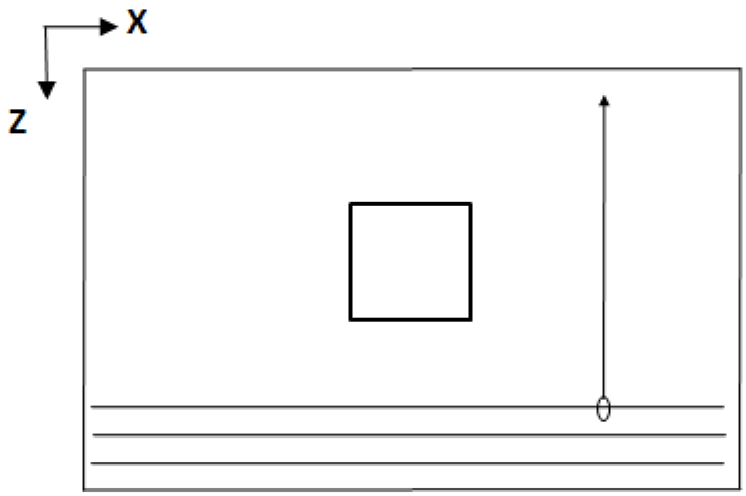
S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø12 @ 105.000 mm o.c.

Along X Axis



PLAN

For moment w.r.t. Z Axis (M_z)

As Per IS 456 2000 Clause 26.5.2.1

Critical Load Case	= #37
Minimum Area of Steel (A_{stmin})	= 885.000 mm2
Calculated Area of Steel (A_{st})	= 2304.792 mm2
Provided Area of Steel ($A_{st,Provided}$)	= 2304.792 mm2
$A_{stmin} <= A_{st,Provided}$	Steel area is accepted

Selected bar Size (d_b) = Ø12

Minimum spacing allowed (S_{min}) = = 50.000 mm

Selected spacing (S) = 141.900 mm

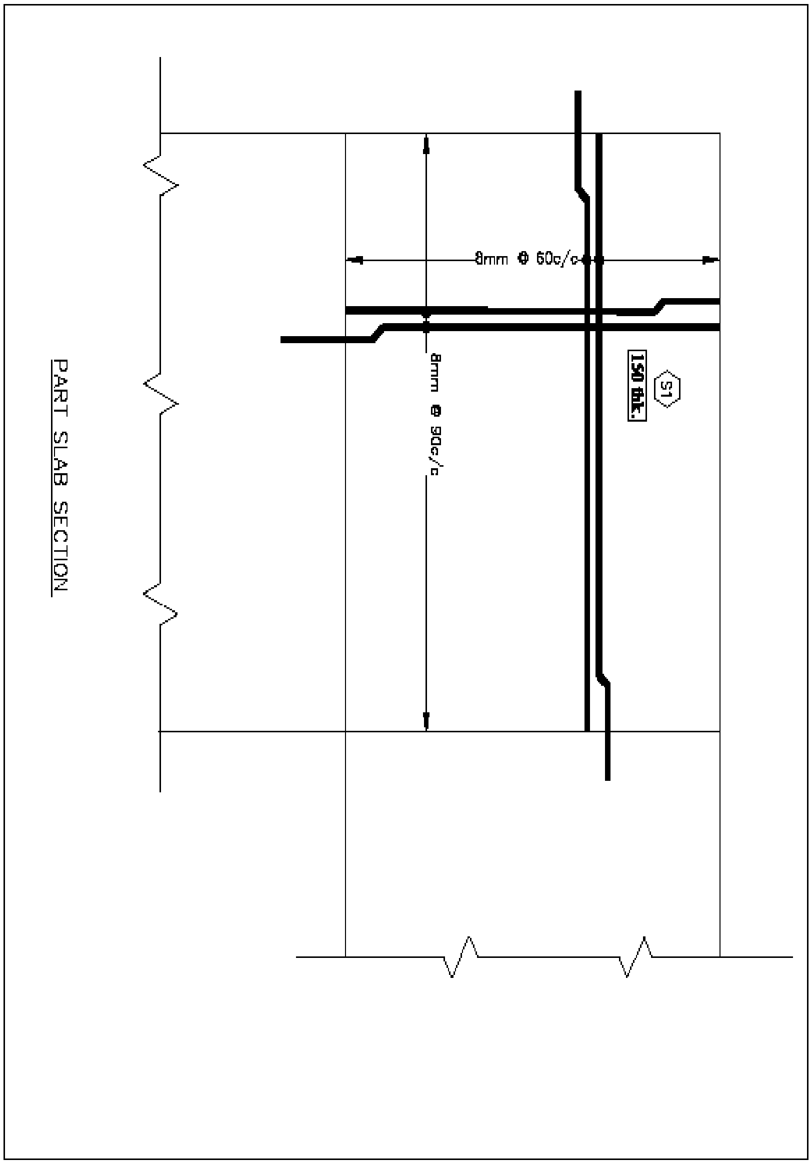
S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size...

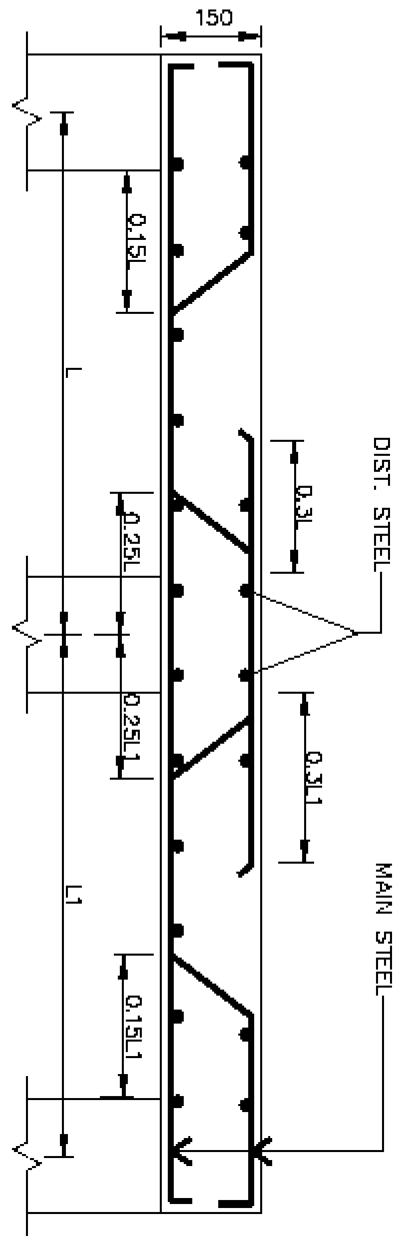
The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø12 @ 140.000 mm o.c.

4.4 TYPICAL SLAB CALCULATION





TYPICAL SLAB SECTION

Ist Case

Panel size = 6 x 8 m

Ly = 8 m

Lx = 6 m

Assume D = 150 mm

d =135 mm

Ly/Lx = 1.33

From IS 456 for Ly/Lx = 1.33 (Case 4)

Negative αx = 0.067

Negative αy = 0.047

Positive αx = 0.051

Positive αy = 0.035

Negative Moment at supports

Negative Mx = 0.067 (9.0 x 1.5) x 6^2 = 23.56kNm

Negative My = 0.051x (9.0 x 1.5) x 6^2 = 16.08 kNm

Positive Moment at midspan

Positive Mx = 0.053x (12.75 x 1.5) x 3.18^2 = 17.85 kNm

Positive My = 0.035x (10 x 1.5) x 3.18^2 = 11.76kNm

$$d = \sqrt{\frac{23.56 \times 10^6}{0.138 \times 20 \times 1000}} = 80.53 < 135\text{mm}$$

Area of steel (Ast) for shorter span (mm^2)

$Mu = 0.87 \times Fy^* A_{st} (d - Fy A_{st}) B \times F_{ck}$ A_{st} x (at edge) = 829.79 mm^2

$A_{st\,min}$ = 0.12% bD = 0.12 x 1000 x 150/100 =180 mm^2

Provide 8mm dia bars @ 60mm c/c parallel to shorter side at middle strip of ¾ Ly for continuous edge.

Ast x(at mid span) = 555.34 mm^2

Provide 8mm dia bars @ 80mm c/c parallel to shorter side at middle strip of ¾ Ly for mid span.

Area of steel for longer span (mm^2)

A_{st} y (at edge) = 601.69 mm^2

$A_{st\,min}$ = 0.12% bD = 0.12 x 1000 x 150/100 =180 mm^2

Provide 8mm dia bars @ 90mm c/c parallel to longer side at middle strip of ¾ Lx for continuous edge.

Ast x(at mid span) = 403.34 $mm^2 < A_{st\,min}$

Provide 8mm dia bars @ 120mm c/c parallel to longer side at middle strip of ¾ Lx for mid span.

1.Check for shear

S.F= Vu = 12.75 x 1.5 x 3.05/2 = 29.165 kN

$\tau_v = \frac{Vu}{Bd} = 0.322$ MPa

$P_t = \frac{100\,Ast}{Bd} = 0.238\%$

From IS 456 :2000

$\tau_c = 0.552$ MPa

$\tau_v < \tau_c$

It is safe in shear.

2.Check for deflection

Required Ast = 829 mm^2

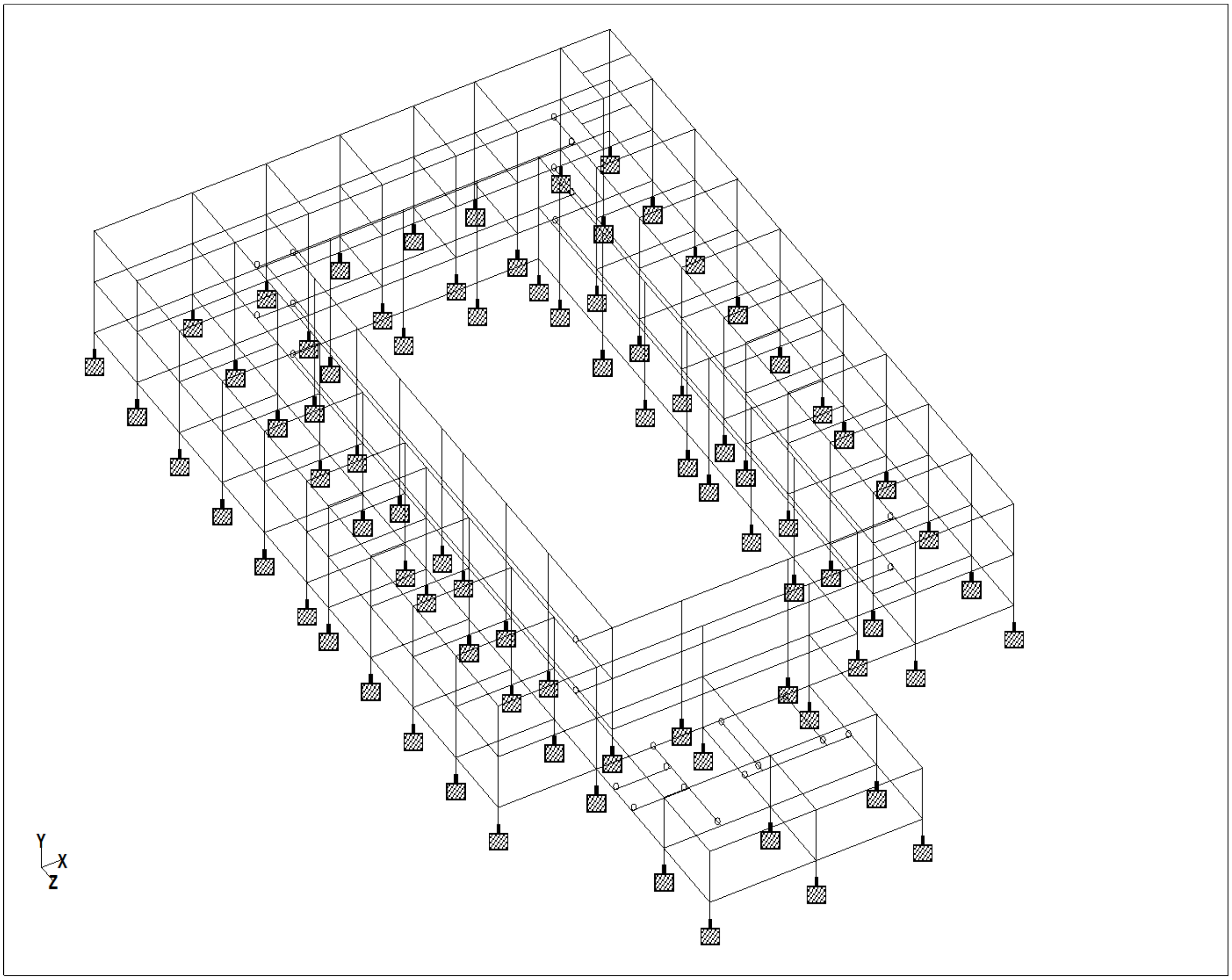
Provided Ast = 833 mm^2 (8 mm @ 60 c/c)

$f_s = 0.58 \times 415 \times 8297/833 = 240$

From Fig. (4) of IS 456 , $\gamma = 1.8$

$d = \frac{Lx}{\alpha\beta\gamma\delta\lambda} = \frac{6000}{26x1x1.8x1x1} = 128 < 135mm$ (OK)

It is safe in deflection.



Fig(4.5)Whole Structure

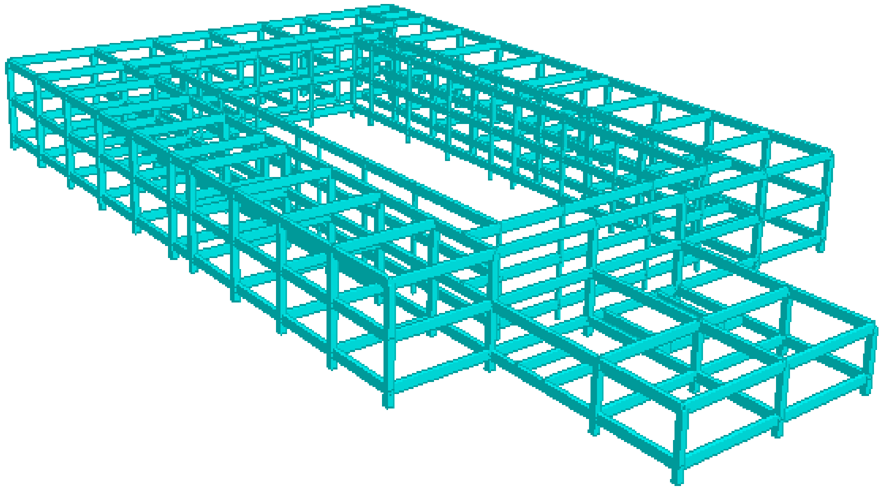


Fig.(4.1) 3D Rendered View On StadPro

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- CBSE Norms For School Designing

Indian Standard Codes and Handbooks

- IS 13920, Ductile Detailing
- IS 456:2000,Columns,Beams,slab

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- Estimating and Costing in Civil Engineering by B.N. Dutta Edition 2012
- Dell'Isola, Alphonse J , and Stephen J. Kirk. Life Cycle Costing for Design Professionals. New York: McGraw-Hill, 1981.
- "Energy benchmarks: a detailed analysis (e-Energy 2006)". ACM. ISBN 978-1-4503-0042-1. Meikel Poess, Raghunath Nambiar, Kushagra Vaid, John M. Stephens, Jr., Karl Huppler, Ev