PLANNING, ANALYSIS AND DESIGN OF AUDITORIUM

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Abstract: This project deals with the design of an auditorium so as to accommodate 1200 persons. Required area is calculated as per NBC. This includes planning, analysis of loads and designing of structural elements based on the loads coming on them (live loads, dead loads, wind loads as per IS:875). The shape of the auditorium is linear(rectangular). This is so because the plan is based on acoustic and vision point of view, which are taken from NBC part-VIII, for which linear shape is best suitable.
Introduction:- One of the important elements of any college to gather people for seminars, workshops or any cultural events is auditorium. The auditorium should provide convenient homage for the people residing in the campus for social and cultural activities like meetings, college day functions, competitions and other programs etc.,This project deals with the planning, analysis and design of an auditorium for a seating capacity of 1200 persons. Regarding the shape, it is a rectangular auditorium. Area and other specifications are taken from IS 2526:1963 (Code of practice for acoustical design of Auditorium and conference halls) and NBC (National Building Code). The limit state method of collapse using IS: 456-2000, and SP-16 have been adopted for the design of structural components like slabs, beams, columns and foundations.
Design and analysis is done manually and the results are verified using STAAD Pro. We have used the AUTO CAD.
Keywords: Design of roof truss-Beams-Slabs-Colums-Staircase-Foundation-Auto cad –Staad Pro.

I. SPECIFICATION

A number of standard codes approved by Indian Standard institutions has specified the following minimum requirements for the construction of the auditoriums

A. FRONT AND REAR OPEN SPACES:
No person shall erect a building unless it is set back at least 6m from the regular line of the street or from the street if no such regular line exists.
B. PLAN AREA:
Plan area of the building is to be fixed at a occupant load of range 0.6 to 0.9m²/member cI
C. SEATING REQUIREMENTS:
Width of the seat should be between 45 to 56cm.The back to back distance of the chairs shall be at least 85cm
D. DOOR AND WINDOW REQUIREMENTS:
Every exit of the auditorium shall provide a clear opening space of not less than 1.5m in width.

II. PLANNING

The cross section of the auditorium is a linear section. Total height of the auditorium is 6.4m Theheight of ground floor is 3.3528m.Balcony floor starts from there and inclined up to a height of 0.762 from 3.3528m.Required area is calculated based on the area required per person which is taken as 0.75m²/member. so, the area required is 10000sq.ft.
Hence the dimensions are fixed as **54.864x18.288m**

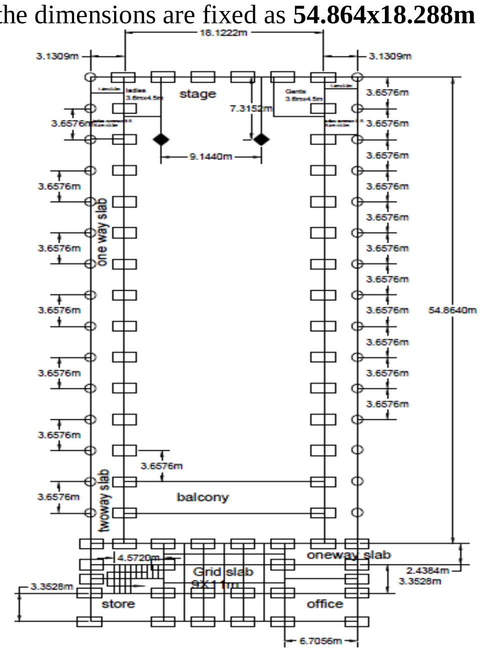


Figure 1:Plan of Auditorium

III. LOAD CALCULATIONS

Dead loads are taken from IS-875 part 1.
Live loads are taken from IS-875 Part2.
Wind loads are taken from IS- 875 Part 3.

IV. STRUCTURAL ANALYSIS

the equilibrium conditions along thatis,
$\Sigma Fx = 0$, $\Sigma Fy = 0$, $\Sigma Fz=0$, $\Sigma My = 0$, $\Sigma Mz = 0$.Then the structure is statically determinate, if not it is statically indeterminate of redundant various methods popularly used for analysis includes
Moment distribution method
Kani'smethod
Substitute framemethod
Slope deflectionmethod
Matrixmethods
4.1 KANI'S METHOD OF FRAMEANALYSIS:
It is also known as Rotation Contribution Method. This is a

good iterative procedure avoiding the mistakes during the execution of the process i.e. error is self- eliminative. Kani's method is used for the analysis of structure.

General slope deflection equations are: Mab =MFab + 2EI/L(-2θa-θb) ………(1)

Mba =MFba +2EI/L(-θa-2θb) ……….(2) Equation 1 can be writtenas

Mab = MFab + 2M´ab+M´ba ……….(3)

V. DESIGN OF STRUCTURAL MEMBERS

DESIGN OF ROOFTRUSS:

Span ofthetruss =18.0m, Height of the truss=3.0m, Angle,θ=18^0,Length of the in cline member=9.48m

5.1 DESIGN OF PURLIN

DEADLOADS:

Self weightofpurlin= 0.100KN/mTotal D.L = 0.3054KN/m

LIVELOADS:As per IS 875part2

Roof Slope	Access	Live Load
≤ 10^0	With access	1.5 KN/m² of plan area
> 10^0	Without access	0.75 KN/m² of plan area Note : For roof sheets or purlins, 0.75 KN/m² less than 0.01 KN/m² for every degree increase in slope up to 200&

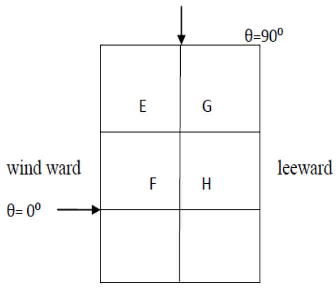
Table 1: Live Loads

Live load on purlin=0.75-0.01 (180-100) =0.66 KN/m² x1.58 cos180 = **1.0KN/m**

Windloads:

Design wind speed Vz = Vb x K1 x K2 x K3 = 50m/s

Design wind pressure, Pz = 0.6 Vz ² = 1500 N/m² = 1.5KN/m²



Roof angle, θ	**θ=0^0**		**θ= 90^0**	
	EF	**GH**	**EG**	**FH**
10^0	-1.2	-0.4	-0.8	-0.6
18^0	-0.539	-0.4	-0.717	-0.6
20^0	-0.4	-0.4	-0.7	-0.6

Table 2: External pressure coefficient valuesinternal pressure coefficient (Cpi) = +0.50 & -0.50

Cpi	Cpe + Cpi			
+0.50	-0.039	0.1	-0.217	-0.1
-0.50	-1.039	-0.9	-1.217	-1.1

Table 3: Wind loads

Try ISMC 150

Section properties

b_f= 75mm; t_f= 9.0mm; t = 5.4mm; h = 150mm;

Deflection check

δ actual = 5/384 x wl3/EI =(5/384) x (2.591x3.65x3650^3x10^3) = 3.84mm<20.27mm

ROOF TRUSS

DEADLOAD

Roof coverings=130N/m²

Purlins=100N/m²,self weightofrooftruss(span/3+5)*10=(18/3 +5)*10 =110N/m², Windbracings12N/m², Total load352N/m²,Total dead load on truss=span *spacing*D.L= 18x3.65x352 = 23126.4N

LIVELOAD

Total live load = 18x3.65x0.66 = 43690.5N

WIND LOAD

Wind pressure = 1500N/ m² critical wind load = -1.217 KN/m²

Total wind load on the sloping length = 9.48x3.65x1217 = 42110.6N

Member	Dead loads		Live loads KN		Wind loads KN		D.L + L.L KN		D.L + W.L KN	
	C	T	C	T	C	T	C	T	C	T
Rafter AL , GH	30.47 24.3		57.57 46.0			105.28 86.6	88.04 70.4			74.81 62.2
Tie AB , FG BC ,		28.91 28.9		54.61 54.6	97.66 97.6			83.52 83.5	68.75 68.7	
Vertical LB , HF		0.00 1.928		0.00 3.64 10.9	0.00 7.404			0.00 5.572	0.00 5.47 9.02	
inclined LC ,	6.099		11.52			23.41	17.62			17.31

Table 4: Summary of loads on roof truss

Design of Rafter Member:

Maximum compressive force=88.043KNFactored compressive force =1.5x88.043 =132.06KN, Maximum tensile force=74.816KN.

Section property

Area = 1858mm²; r_{min} = 24.6mm; t = 6.0mm Take K=0.85 & length, L = 3160mm

In tension

Tensile strength of the section in the gross section yielding is Tdg= fyAg/γmo = (250x1858x10^{-3})/1.10 =422.27KN>

Connections

Let us provide 20mm diameter bolts of grade 4.6Provide 3,20mm ø bolts

Design of Tie Member:

Maximum compressive force =68.758KNMaximum tensile force=83.525KN Try 2Nos ISA 65x65x6.0mm

Section property

Area = 1488mm²; r_{min} = 19.8mm; t = 6.0mm Take K=0.85 & length, L = 3000mm

Connections

Let us provide 20mm diameter bolts of grade 4.6 Provide 3, 20mm ø bolts

Design of Vertical Member:
Maximum compressive force =9.021KN,Factored compressive force =1.5x9.201= 13.531KN, Maximum tensileforce =16.721KN,Length of the member, L =3000mm.Try IS 50x50x6.0mm

Section properties
Area= 568mm²; r_{vv} = 9.6mEffective length, KL = 0.85x3000 = 2550mmλ_{vv}=1/r_{vv} = (2550/9.6)/(1.0x$\sqrt{\pi 2}$ x2x105/250) = 2.9893

Connections
Let us provide 20mm diameter bolts of grade 4.6Provide 2, 20mm ø bolts

Design of Inclined Members:
Maximum compressive force =26.44KN
Factored compressive force =1.5x26.44 =39.66KN
Maximum tensile force =14.264KN
Length of the member, L =3160mm

Section properties
Try IS 60x60x6.0mm
Area= 684mm²; rvv = 11.5mm Effective length, KL = 0.85x3160 = 2686mm

Connections
Let us provide 20mm diameter bolts of grade 4.6Provide 2, 20mm ø bolts

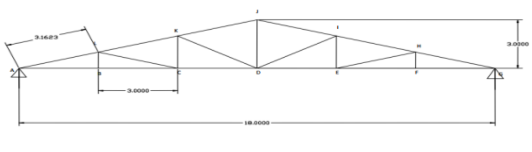


Figure2 - Roof Truss

DESIGN OF GRIDSLAB
Size of grid 11m x 9m, Spacing of ribs = 2mc/c,M25 grade concrete & fe415 steel.

Design Moments And Shear Force
My =αy ×w×lx² =0.056×7.42×11² =50.27KN-m

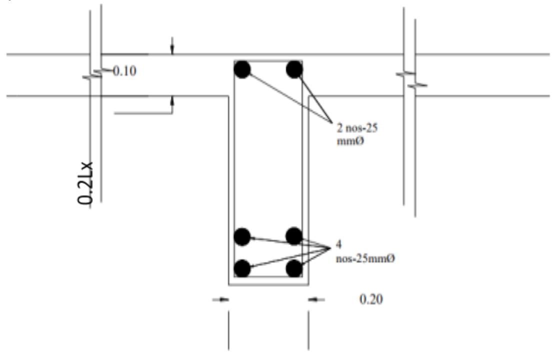


Figure 3:Reinforcement details in grid slab

Design Of Grid Beams
Spacing of grid beams = 2m,Design moment per grid beam = 53.49×2.0 = 106.98KN-m. Ultimate moment Mu = 1.5×106.98 = 160.47KN-m,Provide 3 bars of 20mm Ø as tension reinforcement
Provide 6mm Ø 2 legged stirrups @ 250mmc/c at supports &increase the spacing to 400mm towards centre of span.
Ingrid slabs we provide nominal reinforcement i.e.,6mm Ø bars @ 200mm c/c

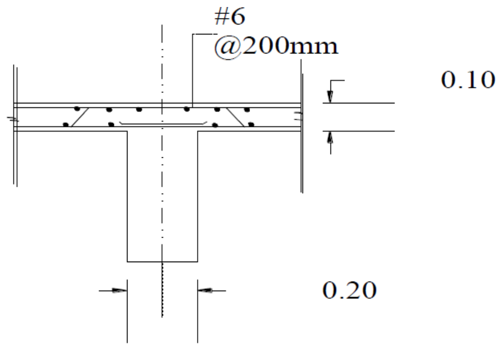


Figure 4: Reinforcement details in grid beam

VI. DESIGN OF TWO-WAY SLAB

Dimension of slab 3.65x3.04m
Ly / Lx = 3.65x3.04 =1.2 < 2
Note:If the span ratio is ≤ 2 it is designed as two-wayslab.
If the span ratio is >2 then it is designed as one-way slab.
Bending Moment
Moment in short span direction
Mx =αx×w×lx² = 0.071x10275x3.173² = 7.344KN-m,Moment in long span direction
My =αy ×w×lx² = 0.056x10275x3.173² = 5.793KN-m,Reinforcement in Short Span Direction Spacing= ∏/4 x10²x1000/167.4 = 450mmc/c 3d = 3x125 = 375mm; 300mm
Provide 10mm ø bars @ 300mmc/c in middle strip & half of the bars will bend from 0.15ly i.e., 560mm
Reinforcement in Edge Strip:
Spacing = ∏/4x8² x1000/ 180 = 270mm c/c

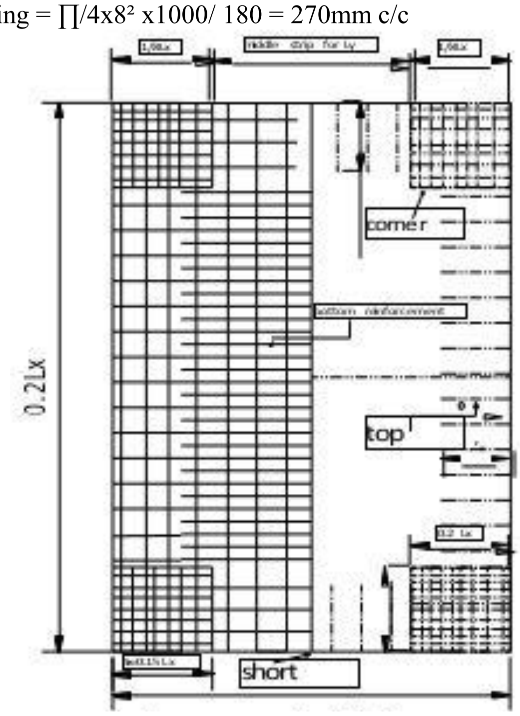


Figure5:Reinforcement details in two-way slab

VII. DESIGN OF ONE WAY SLAB

Span 3x33m, LX = 3m, LY = 33m
LY/LX = 33/3 = 10.8>2Hence it is designed as one-way slab.

Design Moment
M_u = Wu l²/8 = 9938×3.154²/8 = 12357N-m = 12.357×106 N-mm Vu = Wu l/2 = 9938×3.154/2 = 15672.2N

Reinforcement
Use 10mm Ø bars; A_{st} = π/4×10 = 78.54mm Spacing = 1000x π/4×10 / 346.54 = 226.6mm Maximum spacing = 3d (or) 300 mm
= 3×106 = 318mm
Provide 10mm Ø bars @226mm c/c

Distribution steel
Provide 8mm Ø bars; ast= Π/4×8 = 50.26mm Spacing =1000ast/Ast = 1000×50.26/150 = 335mm Maximum spacing = 5d (or) 450mm whichever less≤530 (or) 450mm
Spacing = 330mm

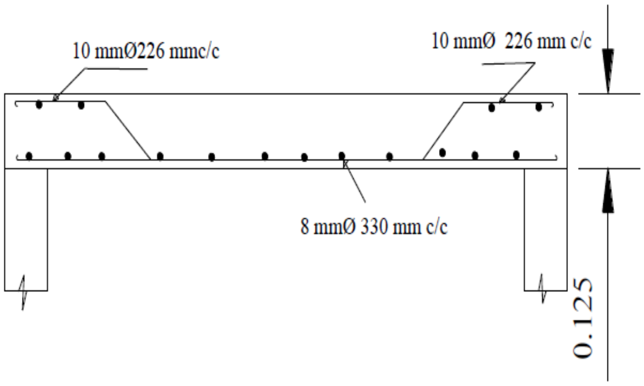


Figure 6: Reinforcement details in one-way slab

VIII. DESIGN OF STAIR CASE

1st Flight
1st flight length=4.57m; Width = 1.676m; No. of rises = 244/15 = 17rises
No. of threads = (n-1) = 17-1 =16 threads Length of flight =16×28 = 448cm(14'8½")

Computation Of Loading
Let the bearing of slab = 160mm
Slab spanning in same direction as the stairs
Let the thickness of waist slab = 200mm
Weight of waist slab on slope = 200/1000×25000 = 5000N/m²
Weight on horizontal area = 5000sec θ = 5000 √ (R²+T²)/T

Computation Of Reinforcement
Spacing = 113×1000/732 = 154.3mm Say 150mm c/c
Provide 12mm Ø bars @150mm c/c per unit meter

Design of Cantilever Beam Under Stair CaseLoading
Total load = 33796.4+28163.7+2250 = 64210.1N/m
Assume 20mm Ø bars & 8mm stirrups Nominal cover = 20mm
Effective depth = 440-20-8-10 = 402mm
Steel Reinforcement:
No. of bars =636.2/314.16 = 2.02 ~ 3 bars of 20mm Ø
Spacing = 100mm c/c
Shear Reinforcement:
Maximum Sv = 0.75×d = 0.75×402 = 301.5mm Provide 2 legged 8mm Ø stirrups @300mm c/c

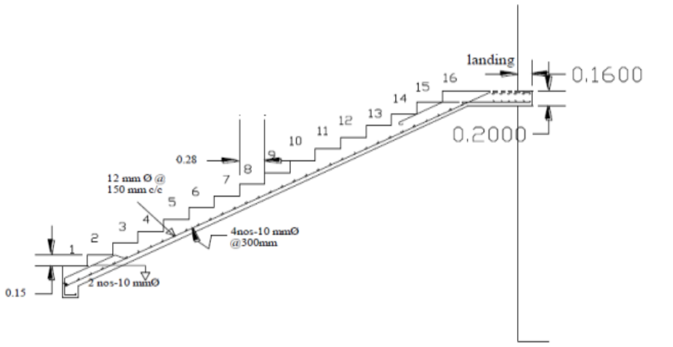


Figure7: Reinforcement details in stair case

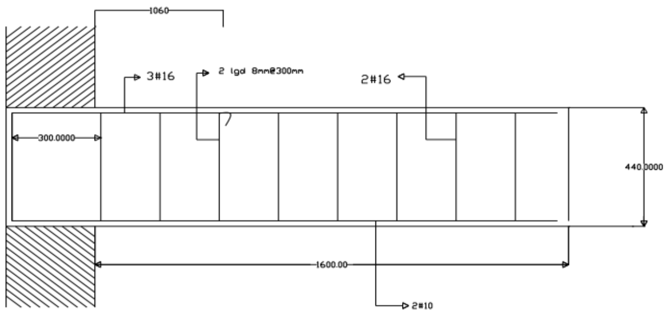
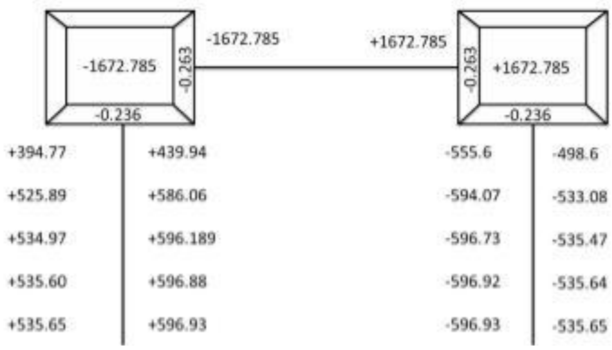


Figure7: Reinforcement details in cantilever beam under staircase

IX. DESIGN OFBEAMS

9.1 Design of L-Beam
General Considerations:
Rise =4"=101.6mm
Thread = 3' = 3x2.54 = 914.4mm
Dead load of waist slab = 12500N/m²
Weight of waist slab on slope = 12577N/m²
Dead weight of steps = (R/2000) x19200 = (101.6/2000)x19200 = 975.35 N/m²
Moment obtained from Kani's method is 1437.8KN-m

To Find Asc :
Provide 8 bars of 32 mm ø as tensile reinforcement & 4 bars of 32mm ø as compression reinforcement



Moment obtained from Kani's method is 1473KN-m
Check for Shear
Spacing, Sv = 0.87fy Asv d/ Vus = 130mm c/c Provide 2 legged 10mm ø stirrups @ 130mm c/c

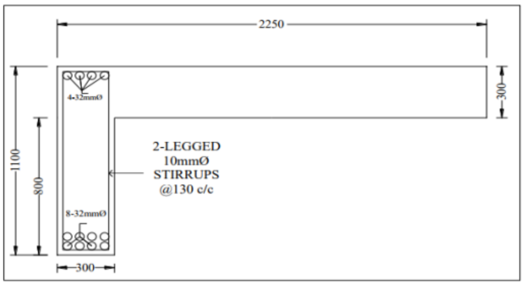
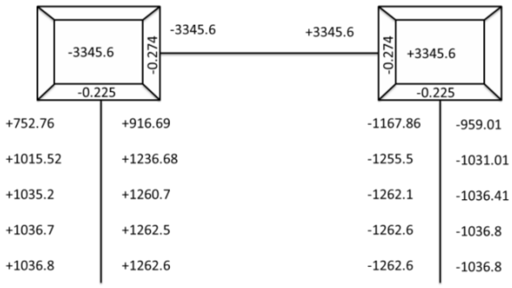


Figure 8: Reinforcement details in L-Beam

9.2 Design ofT-Beam

General considerations:b_f = lo $+b_w$ $+6d_f$ = (0.7x18)/2 +0.3+6x0.3 = 4200mm

Loading:-Total ultimate load coming on to the beam = 123911.4N/m



Reinforcement

Number of bars = 8427/804 = 11bars

Total Ast = 5813.6mm² Provide 11 bars of 32 mm ø

Check for Shear:

Provide 2 legged 8mm ø bars @ 300mm c/c

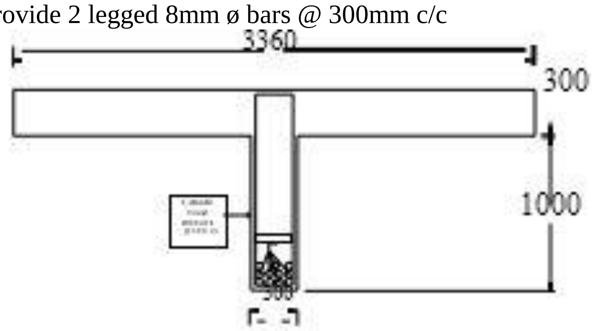


Figure 9: Reinforcement details in T-Beam

X. DESIGN OFCOLUMNS

10.1ExternalColumns

fck = 20N/mm²; fy = 415N/mm² Adopt D=250mm

Longitudinal Reinforcement:

Asc = 1/100 x49087.38 =490.87mm²

Use 12mm ø bars

Number of bars required = 490.87/113.09 = 5barsHowever provide a minimum of 6 bars for circular columns So provide 6 bars of 12mm øLateral Ties

Use 6mm ø bars as lateral ties Spacing:

Provide least of the above 3 values as spacing of the lateral ties So provide 6mm lateral ties @ 190mm c/c

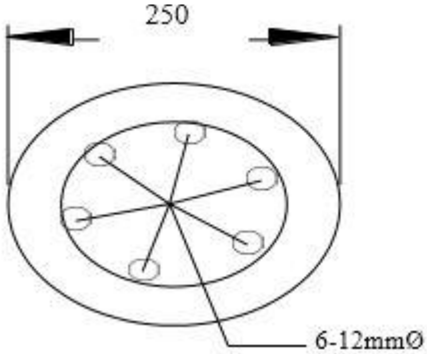


Figure 10: Reinforcement details in external columns

10.2InternalColumns

fck = 20N/mm²; fy = 415N/mm² Adopt b=300mm; d=600mm

Loading:

Dead load of roof truss = 23.126KN Live load on roof truss = 43.690KN

Load coming on to the column from roof truss = 1/2(23.126+43.690) = 50.112KN

Load due to self weight = 174.307KN

Load due to self weight of beams = 10.98KN

Longitudinal Reinforcement:

Asc = 0.8/100 x300x600 =1440mm²

Use 16mm ø bars

Number of bars required = 1440/201 = 8bars Provide 8 bars of 16mm ø

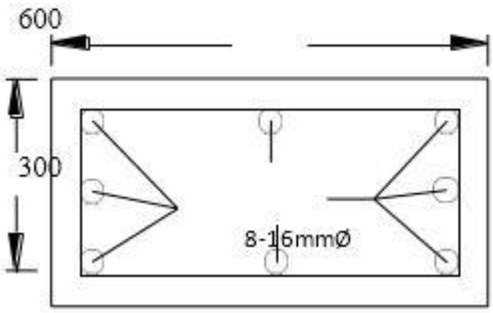


Figure11:Reinforcement details in Internal columns

XI. DESIGN OFFOUNDATION

The type of soil present at the sight is EXPANSIVE SOIL (Black Cotton Soil)whose safe bearing capacity is 50kN/m2. So we have adopted the pile foundation.Ignoring the effect of water table.

Pile foundation:

Under Internal Columns:

Factored Load coming from the column = 550KN As per IS 2911 Part III 1980Provide 7 bars 0f 12mm ø as longitudinal reinforcement with lateral ties spacing at 30cms

Loading:

bending moment = 212.75KN-m Maximum shear = 287.75KN

Main Reinforcement:

Use 25mm ø bars

Required number of bars = 2007/ ∏/4 x25² =5bars provide 5 bars of 25mm ø as main reinforcement

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Secondary Reinforcement:
Use 10mmø bars
Provide 6 bars of 10mmø as secondary reinforcement
Bending Moment
Bending of one pile loaded in the YY-direction (p x distance to CG of 3-piles loads)
M1 = 1566.575 x 2/3 x2.7 = 2819.835 kN-m

Reinforcement

So provide 5bars of 25mm ø as main reinforcement

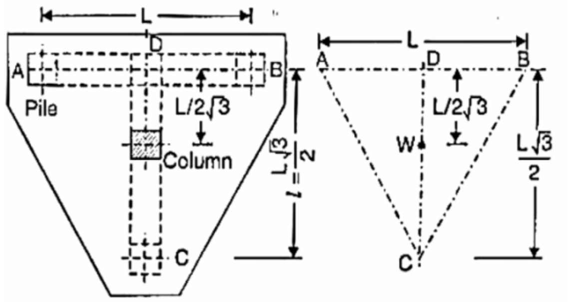
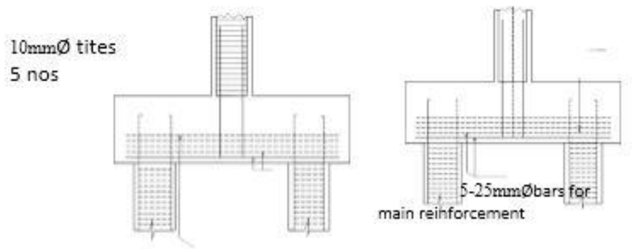
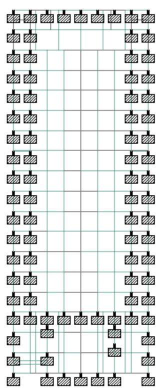


Figure: 12. Layout of Pile cap

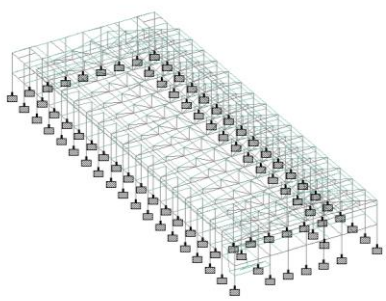


10mmØ ites 5 nos
Figure:13. Reinforcement details in foundation

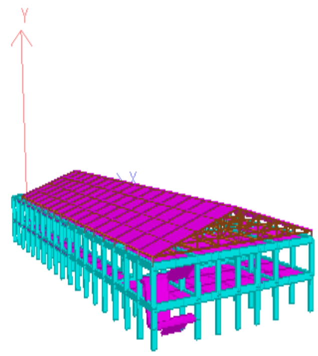
Top view of auditorium from stadd pro v8i



3D- view of auditorium



3D- Rendering of auditorium



XII. CONCLUSION

- Planning has been done for 1200 students in accordance with the specifications made by NATIONAL BUILDING CODE and IS 2526:1963(Code of practice for acoustical design of Auditorium and conferencehalls). This project Gives the brief Idea about how to analyze and design .
- auditorium with minimum facilities required.
- Used AUTOCAD 2010,Staad Pro V8i effective representation ofdrawings.
- Used IS-456:2000 & SP-16, for the design of the STRUCTURAL MEMBERS. i.e., followed the LIMIT STATEmethod.
- Materials used are M20 grade concrete and Fe 415 steel unless mentioned in the particular designelements.
- The construction of auditorium presents a solution of many cultural events programs being held
- In this project Seating Arrangement has provided as per NBC
- It was analysis using STADD .PRO using generic loading

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