SEISMIC ANALYSIS AND DESIGN OF AUDITORIUM

Kishan Dewangan[1], Dr. S. K. Jaiswal[2]

[1]M. Tech Scholar, Bhilai Institute of Technology, Durg, India
[2]Professor, Bhilai Institute of Technology, Durg, India

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Abstract: *This project deals with Seismic analysis and design of an auditorium so as to accommodate 964 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, Seismic as per IS:1893). The shape of the auditorium is linear(i.e Fan 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.*

Keywords: Design of roof truss-Beams-Slabs-Columns-Auto cad –Staad Pro.

1. INTRODUCTION

Auditorium, the part of a public building where an audience sits, as distinct from the stage, the area on which the performance or other object of the audience's attention is presented. In a large theatre an auditorium includes a number of floor levels frequently designed as stalls, private boxes, dress circle, balcony or upper circle, and gallery. A sloping floor allows the seats to be arranged to give a clear view of the stage. The walls and ceiling usually contain concealed light and sound equipment and air extracts or inlets and may be highly decorated. It enables the crowd peoples to watch and hear the ongoing program, performance, speech, drama etc while gathering huge audience in the hall.

The prime motive of this project is to plan acoustically with standard provisions and proper analysis of the different type of loads in different seismic zone (II, III, and IV) in Staad pro v8i and Design it further. It also includes foundation design.

Any engineering structure should satisfy the functional and structural needs, have a sufficient degree of performance, a reasonable cost and should be aesthetically attractive. The purpose of structural analysis and design is to enable the designers to design the structure with adequate strength, stiffness, and stability. Design is done manually. The analysis is done by using STAAD Pro and used AutoCAD for planning. The limit state method collapse using IS: 456-2000 and SP-16 have been adopted.

2. PLANNING

A. General Principles of Design

1) Site Selection and Planning –

The choice of site for an auditorium is governed by several factors which may be mutually conflicting, but a compromise has to be struck between the various considerations involved. The problem of noise is an important consideration. A noise survey of the site should be made in advance so that noise) location s are avoided where! possible, as otherwise elaborate and Expense construction may be required to provide requisite sound insulation. In fact, the quietest possible condition should be provided SO that intelligibility of speech does not suffer and even soft passages of music are heard. It is, particularly necessary to keep the level of extraneous noise low by proper orientation and site selection in caies where no air-conditioning is provided and doors and windows. Are normally kept open during the performance. When air-conditioning is provided special care should be taken to attenuate the plant noise 2nd the grill noise. For this purpose plant should be suitably isolated and ducts as well as the plenum should be so designed that raise gets adequately reduced so as to be within the permissible limits.

2) Size and Shape

The size should be fixed in relation to the number of audience required to be seated. The floor area of the hall including ,gangways (excluding the stage) should be calculated on the basis of 0.6 to 0.9 m2 per person. The height of the hall is determined by such considerations as ventilation, presence (or absence) of balcony and the type of performance.

3) Stage - The size of the stage depends upon the type of performance the hall is to cater for. It would be large for theatres, while it would be comparatively small for cinema halls which again depends on the size of the screen.

4) Rear Wall -The auditorium rear wall(s) should be either flat or convex in shape. This should not be concave in shape, but where it cannot be avoided, the acoustical design shall indicate either the surface to be splayed or convex corrugations given in order to avoid any tendency for the sound to focus into the hall.

5) Side Wall -Where the side walls are non-parallel as in the case of a fan-shaped hall, the walls may remain reflective and may be architecturally finished in any manner required, if sound absorbing material is not required from other considerations. Where the side walls are parallel they may be left untreated to a length of about 7.5 m from the proscenium end. In addition, any of the surfaces, likely to cause a delayed echo or flutter echo should be appropriately treated with a sound absorbing material. Difference between the direct path and the path reflected from side walls shall not exceed 15 m.

1	Shape	Fan + Rectangle
2	Seating Area	Groundfloor-550 m^3 Balcony – 360 m^3
3	Seating Numbers (as per code - 0.9 m^2 per person)	Groundfloor-568 Balcony – 396 Total : 964
4	Height of auditorium	7.5 m Balcony - 4 m
5	Rear wall	Convex in shape
6	Top false Ceiling	Material - High density compressed Plaster of Paris Shape-Concave hanged in Truss
7	Seats	A. Shape-concentric arc circle like B. First row 2.6 m away from stage C. Width of seats-58 cm D. Back to back distance – 90 cm
8	Sound Absorbing material	A. Glass Wool B. Acoustic plaster For rear wall C. Hardboard
9	Stage	16.5 m x 3.3 m
10	Auditorium Area	Hall Area – 40 m x 26.5 m =1060 m^2 Foyer- 440 m^2 Total – 1500 m^2

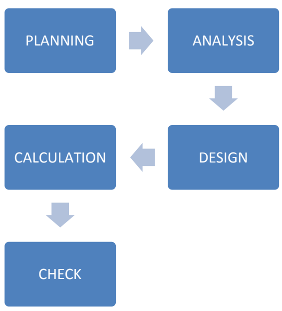


Fig-1 Stages

3. ANALYSIS

3.1 Plan Configuration

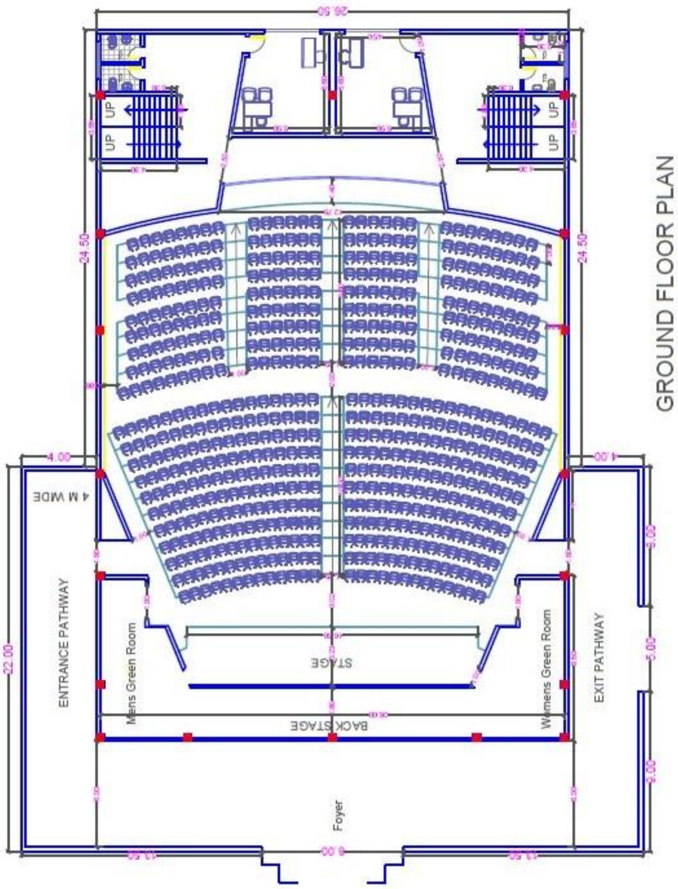


Fig-2 Ground floor plan

3.2 General Truss Data

Span of truss – 26.5 m

Height – 3 m

Roof length – 40 m

Roofing Sheet –ACC sheet @ 150 N/m2

Howe Truss

3.3 Configuration of Howe Truss

Total Number of panel – 8

Half Number of panel – 4

Half Span – 13.25 m

Rise -3 m

Slope (ø) – Tan-1(Perpendicular/Base)

Ø = Tan-1 (BD/AD)

Ø = Tan-1 (3 / 13.25) = 12.75o

Length of Principle Rafter – √(13.25^2+ 3^2)

= 13.6 m

Half Plan Area

= 13.25 x 10 =132.5 m2

Half Slope Area

=13.6 x 10 = 136 m2

3. 4. Dead Load

1. Weight of roof material (i.e. ACC Sheet) @ 150 N/m2

On slope area

= weight of a roof material

=150 x slope area

=20400 N

2. Weight of Purlin

i.e. 120 N/m2 on Plan area

= 120 x Plan area

=120 x 132.5

=15900 N

3.Self Weight of roof truss

= 10 (Span/3+5) N/m2

=10 (26.5/3+5) N/m2 =138.34 N/m2 On plan Area

Hence , Self Weight of Purlin in plan area = 138.34 x 132.5 = 18330 N

Total Dead Load = 20400 + 15900 +18330

= 54630 N

Deal Load per Panel Point (Full Panel Points I.P.P) = 54630/4 = 13658 N

Deal Load per Panel Point (Half Panel Points E.P.P) = 13658/2 = 6828.75 N

3.5 Live Load

As per IS Code

On Purlin = 750 – 20 (ø -10) N/m2

= 750 – 20 (12.75 -10) N/m2

= 695 N/m2 > 400 N/m2 OK

Live load on Roof Truss = 2/3 x 695 = 463 N/m2 on plan area

Total live load = 463 x 132.5

= 61392 N

Deal Load per Panel Point (Full Panel Points I.P.P) = 61392/4 = 15348 N

Deal Load per Panel Point (Half Panel Points E.P.P) = 15348/2 = 7874 N

3.6 Dead Load Calculation of Structure

3.6.1 Slab –

First Floor Slab

Thickness = 120 mm

Self weight of slab = 0.12 x 25 x 1

= 3 KN/m2

Entrance Slab

Thickness = 100 mm

Self Weight of Slab = 0.1 x 25 x 1

=2.5 KN/m2

3.6.2 Brick wall -

First Floor

Thickness = 250 mm

Dead Load = .25 x 3.5 x 25

=21.87 KN/m2

Ground Floor

Thickness = 250 mm

Dead Load = .25 x 4 x 25

=25 KN/m2

3.6.3 Floor Finish – 1 KN/m2

3.7 Imposed Load Calculation of Structure

As per code 456:2000 –

With Fixed Seats in the Auditorium = 4 KN/m2

Section Property

Beam

1 .Main Beams – A) 350 x 700 mm

B) 300 x 700 mm

2. Other Beams – 350 x 450 mm

Columns

1. Main Columns – A) 800 x 900 mm

B) 700 x 800 mm

2. Other Columns – 350 x 450 mm

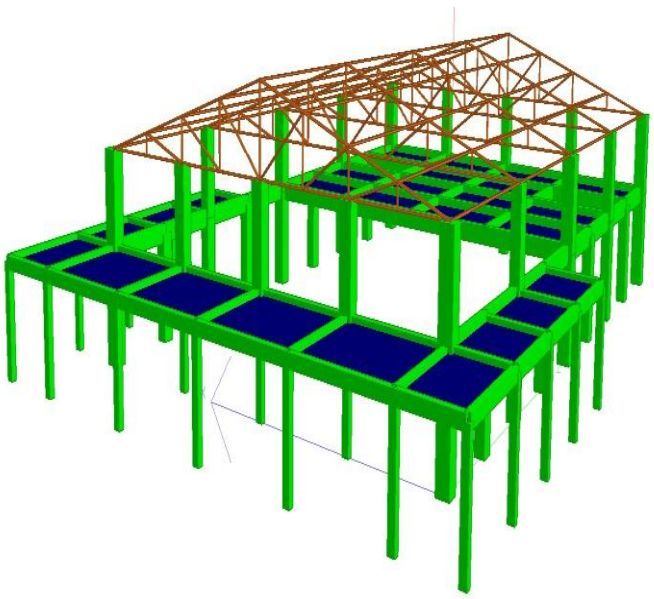
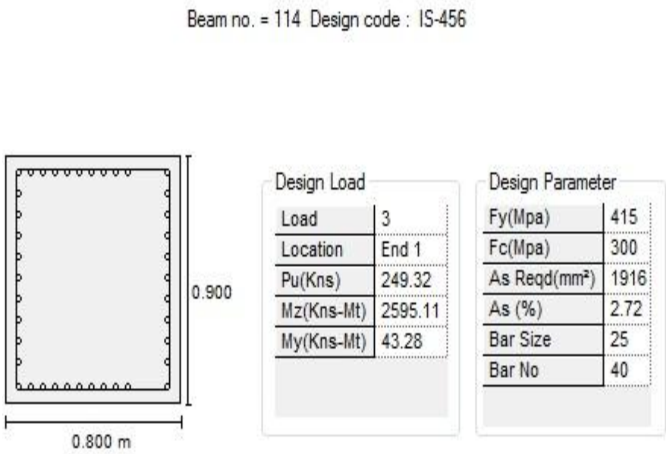


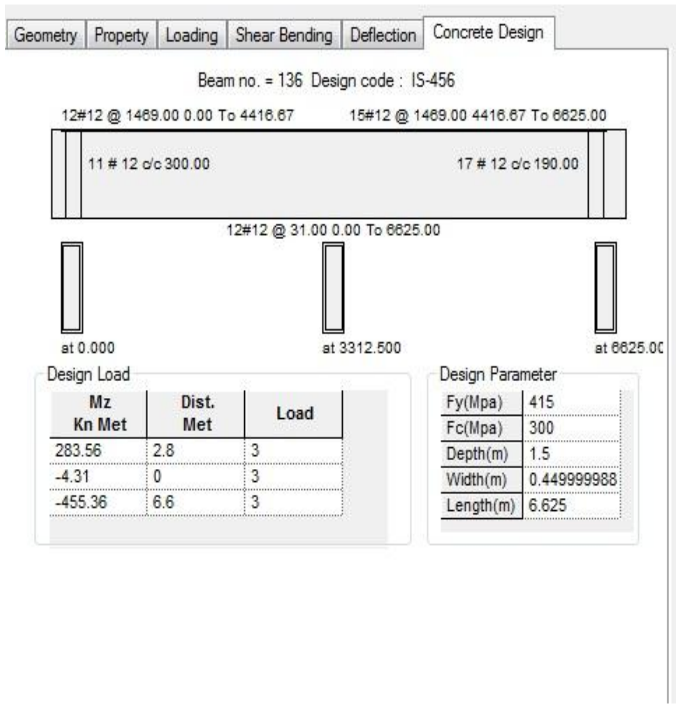
Fig 3-Staad Pro V8i Model

4. Design

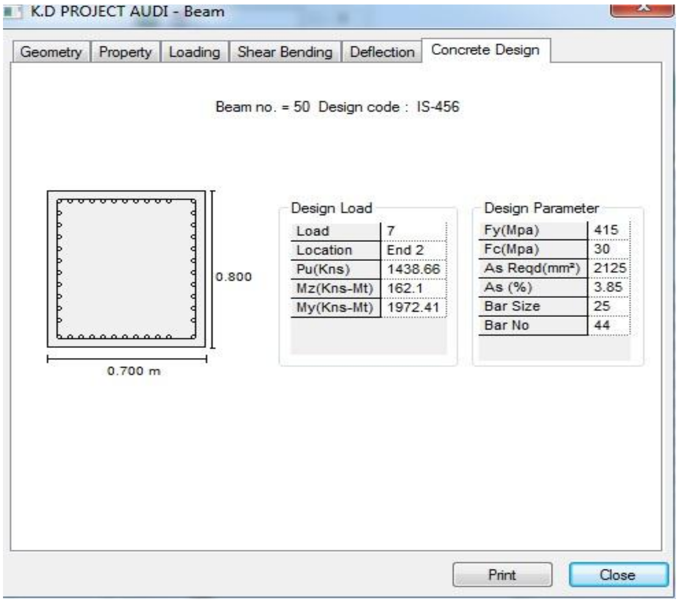
4.1 Column Design non-seismic



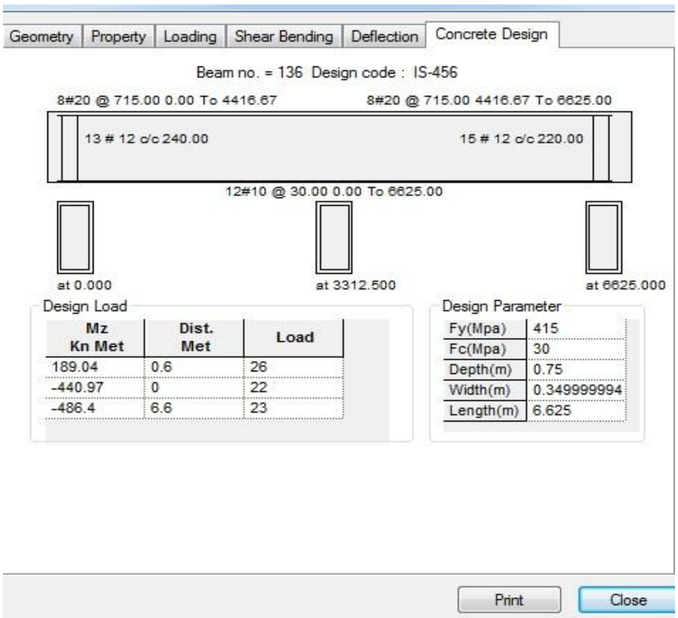
4.2 Beam Design non-seismic



4.3 Column Design seismic



4.4 Beam Design seismic



5. RESULTS

5.1 Dead Load Result

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mz kNm
Max Fx	48	1 D.L	6	1180.01	950.468	176.001	1134.56
Min Fx	527	1 D.L	216	-137.734	-0.147	0.018	-0.422
Max Fy	48	1 D.L	6	1180.01	950.468	176.001	1134.56
Min Fy	47	1 D.L	5	1179.98	-950.9	175.685	-1134.49
Max Fz	49	1 D.L	7	1045.68	139.472	1243.003	347.105
Min Fz	52	1 D.L	10	1045.65	139.763	-1243.13	347.809
Max Mx	165	1 D.L	81	144.739	395.642	1.632	1395.81
Min Mx	170	1 D.L	102	145.059	-97.024	-1.624	-236.071
Max My	49	1 D.L	79	989.684	139.472	1243.003	-210.781
Min My	52	1 D.L	82	989.655	139.763	-1243.13	-211.241
Max Mz	161	1 D.L	78	165.811	-763.959	-1.64	3642.59
Min Mz	48	1 D.L	78	1108.013	950.468	176.001	-2667.31

Table – 1 Dead load Result Summary

5.2 Live Load Result

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mz kNm
Max Fx	50	2 L.L	8	265.732	30.248	126.367	84.03
Min Fx	532	2 L.L	221	-135.427	0.145	-0.011	0.063
Max Fy	166	2 L.L	80	32.645	177.692	0.216	763.638
Min Fy	173	2 L.L	83	32.647	-177.691	-0.216	763.632
Max Fz	49	2 L.L	7	223.364	37.587	299.955	91.327
Min Fz	52	2 L.L	10	223.359	37.651	-299.934	91.481
Max Mx	165	2 L.L	81	34.96	104.464	0.45	369.111
Min Mx	170	2 L.L	102	34.959	-21.964	-0.451	-49.683
Max My	49	2 L.L	79	223.364	37.587	299.955	-59.019
Min My	52	2 L.L	82	223.359	37.651	-299.934	-59.122
Max Mz	158	2 L.L	77	-39.546	157.444	0.209	794.808
Min Mz	114	2 L.L	77	51.898	-142.814	4.02	-497.296

Table 2 – Live load Result Summary

5.3 Combination Result

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mz kNm
Max Fx	74	1.5 (DL + IL)	41	1546.603	0.031	-1076.169	0.077
Min Fx	532	1.5 (DL + IL)	221	-458.637	0.829	-0.059	0.362
Max Fy	167	1.5 (DL + IL)	79	366.12	828.913	1.164	3783.081
Min Fy	176	1.5 (DL + IL)	82	366.114	-828.909	-1.165	3783.025
Max Fz	49	1.5 (DL + IL)	7	1357.038	161.709	1437.002	382.046
Min Fz	52	1.5 (DL + IL)	10	1357.008	162.012	-1436.913	382.755
Max Mx	165	1.5 (DL + IL)	81	193.906	466.99	1.973	1759.322
Min Mx	170	1.5 (DL + IL)	102	193.913	-158.033	-1.973	-311.073
Max My	49	1.5 (DL + IL)	79	1277.871	161.709	1437.002	-264.79
Min My	52	1.5 (DL + IL)	82	1277.841	162.012	-1436.913	-265.294
Max Mz	158	1.5 (DL + IL)	77	-32.752	783.451	1.38	3957.341
Min Mz	159	1.5 (DL + IL)	98	-18.48	150.408	0.452	-2329.06

Table-3 Combination Loads Result Summary

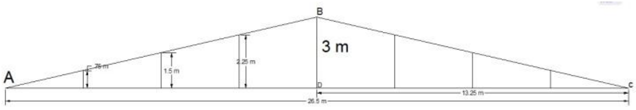


Fig- 4 Triple Howe Truss

6. CONCLUSIONS

1. Above Results Shows the Differences in Bending moment due to seismic condition.

2. The Design has been done accourding to the Bending moments and shear forces.

3. It is Seen that the dead load and live load is more then seismic load but due to seismic torsions effect noted .

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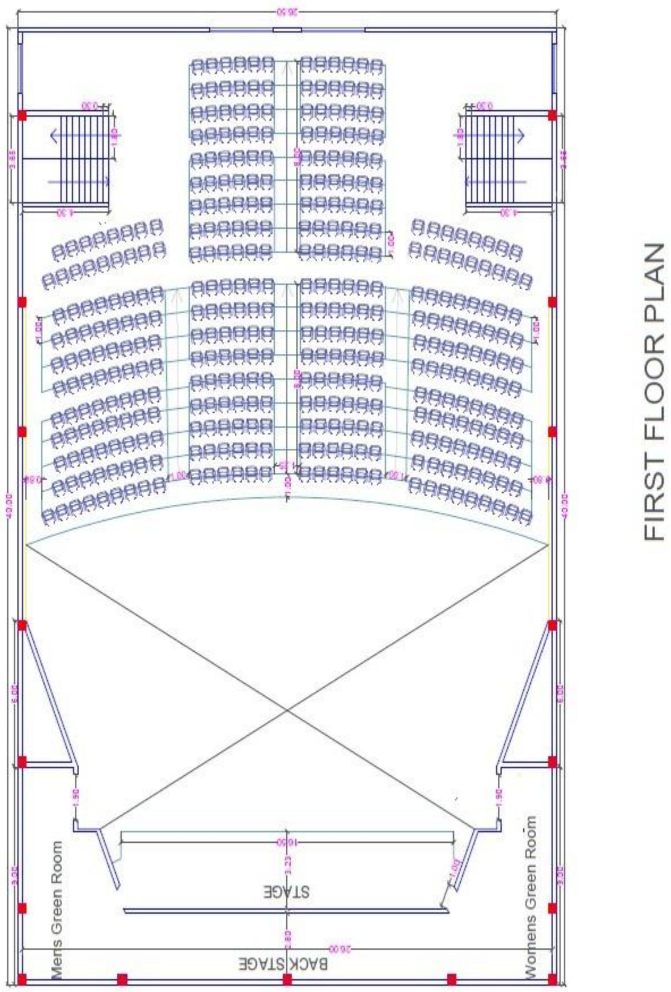

Fig-5 First Floor Plan