PLANNING, ANALYSIS AND DESIGN OF AN AUDITORIUM

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Abstract: This paper deals with planning, analysis and design of an auditorium at Calicut, Kerala, India. In this paper, it deals with the design of an auditorium for the accommodation of 1000 persons. The shape of the auditorium is rectangular. The dimension of the auditorium is 41.46 x 57.23 m. The structure shall be being designed to resist and must bear all load liable to act on it at some point of its lifestyles. It shall additionally satisfy serviceability requirements including limitations on deflection and cracking. In our paper, Planning is done using KPBR rule and drawing is done using AutoCAD. The analysis is done using STAAD software. Design is done using IS codes. Project is primarily based on limit state concept.

Index Terms **– STAAD Pro, AutoCAD**

I. INTRODUCTION

An auditorium is a room built to enable an audience to hear and watch performances at venues such as theatres. For movie theatres, the number of auditoriums is expressed as the number of screens. Auditoria can be found in entertainment venues, community halls, and theatres and may be used for rehearsal, presentation, performing arts productions or as a learning space. A reinforced concrete construction typically consists of three phases; namely planning, design including analysis and construction. This project deals with planning phase, analysis phrase and the design phase. 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 we have used AutoCAD for planning. The limit state method collapse using IS:456-2000 and SP-16 have been adopted.

II. METHODOLOGY

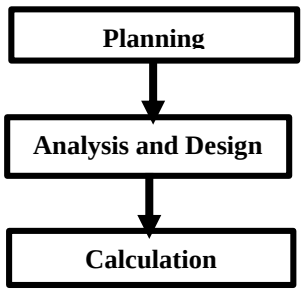

Fig 1: Shows the methodology of the project

The above fig 1, shows the methodology of the project. The first phrase is planning, which is done as per KPBR and it is plotted using AutoCAD. The second phrase is analysis and design, in which analysis is done by using STAAD pro and design is done manually The third phrase is calculation, referring to IS 875-1987 codes and the design load is calculated.

III. SPECIFICATION

The specification of the proposed auditorium is shown in table 1. In this table various facilities which auditorium consists of, is listed below and provided dimensions to the auditorium is compared with the KPBR rule.

Table 1: Dimension for Auditorium

Sl. NO	Facilities	As per KPBR	Provided
1.	Access width	5m	7m
2.	Front	6m	7.2m
3.	Sides	1.5m	11.7m
4.	Setback	2m	6.6m
5.	Parking for cars	15 seats – 1 parking 1 parking – 1.5sqm	6.6 parking 100.5sqm
6.	Parking for bikes	25% of car parking	25.125sqm
7.	Height of each floor	3m with A/C	4m
8.	Staircase	Width – 1.2m Rise – 0.15m Tread – 0.30m Handrail – 0.90m	1.9m, 1.5m 0.15m 0.30m 0.90m 4 staircases
9.	Toilets	200 men – 1no 100 women – 1 no	11nos 13nos
10.	Urinals	50 members – 1no	12nos
11.	Washbasin	200 members – 1no	2nos on both side
12.	Chair size	0.45x0.45m	0.53x0.63m
13.	Column size	0.5x0.1m	0.4x0.4, 0.4x0.6m
14.	Beam size	0.5x1.5m	0.4x0.6m
15.	Slab size	0.12m	0.12, 0.15, 0.2m
16.	Isolated footing	0.45x0.45m	2x2m

IV. PLANNING

As per KPBR, our building comes under the category of group D, assembly building. The total height of the auditorium is 14.33m. The height of the ground floor is 4m and the height of the first floor is 4m. The shape of the assembly area is rectangular. The dimension of the auditorium is 41.46 x 57.23m.

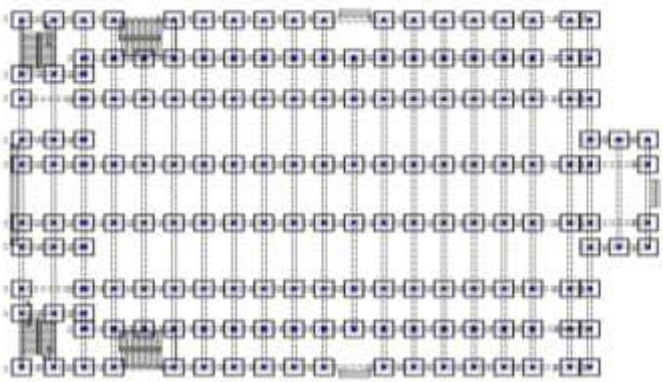

Figure 1: Plan of the auditorium

V. STRUCTURAL ANALYSIS

Calculation of the response of structures to actions. The analysis is done by using STAAD Pro. STAAD Pro is a structural analysis design program software. It is used for 3D model generation, analysis, and multi-material design.

Input parameters: Grade of concrete: M25**,** Grade of reinforcement: Fe500

Load Calculation

Truss:

Dead Load

1. At the joint = -3.4Kn
2. At the end joint = -3.48kN

Live Load

1. At the joint = -4.96KN
2. At the end joint = -2.48kN

Wind Load

1. Wind force = -15.31kN

2. Wind load = -7.65kN

Building:

Dead Load

Self-weight = -1kN/m^2

Live Load

Table 2: Live load

Assembly Building	UDL
Assembly area with fixed seat	4kN/m^2
Stage	3kN/m^2
Office room, Kitchen	2kN/m^2
Dressing room	2kN/m^2
Toilets and Bathroom	2kN/m^2
Girder, Passages, Staircases, Fire escape	4kN/m^2

Load Combination:

1.5(DL+LL+WL) for Truss

1.5(DL+LL) for Building

STAAD Modelling and Analysis

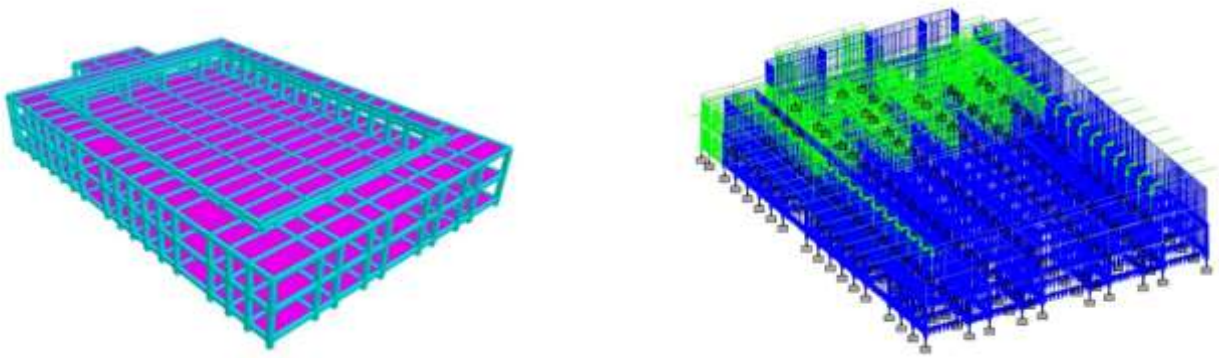

Figure 2: 3D Frame structure of our proposed auditorium(left), Load distribution of our proposed auditorium(right)

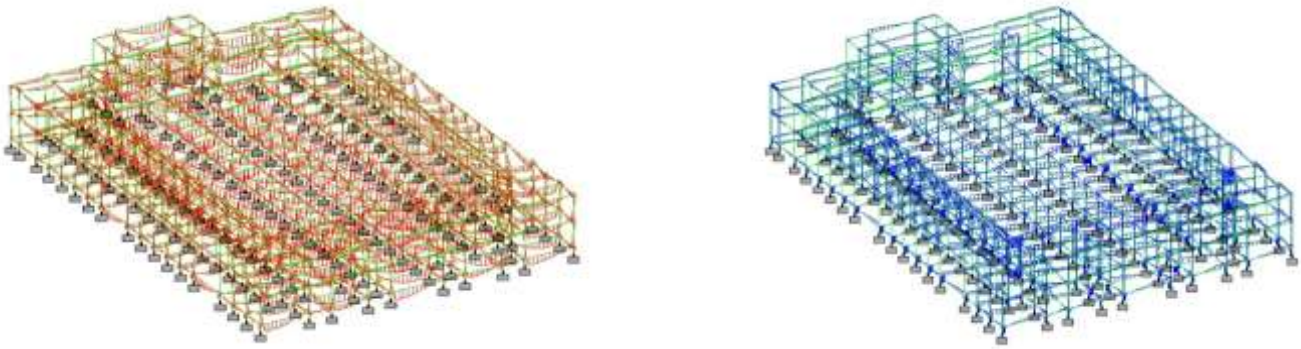

Figure 3: Bending moment diagram of our proposed auditorium (left), Shear force diagram of our proposed auditorium (right)

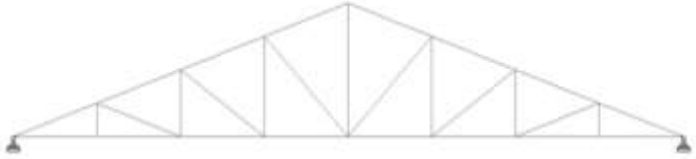

Figure 6: Truss of our proposed auditorium

VI. STRUCTURAL DESIGN

Design of Beam:

M_u = 53kN

V_u = 50kN

Beam size = 400x600mm

Effective depth = 600-40 = 560mm

A_{st} provided = 452.38mm²

Result: -

Provide 4nos of 12mm ∅ bars in two layers

Provide 8mm bars ∅ 2 legged stirrups @ 230mm c/c spacing

Design of Column:

P_u = 1129.48kN

M_u = 35.456kNm

Column size = 400x400mm

Column were designed as bi-axially loaded column

Hence, the column is Short column

Result: -

Main reinforcement:

Provided 12nos of 12mm ∅ bars

Lateral reinforcement:

Provided 8mm ties @ 200mm c/c

Design of Footing:

Size of column = 400x400mm

Vertical load = 874.924kN

Safe bearing capacity = 400kN/m^2

Total load = 874.924+87.4924 = 962.42kN

Depth of footing below @ face of column = 1m

Area required = 962.42/400 = 2.4m^2

Length provided = 2m

Breadth provided = 2m

M = 139.98x10^6Nmm

V = 239.728kN

Using 12mm ∅ bar at 60mm clear cover

Total depth, D = 252+6+60 = 318mm

Total Depth Provided, D = 410mm

A_{st} = 1642.048mm²

Result: -

Provided 15nos of 12mm ∅ bar

Design of Two-Way Slab:

Internal dimension = 4.53x3.72m

Overall depth = 150mm

L_y/L_x = 4.53/3.72 = 1.217<2

Hence, Two-way slab

Load on slab: -

Self-weight = 0.15x25 = 3.75kN/m^2

Floor finish = 1kN/m^2

Live load = 4kN/m^2

Total load = 8.75kN/m²

Factored load = 8.75×1.5=13.125kN/m²

M_x = 0.043×13.125×3.846² = 8.34kNm

M_y = 0.032×13.125×3.846² = 6.212kNm

Main reinforcement:

Spacing of 8mm bar = (1000×$\frac{\pi}{4}$×8²)/139.17 = 361.18mm = 360mm

Edge reinforcement:

Spacing of 8mm bar = (1000×$\frac{\pi}{4}$×8²)/188.26 = 267mm = 260mm

V_u = 25.23kN

Effective span = 150-20-8/2 = 126mm

Result: -

Main reinforcement:

Provide 8mm bar at 360mm c/c

Edge reinforcement:

Provide 8mm bar at 260mm c/c

Design of One-Way Slab:

Internal dimension = 7.7×3m

Overall depth = 200mm

L_y/L_x = 7.7/3 = 2.56>2

Hence, One-way slab

Load on slab:

Self-weight = 0.2x25 = 5kN/m^2

Floor finish = 1kN/m^2

Live load = 4kN/m^2

Total load = 10kN/m²

Factored load = 10×1.5=15kN/m²

Maximum moment, M_{u_x} = 15×3.176²/10 = 15.13kNm

Main reinforcement:

Spacing (min) A_{st} = $\frac{1000\times\frac{\pi}{4}\times8^2}{211.2}$ = 237 mm ≈ 230 mm

Maximum permissible spacing lesser of:

1. 3×d = 3×176 = 528 mm
2. 450 mm

Distribution reinforcement:

Spacing = $\frac{1000\times\frac{\pi}{4}\times8^2}{240}$ = 209.43mm≈200mm

Result: -

Main reinforcement:

Provide 8 mm bar at 230 mm c/c spacing

Distribution reinforcement:

Provide 8mm bars at 200mm c/c spacing

Design of Staircase:

Rise = 0.15m, Tread = 0.30m, Width =1.9m

Overall depth = 160mm

No of rise = 2.1/0.15 = 14

No of tread = 14-1 = 13

No of steps in flight = 14

Load on flight:

Dead weight of slab = 0.16×25×$\sqrt{0.15^2+0.3^2}$/0.3 = 4.47kN/m²

Dead weight of step = 0.5×0.15×25 = 1.875kN/m²

Live load = 4kN/m²

Floor finish = 1kN/m²

Total load = 11.35kN/m²

Load on landing: -

Dead load of slab = 0.14×25 = 3.5kN/m²

Live load = 4kN/m²

Floor finish = 1kN/m²

Total = 8.25kN/m²

Design load on flight = 1.5×11.35=17.025kN/m²

Design load on landing = 8.5×1.5=12.75kN/m²

BM_{max} = R_B×x-17.025×x²/2 = 66.766kNm

Mu = 0.36×$X_{u_{max}}$/d(1-0.42×$X_{u_{max}}$/d) fck×b×d²

66.766×10^6 = 0.36×0.48(1-0.42×0.48) ×25×1000×d²

d = 139.13mm = 140mm

Main reinforcement:

Spacing = (1000× (π/4)×14²)/1640.71 = 93.82 ≈ 90

Distribution reinforcement:

Spacing = 1000× ($\pi/4$) ×8^2/192 = 261.799mm

Result: -

Main reinforcement:

Provide 11nos of 14mm ∅ bar @90mm c/c

Distribution reinforcement:

Provide 8mm bar at 250mm c/c

VII. CONCLUSION

An auditorium is designed for 1000 seating capacity and with the dining hall. Considering the present market trend, artificial lighting and ventilation are adopted. Trussed roof with false ceiling is proposed. In this project work, we have included Load Calculation, Design of Slabs, Stairs, Beams, and Columns and Footing. 2D analysis of the building was done using the Software STAAD Pro. Moreover, manual calculations were done in accordance with the relevant codes. Architectural drawings have been prepared.

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