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Planning, Analysis and Design of an Institutional Building

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A B S T R A C T

Any construction project will start with the Planning, Layout of the building or structure followed by design and analysis of the structure which is followed by cost estimation. This project involves the layout, design, analysis, planning and cost estimation of an Institutional building located in Thudiyalur municipal area, Coimbatore. Under this layout of the given site has been prepared. The height of each floor is 3.6 m from floor level to top of the roof slab. It is provided with R.C.C. roof slab supported on R.C.C. frames. The columns are connected with beams at roof level. The main outer walls and cross walls are 230mm thick brick masonry in cement mortar thickness 0.1mm. The slab, beams, columns and footing are designed as per IS 456-2000.The design are based on the limit state design method. Imposed and dead loads are only considered for design. The drawings are prepared using AutoCAD. The analysis is done both manually and by using software.

Keywords:Planning, Institutional, Construction.

1. Introduction

In this project it was proposed to plan, analyse, design and estimate an Institutional building. The Plot area of the site is 16.7 acres. The College is an engineering college with 5 departments. It consist 5 Identical Blocks. A block is designed and similar way is adopted to all the remaining blocks. The college is located at Thudiyalur, Coimbatore, TamilNadu. The height of each floor is 3.6 m from floor level to roof level. It is provided with R.C.C roof slab supported on R.C.C frames and masonry infills. The columns are connected with the beam at roof level. The main outer wall and cross wall are 230 mm thick brick masonry in CM 1:5. Contour maps, Planning of the building and roads, Layouts of various facilities were obtained, Area calculations, Lift calculations were done. The 2D analysis of the structural elements has been done by substitute frame method, cantilever method and result has been cross-checked by using the STAAD PRO results to find the percentage difference. Slabs, beams, columns and footing has been designed manually with the help of IS 456 -2000, SP-16 and IS 875-1987(Part I, II, III).M25 grade concrete is used for slab and beam and M30 for column and footing. Fe 415 steel has been used for the design of all the structural components. SBC of the soil is considered to be 300 kN/sq.m.. The cost of construction is arrived by estimating in Microsoft Excel by market and SOR rates. The project planning is done by using Microsoft Project in which time and resources are allocated for individual activity and thus the entire project duration is found out.

1.2 Topography

The Topography is used to describe the detailed study of the earth's surface. This includes changes in the surface such as mountains and valleys as well as features such as rivers and roads. A Topographic Survey is a survey that gathers data about the elevation. A typical Topography and Contour layout is shown in Fig 2(a),2(b).

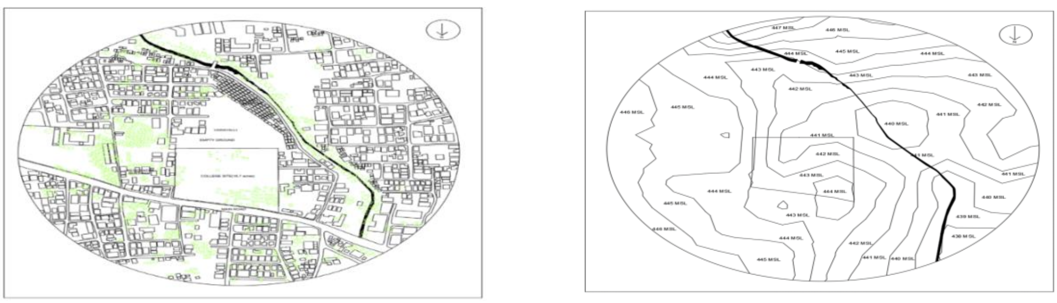

Fig. 2 - (a) Topographic layout of the site; (b) Contour layout of the site

1.3 Layout

Layout plan shows the arrangement of all facilities which are required to make the structure more versatile to use. A typical layout plan is shown in Fig 3(a),3(b).

Fig. 3 - (a)Ground and First floor plan; (b) Second and Third floor plan.

Section

The section shown in Fig 4 shows the height of the floors and the material involved in construction from plain cement concrete to the description of the parapet wall.

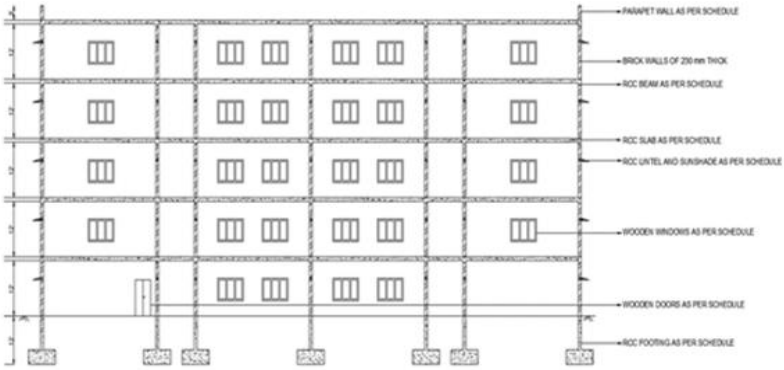

Fig. 4 – Section cut along the X axis.

Soil report recommendations

The primary purpose of our investigation is to obtain data to develop foundation design recommendations for the above work. At, first instance, one borehole was bored at site. Client's representatives selected the locations of borings.

To accomplish these purposes, the following tasks were performed:

1. Detailed soil borings were done up to stratum to explore the sub surface stratigraphy and obtain soil samples for testing. Field and laboratory tests were conducted to evaluate the index and engineering properties of the soils

2. Engineering analysis was performed to develop foundation design information for proposed structure.

Based on the sub-soil condition and possible loads on foundation, the following recommendations for proposed construction of Institutional building (G+4).

- The Isolated / combined footing will be recommended for proposed Structure.
- Foundation depth up to 3.6m from existing ground level.
- SBC recommended is 300 KN/m^2 at 2.2 m depth based on STP- N value conducted inside the boreholes (shear failure and settlement criteria).

Analysis

2D modelling is done by using Staad pro. The components of the size obtained from basic assumption are modelled and loading of the component i.e., combination of dead load, live load and floor finishes are applied and the model is analyzed.

Here the 2D analysis is carried out for the Critical frame (Fig 5) i.e., the mid frame.
Substitute Frame Method:
Load Calculations:
Self-weight of the beam= 0.3 x 0.3x 25x1.5 = 3.375 KN/m
Dead Load of slab= 3.66 x1x0.15x25=13.725 KN/m
Floor Finishes=1 KN/m
Live Load=4kN/m
Total Load=22.1KN/m

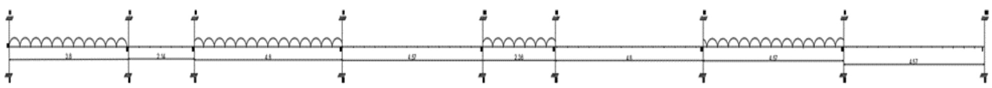

Fig. 5 – Critical frame

Table 1 – Manual and software comparison of results

Member	Manual	Software	% variation
AB	-23.77	-25.21	6.06
AS	11.87	13.45	13.31
AJ	11.87	13.45	13.31
BC	-9.33	-10.23	9.65
BA	26.215	28.22	7.65
BT	-8.64	-9.73	12.62
BK	-8.64	-9.73	12.62
CD	-38.45	-40.76	6.01
CB	13.63	15.56	14.16
CU	11.99	13.73	14.51
CL	11.99	13.73	14.51
DE	-34.66	-36.22	4.50
DC	43.129	47.88	11.02
DV	-4.225	-4.9	15.98
DM	-4.225	-4.9	15.98
EF	-13.11	-14.23	8.54
ED	27.61	34.88	26.33
EW	-7.56	-8.22	8.73
EN	-7.56	-8.22	8.73
FG	-31.24	-34.88	11.65
FE	13.95	14.99	7.46
FX	8.68	9.89	13.94
FO	8.68	9.89	13.94
GH	-38.43	-40.11	4.37
GF	-32.85	-35.76	8.86
GY	0.87	1	14.94
GP	0.87	1	14.94
HI	-34.76	-35.83	3.08
HG	38.02	40.72	7.10
HZ	-1.69	-2.01	18.93
HQ	-1.69	-2.01	18.93
IH	25.89	27.89	7.72
IA1	-13.1	-13.9	6.11
IR	-13.1	-13.9	6.11
		Average	11.24

2. Details of structural members

Table 2 – Details of slab.

SLAB NO	LONGER SPAN		SMALLER SPAN		Longer span/ smaller span	Type of Slab	Req.Depth of Slab	Provided Depth	Reinforcement details in shorter Direction	Reinforcements details in Longer direction	Torsion Reinforcement Area	Torsion Reinforcemts in Both Direction
	FEET	INCHES	FEET	INCHES			mm	mm				
S1	19	3	14	6	1	two way slab	140	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S1a	19	3	14	9	1	two way slab	140	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S2	19	3	17	2	1	two way slab	150	150	10mm dia bars @280 mm C/C	10 mm dia bars @ 270 mm C/C	1070 x 1070 mm	8mm dia @ 290 mm C/C
S3	19	11	12	0	2	two way slab	130	150	10mm dia bars @280 mm C/C	10 mm dia bars @ 240 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S4	19	11	6	6	3	One way slab	80	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S5	15		14	6	1	two way slab	140	150	10mm dia bars @260 mm C/C	10 mm dia bars @ 260 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S5a	15		14	9	1	two way slab	140	150	10mm dia bars @290 mm C/C	10 mm dia bars @ 290 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S6	15		7		2	two way slab	90	150	10mm dia bars @200 mm C/C	11 mm dia bars @ 180 mm C/C	440 x 440 mm	8mm dia @ 290 mm C/C
S7	14	6	14	3	1	two way slab	140	150	10mm dia bars @260 mm C/C	10 mm dia bars @ 260 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S7a	14	9	14	3	1	two way slab	140	150	10mm dia bars @260 mm C/C	10 mm dia bars @ 260 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S8	14	3	7		2	two way slab	90	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	440 x 440 mm	8mm dia @ 290 mm C/C
S9	14	6	7		2	two way slab	90	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	440 x 440 mm	8mm dia @ 290 mm C/C
S9a	14	9	7		2	two way slab	90	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	440 x 440 mm	8mm dia @ 290 mm C/C
S10	7		7		1	two way slab	90	150	10mm dia bars @200 mm C/C	11 mm dia bars @ 180 mm C/C	901 x 900 mm	8mm dia @ 290 mm C/C
S11	14	9	7		2	two way slab	90	150	10mm dia bars @200 mm C/C	10 mm dia bars @ 180 mm C/C	440 x 440 mm	8mm dia @ 290 mm C/C
S12	14	9	14	6	1	two way slab	140	150	10mm dia bars @260 mm C/C	10 mm dia bars @ 260 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C
S13	14	9	14	9	1	two way slab	140	150	10mm dia bars @260 mm C/C	10 mm dia bars @ 260 mm C/C	900 x 900 mm	8mm dia @ 290 mm C/C

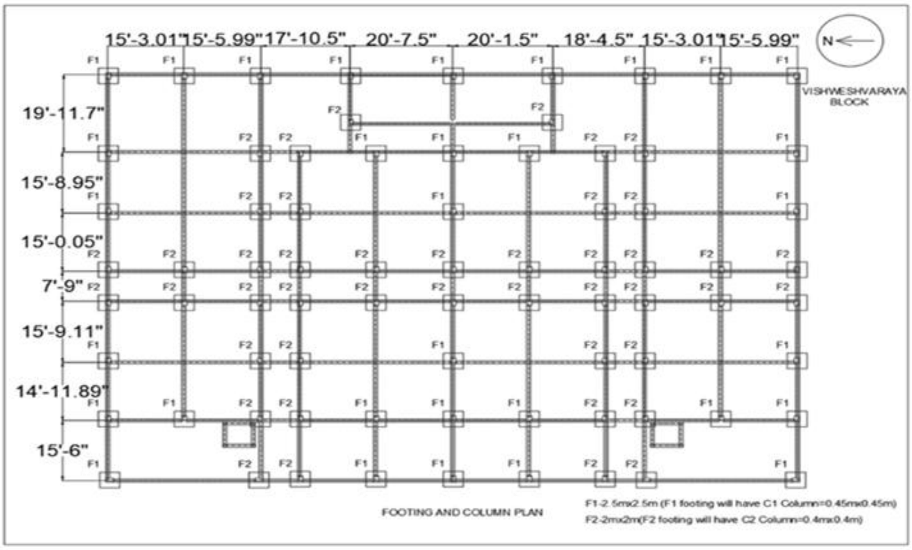

Fig. 6 – Footing and Column layout

Table 3 – Details of column

Column name	Column size	Main reinforcement	Shear reinforcement
C1	0.45m x 0.45m	6# 25mm diameter	8mm diameter @ 300mm c/c
C2	0.4m x 0.4m	6# 25mm diameter	8mm diameter @ 300mm c/c

Table 4 – Details of footing

Footing name	Footing size	Main reinforcement	Distribution reinforcement

F1	2.5m x 2.5m	12mm diameter @ 90mm c/c	12mm diameter @ 90mm c/c
F2	2m x 2m	12mm diameter @ 100mm c/c	12mm diameter @ 100mm c/c

Design of lift

(AS Per NBC 2016 Part 8 Sec 5A)

LIFT CALCULATION:

No of lifts in main block = 2

No of lifts in other block = 1(per block)

No of floors (excluding G.F) = 2

Lift capacity = 10 persons

(From table 11)

Lift speed = 1 m/s

(From table 13)

Rated load = 680 kg

Minimum car size = 1.5m x 1.5m

Door adopted center opening power operated door

COPD door width = 0.8 m

From table 15,

Pit depth = 1.5 m

Overhead height = CH+1.6 m

Consider car clear inside height (CH) =2.5 m

Overhead height =4.1 m

Machine room height =2.5 m

Entry of Passengers in Ground floor:

Time required for entry of one passenger when lift is partially empty=1 sec

Lift capacity =10 nos

Time of entry of passengers =10x1=10 sec

Entry of passengers on each floor:

Time required for entry of one passenger when lift is partially empty= 1 sec

Lift capacity/4 (assuming 50% entry of passengers) =5 nos

Time of entry of passengers at each floor=5 x 1=5

Total entry on all floors going up=5 x 2=10 sec

Total entry on all floors going down=5 x 2 =10 sec

Total entry on going up and down=20 sec

Exit of passengers on each floor:

Time required for exit of one passenger when lift is partially empty =0.75

Lift capacity/4(assuming 50% entry of passengers) = 5 Nos

Time for entry of passengers at each floor=0.75x5=3.75 sec

Total exit on all floors going up=3.75x2=7.5 secs

Total exit on all floors going down=3.75x2=7.5 secs

Total exit on all floors going up and down=15 secs

Exit of passengers on top and bottom floor

Time required for exit of one passenger=0.75 secs

Lift capacity=10 nos

Time of exit of passengers=0.75x10=7.5 sec

Time of exit on bottom and top floor=15 sec

Door closing and opening time:

Door opening & closing time at each floor (Door is power operated central open,

for 6 persons capacity) = 3 secs

Number of floors (Except GF) = 2 Nos

Door closing and opening time at GF = 4 secs

Total time for opening and closing of doors = (3 x 2) + 4 =10 secs

Total time for opening and closing of doors going up and down =10 secs

Acceleration periods:

Acceleration period for each cycle (Assume) =1.5secs

No of floors excluding GF =2 Nos

Total Time = 1.5 x 2 = 3secs

Deceleration periods:

Deceleration period for each cycle (Assume) =2secs

No of floors excluding GF = 2Nos

Total Time = 2 x 2 =4 secs

Stopping and levelling periods:

Stopping and levelling periods =2 sec(assume)

No of floors =2 nos

Total time=2x2=4 sec

Distance travelled by lift during acceleration or deceleration=$d=ut+0.5ft^2$

u = 0 m/s

T=1.5 sec per cycle

F(for lift speed 1.5 m/s)=0.75 m/s^2

Period of full rated speed between stops going up

Distance travelled with full rated speed per floor=2.15 m

No of floors=2 nos

Total distance travelled with full rated speed=4.3 m

Full rated velocity=1 m/s

Time taken=4.3 sec

Period of full rated speed between stops going down

Distance travelled with full rated speed per floor = 2.15m

No of floors = 4 Nos

Total distance travelled with full rated speed = 4.3m

Full rated velocity = 1 m/s

Time taken = 4.3 secs

Round Trip Time = Total time to discharge full one load of passengers from ground floor to roof floor and coming back to ground floor = 117.1 Sec

Number of lifts = 1

Waiting interval = RTT/n

= 117.1 /1 = 117.1 Sec

Average number of passengers carried in a car (80% of capacity) = 8 Nos

Total population = (No of floors x Net usable area per floor) / Population Density

Determination of handling capacity(cl:6.2.9)

Handling capacity = (300xQx100)/(TxP)

H = handling capacity as the percentage of the peak population during 5min period

P = total population to be handled during peak time

Net usable area per floor =104.7 Sq.m

No. of landings including ground = 3

Assuming population density 12.5 per person

Probable population P= (3 x 104.7) /12.5 = 25.126 persons

Q = Average no. of passengers carried in a car = 80% of capacity =8 Nos

H = (300 x 8 x 100)/ (25.128 x 117.1) =8.15 %

Provided 1 number of lifts of speed 1 m/s.

4. Conclusion

The ultimate aim of the project work is to give a practical exposure of the designing work of structures from various cadre of the society. A detailed plan of the Institutional building has been prepared taking into account functionality, utility, economy and feasibility. Planning has been done in accordance with University Grants Commission norms, All India Council for Technical Education norms and National Building Code. Area of the site has been efficiently planned such that effective construction will be ensured. Analysis of the structural members has been successfully done by Substitute frame method and are checked using the results obtained from STAAD Pro software. The structure members have been designed by limit state method. Structural drawings have been prepared with the help of AUTOCAD software. All members are economic sections and safe against failure. The total cost of the institutional building has been estimated to be ₹ 8.62 crores (approximately). The plinth area rateis calculated as ₹ 1400 per sq ft. The future scope stands with scheduling this project and carrying out works of library, auditorium, indoor stadium etc.

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