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Planning, Analysis, Design and Detailing of degree college building by adapting green building concept and sustainable concepts

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Abstract- *Any construction project to begin with the Layout of the building or structure followed by the Design & Analysis of the structure which is succeeded by cost estimation and planning for the said project. This project involves the layout, design, analysis, planning & cost estimation of a G+1 college building. In this project, we considered the complete planning, designing, detailing, drafting and estimation of a degree building. The area reserved for the college building is around 1 acre. And the complete planning and detailing was done by using AUTO Cad software. The layout of the proposed Ground and first floor degree building is based on a plot of size 28654 Sft. All the drafting work was done by AutoCAD. Designing is done manually. The cost estimate for the project has been calculated using Microsoft Excel. For the abstract cost, Public Work Department (PWD) Schedule of rates has been followed by the Government of Karnataka for the year 2022-23 and a total abstract cost is around* ***5.00 crores****.*

Keywords— *Analysis, Structural design, Estimate, building*

1. INTRODUCTION

1.1 GENERAL

A structure is a series of connected, interrelated elements that form together systems that can resist a series of external load effects applied to it, which includes its self-weight, and provide adequate rigidity. RC Structure: structure made of a composite material constituted by concrete material with a good performance of compressive strength but relatively low tensile strength, and steel bar having high tensile strength hence commonly named by a Reinforced concrete structure. Building systems are classified under 2 groups:

1. Load Bearing Masonry Buildings. 2. Framed Buildings.

1. **Load Bearing Masonry Buildings**: In this type of structure the loads on the structures are transferred vertically downward through walls. Such constructions are used in residential buildings where dimensions of rooms are less. Residential buildings up to G+2 floors can be built economically with such structures. Small buildings like houses with minimum spans of beams and slabs are generally constructed as load-bearing brick walls with reinforced concrete slab beams.

2. Framed Buildings: In this type of structure a framework of columns, beams and floors is built first. The walls are built to partition the area. The walls are subjected to self-weight only and won't carry any loads. The brick walls are to be considered as non-load-bearing filler walls. This type of super structure is required when the no. of stories in a building is more and also when larger areas are to be converted free from walls. Reinforced concrete frames are provided in both prime directions to resist vertical loads and they are transmitting the load to the vertical framing system i.e., columns and foundations. This type of system is effective in resisting both vertical loads and horizontal loads.

1.2 STRUCTURAL ANALYSIS

The structural analysis involves the calculation of the effects of loads like axial forces, shear force, bending moments, etc., on the physical structure and their component members for which these members are to be design under the action of given external loads.

1.2.1 Analysis Method

To perform an accurate analysis it is important to determine the basic information's such as structural loads, geometry, support conditions, & properties of the materials. The results of such an analysis typically include support reactions, stresses, Bending moments, and displacements. This basic information's is then compared to the criteria that indicate the failure conditions. Advanced structural analysis may examine dynamic response, stability, and non-linear behavior.

1.3 STRUCTURAL DESIGN

Structural design is an art and science of creation, with economy and elegance, a safe, serviceable, and durable structure. The design of the structure must satisfy following 3 basic requirements:

• Stability: To prevent overturning effect, sliding effect or buckling of the structure or parts of it under the loads action.

• Strength: To resist safely, the stress induced by the load in the various structural members.

• Serviceability: To ensure satisfactory performance under service load conditions which implies providing sufficient stiffness to contain deflection, crack width, and vibrations within acceptable limits and providing impermeability, durability etc.,

1.3.1Method of Design

The structural design requires the following information of data during design: 1. A set of architectural drawings 2. Soil Investigation Report (SIR) of soil data; 3. Location of the place or type of building to decide loadings; The process of structural design involves the following data: Structural planning Estimation of loads Analysis of structural elements Design of structural elements Structure and structural elements shall normally be designed by Limit State Method. Where the Limit State Method cannot be conveniently adopted, Working Stress Method may be used.

1.3.2 Design Philosophies

RC structures can be designed by using the following design philosophies.

- Working-Stress Method (WSM)for serviceability
- Ultimate-Load Method (ULM) or Load factor (LF) for safety
- Limit-State Method (LSM) In this project limit state method is adopted.

1.4 Limit State Method of Design

This is the most normal method which takes into consideration of the ultimate strength of the structure and also the serviceability requirements. It is a judicious combination of working stress and ultimate load methods of design. The acceptable limits of safety and serviceability requirements before failure occurs are called a limit state. The limit-state method is based on the concept of safety at ultimate loads (ultimate load method) and serviceability at working loads (working stress method). There are two types of limit states to be considered in design are:

1. Limit-state of collapse: It concentrates on the strength, overturning, sliding, buckling, fatigue, fracture, etc.

2. Limit-state of serviceability: It observe with the comfort to accompany and malfunction, caused by excessive deflection, crack width, vibration, and loss of durability.

1. Limit State of Collapse

This limit state corresponds to the strength of the structure and is categorized into the following types: (a) Limit state of collapse: Flexure. (b) Limit state of collapse: Shear and bond. (c) Limit State of collapse: Torsion. (d) Limit state of collapse: Compression.

2. Limit State of Serviceability

This limit state corresponds to the serviceability requirements i.e., deformation, cracking, etc,. It is categorized into the following types: (a) Limit state of deflection. (b) Limit state of cracking (c) Limit state of vibration. The basis of this method is, the probabilities variation in the loads and material properties. Limit state method takes into account the uncertainties associated with loads and material properties and thus uses partial factors of safety to obtain design loads and design stresses. The limit state method is based on predictions, unlike the working stress method which is deterministic, and assumes that the loads, factors of safety and material stresses are known accurately. In the limit state method, the partial safety factors are derived using probability and statistics and are different for different load combinations, hence giving a more rational and scientific design procedure.

1.5 BUILDING BYE-LAWS & REGULATIONS

- Open spaces around residential buildings.
- Minimum standard dimensions of building elements.
- Provisions for lighting and ventilation.
- Provisions for safety from an explosion. Provisions for means of access.
- Provisions for drainage and sanitation.
- Provisions for the safety of works against hazards.
- Requirements for off-street parking spaces.
- Requirements for landscaping.

1.6 ORIENTATION

Orientation is the positioning of a building concerning seasonal variations in the sun path, wind, rain, topography and outlook and at the same time providing convenient access both to the street and back yard. Good orientation can increase the energy efficiency of your home, making it more comfortable to live in and cheaper to run.

1.6.1 Factors that affect the orientation

- Solar heat
- Wind direction
- Humidity
- Rainfall
- Intensity of wind
- site condition

- Lightings and ventilation

1.7 ENVIRONMENTAL ISSUES AND PROBLEMS

• Nowadays, people are migrating from villages to towns for educational facilities, for not having proper education facilities in their places.

• Vertical growth of buildings has become an ultimate option available due to the rapid growth of the population.
• High cost of land.

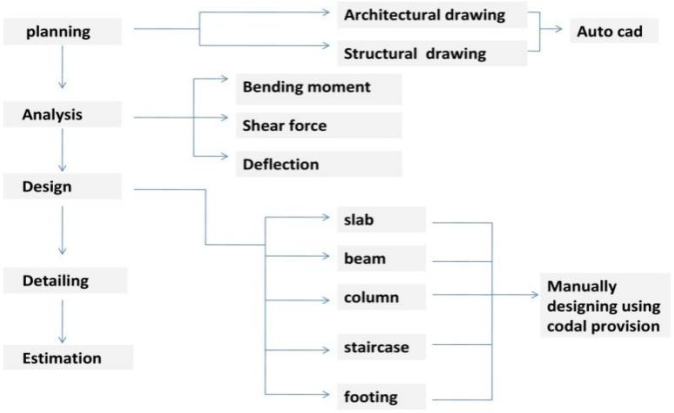
• Modern multi-story buildings are failing to achieve harmony with the environment due to their increased CO_2 emission, and embodied carbon content which eventually affect the environment.

• Hence we aim to propose a College building with green building and sustainable design techniques near MIT College which helps to overcome the above-mentioned problems.

2. OBJECTIVES

- To understand the concept behind planning, analysis, design, detailing, and estimation of college building.
- To understand the behaviors of the components of the building under different loading combinations.
- To analyze, design and estimate the structure by using software and manual approach.
- To implement green building techniques for better serving the environment.

3. METHODOLOGY



3.1 STEPS TO BE INVOLVED IN METHODOLOGY TO ACHIEVE THE OBJECTIVE OF THE RESEARCH

Step-1: Planning: In planning based on the 400 students to accommodate the college, the layout of the proposed G+1 college building is done. The ground floor of the college building consists of three flats.

Step-2: Analysis: The analysis of the building structure is done under different loading conditions by applying dead load, floor finish load and live load etc., on the structural components. We have calculated the shear forces, bending moments and deflections. Based on their analysis results the dimensions of structural design and their reinforcements are fixed. The analysis is done manually using code provisions as per the Indian Standard method.

Step-3: Design: The design of structural components slab, beam, column, staircase and footing is done manually as per Indian Standards using codal provisions and the dimensions of structural components are fixed. The thumb rule dimensions provided are compared with the required dimensions results got from the analysis part to ensure that the structure is economical and safe under gravity loading conditions and to fulfill the function for which the structures have been built.

Step-4: Detailing: In detailing part like the detailed drawings of the plan, cross-section, longitudinal section, and elevation of hostel buildings components slab, beam, column, staircase and footing, AutoCAD tool was used to do the detailing part of the building components.

Step-5: Estimation: At last Estimation is done using Excel tool to show the effective cost for whole college building structure components.

4. LAYOUT OF THE BUILDING

The building layout or a structure shows the plan of its foundation on the ground surface according to its drawings so that excavation can be carried out exactly where it required, its position and the orientation of the building are exactly specified.

4.1. Planning of the building using AutoCAD:

The building layout is planned as per the present requirements of the college building (As per Building Bye-Laws), as the total area of land reserved for the college was around 1 acre. The drafting was done by using AUTO Cad software. The total built-up area of the building was 28,654 Square feet. Number of floors considered for the building is Ground floor and First floor. Fig.1 shows the Ground floor plan of college building.

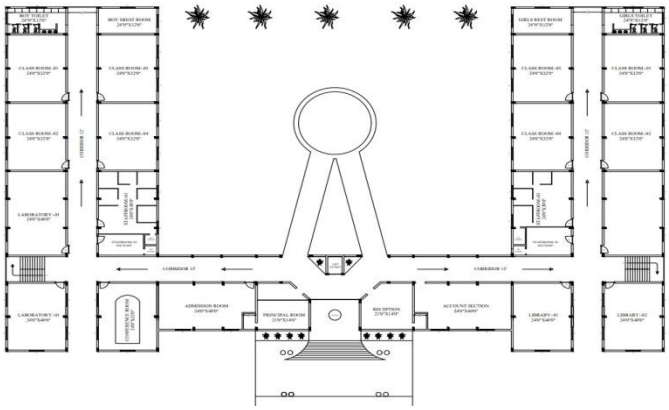


Fig 1. Floor Plan

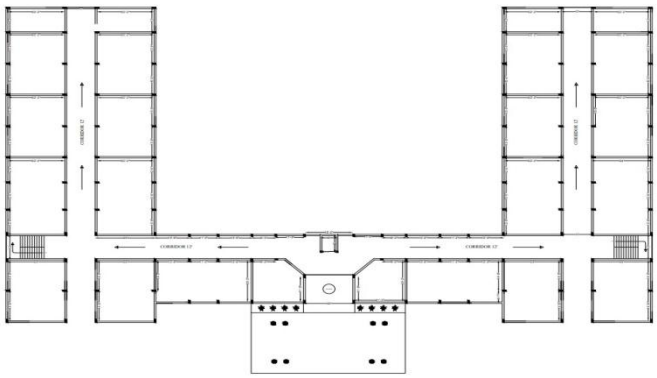


Fig 2 Column positioning

5. ANALYSIS OF STRUCTURE

Analysis and design of the building components are done by using IS 456-2000 provisions, and the loads considered for the design is as per IS 875-1987. The above Fig.2 shows the locations of the beam and column.

Table 1. Details of the Building

Length of the Building	80.00 m
Width of the Building	30.00 m
Height of the building (Each 3.5 m height)	7.00 m
Live load on the floor	3 KN/m
Grade of concrete (F_{ck})	25 N/mm^2
Grade of Steel (F_y)	415 N/mm^2
Column	3 types
Beam Size	600 X 230 mm 350 X 230 mm 300 X 230 mm
Slab Thickness	150 mm
No of Columns	106
No of Beams	Type 1- 54 no's Type 2- 52 no's Type 3- 90 no's Total no -196 no's.
No of Footings	106 No's

A. Materials:-The materials for the structure are selected as concrete with their property and constants as per IS Codes.

B. Loading: - The different types of loads that are considered for the design of the structural components are - Self-Weight, Dead Load, Live Load.

6. STRUCTURAL DESIGN

After the analysis of the building components manually. The Design of the beam, column, slab, and footing, are done manually by using the values obtained from the analysis. And the Design details are as follow-

6.1 Design of slabs

By considering critical sections, the design shows the following requirements;

For one way slab:-Dimension: 3.60 m x 8.70 m

Total load: 12.45 kN/m/meter width.
The thickness of slab: 180 mm
Reinforcement required:
Provide 12Φ - @250 mm C/C along shorter span.
Provide 10 Φ -@ 200 mm C/C along longer span.

For two way slabs:-Dimension: 4.11 m x 7.30 m
Total load: 12.45 kN/m per meter width.
The thickness of slab: 180 mm
Reinforcement required:
Provide 12Φ - @300 mm C/C along shorter span.
Provide 8 Φ -@ 150 mm C/C along longer span.

'THE SLAB IS SAFE UNDER SHEAR AND DEFLECTION'

6.2 Design of Beams

Based on different conditions, there are 3 groups of beams.

Group 1
Load considered = 36.275 kN/m
span = 7.20 m
Dimensions provided :- 230 mm x 600 mm
Reinforcement provided:-
#5-20 mm dia @ mid-span(tension steel)

#3-20 mm dia @ support
#2L-8 mm dia vertical stirrups @ 250 mm c/c
#2-12 mm dia nominal reinforcement.

Group 2
Load considered:- 28.00 kN/m
Span:-4.04 m
Dimensions provided: 230 mm x 350 mm
Reinforcement provided:-
#4-16 mm dia (tension steel_)
#2L-8 mm dia vertical stirrups @ 250mm c/c
#2-12 mm dia nominal steel.

Group 3

Load considered:-18.61 kN/m
Span:-4.01 m
Dimension provided:-230 mm x 300 mm
Reinforcement: - #2-16 mm dia & #2-12 mm dia as tension steel.

6.3 Design of Column

Based on loading-conditions, there are two types of columns are designed and following details shows the reinforcement details of the columns.

Type 1:-

Load coming = 1425 kN
column height = 3.20 m
Dimension provided :- 230x450mm
Reinforcement provided :
#6-20mm dia
#2L-12 mm dia lateral ties @ 250 mm c/c.

Type 2:-

Load coming = 1000 kN
column height = 3.20 m
Dimension provided: - 230 mm x 300 mm
Reinforcement provided:
#6-16 mm dia

#2L-12 mm dia lateral ties @ 250mm c/c

7. ESTIMATION

Estimation which concerned about the calculation of the quantities of the materials in detail and costing which concentrates on the amount involved during the construction, are determined by the suitable methods, and are tabulated in the Table. 2. The abstract estimation consists of the quantities of materials, tools and plants, equipment, labors etc., and the cost associated with them. Water supply, sanitary arrangements, cupboard & compound wall arrangements, Electrification arrangement, Material conveyance, machinery hire charges, labour charges & contractor's profit (including all). The total abstract cost of the building is 5,00,00,000 (In words – Five crores only)

Table 2. Abstract estimate of the college Building

Sl.	Descriptions	Quantity	Unit	Rate	Amount
1	Earth work excavation	1071.95	m^3	267	286211
2	Plane Cement Concrete in foundation	187.00	m^3	5100	953700
3	SSM in Foundation & Plinth	1200.00	m^3	2100	2520000
4	Plane Cement Concrete in plinth	90.00	m^3	2100	189000
5	BBM in Superstructures	980	m^3	7000	6860000
6	Reinforced Cement Concrete	1500.00	m^3	7500	11250000
7	Quantity of Steel	180.00	Ton	70000	12600000
8	Solid panel PVC one side open door frame with shutter	141.00	m^2	3650	514650
9	Flooring work	4800.38	m^2	620	2976235.6
10	Plastering work	2500.00	m^2	380	950000
11	Painting work	2500.00	m^2	250	625000
		Ground floor			**39724796**
		First floor			**10270000**
		Rounding off			**5204**
		Total			**50000000**
		Rupees Five crores only			

8. CONCLUSION

This project includes the planning of a G+1 college building using AutoCAD, Analysis and Design by manual approach using suitable IS code provisions. Surveying was done using chain & tape surveying, total station and concludes with the cost estimate for the entire project. The concluding remarks are as follows-

• The preparation of the project has provided an excellent opportunity to emerge ourselves in the planning and designing of the Ground floor and First floor college building.

• This project has given us an opportunity to re-collect and co-ordinate the various methods of Planning, Analysis, Designing, Estimation and engineering principles that we have learned in the academic.

• All the members of our team have learned to plan a building, this project is very useful to learn about the design of structural elements like beams, columns, footings and slabs by using IS 456-2000.

• After analysis of the G+1 proposed college building structure, we concluded that the structure is safe in different loads and load combinations, viz., dead load, live load, and wind load etc., Member dimensions (Beam, Column, and Slab) are assigned by calculating the load type applied on it.

• Manual design has been done for different dimensions of the beam, column, stairs, footing and slab of the building as per the IS 456-2000 and SP 16. The results obtained are safe from the manual calculation.

• We observed the difficulties during the detailing and drafting of the building components using Auto CAD software. The components considered for drafting are plans, elevation, cross-section, longitudinal section and cross section of the beams, columns, footing and slab.

• It has been observed the difference between planning of the such building theoretically and what are all the practical constrains are there during execution of the projects.

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