Analysis and Design of Hostel Building for 500 Students Capacity Considering Gravity Loads Using Staad-Pro

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Abstract— The main objective of the project is to Analyze and Design of Hostel Building for 500 student's capacity considering Gravity Loads (Dead and Live Loads) using STAAD-Pro. The foremost basic in structural engineering is the design of simple basic component and members of a building such as Slabs, Beams, Columns, staircases and Footings. The first step is to obtain the plan of the building. Then depending upon the area of the plot and demand for the size of the rooms number of columns are fixed up accordingly. Then the layouts of beams are prepared. Thereafter, the loads are calculated namely the dead loads and live loads. Once the loads are obtained, the component that takes the load first i.e. the slabs is designed depending upon the end conditions and the loading. From the slabs, the load is transferred to the beams. Thereafter, the loads from the beams are taken by the columns. For designing columns, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done using Staad-Pro.

Key words: Gravity Load, Beam, Column, Footing, Staircase

I. Introduction

We are aware of the problem and challenges posed by housing in the present age of shrinking space, time and rising expectations. The word housing is a generic term involving a series of relative kinds of activity, such as architecture, town planning and so on. Thus holding should not be regarding as something that provide shelter, but should be seen in a broader sense of providing "Built Environment". Man started delight not only in art of construction, but as well in painting, sculpture etc. The construction forms changed gradually as an introduction in new era with new art and science known as "Architecture". Architecture concerns itself not only with the external appearance but also with the creation of a desirable environment inside the building through dynamic interplay of space.

A. Engineering Structure and Structural Design

An engineering structure is an assembly of members or elements transferring the load or resisting external actions and providing a form to serve the desired function. The structural design is a science and art of designing with economy and elegance. A durable structure is one which can safely carry the forces and can serve the desired.

Function satisfactorily during its expected service life plan

B. Basic Requirements of Structural Design

- Serviceability
- Safety
- Durability
- Economy
- Aesthetic beauty

C. Stages in Structural Planning

Once the type of structure is finalized and planned, design of structure involves the corresponding stages in the planning.

- Column positioning
- Orientation of columns
- Beam location
- Spanning of slabs
- Layout and planning of stairs
- Type of footing.

Building is defined as any structure for whatsoever purpose and of whatsoever materials constructed and every part thereof whether used as human habitation or not and includes foundation, plinth, walls, floors, chimneys, plumbing and building services, fixed platforms, verandah, balcony, cornice(or projection), and signs and outdoor display structures. Broadly speaking, buildings consist of three parts, namely (1) Foundation (2) Plinth (3) Superstructure.

1) Foundation

It is the lowest artificially prepared part ,below the surface of the surrounding ground ,which is in direct contact with sub-strata and transmits all the loads to the sub-soil.

2) Plinth

It is the middle part of the structure, above the surface of the surrounding ground up to the surface of the floor (i.e., floor level), immediately above the ground.

3) Super structure

The part of structure constructed above the plinth level (or ground floor level) is termed as superstructure.

Buildings are generally classified on the basis of occupancy and types of construction. Based on occupancy buildings are classified as Residential, Educational, Institutional, Assembly, Business, Mercantile, Industrial Storage and Hazardous.

II. Description of the Project

Since the object project is to work out that designing of R.C.C member of framed structure the plan is so chosen that it incorporates the design of different of member, mainly.

A. SLABS

- One way slab
- Two way slab

B. BEAMS

- Continuous Beam
- T-Beam
- L-Beams

C. Columns

- Axially loaded Columns
- Bi-axially loaded Columns
- Uni-axially loaded Columns

D. FOOTING

- Isolated footing

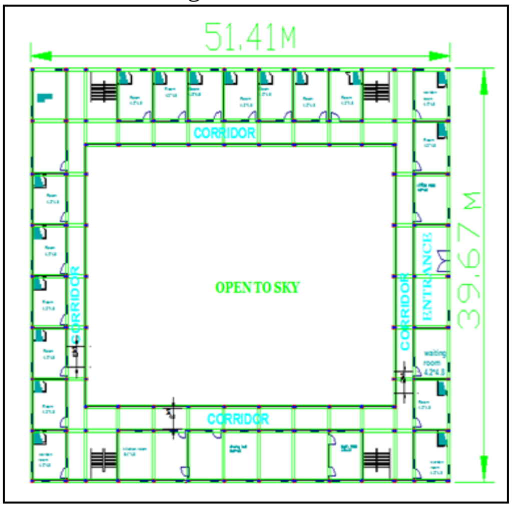

Fig. 1: Architectural Plan of typical floors

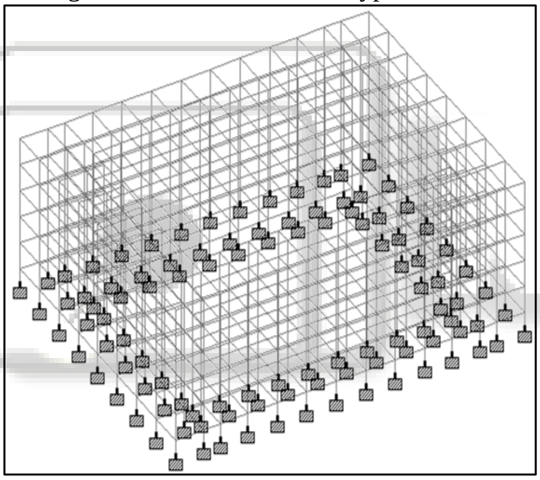

Fig. 2: 3D modelling

E. Project Data

Type of Building	G+4 Hostel Building of R.C.C framed structure
Height of building	3m (for each floor)
Area of the plot	51.41m x 39.67 m = 2039.43 m^2
Width of corridors	2.00 m
Outer wall thickness	0.23 m
Inner wall thickness	0.115 m
Wall thickness @ staircases	0.23 m
RCC	25 kN/m^3
PCC	24 kN/m^3
Brick	19 kN/m^3
Live load on building	2 kN/m^2 (IS -875-2000)
Balcony and staircase	3kN/m^2(IS -875-2000)
Floor finishes	1.0 kN/m^2(IS -875-2000)
Partitions load	1.0 kN/m^2(IS -875-2000)
Office room load	2.5 kN/m^2(IS -875-2000)
Washroom load	2.0 kN/m^2(IS -875-2000)
Grade of concrete for Slab, Column, Footing and Beam	M20
Grade of steel	Fe415
Beam size	300mm x 380mm
Column size	300 mm x 450 mm

Table 1: Structural parameters

III. STRUCTURAL DESIGNING

Structural design for framed R.C.C structure can be done by three methods:

1) Working Stress Method
2) Ultimate Load Method
3) Limit State Method

A. Working Stress Method

Working stress method is based on elastic theory assuming reinforced concrete as elastic material. The stress strain curve of concrete is assumed as linear from zero at the neutral axis to a maximum value at the extreme fiber. This method adopts permissible stresses which are obtained by dividing ultimate stress by a factor known as

In working stress method, the structural members are designed for working loads such that the stresses Developed are within the allowable stresses. Hence, the failure criterion is the stress. This method is simple and reasonably reliable

B. Ultimate Load Method

In ultimate load method, structural elements are designed for ultimate loads which are obtained by multiplying the working loads with a factor known as load factor. Hence, the designer can able to predict the excess load the structure can carry beyond the working loads without collapse. Hence, this method gives the true margin of safety. This method considers the actual stress strain curve of concrete and the failure criteria is assumed as ultimate strain.

C. Limit State Method

A structure may become unfit for use not only when it collapses but when it violates the serviceability requirements such as deflections, cracking etc. A structure is said to have reached its limit state, when the structure as a whole or a part becomes unfit for use, during its expected life. The limit state of a structure is the condition of its being not fit for its intended use. The philosophy of limit state method of design is to see that the structure remains fit for use throughout its life period by assuring safety against strength and serviceability requirements i.e. the structure will not reach the limit state in its life time.

1) Limit State Concept

Limit states are the acceptable limits for the safety and serviceability requirements of the structure before failure occurs. Many types of limit states or failure conditions can be specified. The two major limit states which are usually considered are of the following.

- Limit state of collapse.
- Limit state of serviceability.

- Limit State of Collapse**:** It is the limit state at which the structure is likely to collapse. The structure may collapse due to rupture of one or more critical sections or loss of overall stability due to buckling or overturning. The limit state may correspond to:
  - Flexure
  - Compression
  - Shear
  - Torsion
- Limit State of Serviceability**:** Limit state of serviceability relate to the performance of the structure at working loads. It is the limit state at which the structure undergoes excessive deflection, which adversely affect the finishes causing discomfort to the users and excessive cracking which affects the efficiency or appearance of the structure. This limit state may correspond to:
  - Deflection
  - Cracking
  - Other limit states (Vibrations, Fire resistance, Durability)

IV. DESIGN OF R.C.C ELEMENTS

A. Design of Slab

Slabs are plain structural members forming floors and roofs of building whose thickness is quite small compared to their other dimensions. These carry load primarily by flexure and are in various shapes such as square, rectangular, circular and triangular in buildings, tanks etc. inclined slabs may be used as ramps for multistoried as parking. A staircase is considered to be an inclined slab.

Slab may be supported by beams or by walls and may be simply supported or continuous over one or more supports. When the ratio of the length to the width of a slab is more than 2, and then most of the load is carried by the shorter span and in such a case is known as one-way in case the ratio is less than 2 then it is called a Two-way slab, which is further classified as restrained and simply supported slabs.

Design of Two Way Slab for the S_1 Slab Panel (Similar To S_1panel of Ground, 1st, 2nd, 3rd, 4th Floors).

Lx= 3.65 m (Shorter Span)

Ly= 4.55 m (Longer Span)

Ly/Lx =4.55/3.65 = 1.24 ≤ 2;

So design as two way slab

Effective depth d= Lx/28

= 3650/28 = 130 mm.

Top reinforcement	#10mm @ 300mm c/c
Bottom reinforcement	#10mm @ 300mm c/c
Edge strip reinforcement	#10mm @450mm c/c
Torsion reinforcement	#8mm @375mm c/c

Table 2: reinforcement details in slab

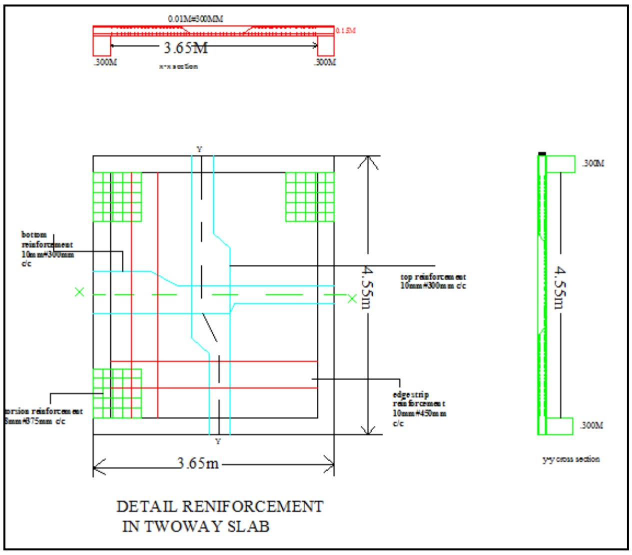

Fig. 3: Detail Reinforcement in Two Way Slab

B. Design of beam

A reinforcement concrete beam should be able to resist tensile, compressive and shear stresses induced in it by the on the beam. Concrete is fairly strong in compression but very weak in tension. Paint concrete beams are thus limited in carrying capacity by the low tensile strength. Steel is very strong in tension. Thus, the tensile weakness of concrete is overcome by the provision of reinforced steel in the tension zone round the concrete to make a reinforced concrete beam.

b=300 mm

D= 380 mm

f_{ck}= 20 N/ mm^2

f_y= 415 20 N/ mm^2

$M_{u=}$ 44.09 kN-m

Design end section as rectangular beam

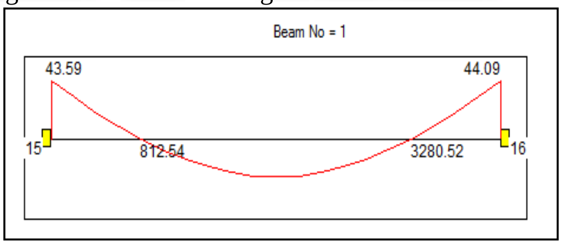

Fig. 4: Bending Moment

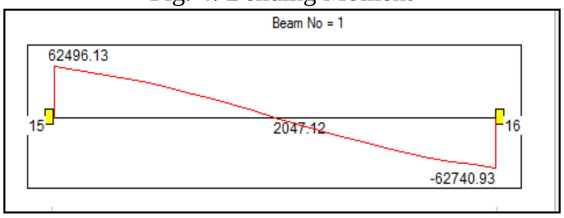

Fig. 5: Shear force

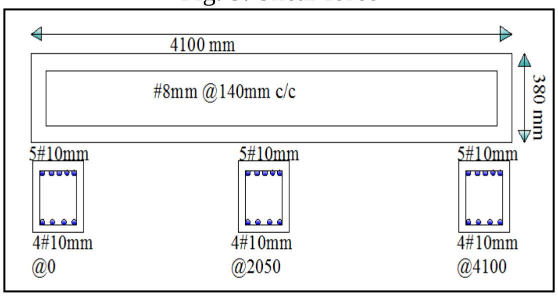

Fig. 6: Detail reinforcement in Beam

C. Design of Column

A column or strut is a compression member, which is used primarily to support axial compressive loads and with a height of at least three times it's least lateral dimension.

Pu= 558.26 kN
M_z= 14.58 kN-m
M_y=18.79 kN-m
f_{ck}= 20 N/ mm^2
f_y= 415 N/ mm^2
L= 3m
Size of column= 300x450 mm

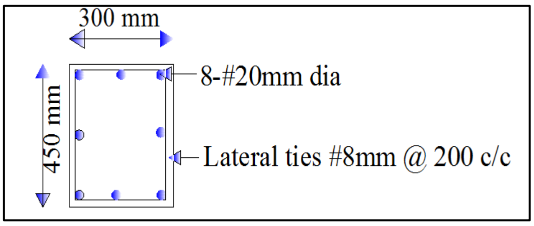

Fig. 7: Detail Reinforcement in column

D. Design of footing

The type of footing depends upon the load carried by the column and bearing capacity of the supporting soil. It may be noted that the earth under the foundation is susceptible to large variations. Even under one small building the soil may vary from soft clay to hard murum.

Pu= 558.26 kN
M_z= 14.58 kN-m
M_y=18.79 kN-m
f_{ck}= 20 N/ mm^2
f_y= 415 20 N/ mm^2

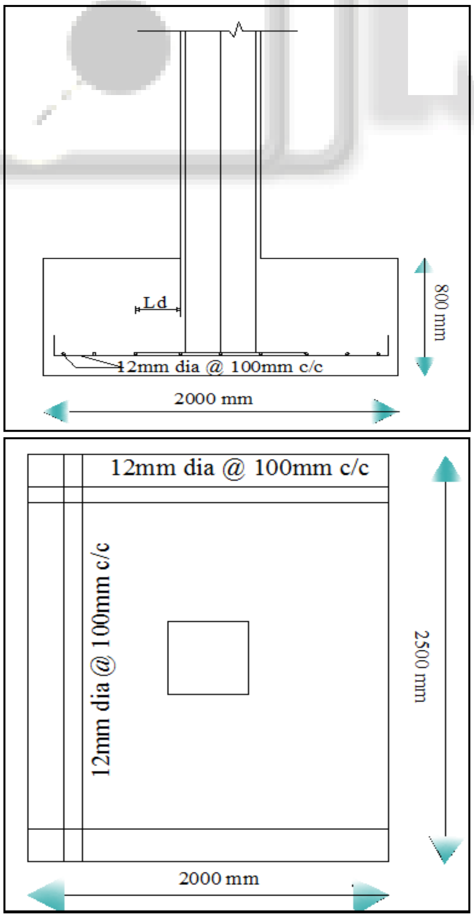

Fig. 8: Column and Footing reinforcement details

V. CONCLUSION

- Steel provided in the structure is economical.
- By used structural sizes in building are safe under all critical conditions.
- Torsion effect in all columns very less.
- All Columns are safe against local buckling.
- All beams are safe in deflection.

VI. SCOPE OF FURTHER STUDY

- The same analysis can also be done by using ETAB Software.
- Structural elements can be designed by individually to get even more economical structure.

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