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Analysis and Design of a Commercial cum Residential Building By Using STAAD Pro

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Abstract - *Computer Aided Design of Commercial cum Residential Building involves analysis of building frames by using STAAD Pro and manual design of the frame elements. Conventional method of analysis involves lot of complications and tedious calculations such analysis is a time consuming task. Analysis can be made quickly by using software's.*

STAAD Pro is the leading design software in the market. Many design companies use this software for their project design purposes. Hence this project mainly deals with the analysis of the building by using STAAD Pro. These analysis results will also be compared by manual calculations of a sample beam and column of the same structure and these elements are design manually as per IS 456-2000.

Key Words: STAAD PRO, Design of RCC elements, Analysis, multi-storey building, slab, beam, column, footing and stair case etc.....

1. INTRODUCTION

Structural design is an art and science of designing, with economy and elegance, a safe, serviceable, and a durable structure. The entire process of structural planning and design requires not only imagination and conceptual thinking (which form art of designing) but also sound knowledge of science of structural engineering besides knowledge of practical aspects, such as relevant design codes and bye-laws, backed up by ample experience, institution and judgment.

The process of design commences with planning of a structure, primarily to meet the functional requirements of the user or the client. The requirements proposed by the client may not be well defined. They may be vague and may also be impracticable because is not aware of the various implications involved in the process of planning and design and about the limitations and the intricacies of structural science. The functional requirements and the aspect of aesthetics are look into normally by an architect while the aspect of safety, serviceability, durability and economy of the structure for its intended use over life span of the structure are attended by the structural designers (many times, a structural engineer is require to act in capacities of both the architect and the structural designer

1.1. Stages in Structural Designs:

The process of structural design involves the following stages.

The process of structural design involves the following stages: Structural planning, Computation of loads, Method of analysis, Member design and Detailing, drawing and preparation of schedules

1.2 About STAAD Pro:

It is widely used software for structural analysis and design from research engineers international it consists of following.

It is a graphical user interface, (GUI) it is used to generate the model, which can then be analyzed using STAAD engine. After analysis and design is completed, the GUI can also be used to view results graphically.

The STAAD analysis and design engine:

It is a general purpose calculation engine for structural analysis and integrated steel, concrete, timber and aluminum design. The documentation for STAAD pro consists of a set of manual as described.

1.3 Getting started:

This manual contains information on the contents of the STAAD Pro package computer system requirements installation process, copy protection issues and description on how to run the programs in the package. Tutorials that provide detailed and step-

by-step explanation on using the program are also provided.

1.4 Graphical environment:

The manual contains a detailed description of the GUI of STAAD Pro. The topics covered include mode generation, structural analysis and design, result verification and report generation.

1.5 Technical Reference:

This manually deals with the theory behind engg calculations made by STAAD engine. It also includes an explanation of commands available is a STAAD command file.

1.6 Release report:

This manually deals with the latest enhancement of program which is being supplied to the users as ready reference. It includes all related technical understanding and graphical changes from the last version

2. Modeling:

- Graphical mesh generation facilities available for generating elements from complex shapes with holes.
- Import of DXF files, for 3D surface entities.
- Degree of freedom at nodes can be released selectively.

2.1 Property and loading

- Constant thickness as well as linearly varying thickness between nodes.
- New IBC 2003 code for automatic distribution of seismic load.
- New loading for sample application of complex loading patterns.
- New floor load generator which automatically updates the pressure distribution if floor changes also allows for elimination of floor members and creation of floor groups.
- Automatically reduces the live loads dubbed as live load or roof load (live) as per UBC/IBC.
- Wind load on open lattice structure.

2.2 Analysis capabilities:

Static, P-Delta, Non-linear Analysis.

- Liner, P-Delta analysis.
- Non-linear with automatic load stiffness connection.
- Multiple analyses in same run.
- True curvilinear beams (not piecewise linear).
- Plate elements contain extra drilling degree of freedom.
- Tapered tabular cross section such as Hexagonal octagonal, etc (excellent for poles).
- Unidirectional support (compression only/tension only) for generation of soil springs.
- Master/slave capabilities.
- I beam warping end restraint added an option for torsional stiffness.
- Bulking analysis.

2.3 Concrete design:

- Two way slab design to design irregular shaped slabs full reinforcement contour and reinforcement layout plans are created.
- Rectangular concrete shear wall design (with deep beam design) and automatically mesh all existing wall and provide horizontal, vertical and edge reinforcement, based on axial moments.
- Automatic calculation of cracked moment of inertia for concrete design.

3. OBJECTIVES

Computer aided design of commercial cum residential building by using STAAD PRO which includes.

- Generating structural framing plan
- Creating model in STAAD PRO
- Application of loads on the member
- Analysis of the structure
- Design the structure (manual design

4. DESIGN PROCEDURE

A four floor commercial cum residential building is considered whose architectural plan and structural framing plans were prepared as shown in figure 1 to 4 below before it is modeled in STAAD Pro.

The entire analysis of building has been done in one stage keeping the IS code provision in view wherever necessary. The whole building has been split into its structural components viz., slab, beams, columns and footings. These components are designed for M20 grade concrete and Fe415 grade steel.

At first the slab have been classified into two types based on edge conditions, spans, dimensions, Lx and Ly ratios and typical analysis suggested. The loads of these slabs (dead load + live load) are transferred on the beam both in X and Y direction.

A preliminary design of typical beam had been carried out based on the loads carrying over through slab, their own dead weight (section assumed) all the wall loads coming as such. The column section has been proportioned to take the loads. The maximum positive and shear have been evaluated for beam and column

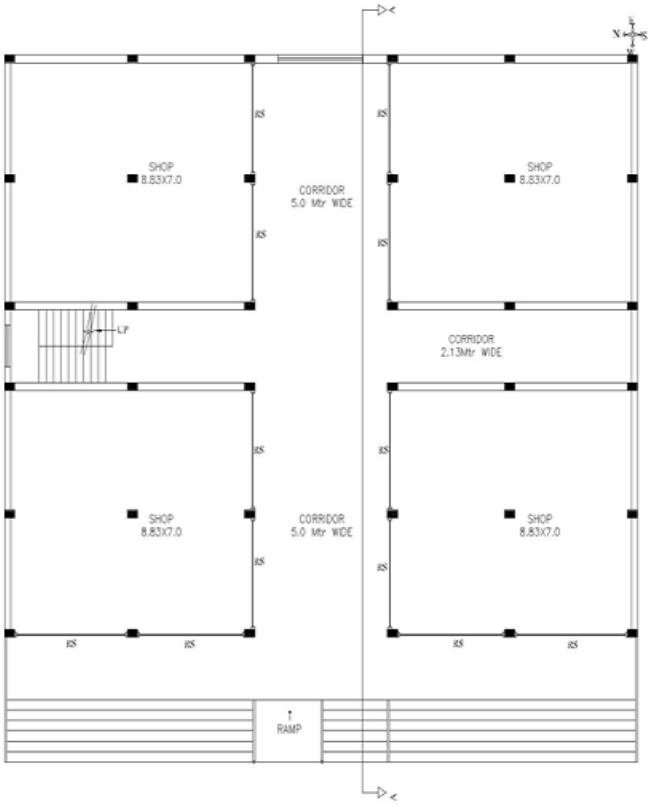

Fig 1. Plan of a building

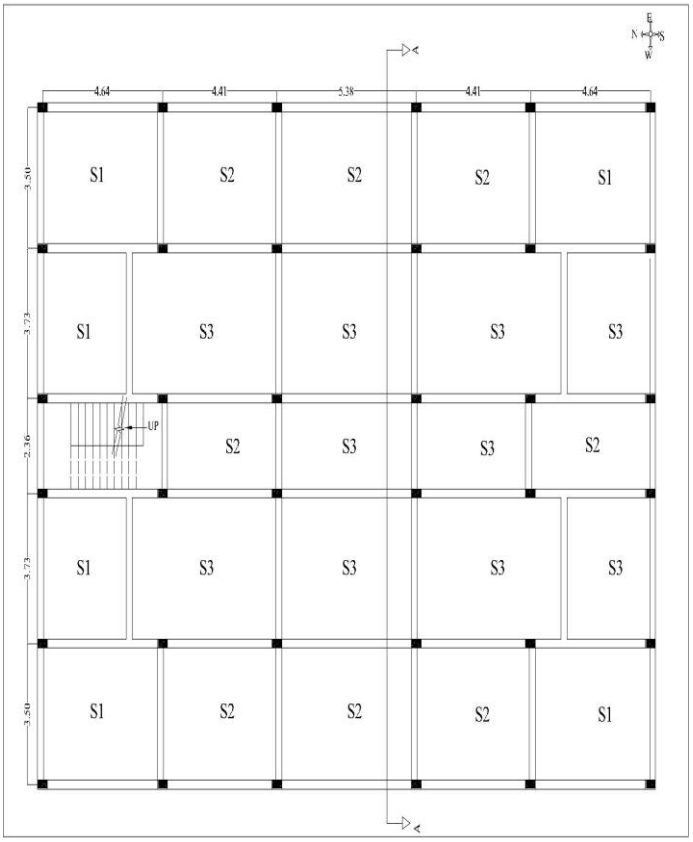

Fig 2. FRAMING PLAN

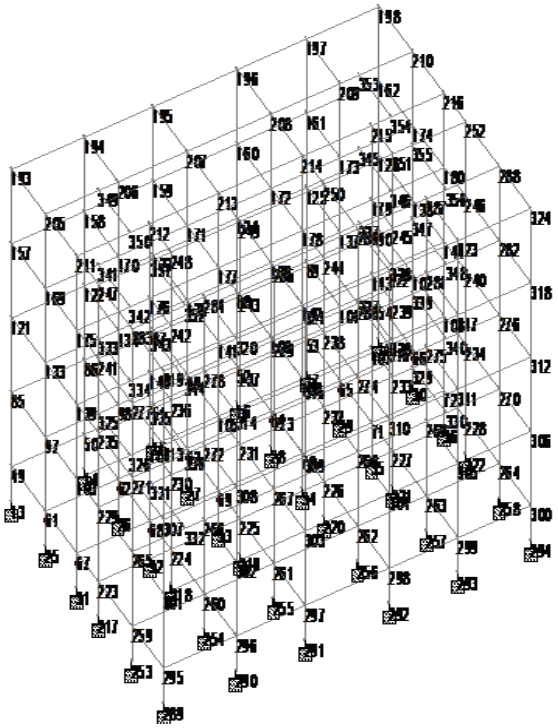

Fig 3. 3D modelling

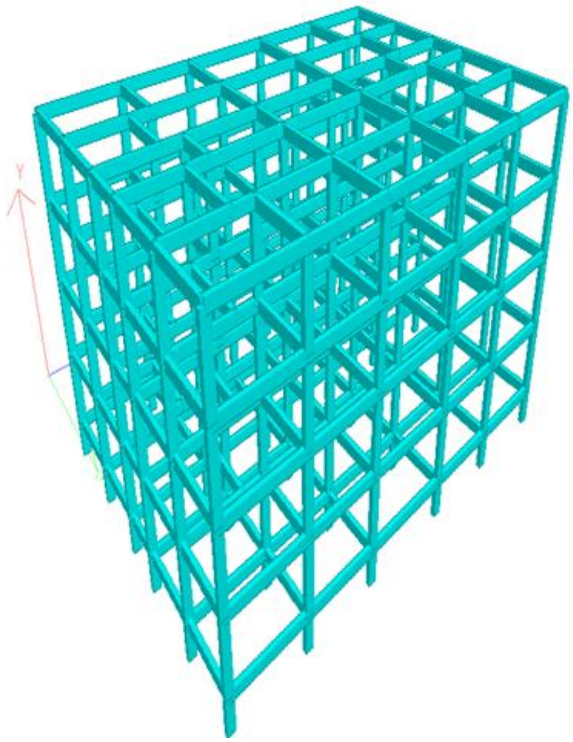

Fig 4. 3D rendering

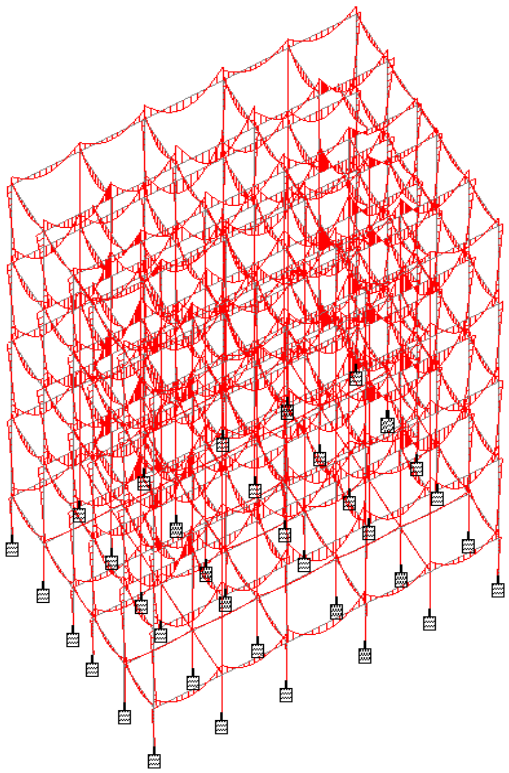

Fig 5. Bending moment diagram

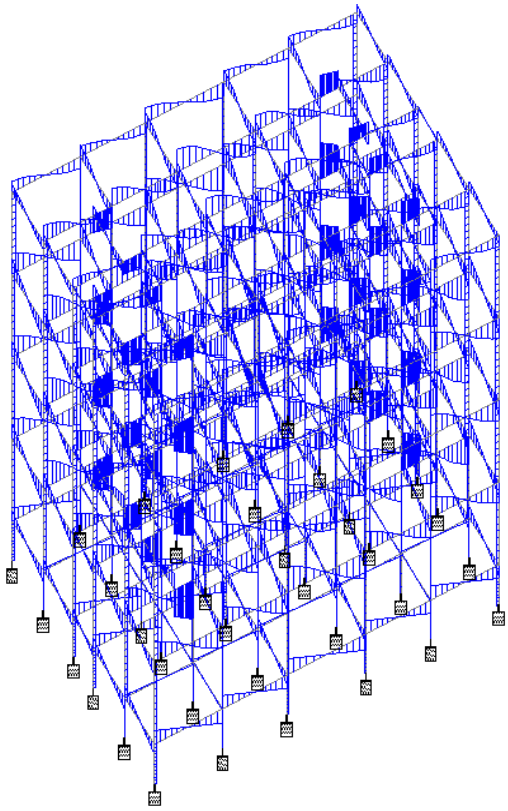

Fig 6. Shear force diagram

5. DESIGN OF RCC ELEMENTS

5.1 Design of slab

5.1.1 Design of two way slab s1 (from is 456-2000, annex-d-1.1, table-26 & sp-16, table-2)

Short span S= 3.50 mts

Long span L= 4.64 mts

Assumed slab thickness t = 0.15mts greater than 'min. eff depth reqd'. Hence ok

Grade of concrete fck = 20N/mm^2

Grade of reinforcement fy = 415N/mm^2

Type of panel Two adjacent sides discontinuous

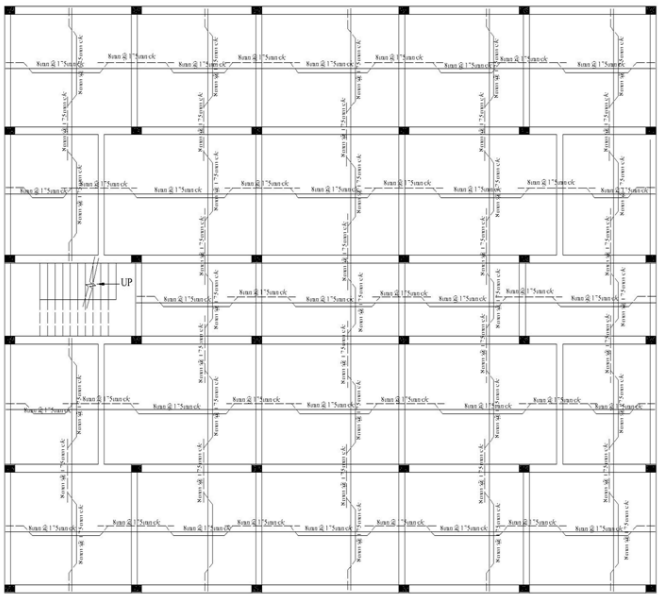

Fig 7. Slab reinforcement details

5.2 Design of beams

Design of Beam B1, B2 & B3

Design end section as rectangular Beam

b = 230mm

D = 450mm

f_{ck} = 20 N/mm²

f_y = 415 N/mm²

M_u = 93.77 KNm

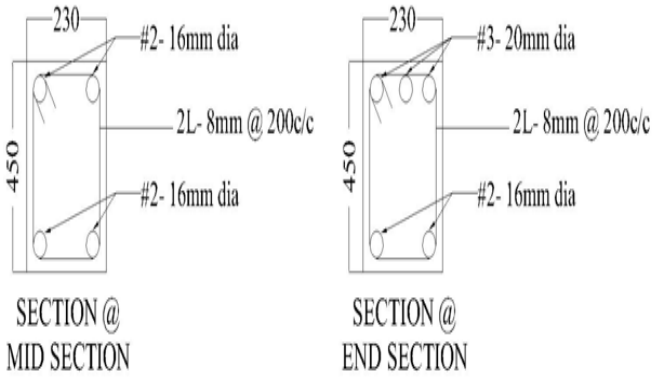

Fig 8. Beam reinforcement details

5.3 DESIGN OF COLUMN

A column may be defined as an element used primarily to support axial compressive loads coming from the beam. All columns are subjected to axial force and some moments. The column is design as uniaxial column. The column is designed according to SP 16 Code practice. From the STAAD Pro output values, considering the column which is subjected to maximum axial load & moment.

Table 1. Loads from STTAD Pro

Member Number	Axial Load KN	Moment KN.m
521	1.41X10³	1.095

P_u = 1410KN

M_u = 1.095 KNm

f_{ck} = 20N/mm²

f_y = 415N/mm²

L = 1.5m

From IS 456-2000 Page No.94

$L_{eff.}$ = 0.65 l = 0.65x1.5 = 0.975m

5.4 DESIGN OF FOOTINGS

Consider the column member which is subjected to maximum axial load & moment.

Table 2. Loads from STTAD Pro

Member Number	Axial Load KN	Moment KN.m
521	1.41X10³	1.095

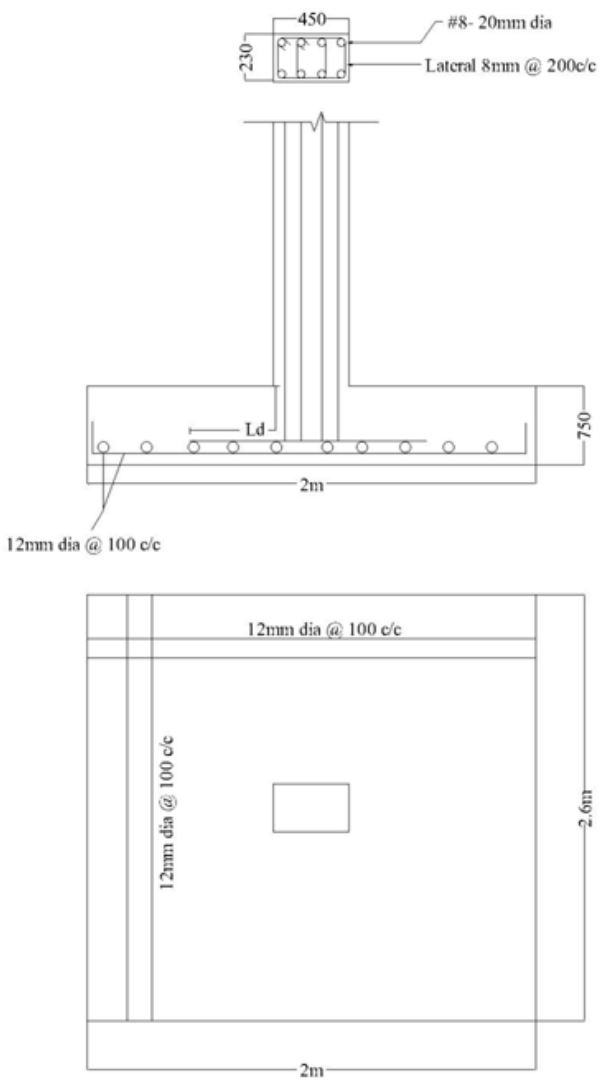

Fig 9. Column and Footing reinforcement details

5.5 DESIGN OF STAIR CASE

The purpose of a stair case to provide access to pedestrian in a building. The geometrical forms of staircase may be quite different depending on the individual circumstances involved. The shape and structural arrangement of a staircase would generally depend on two main factors.

1. Type of construction of structure around the stair case that is load bearing brick structure or reinforced concrete framed structure.

2. Availability of space.

Type of staircase provided for the proposed building is Bifurcated staircase, which consists of two flights. The first flight starts from plinth level to lintel level and second flight starts from lintel level to roof level.

Design of First Flight:

Size of Room = 2.36x4.64

Width of the flight = 1.2m

Assuming rise = 150mm

Tread = 250mm

Number of rise = 1500/150 = 10 Nos.

Number of tread = 10-1 = 9 Nos.

Providing landing width = 1200mm

Effective span = (9x250) +1200

= 3450mm

Assuming thickness overall = 400mm

Waist slab = 40x3.45 = 138 mm

= 150mm

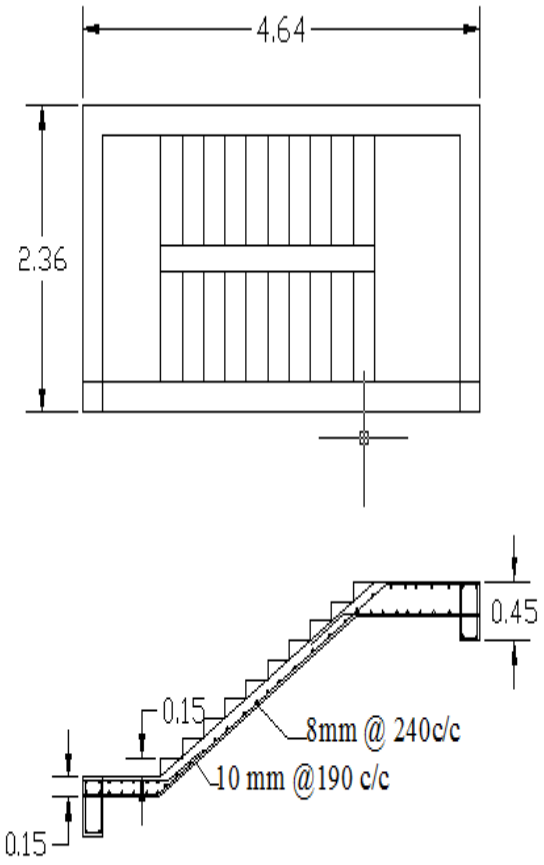

Fig 9. Stair case reinforcement details

6. CONCLUSIONS

1. Short term deflection of all horizontal members is within 20mm.
2. The structural components of the building are safe in shear and flexure.
3. Amount of steel provided for the structure is economic.
4. There is no such large difference in analysis results of STAAD Pro and Kanis method.
5. Proposed sizes of the elements can be used in the structure.

7.FUTURE SCOPE OF STUDY

- By keeping the same analysis results of software, the design can be made more economical by designing members individually or in group.
- Meshing of the slab element can be done to get the accurate load distribution.

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  - SP-34 (Detailing).