

“Design and modeling of commercial cum residential building by using Autodesk Revit and StaadPRO.”

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ABSTRACT:

It is not easy to design a huge building by manually it takes time and manpower too, but by using software it saves time and manpower. The commercial cum residential building has mixed stories, with the ground floor consisting of commercial shops and the first floor consisting of residential floor of 2BHK flat. In big cities, very limited land is available and it is of high cost. The primary goal of our project is to gain sufficient knowledge in planning, design, modeling, and analysis of a commercial cum residential building. In this project, planning and drafting are done by using Autodesk AutoCAD, 3D Modeling is done by using Autodesk Revit Architecture, and Analysis and Design are done by using StaadPRO.V8i. Manual calculations of structural members like Slab, Beam, Column, and footing are done by the Limit State Method by using IS456:2000, IS875 and design aid SP16 code.

KEYWORDS- Autodesk AutoCAD, Autodesk Revit Architecture, StaadPRO.V8i, Planning, Design, Modeling, analysis.

1. INTRODUCTION:

Our project is “Design and modeling of commercial and Residential Building by using Autodesk Revit Architecture and StaadPRO.” The main objective of our project is to gain sufficient Knowledge in planning, Design, Modeling and Analysis of a commercial cum residential building. It is a reinforced concrete framed structure consisting of G+1. All the structural members are designed by using National Building Code. IS 456:2000, IS 875, and design aid SP16. The structural components like Slab, Beam, Column and footing are manually designed by using Limit State Method.

Materials were used as specified by the National Building Code. For all the design, Concrete M20 grade and Fe 500 steel bars. Brick walls are in C.M 1:5 mix with wall external and internal wall thickness of 230 mm and 150 mm

respectively. The total area of our building is 139 sq.m. The commercial shops had a glass wall for shops. Commercial space includes three shops, Two Store rooms, One Staffroom and two separate toilets for male as well as female and a staircase of 3 m wide. First floor is a residential floor (2BHK) with all the facilities.

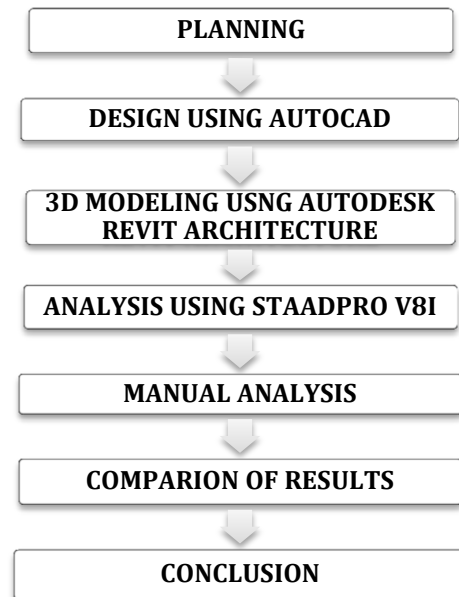
LITERATURE REVIEW-

1. **V. S. Nagasai et al. (2019)**, “Planning, Analysis and Design of Residential Building (G+5) By using STAAD Pro.” This paper deals with Frame analysis, which was done by STAAD.pro. Slab and beams were designed as per IS code 456-2000. The properties such as shear, deflection, development, torsions are defined by the IS code provisions.
2. **Falak Vats (2019)**, “Review paper on design and analysis of multi-storey building by the use of Stadd.Pro,” He concluded that Stadd.Pro provides a much faster approach to structural analysis and design with a chances of minimum errors. There has been several research conducted comparing the results from Stadd.Pro to the manually calculated results, which all support the use of Stadd.Pro over manual the one. Stadd.Pro is a much better way to analyse complicated load combinations and is quite versatile.
3. **Sowrav Saha, et al. (2021)**, “Design and Analysis of Multistorey (G+14) Residential Building Using Staad.Pro & Autocad” The aim of their project was to bring an idea to plan, through analysis and design of a multi-storeyed, earthquake resistant residential building. They were unsuccessful in fully completing the project in a successful and efficient manner by considering all the relevant features given.
4. **R. S. Bute, et al. (2018)**, – “Design a detailed 3D model of a building With the comparison of manual and Software estimates on Autodesk revit”, they

concluded for the uses of scheduling and cost estimating in Autodesk Revit respectively, and provided a case study to show how Autodesk Revit can work for Architects, Engineers and contractors. As well as comparing Autodesk Revit Estimate with Manual Estimate.

5. **Amar Hugar et al. (2016)**, has been discussed that the Computer Aided Design of Residential Building involves scrutiny of building using STAAD.Pro and a physical design of the structure. Traditional method of study show tedious calculations, and such tests are time consuming task. Analysis is made quickly by using software. This project completely deals with scrutiny of the building using the software STAAD.Pro. Finally, the results are compared with physical calculations. The elements are created as per IS:456-2000.
6. **Bandipati Anup et al. (2016)**, this paper deals with evaluating and planing a multi-storeyed building [G + 2 (3- dimensional frame)] adopting STAAD Pro. The technique used in STAAD.Pro is limit state technique. Initially they have created 2-D frames and cross checked with manual calculations. They tested and created a G + 2 storey building [2-D Frame] instantly for all feasible load combinations. The work has been finished with some more multi-storyed 2-Dimensional and 3- Dimensional frames beneath various load combinations.

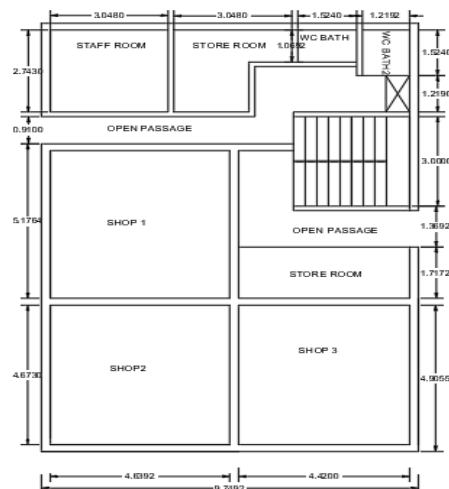
4. METHODOLOGY



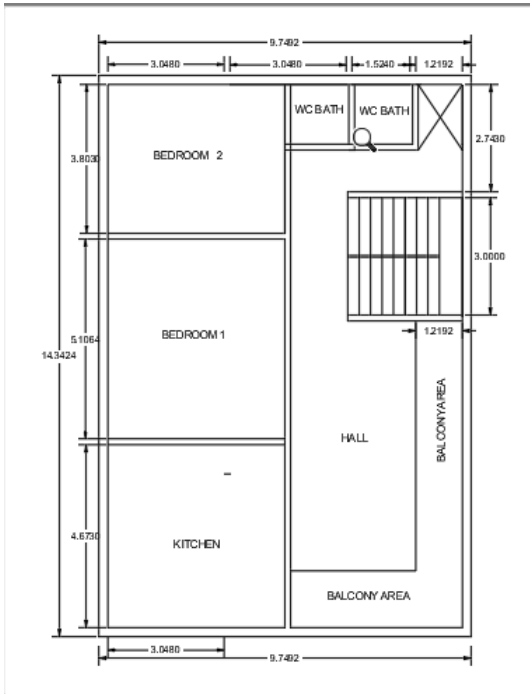
4.1 DESIGN USING AUTOCAD-

AutoCAD is a computer-aided design and drafting software application. AutoCAD is used to draft out plans, elevations, cross sections etc. of a building. The CAD drawing helps to identify the details such as balcony, kitchen, rooms, dining hall, thickness of wall, site details etc.

AUTOCAD PLAN-



Ground Floor Plan



First Floor Plan

4.2 AUTODESK REVIT ARCHITECTURE 3D MODELING:

Nowadays, it is necessary to complete a project within a reasonable time and economically. Autodesk Revit is building information modeling softwares i.e., BIM software for architects, landscape architects, structural engineers, designers, and contractors. Autodesk Revit allows us to design and document a building by creating a three dimensional model that includes design and construction information, which is also known as building information modeling. After creating the model we used Revit rendering tool to make the model more realistic.



4.3 STAAD ANALYSIS AND MODELING

STAAD PRO is one of the most popular software that is used for analysis and designing towers, bridges, buildings etc. The first step in our process will be reading the plan that has been created. From this reading process, we will get all the information such as the number of storeys, number of bays, loadings, etc. The G+1 building is modelled using the Structure Wizard inside STAAD Pro according to the building.

Member Section	Dimensions (mm)
Beam	230 x 300
Column	230 x 300
Slab Thickness	100
Wall Thickness	External-230 Internal -150

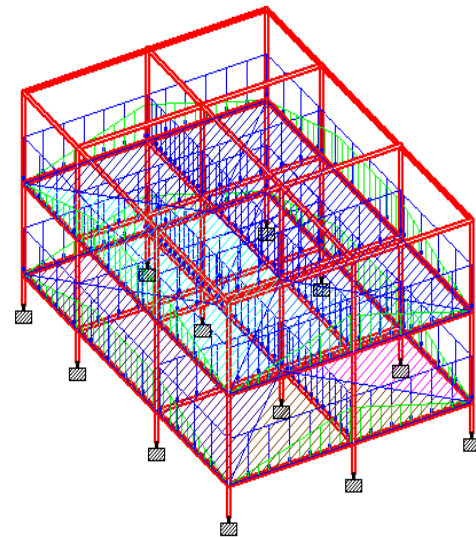
Density of materials used:

MATERIAL	DENSITY
Plain concrete	24.0 KN/m
Reinforced	25.0KN/m
Flooring material (cm)	20.0KN/m

4.3.1 DEAD LOAD -

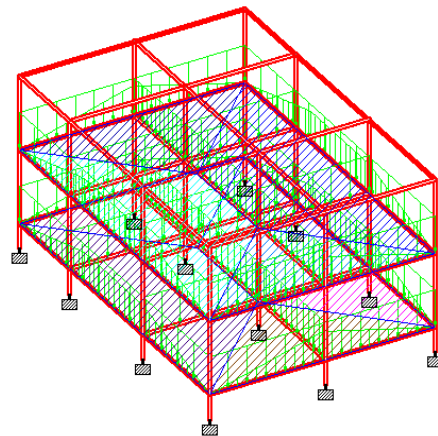
Dead loads are the structural loads that include the self weight of the structural members such as walls, ceilings, floors, plaster etc. According to IS 875 part 2,

Dead load- 15KN/M



Self-weight is the body's own weight of body, due to the mass present in it. In STAAD Pro, we can directly add the self-weight by selecting the whole structure and simply specifying the direction of force. It is a dead load. According to IS 875 part 2,

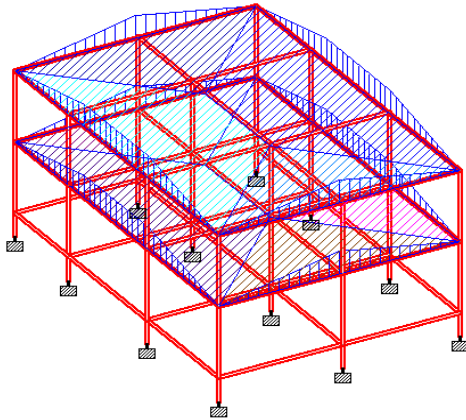
Self weight - Factor = -1KN/M



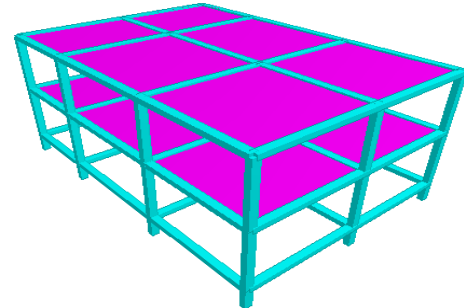
4.3.2 LIVE LOAD-

Live loads are temporary loads that are applied to the structure on and off over the life of the structure. According to IS 875 part 2,

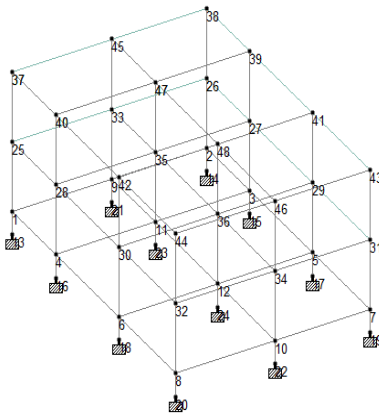
Live load- 2KN/M



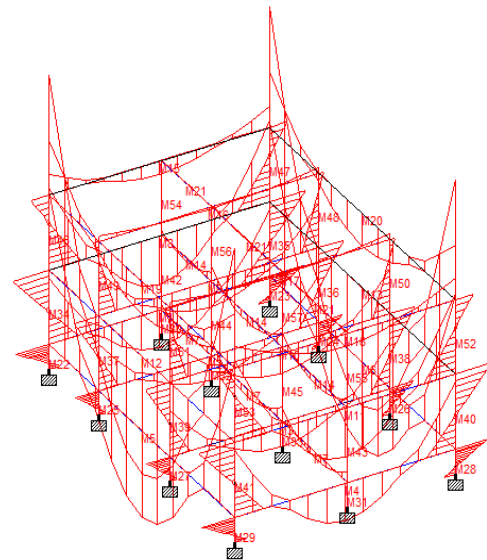
RENDERING-



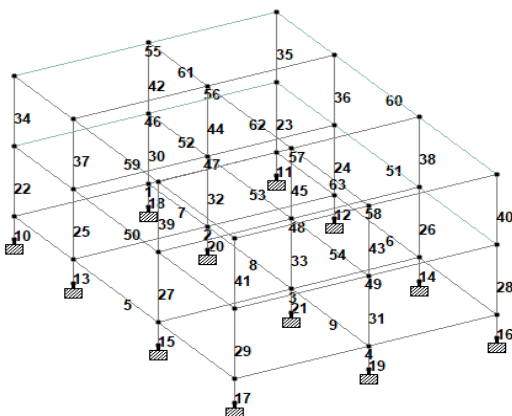
NODE NUMBER-



BENDING MOMENT-



BEAM NO-



4.3.3 STAAD EDITER SAMPLE RESULTS -

CONCRETE GRADE	M20
STEEL GRADE	Fe500
LENGTH	4863 mm
SIZE	300 mm x 230 mm
COVER	25mm
SHEAR REINFORCEMENT	8 mm Ø 2 legged vertical stirrups @145 mm c/c.
TOP REINFORCEMENT	8 bars of 12 mm dia.
BOTTEM REINFORCEMENT	4 bars of 16 mm dia.

5. SAMPLE MANUAL CALCULATION-

5.1 Design of Beam

Beams shall normally be provided under the wall or under a heavy concentrated load. Beams transfer load from slabs to columns, beams are designed for bending. In general, we have two types of beam: single and double. Similar to columns, the geometry and perimeters of the beams are assigned.

There are three types of reinforced concrete beams

1. Single reinforced beams
2. Double reinforced concrete
3. Flanged beams

Step 1

Dimensions

AB = 4.83m

BC = 4.60m

Beam Size = 230mm *300mm

Cover = 50mm

Effective Depth = 250 mm

For M20 concrete and Fe 500 steel

Step 2

Load Calculation

- For span AB

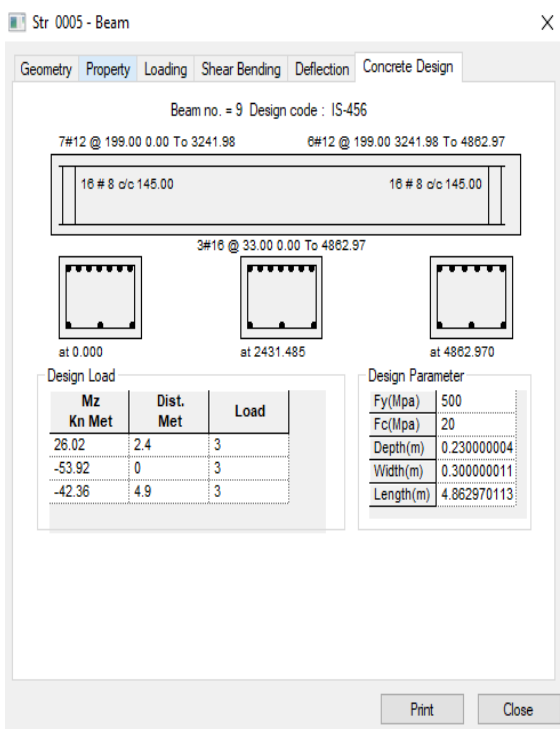
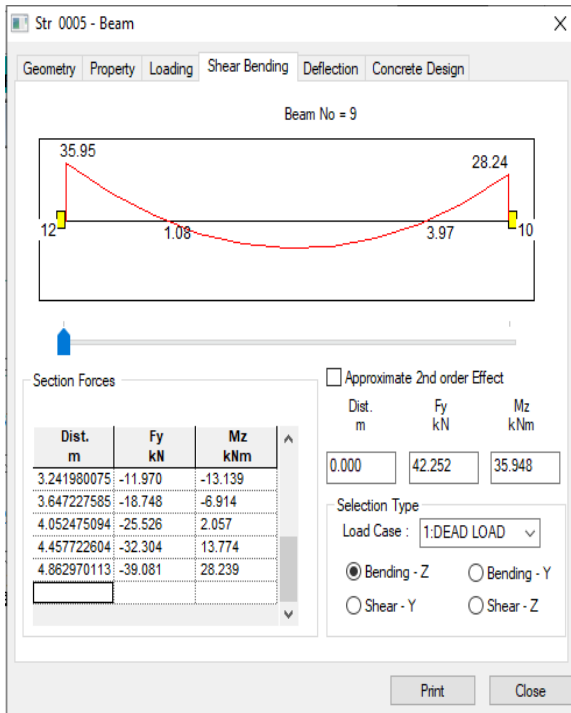
Trapazoidal Area = $\frac{1}{2} * (0.03+4.83) * 2.415 = 5.86 \text{ m}^2$

- i. Self weight = $0.23*0.30*1*25 = 1.725 \text{ KN/m}$
- ii. Wall Load = $0.23*1*19 = 4.37 \text{ KN/m}$
- iii. Slab Load = $12*5.86/4.83 = 14.55 \text{ KN/m}$

Total Working load = 20.645 KN/m

Factored Load = 30.96 KN/m

- For Spam BC



Trapezoidal area = $\frac{1}{2} * (0.25+4.61)*2.30 = 5.59 \text{ m}^2$

- i. Self weight = 1.725 KN/m
 - ii. Wall load = 4.37 KN/m
 - iii. Slab Load = 13.64 KN/m
- Total working load = 19.74 KN/m
Factored load = 29.60 KN/m

Step 3

Calculation of FEMs

- Span AB
 $MAB = -wl^2/12 = -30.96*4.83^2/12 = -60.18 \text{ KN}$
 $MBA = 60.18 \text{ KN}$
- Span BC
 $MBC = -wl^2/12 = -29.60*4.61^2/12 = -52.42 \text{ KN}$
 $MCB = 52.42 \text{ KN}$

Step 4

Calculation of Distribution Factor

Joint	Member	Stiffness	Total Stiffness	DF
	BA	0.20		0.48
B			0.42	
	BC	0.22		0.52

Step 5

Moment Distribution Table

Joint	A	B		C
	AB	BA	BC	CB
DF		0.48	0.52	
	-60.18	60.18	-52.42	52.42
		-3.72	-4.03	
	-1.86			-2.015
Final	-62.04	56.46	-56.46	50.405

RA = 76.76 + 1.15 = 88.27 KN
 RB = 74.76 + 68.22-1.15+1.31 = 143.14 KN
 RC = 68.22-1.31 = 66.91 KN

S.F. Calculation

SFAL= 0
 SFAR= 88.27 KN
 SFBL = 88.27 - (30.96*4.83) = -61.26 KN
 SFBR = -61.26+143.14 = 81.88 KN
 SFCL = 81.88- (29.60*4.61) = -66.91 KN
 SFCR = 0

Calculation of Mulim

=0.133Fckbd² = 0.133*20*230*250² = 38.24 KN
 Span AB = $Wl^2/8 = .96*4.83^2/8 = 90.28 \text{ KN.m}$
 Span BC = $Wl^2/8 = 29.60* 4.61^2/8 = 78.63 \text{ KN. M}$

Calculation of Ast

Span AB

Ast=0.5*20/500*[1-4.6*59.25*10⁶/20*230*250²]
 *230*250
 = 887.75 mm²
 No. of Bars = 887.75/π/4*16² = 4.41 ≈ 6 Nos.
 Asc=0.5*20/500*[1-4.6*31.03*10⁶/20*230*250²]
 *230*250
 = 333.96 mm²
 No. of Bars = 333.96/π/4*12² = 2.95 ≈ 4 Nos.

Span BC

Ast=0.5*20/500*[1-4.6*53.43*10⁶/20*230*250²]
 *230*250
 = 711.91 mm²
 No. of Bars = 711.91/π/4*16² = 3.50 ≈ 4Nos.
 Asc=0.5*20/500 * [1- 4.6*25.2*10⁶/20*230*250²]
 *230*250
 = 261.59 mm²

No. of Bars = $261.57/\pi/4*12^2 = 2.30 \approx 4$ Nos.

Check for shear

For span AB

$V_u = Wl/2 = 74.76$

$\tau_c = 74.76*10^3/230*250 = 1.30$

$P_t = 887.75/230*250 *100 = 1.54$

Pt	
1.50	0.72
1.54	X
1.75	0.75

$X = 0.75 - (0.75-0.72)/ (1.75-1.50) * (1.54-1.50)$

$X = 0.74$

$\tau_v > \tau_c$

Assume 8 mm 2 legged vertical stirrups.

$V_s = V_u - \tau_c *b*d = 74.76*10^3 - 0.74*230*250$

$V_s = 32.21$ KN

Spacing = $0.87*500*100.53*250/ 32.21*10^3$

= 339.41 mm

$S_v = 0.75d = 0.75*250 = 187.5$ mm

$S_v = 300$ mm

Provide 190 mm Spacing.

Check for shear Span BC

$V_u = Wl/2 = 68.22$

$\tau_v = 68.22*10^3 /230*250 = 1.18$

$P_t = 711.91/230*250 *100 = 1.23$

Pt	
1.00	0.62
1.23	X
1.25	0.67

$X = 0.67 - (0.67-0.62) / (1.25-1.00)* (1.23*1.00)$

$\tau_c = 0.62$

$\tau_v > \tau_c$

Hence, shear reinforcement required.

Provide 8mm Ø 2 legged vertical stirrups

$V_s = V_u - \tau_c *b*d = 68.22*10^3 - 0.62 * 230 *250 = 32.57$ KN

Spacing = $0.87*500*100.53*250/ 32.57 *10^3$

= 335.67 mm

$S_v = 0.75d = 0.75*250 = 187.5$ mm

$S_v = 300$ mm

Provide 8 mm 2 legged vertical stirrups @190 mm Spacing.

6. CONCLUSION-

- The primary goal of the project has been met, which is to gain knowledge in design, modeling, drafting and analysis using software's.
- Getting familiar with structural software like AutoCAD, Autodesk Revit Architecture and staadPro.
- StaadPro frame analysis of a building is done by StaadPro as per IS456-2000, IS875 and Design Aid SP-16. The shear and deflection are within the Is 456:2000.
- Software analysis was compared with manual analysis, and the results were almost the same.
- After comparison of the sample data for beam, the Ast requirement is the same in manual analysis as well as software analysis.
- The modeling of the building in Autodesk Revit software gives a beautiful, realistic view of the building.

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