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Analysis, Design and Estimation of G+5 Residential Building Using Staad Pro

Kocharala Srinivasa Rao[1*], Nakkala Yesubabu[2], Pedakapu Koushik[3], Talakayala Sandeep Kumar[4], Obulasetti Aparna[5]

[1,2,3,4]*Student, Department of Civil Engineering, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru, India*
[5]*Assistant Professor, Department of Civil Engineering, Seshadri Rao Gudlavalleru Engineering College, Gudlavalleru, India*

***Abstract*: Structural design is an investigation method of the rigidity, strength and stability of the building. The essential aim in structural analysis and design is to construct a structure capable of overcoming all applied loads without failure during it's intended life. The process of structural design involves various stages such as computation of loads, member design, detailing and many more. The conventional method of structural design and analysis leads to lot of complications and tedious calculations which are time consuming. It is used for Geometry - Run structure wizard - Frame model to bay frames. And to extended Frames in Vertical in G+5 Floors are used in the Translational Repeat. Commands – Member Property – Prismatic are creating Columns are assigned to selected beams, beams are assigned to selected beams and slabs are assigned to selected beams. Commands – Supports Specifications – fixed Support are assigned to selected nodes using bottom of the ground. Commands – Loadings – Primary Load - Dead load are assigned to view in overall building, Live Load are assigned to view in overall building, Wind Load are assigned to view in windward direction X-axis and Z-axis. Commands – Analysis to perform analysis are applied in All. Click on the analyze to Run analysis (Ctrl + F5). Commands – Design to Concrete Design are using Code IS 456. Selected Parameters and Define Parameters are Fc, Fymain, Fysec, Maxmain, Maxsec, Md1, Md2 are assigned to view. Commands to Design Column are assigned to view, Design Beam are Assigned to view, Design Slab are Assigned to view. Now-a-days to complete a design and analysis in efficient manner, fast software's are used. Computer aided design of residential building by using STAAD PRO which includes- Generating structural framing plan, Getting Model, Analysis of structure, Design of structure.**

***Keywords*: plan, layouts of columns and beam, analysis, design, STAAD pro, residential building, shear force, bending moment and axial load, excel.**

1. Methodology

- Prepare a plan with AutoCAD
- Prepare Layout of columns.
- Prepare a Layout of beams.
- Dead load, Live load, are calculated by manual calculation.
- Run Structure Wizard ------ Frame Models.
- Create a ground floor frame of column, beams and slabs
- Translational Repeat extend the floors in vertically
- Member property ------ Prismatic
- Supports Specifications ----- Fixed
- Loadings ----- Primary Load
- Analysis ---- Perform Analysis
- Design ----- Concrete Design
- Define Parameters
- Select Parameters
- Commands ---- Design Beam
- Design Column
- Design Slab/Elements
- Take Off
- To analyze the residential building and structural elements like beams, stairs, columns, slabs.
- To model the residential building using the STAAD Pro software and analyze the same structure using STAAD Pro
- To design the residential building using STAD Pro - To design the structural elements like beams, stairs, columns, slabs using software.
- Finally, Estimation Calculated with Excel.

2. AutoCAD

AutoCAD is a commercial software application for 2D and 3D computer aided design and drafting for various fields in engineering like civil, mechanical, electrical, automation, architecture etc. It was first launched in 1982 by Autodesk, Inc. AutoCAD Architecture allows designers to draw 3D objects such as walls, doors and windows, with more intelligent data associated with them rather than simple objects. The data can be programmed to represent products sold in the building industry, or it can be extracted into a file for pricing material estimation etc. AutoCAD or Computer Aided Design is a very helpful tool in drafting and designing any structure. AutoCAD uses a Graphical User Interface for the purpose of drafting and designing any structure. The software has various inbuilt tools for complex drafting. Also, AutoCAD can be used for 2D and 3D design and also for perspective design. Below is a screenshot of the GUI of AutoCAD. With the help of AutoCAD all the drafting for the project has been done. It has made the life of a drafter quite easy than the conventional drafter using paper and pencil. It has made possible to make easy changes in

*Corresponding author: srinukocharala2001@gmail.com

the drawing as and when required. Also, various commands such as COPY, OFFSET, ROTATE, MOVE have made the tedious process of redundant work quite easy and faster. Also, one of the important features of AutoCAD is the import and export feature which allows users to move their plans drawn using autocad to other design software's such as STAAD Pro and ETABS with the help of DXF file format which has in turn reduced load on the designer. Also, structural designs made on STAAD and ETABS are also exportable to AutoCAD for minute detailing required.

3. Plan

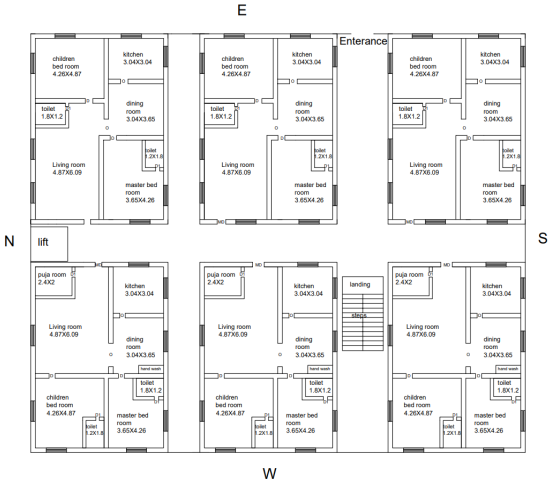


Fig. 1. Plan

A. Layout of columns and beams

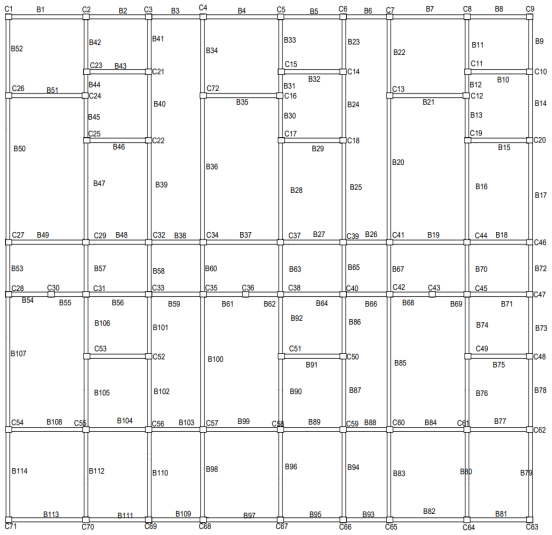


Fig. 2. Layout of column and beam

Weight of the column, beam and slab:

Column:

Number of column = 72 Nos.
Height of each column =3.048 m
Density of concrete = 25 KN
Size of column = 0.4 X 0.6 m
C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,……,C72
Total volume of concrete = 0.4 X 0.6 X 3.048
= 0.73152 m^3

Weight of concrete = 2500 X 0.73152
= 1828.8 Kg

Single column of the weight = 1828.8 Kg
Total Column of the Weight in floor = 72 X 1828.8 = 131673.6 Kg

Beams:

Number of Beams = 115 Nos.
Beam Size = 0.3 X 0.6 (including slab) Z- Axis Direction
Beam Size = 0.3 X 0.45 (Excluding slab) X- Axis Direction
Each beam in the structure is different length

B1 = 5.02 – 24 Nos.
B2 = 3.89 – 24 Nos.
B3 = 3.40 – 10 Nos.
B4 = 3.00 – 06 Nos.
B5 = 7.29 – 03 Nos.
B6 = 2.79 – 09 Nos.
B7 = 7.90 – 03 Nos.
B8 = 4.39 – 03 Nos.
B9 = 3.65 – 03 Nos.
B10 = 5.64 – 06 Nos.
B11 = 3.34 – 06 Nos.
B12 = 3.95 – 06 Nos.
B13 = 2.41 – 03 Nos.
B14 = 1.39 – 03 Nos.
B15 = 2.83 – 03 Nos.
B16 = 2.48 – 03 Nos.

B1:
Size = 300 X 600 mm
Length = 5.02
Volume = 0.3 X 0.6 X 5.02
= 0.903 m^3
Concrete weight = 0.903 X 2400
= 2168.64 kg
Total Beam weight = 2168.64+141.3
= 2309.94 kg

B2:
Size = 300 X 600 mm
Length = 3.89
Volume = 0.3 X 0.6 X 3.89
= 0.7002 m^3
Concrete weight = 0.7002 X 2400
= 1680.48 kg
Steel weight = 2% of concrete
= 0.700 X 0.02 X 7850
= 109.9 kg
Total Beam weight = 1680.48 + 109.9
= 1790.38 kg

B3:
Size = 300 X 600 mm
Length = 3.40
Volume = 0.3 X 0.6 X 3.40
= 0.612 m^3
Concrete weight = 0.612 X 2400
= 1468.8 kg
Steel weight = 2% of concrete
= 0.612 X 0.02 X 7850
= 96.08 kg
Total Beam weight = 1468.8 + 96.08
= 1564.884 kg

B4:
Size = 300 X 600 mm
Length = 7.29
Volume = 0.3 X 0.6 X 7.29
= 1.312 m^3
Concrete weight = 1.312 X 2400
= 3149.28 kg
Steel weight = 2% of concrete
= 1.312 X 0.02 X 7850
= 205.984 kg
Total Beam weight = 3149.28 + 205.984
= 3355.264 kg
B5:
Size = 300 X 600 mm
Length = 2.79
Volume = 0.3 X 0.6 X 2.79
= 0.502 m^3
Concrete weight = 0.502 X 2400
= 1205.28 kg
Total Beam weight = 1205.28+78.814
= 1284.09 kg
Slabs:
Volume = 0.15 X 2400
= 360 kg
Total Slab of the weight = 3600 Kg
Dead Load = 0.5 KN
Super Imposed Live Load = 2 KN

STAAD Pro:

STAAD Pro V8i has a very user-friendly interface and very useful for designing complex structures and analyzing them. STAAD Pro V8i is a design and structural analysis program developed by Research Engineers International, CA. It was acquired by Bentley Systems in 2005. It is one of the most widely used design and structural analysis software's for concrete, steel and timber design codes. STAAD pro allows designers and structural engineers to design and analyses virtually any type of structure through its very flexible modelling environment, fluent data collection and advanced features. STAAD pro supports over 70 international codes including IS456:2000, IS800:2007 and over 20 U.S codes in more than 7 languages. The GUI or Graphical User Interface or user communicates with the STAAD Pro analysis engine through the standard input file. That input file, a text file consists of a series of commands which are sequentially executed.

Commands are used to input data and instructions for defining the geometry, properties, loading conditions, analysis settings, and design criteria for a structural model. These commands are typically written in a specific syntax within the input file or input editor of the software.

Some common types of commands in STAAD.Pro include:

1. Geometry commands: Define the nodes, members, and connectivity of the structural model.
2. Member property commands: Specify the properties of structural members such as cross-sectional dimensions, material properties, and section types.
3. Load commands: Input external loads such as dead loads, live loads, wind loads, seismic loads, temperature loads, and other relevant loads.
4. Analysis commands: Set up the analysis type, parameters, and options for solving the structural model.
5. Design commands: Define design parameters and criteria for checking the structural members against code requirements and specifications.
6. Output commands: Specify the type and format of output results generated by the analysis and design processes.

3D Rendering: STAAD.Pro primarily focuses on structural analysis and design rather than 3D rendering. While it provides tools for visualizing and reviewing analysis results in a 3D environment, it's not typically used for high-quality rendering like specialized 3D rendering software. However, you can export your 3D model from STAAD.Pro to other software like Autodesk Revit or SketchUp for detailed rendering and visualization.

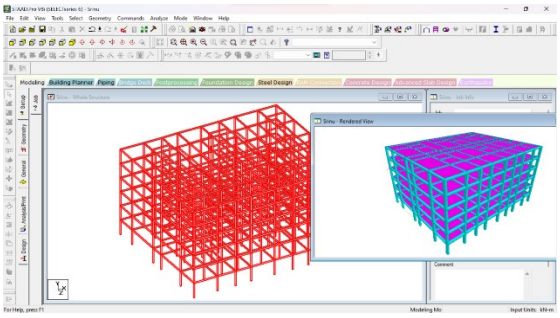


Fig. 3. 3D rendering

Geometry:

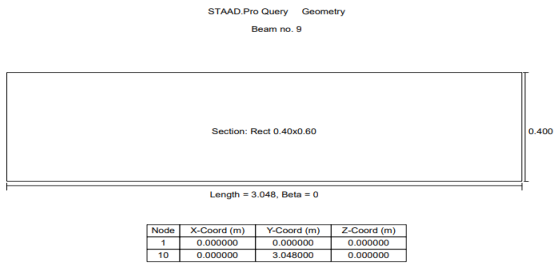


Fig. 4. Geometry

Property:

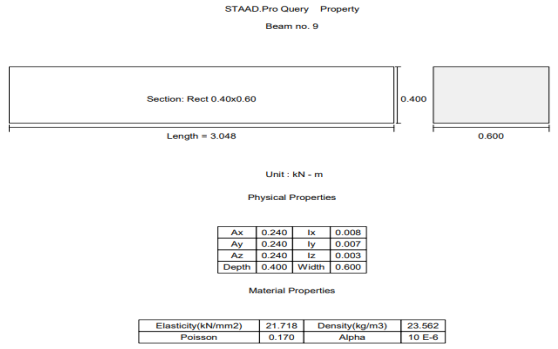
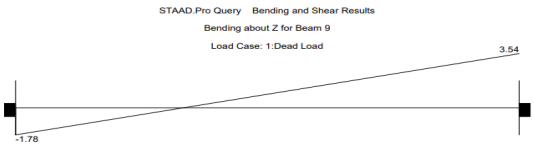


Fig. 5. Property

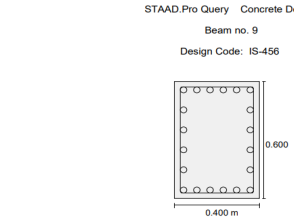
Bending and shear Force:



Dist.m	Fy(kN)	Mz(kNm)
0.000000	-1.7453	-1.7760
0.254000	-1.7453	-1.3327
0.508000	-1.7453	-0.8894
0.762000	-1.7453	-0.4461
1.016000	-1.7453	-0.0028
1.270000	-1.7453	0.4405
1.524000	-1.7453	0.8838
1.778000	-1.7453	1.3271
2.032000	-1.7453	1.7704
2.286000	-1.7453	2.2137
2.540000	-1.7453	2.6570
2.794000	-1.7453	3.1003
3.048000	-1.7453	3.5436

Fig. 6. Bending and shear force

Column Concrete Design:



Design Load

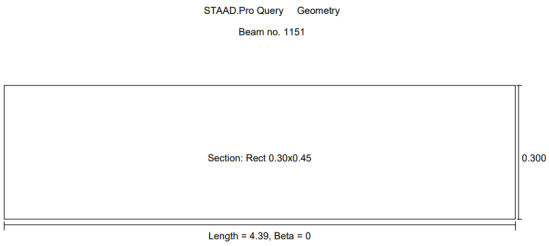
Load	2
Location	End 1
Pu(Kns)	-116.599998
Mz(Kns-Mt)	0.960000
My(Kns-Mt)	0.760000

Design Results

Fy(Mpa)	415
Fc(Mpa)	28
As Reqd(mm²)	1920.000000
As (%)	0.942000
Bar Size	12
Bar No	20

Fig. 7. Column concrete design

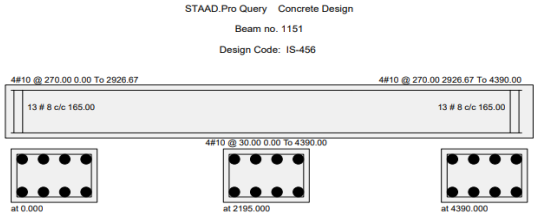
Geometry:



Node	X-Coord (m)	Y-Coord (m)	Z-Coord (m)
435	0.000000	18.288000	0.000000
498	0.000000	18.288000	4.390000

Fig. 8. Geometry

Beam Concrete Design:



Design Load

Mz(Kn Met)	Dist.et	Load
4.200000	4.400000	2
-7.370000	0.000000	1
-3.090000	4.400000	1

Design Parameter

Fy(Mpa)	415.000000
Fc(Mpa)	28.000000
Depth(m)	0.300000
Width(m)	0.450000
Length(m)	4.390000

Fig. 9. Beam concrete design

Axial Load:

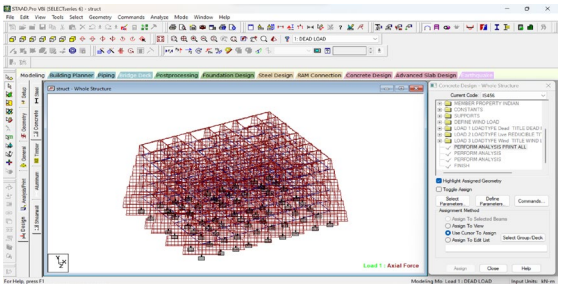


Fig. 10. Axial load diagram

Bending Moment:

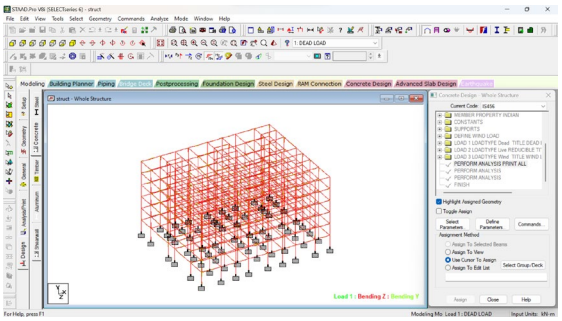


Fig. 11. Bending moment diagram

Shear Force:

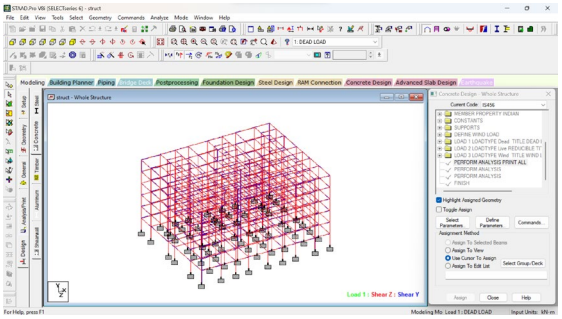


Fig. 12. Shear force diagram

Analysis Result:

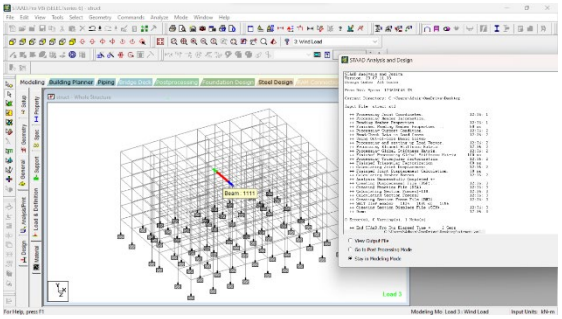


Fig. 13. Analysis result

Analysis and Design Result:

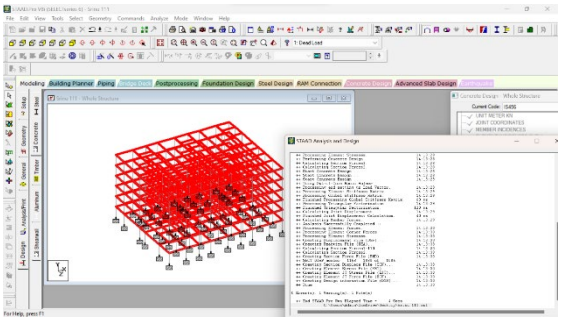


Fig. 14. Analysis and design result

4. Estimation

A. Introduction

Estimating is the technique of calculating or computing the various quantities and the expected Expenditure to be incurred on a particular work or project. In case the funds available are less than the estimated cost the work is done in part or by reducing it or specifications are altered, the following requirement are necessary for preparing an estimate.

a) Drawings like plan, elevation and sections of important points.
b) Detailed specifications about work men ship & properties of materials etc.
c) Standard schedule of rates of the current year.

Estimation, costing, and valuation form the cornerstone of project management, construction, and financial planning. Estimation involves predicting the quantities and costs of materials and resources needed for a project. Costing involves calculating the total expenditure, considering factors like labor, materials, and overhead. Valuation, on the other hand, assesses the monetary worth of assets or properties. Together, these processes provide a comprehensive framework for evaluating, planning, and managing the financial aspects.

Planning:

Conducted a feasibility study considering market demand, zoning regulations, and environmental impact. Developed architectural plans and obtained necessary permits.

Estimation:

Estimated quantities of materials, labor costs, and other expenses.

Created a detailed budget for the construction phase.

Costing:

Regularly updated the cost tracking system to monitor actual expenses against the budget. Addressed any cost overruns promptly, making adjustments to maintain financial control.

B. Plan of the Building

Building plans are the set of drawings which consists of floor plan, site plan, cross sections, elevations, electrical, plumbing and landscape drawings for the ease of construction at site

1. The floor plan is the most fundamental architectural diagram, a view from above showing the arrangement of spaces in building in the same way as a map, but showing the arrangement at a particular level of a building.
2. The site plan is a comprehensive detailed drawing of the building or an apartment representing the whole plan of a building. It shows property boundaries and means of access to the site, and nearby structures if they are relevant to the design.
3. Cross-section is a vertical cut section of any building which shows the details of dimension, thickness of any component of a building. It also represents the sill height, lintel height, floor height.

C. Location of the Building

A location is the place where a particular point or object exists. Location is an important term in geography, and is usually considered more precise than "place." A locality is a human settlement: city, town, village, or even archaeological site.

A place's absolute location is its exact place on Earth, often given in terms of latitude and longitude.

Markapuram is a town in Prakasam district of the Indian state of Andhra Pradesh. It is a municipality and is the headquarters of Markapuram mandal in Markapuram, revenue division.

D. Detailed & Abstract Estimation

A detailed estimate is a comprehensive cost estimate that includes the quantities and costs of everything required to complete a project. This includes materials, labor, equipment, insurance, bonds, overhead, and an estimate of the profit. The detailed estimate is prepared in two stages:

Details of measurements and calculation of quantities: The complete work is divided into various items of work such as earthwork concreting, brickwork, reinforced concrete, plastering, etc. The details of measurements are taken from drawings and entered in respective columns of prescribed proforma. The quantities are calculated by multiplying the values that are in numbers column to Depth column.

Abstract of Estimated Cost: The cost of each item of work is worked out from the quantities that already computed in the detailed measurement form at workable rate. But the total cost is worked out in the prescribed form is known as abstract of estimated form. 4% of estimated Cost is allowed for Petty Supervision, contingencies, and unforeseen items. The detailed estimate should be accompanied by a report, specification, drawings (plans, elevation, sections), design charts and calculations, and a standard schedule of rates. Factors to be considered while preparing a detailed estimate include the quantity and transportation of materials, location of the site, and local labor charges. The process of working out the cost or rate per unit of each item is called data. In preparation of data, the rates of materials and labor are obtained from current standard scheduled of rates and while the quantities of materials and labor required for one unit of item are taken from Standard Data Book (S.D.B). The rate per unit of an item includes the quantity of materials and cost, cost of labor, cost of equipment (T&P), and overhead charges.

Table 1
Calculation if quantity

S.No.	Description	Nos	Length	Breadth	Height	Quantity	Total Quantity
1	**Excavation**	72	2	2	2.2	633.6	633.6
2	**P.C.C**	72	2	1.2	0.4	69.12	69.12
3	**Concrete Footing**						205.2522
	Rectangle	72	2	1.2	0.8	138.24	
	Trapezoidal	72	0.9221			66.3912	
	Lift Raft Slab	1	2.3	1.8	0.15	0.621	
4	**Concrete for Column**						
	Ground level to First level	72	0.3	0.6	3.048	39.50208	198.5684
	first Floor to Second Floor	72	0.3	0.6	3.048	39.50208	
	Second Floor to Third Floor	72	0.3	0.6	3.048	39.50208	
	Third Floor to Fourth Floor	72	0.3	0.6	3.048	39.50208	
	Fourth Floor to Fifth Floor	72	0.3	0.6	3.048	39.50208	
	Fifth Floor Top to Headroom Slab Top	4	0.23	0.23	3	0.6348	
	Headroom Slab Top to Water Tank	4	0.23	0.23	2	0.4232	
5	**Lift Wall**						
	Sw1	2	1.8	0.15	15.24	8.2296	15.3036
	Sw2	2	2	0.15	15.24	9.144	
	Deduct						
	Door	-5	1.2	0.15	2.3	-2.07	
6	**Beam**						
	Ground level Beam						
	B1	24	5.02	0.3	0.45	16.2648	375.8805
	B2	24	3.89	0.3	0.45	12.6036	
	B3	10	3.4	0.3	0.45	4.59	
	B4	3	7.29	0.3	0.45	2.95245	
	B5	9	2.79	0.3	0.45	3.38985	
	B6	3	7.4	0.3	0.45	2.997	
	B7	3	4.39	0.3	0.45	1.77795	
	B8	6	3	0.3	0.45	2.43	
	B9	3	3.65	0.3	0.45	1.47825	
	B10	6	5.64	0.3	0.45	4.5684	
	B11	6	3.34	0.3	0.45	2.7054	
	B12	6	3.95	0.3	0.45	3.1995	
	B13	3	2.41	0.3	0.45	0.97605	
	B14	3	1.39	0.3	0.45	0.56295	
	B15	3	2.83	0.3	0.45	1.14615	
	B16	3	2.48	0.3	0.45	1.0044	
					Total	62.64675	
	Up to First Floor						
	B1	24	5.02	0.3	0.45	16.2648	
	B2	24	3.89	0.3	0.45	12.6036	
	B3	10	3.4	0.3	0.45	4.59	
	B4	3	7.29	0.3	0.45	2.95245	
	B5	9	2.79	0.3	0.45	3.38985	
	B6	3	7.4	0.3	0.45	2.997	
	B7	3	4.39	0.3	0.45	1.77795	
	B8	6	3	0.3	0.45	2.43	
	B9	3	3.65	0.3	0.45	1.47825	
	B10	6	5.64	0.3	0.45	4.5684	
	B11	6	3.34	0.3	0.45	2.7054	
	B12	6	3.95	0.3	0.45	3.1995	
	B13	3	2.41	0.3	0.45	0.97605	
	B14	3	1.39	0.3	0.45	0.56295	
	B15	3	2.83	0.3	0.45	1.14615	
	B16	3	2.48	0.3	0.45	1.0044	
					Total	62.64675	
	Up to Second Floor				Total	62.64675	
	Up to Third Floor				Total	62.64675	
	Up to Fourth Floor				Total	62.64675	
	Up to Fifth Floor				Total	62.64675	
7	**SLAB**						
	Ground Floor	1	32.85	27.4	0.15	135.0135	810.081
	First Floor	1	32.85	27.4	0.15	135.0135	
	Second Floor	1	32.85	27.4	0.15	135.0135	
	Third Floor	1	32.85	27.4	0.15	135.0135	
	Fourth Floor	1	32.85	27.4	0.15	135.0135	
	Fifth Floor	1	32.85	27.4	0.15	135.0135	
						Total Quantity	2307.8057

5. Conclusion

AutoCAD design plays a crucial role in modern engineering by improving accuracy, enhancing productivity, facilitating collaboration, enabling simulations and prototyping, and offering a cost-effective design solution.

The aim of our project was planning, analysis and design of a multi-storeyed, earthquake resistant residential building. We were able to complete the project in a successful and efficient manner by considering all the relevant features given as five chapters. Planning of this building has been done based on the space requirements suggested by the Residential Building. The design is completely based on relevant Indian Standard Codes. The analysis has been done with the help of STAAD Pro and the drawings have been made with the help of AutoCAD. We have completed this project to the best of our knowledge and ability. Excel is help of the quantity calculation.

References

[1] IS 456:2000
[2] IS 875 (Part 2):1987 (Reaffirmed 1997)
[3] IS 875 (Part 3):1987 (Reaffirmed 1997)
[4] IS 1893 (Part I):2002
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