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Planning, Analysis, Design and Estimation of a Residential Building

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Abstract: ***One of the main issues facing the nation is its fast expanding population, which requires more facilities due to the limited amount of land available.***

To some extent, this can be resolved by developing residential buildings. A residential building is any structure that offers lodging, such as private homes, apartments, hotels, dorms, or other types of lodging.

In this project, a 40 x 60-foot G+5 residential building with three bedrooms, a hall, and a kitchen will be analyzed and designed in accordance with local guidelines as well as municipal rules and regulations.

In accordance with IS 875 (Part-1), IS 875 (Part-2), and IS 875 (Part-3)-1987, gravity loads such as dead loads and live loads are provided for analysis and design utilizing STAAD pro software. Lastly, calculate the building's overall cost.

Key words: Residential Buildings, Auto CAD 2014, STAAD Pro V8, IS 875 (Part-1), IS 875 (Part- 2) and IS 875 (Part-3) - 1987.

I. INTRODUCTION

General Introduction

The basic necessities of human existence—food, clothing, and shelter—are fundamental to survival and have driven human innovation and progress throughout history. Among these, shelter is of paramount importance as it provides safety, security, and a sense of belonging. Over time, humankind has continuously sought to improve their standards of living, with significant focus on enhancing the quality, comfort, and efficiency of their dwellings. The effort to create shelters that are both economical and functional reflects the evolving aspirations of individuals and societies alike.

Possession of a shelter is more than just owning a structure; it imparts a profound sense of security, fosters responsibility, and often serves as a marker of social status. A home provides a personal sanctuary where one can experience peace and comfort. For this, a dwelling must be located in a safe and convenient area, ideally surrounded by a pleasant environment that supports healthy and harmonious living.

When planning and designing residential structures, engineers and architects face the challenge of balancing multiple considerations. These include adherence to municipal conditions, compliance with building byelaws, and the integration of environmental concerns. Additionally, factors such as the financial capacity of the homeowner, the availability of water supply, sewage systems, and future-proofing provisions must be taken into account. Proper aeration and ventilation are critical for maintaining indoor air quality, while principles like Vaastu Shastra or Feng Shui may also influence the design to align with cultural and traditional beliefs.

A well-designed residential building should have adequate ventilation to ensure the circulation of fresh air and maintain a healthy indoor environment. This requires the inclusion of sufficient doors and windows in strategic locations to optimize airflow and natural lighting. Structural analysis is a key part of the design process, involving the determination of a building's general shape and precise dimensions. This ensures the structure is not only aesthetically pleasing but also capable of withstanding the loads and stresses it will encounter throughout its lifespan. The primary goal is to create a safe, functional, and durable structure that meets the needs of its occupants.

The rapid growth of urban populations has intensified the demand for housing, particularly in major cities where land is both scarce and expensive. The phenomenon of population concentration, coupled with the skyrocketing cost of land, has necessitated innovative solutions to address the housing crisis. One such solution is the construction of multi-story buildings, which have become increasingly prevalent in urban areas. These vertical developments maximize the efficient use of limited land resources and accommodate a larger number of residents in a compact footprint.

By embracing modern construction techniques and sustainable practices, architects and engineers play a pivotal role in shaping urban landscapes. Their work not only provides shelter but also fosters a sense of community, contributes to economic development, and enhances the overall quality of life for individuals and families.

A. Demand of Houses and practical consideration

1) Demand of Houses:

A house represents the fundamental unit of society and serves as the primary domain of human habitation. It is not merely a structure of walls and a roof but a space that fulfils the essential human need for protection, privacy, and belonging. Throughout history, houses have been constructed to shield individuals and families from the elements, such as harsh winds, rain, heat, and cold, ensuring a safe and comfortable environment regardless of external conditions.

The demand for housing stems from its vital role in providing security—both physical and psychological. A house safeguards its occupants against various physical insecurities, such as theft, vandalism, and other potential threats. It also provides a stable foundation for individuals to grow and thrive, offering a sanctuary where they can rest, rejuvenate, and cultivate relationships.

In addition to serving as a place of residence, a house holds cultural, economic, and social significance. It is often seen as a representation of a people or family's status, values, and aspirations. The need for housing is deeply tied to the growth and development of societies, as it reflects the evolution of human settlements and urbanization.

With the rise in global population and increasing migration to urban areas, the demand for houses has grown exponentially. This demand is further fuelled by factors such as:

a) Population Growth: An expanding population naturally requires more housing to accommodate new households.

b) Urbanization: The movement of people from rural areas to cities in search of better opportunities has led to an unprecedented concentration of populations in urban centres.

c) Economic Development: As income levels rise, so do expectations for better living standards, driving the demand for more spacious, modern, and well-equipped houses.

d) Changing Family Structures: The shift from joint family systems to nuclear families has created a need for additional housing units to cater to smaller family sizes.

This increasing demand has also brought challenges, such as the need for sustainable housing solutions, affordability, and efficient use of available resources. Addressing these challenges requires innovative approaches in construction, urban planning, and policy-making to ensure that everyone has access to a secure and comfortable place to live.

In essence, a house is more than just a shelter; it is a cornerstone of human civilization, symbolizing safety, stability, and the aspiration for a better life.

The special features of the demand for housing consists of in its unique nature and demand on the following factors,

- Skilled labour is available.
- The availability of funding.
- The accessibility of transportation facilities.
- The price of labor and building supplies.
- Demand forecasts for the future.
- Interest rate on investment: Low interest rates combined with long-term payment options may make it easier to invest in real estate.
  7. The rate of urbanization and population growth.
- Reasonably priced developed plots are available.
- The real estate tax policy.
- Environmental circumstances and town planning.

2) Practical considerations:

- The building's components should be robust and able to endure the expected negative effects of natural forces.
- ➢ When planning, the inhabitants' comfort, convenience, strength, and stability should come first.
- ➢ Elevation ought to be straightforward yet appealing. For a bank building, there should be fewer doors and windows.
- ➢ From a utility perspective, having built-in furniture in strategic locations is beneficial.
- A place for comfortable and pleasant living requires considered and kept in a view.

- A peaceful environment.
- Safety from all natural sources and climatic conditions.
- General facilities for community of residential are

B. Classification of buildings based on occupancy

1) Residential buildings: Residential buildings are structures designed primarily to provide accommodation for individuals or families for normal living purposes. These buildings are essential in fulfilling the fundamental need for shelter and vary greatly in size, style, and functionality depending on the socio-economic, cultural, and environmental factors of the region. They are characterized by spaces that cater to daily activities such as sleeping, cooking, dining, and relaxation.
2) Education buildings: Educational buildings are structures specifically designed and utilized for purposes such as instruction, training, education, and recreation. These facilities cater to students, teachers, and staff and are equipped to support a variety of educational activities, ranging from formal instruction to extracurricular programs. They are distinct from assembly buildings, as their primary purpose is focused on education rather than large gatherings for general purposes.
3) Institutional buildings: These buildings are used for different purposes, such as medical or other treatment or care of persons suffering from physical or mental illness, diseases or infirmity, care of infant, aged persons and penal detention in which the liberty of the inmates is restricted. Institutional building ordinarily provides sleeping accommodation for the occupants.
4) Assembly buildings: These are the buildings where groups of people meet or gather for amusement, recreation, social, religious, assembly halls, city halls, marriage halls, exhibition halls, museums, places of worship etc.,
5) Business buildings: These buildings are used for transaction of business, for keeping of accounts, records and for similar purposes, offices, banks, professional establishments, court houses, libraries. The principal function of these buildings is transaction of public business and keeping of books and records.
6) Mercantile buildings: These buildings are used as shops, stores, market, for display and sale of merchandise either wholesale or retail office, shops, storage service facilities incidental to the sale of merchandise and located in the same building.
7) Industrial building: These are building where products or materials of all kinds and properties are fabrication, assembled manufactured or processed, as assembly plant, lab- oratories, dry cleaning plants, power plants pumping stations, smoke houses, etc.,
8) Storage building: These buildings are used primarily for the storage or sheltering of goods, wares or merchandise vehicles and animals, as ware house, cold, storage, garages, trucks.
9) Hazardous buildings: These buildings are used for the storage, handling, manufacture or processing of highly combustible or explosive materials or product which are liable to burn with extreme rapidly and/or which may produces poisonous elements for storage handling, acids or other liquids or chemicals producing flames, fumes and explosive poisonous irritant or corrosive gases processing of any material producing explosive mixtures of dust which result in the division of matter into the fine particles subjects to spontaneous ignition.

C. Scope

- In his emerging world, the requirements of houses are more. To overcome that require- ment, the houses are built by proper utilization of area.
- By constructing the residential house, the consumption of area is less, it leads to enhance the opportunities for both agriculture and residential purpose.

  The design plans and specifications contain no errors and meet the appropriate code as well as owner requirements.

1) Error-Free Design Plans:

Creating residential houses requires meticulous attention to detail in the design phase. Proper design plans and specifications are critical in ensuring that the final construction is safe, functional, and meets the needs of the occupants. Key factors in achieving error-free designs include:.

2) Compliance with Building Codes:

To ensure that residential buildings are safe, efficient, and liveable, all design plans must meet the **appropriate building codes** and regulations. These codes typically cover a range of important factors:

- Structural Integrity**:** Codes ensure that the building can withstand external loads (such as wind, earthquake, and snow loads) and internal loads (like the weight of the structure, furniture, and occupants). These standards protect residents from structural failures.
- Fire Safety: Design specifications must include fire-resistant materials, fire exits, fire suppression systems, and other safety measures to ensure the protection of life in case of a fire.
- Electrical and Plumbing Systems**:** The design must incorporate safe and efficient electrical and plumbing systems, ensuring safe energy distribution and water supply, as well as drainage. The systems should be easy to maintain and comply with local standards.
- Energy Efficiency**:** Building codes also regulate energy efficiency standards, encouraging the use of insulation, energy-efficient windows, and renewable energy sources to reduce the building's overall energy consumption and environmental impact.
- Accessibility**:** Codes ensure that residential buildings are accessible to all individuals, including those with disabilities, by providing accessible routes, ramps, and other necessary features

While building codes set the minimum standards, the design plans should also incorporate the specific needs and preferences of the property owner. This ensures that the final design meets their expectations in terms of:

- Space Configuration: The number of bedrooms, bathrooms, living areas, and additional spaces like home offices or gyms.
- Aesthetic Preferences: The owner's preferences for architectural styles, interior finishes, and overall appearance.
- Budget Considerations: The design must align with the available budget, ensuring cost-effective solutions without compromising on essential elements of the design.

In addition to the design plans, the construction specifications should provide detailed instructions on the materials, methods, and quality standards to be followed. These specifications help ensure that the construction process runs smoothly, the materials used are durable and of high quality, and the finished product adheres to the design intent. Key areas covered in construction specifications include:

- Material Selection: Specifications for concrete, steel, wood, insulation, flooring, finishes, and other materials.
- Construction Techniques: Guidance on construction practices, including structural reinforcements, waterproofing, and detailing for different building components (foundation, walls, roof, etc.).
- Quality Assurance: Ensuring that the construction follows the approved plans and specifications through inspections and testing during various stages of the construction.

D. Objectives

The specific objectives of the present investigation are listed below:

1) To know various design aspects of planning, analysis and design of a residential building.
2) To estimate the cost of the building considering various activities involved in the con- struction of a building.
3) To evaluate each and every activity involved in construction of a building.
4) To manually analyze the problem frame, under vertical loading conditions.
5) To perform the same analysis using standard analysis software Staad .Pro.
6) Perform substitute frame analysis for the loading cases.
Compare the accuracy of the substitute frame analysis with manual and Staad.Pro anal- ysis and check its validity in lateral loading cases.
7) Design the structural members of the residential b

II. REVIEW OF LITERATURE

A. Plan

Building plans are graphical representations that outline the design, layout, and structure of a building before it is constructed. These plans serve as essential tools for architects, builders, contractors, and engineers, providing a detailed visualization of the building's appearance and functionality upon completion. Beyond guiding construction, building plans are crucial for cost estimation, project budgeting, and ensuring compliance with regulatory requirements.

Importance of Building Plans

1) *Visualization of the Project:*
- Building plans allow stakeholders to visualize the final structure, helping them understand its layout, dimensions, and overall design.

2) *Guidance for Construction:*
- They act as a reference for contractors and builders, ensuring that every element of the project aligns with the intended design.

3) *Cost Estimation and Budgeting:*
- Detailed plans enable accurate calculations of material requirements, labor, and associated costs, aiding in project budgeting.

4) *Regulatory Compliance:*
- Plans are often required for obtaining permits and approvals, ensuring that the building adheres to local building codes and regulations.

5) *Coordination Among Teams:*
- Serve as a communication tool among architects, engineers, and construction teams, ensuring smooth collaboration and minimizing errors.

B. Selection of plot and study

Selecting of plot is very important for building a house. Site should be in a good place where three is a community but service is convenient. But not so closed that becomes a source of in- convenience or noisy. The conventional transportation is important not only because of present need but for retention of property value in future which is closely related to are transportation, shopping, facilities also necessary. One should observe the road condition whether there is indication of future development or not in case of undeveloped area.

The factors to be considered while selecting the building site are as follows:

1) Access to park and play ground.
2) Agricultural polytonality of the land.
3) Availability of public utility services, especially water, electricity and sewage disposal.
4) Contour of land in relation the building cost. Cost of land.
5) Distance from places of work.
6) Ease of drainage.
7) Location with respect to school, college and public buildings.
8) Nature of use of adjacent area.
9) Transportation facilities.

C. Vaasthu advice for building

Building is a structure with multiple floors that can be used as either for commercial or resi- dential purpose by making shopping complex or apartment. Vaasthu of a building is necessary for the success and peace of people working or living here. The principles of Vaasthu-Shastra help making a plot into healthy building to promote health, wealth and well-being of people. Therefore it become essential to get vaasthu done for a building constructed for any purpose. A healthy building not only promotes health and wealth but keep stress and negative vibration at bay and helps making the people successful. Vaasthu works on underlying norms embedded in ancient text of vedas to render a peaceful and posper life to the mankind. That is why Vaasthu is necessary for every building whether it is residential or commercial purpose.

Incorporating Vastu principles into building design is not merely a tradition but a scientifically rooted practice aimed at fostering harmony and well-being. Whether the building is intended for residential or commercial purposes, aligning its construction with Vastu Shastra ensures a positive environment that supports the physical, emotional, and financial prosperity of its occupants. As a result, Vastu has become a vital consideration in modern architecture, blending ancient wisdom with contemporary design.

D. Vaasthu tips for building are as follows-

1) Plot chosen for a building shall be particularly square or rectangle while avoid any irreg- ular shaped building which can bring bad fate for inmates.
2) Avoid buildings having extension in south or west whereas cuts in North or East shall also be avoid.
3) There should be more open space towards North, North-east and East where open lawns, parking, garden etc. can be constructed. But these important and vital directional areas must not be covered or constructed.

4) Entrance or main door of building should essentially be constructed in East which has to be huge and bigger than other gates especially exit door.
5) The height of the building should be more on South and West.
6) Stair case should ideally be placed in South-west.
7) Kitchen in the building is best to be place in South-east.
8) By adding all the doors, windows and ventilators of a building should be in an even number and it should not end with zero.
9) Balcony should be made in East or North.

E. Importance of North direction in construction

When we are making a land layout / building, we are using an instrument "compass", which is having needle in North-South direction. The accurate making of East, West, North and South directions are required to do the marking of roads, plots and buildings.

North side main door, window, French window, ventilator and roof top North light provision will bring more sunlight inside the house from morning to evening. So North direction is very important in building construction.

Figure 2.2: Compass

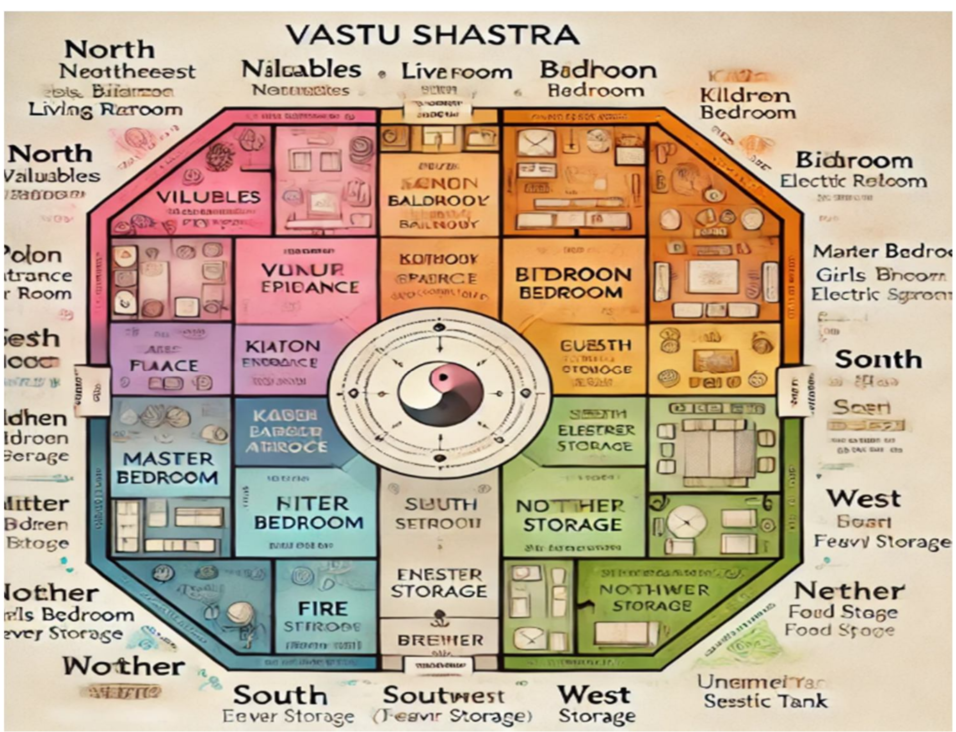

Figure 2.1: Bramha Sthana

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F. Details of a structure

1) Size of the structure = 40ft x 60ft
2) No. of stories of building = 5
3) Height of ground floor = 3.5m
4) Height of each storey = 3m
5) Total height of building = 18.5m

The plan of a building is drawn using Auto CAD software.

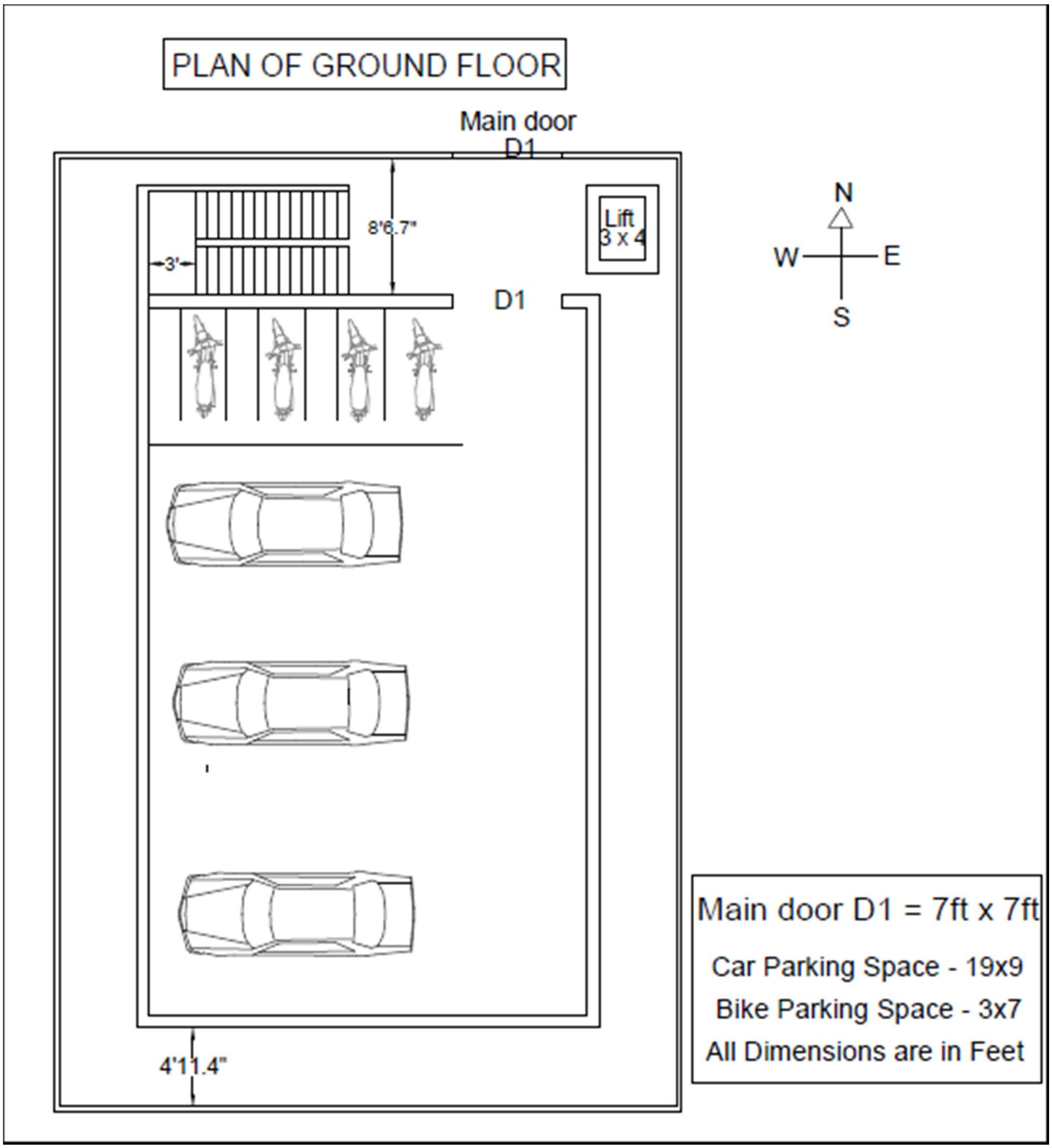

Figure 2.3: Ground floor Plan

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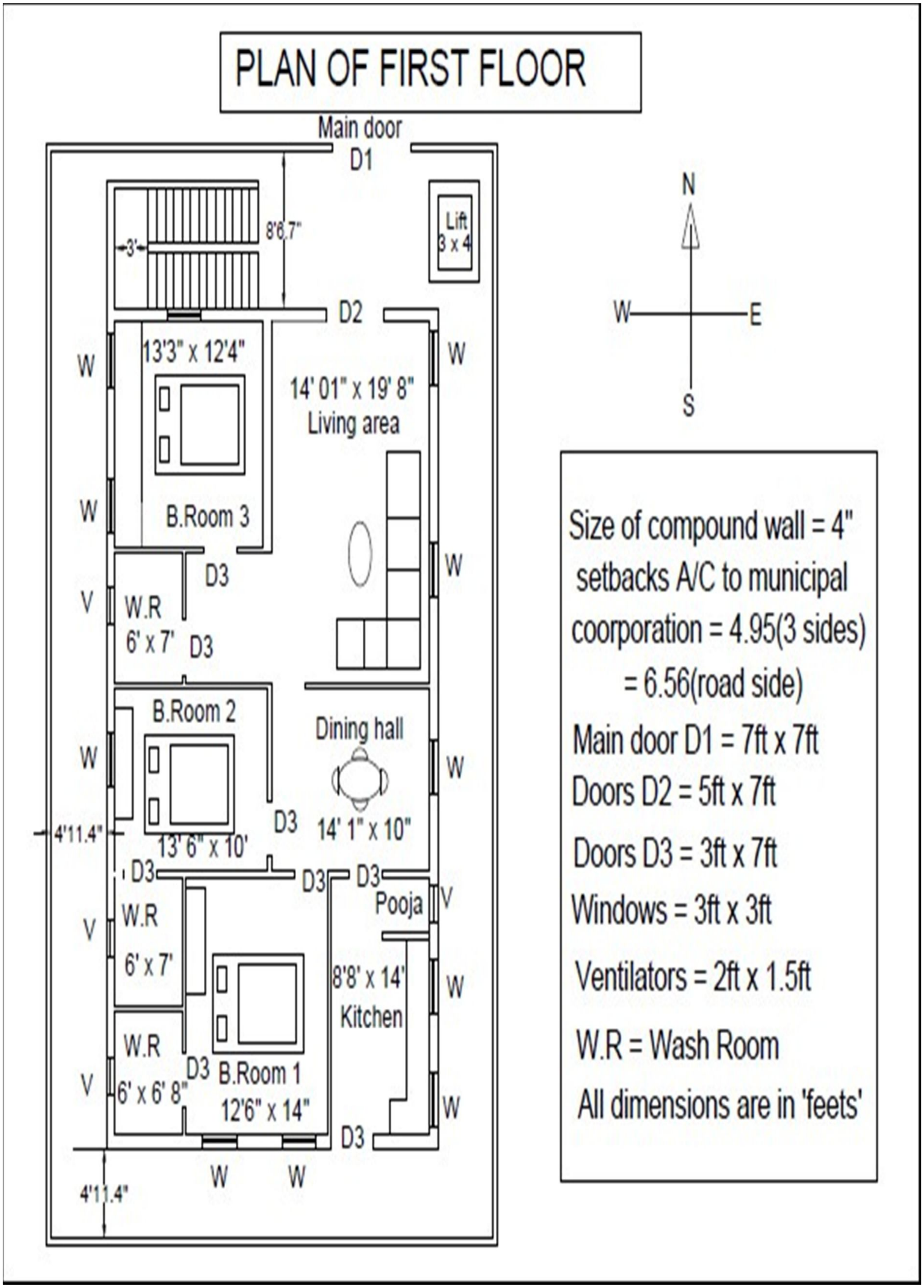

Figure 2.4: First floor Plan

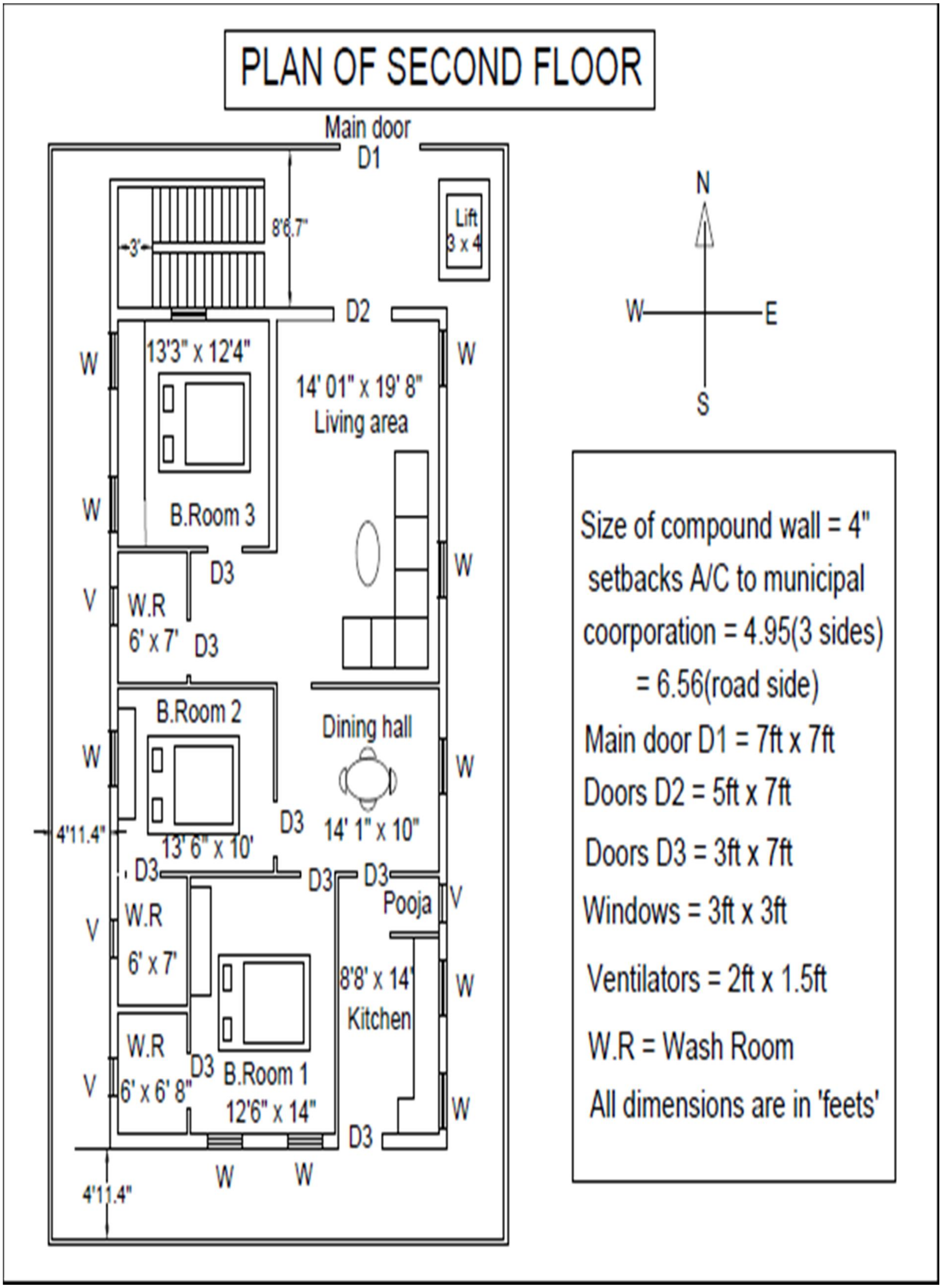

Figure 2.5: Second floor Plan

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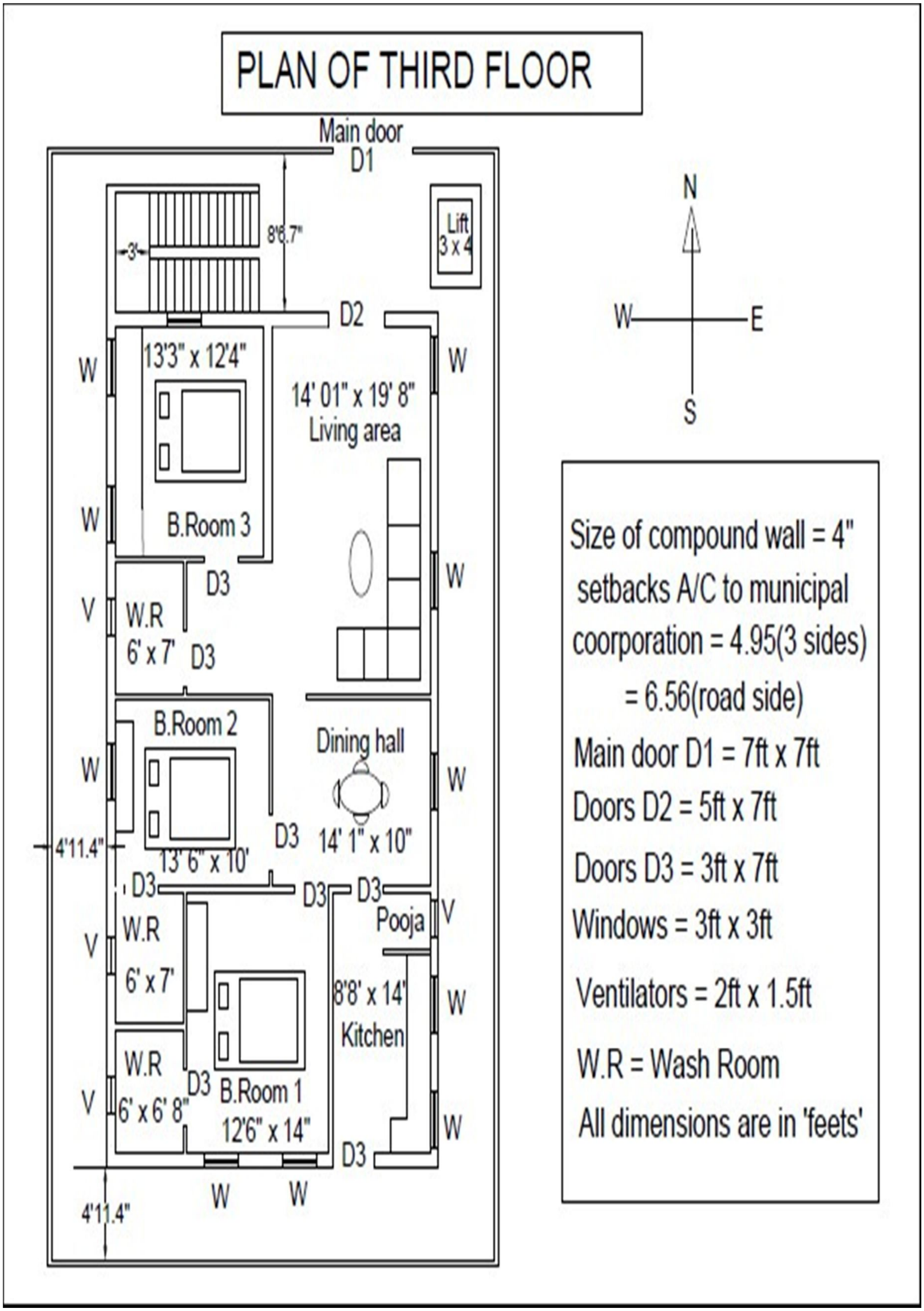

Figure 2.6: Third floor Plan

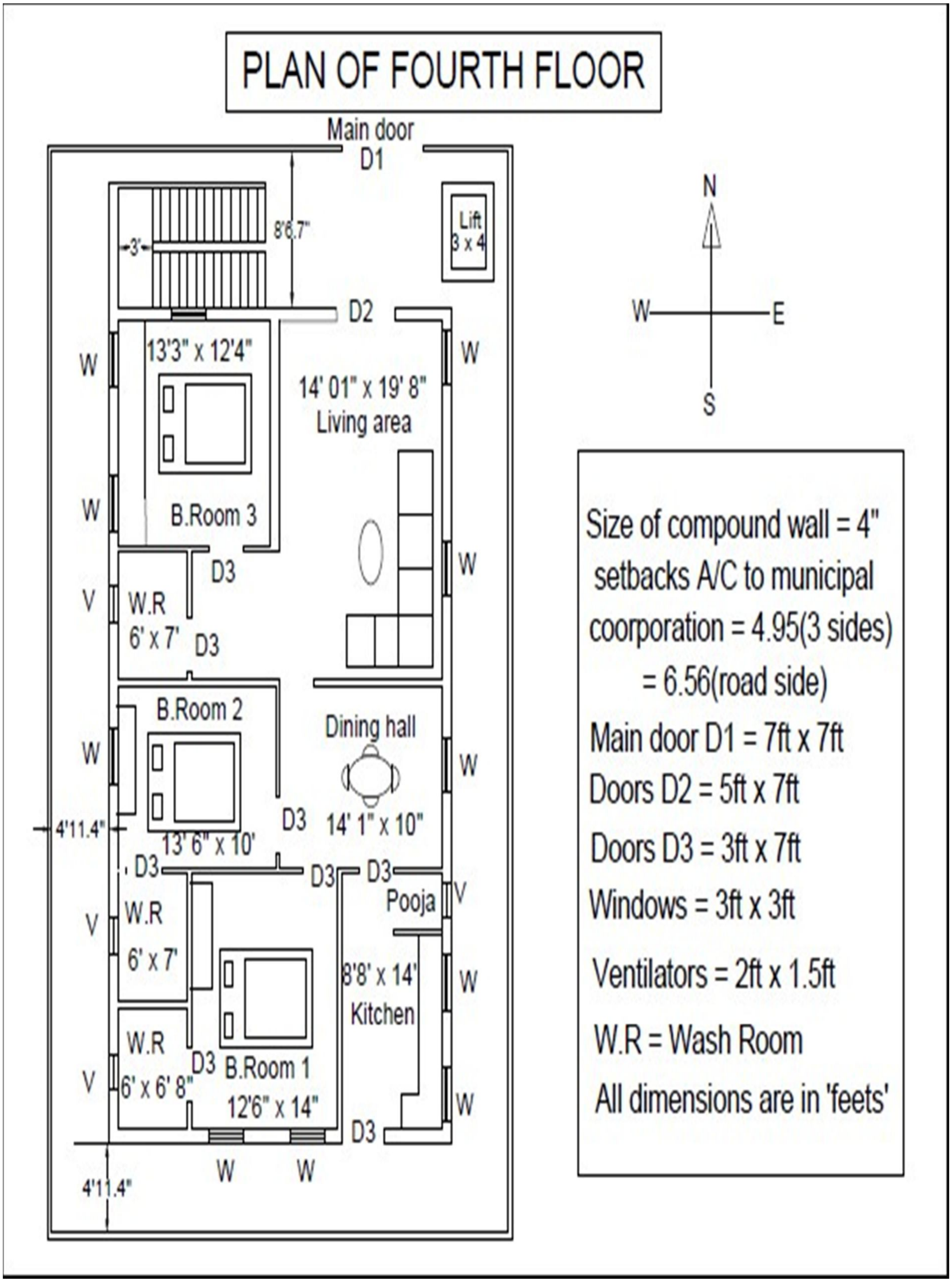

Figure 2.7: Fourth floor Plan

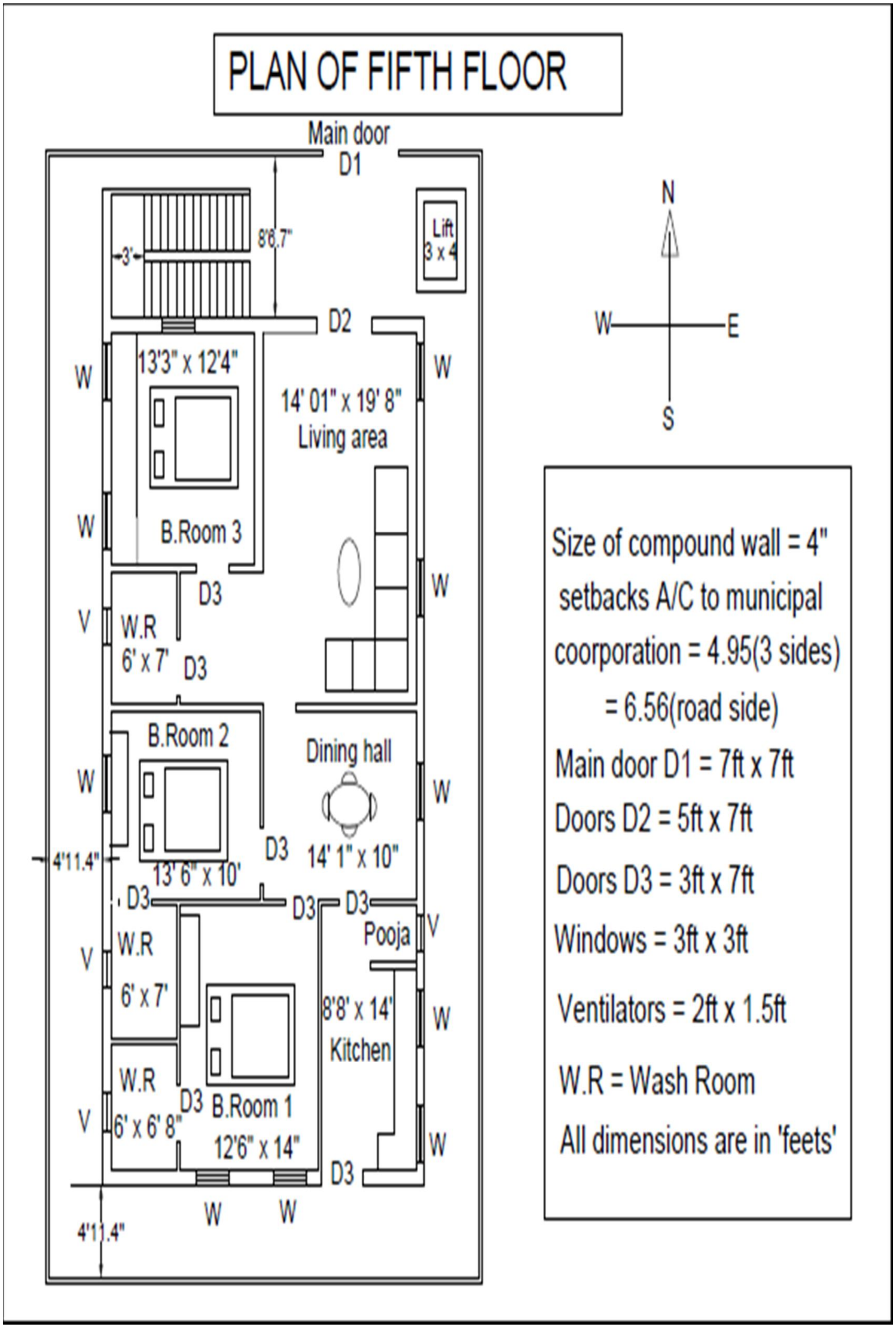

Figure 2.8: Fifth floor Plan

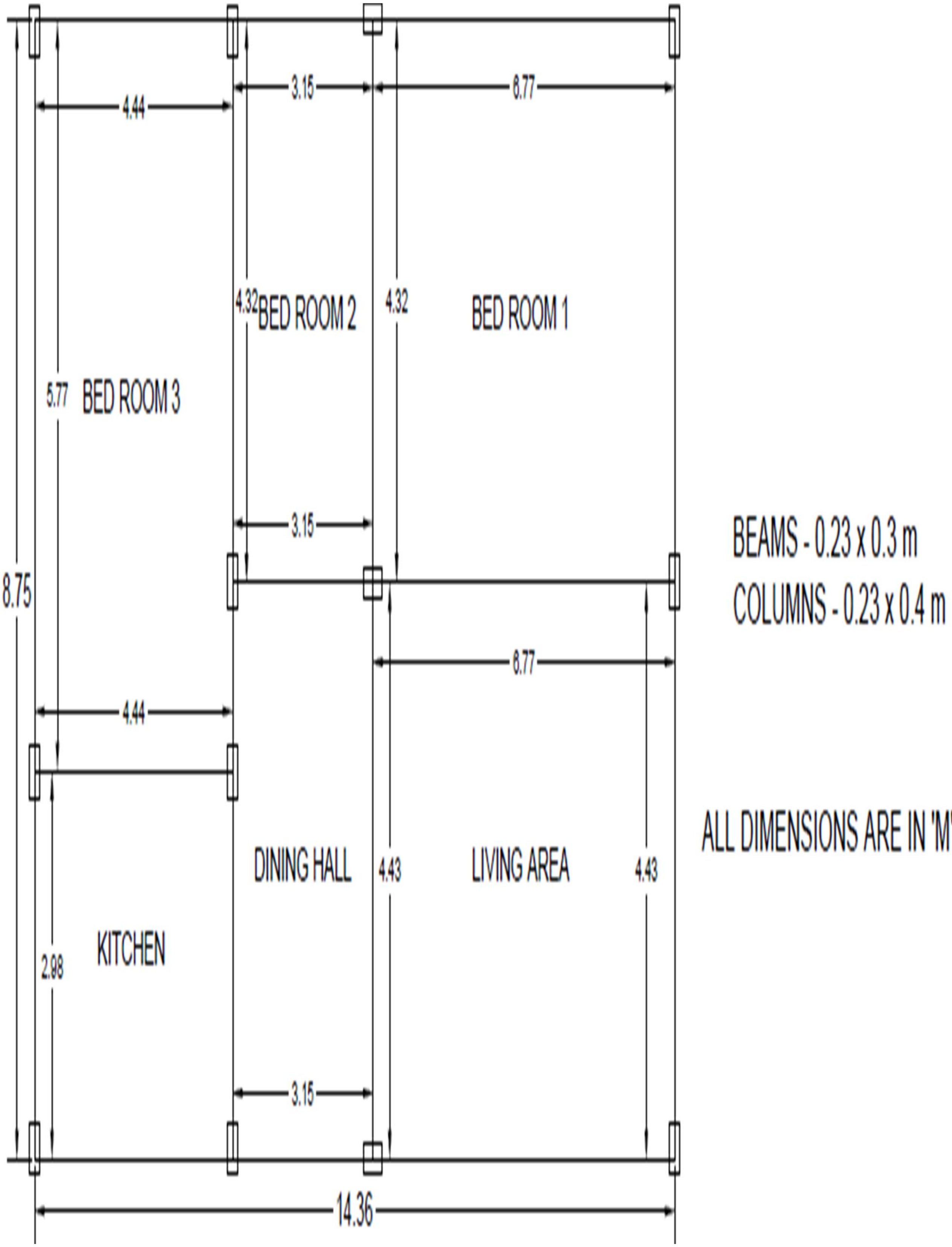

Figure 2.9: Grid line marking

G. Code books Used
1) IS 456 : 2000
2) IS 875 (Part-1) : 1987 (Dead loads)
3) IS 875 (Part-2) : 1987 (Live loads)
4) IS 875 (Part-3) : 1987 (Wind loads)

H. Software's Used
1) Auto CAD 2014
2) STAAD PRO V8

III. GRAVITY LOAD ANALYSIS

A. Introduction
Load Analysis is the process of determining forces in each element in a structure. Gravity load include ”dead”, or permanent load, which is the weight of the structure, including walls, floors, fnishes and mechanical systems and ”live”, or temporary load, which is the weight of structure's contents and occupants. The gravity loads as shown in fig..,

Figure 3.1: Gravity loads

B. Load calculations
- Assumed the thickness of the slab = 0.15 m
- Assumed dimensions of beams = 0.23 x 0.3 m
- Assumed dimensions of columns = 0.23 x 0.4 m
- Assumed Live load on slab = 2 kN/m^2
- Assumed Floor finish load = 1 kN/m^2
- Dead load = 0.15 x 25 = 3.75 kN/m^2
- Total load = W = 3.75+2+1= 6.75 kN/m^2

Load distribution on longer span = [[Wlx/6][3-[lx/ly]^2]] Load distribution on shorter span = [Wlx/3]
Where,
Lx = Length of shorter span Ly = Length of longer span

C. Load calculations on Beams

For Slab 1

B2, B4 are shorter beams = 2.81m B1, B3 are longer beams = 4.44m

- Thickness of slab = 0.15m
- Density of concrete = 25 kN/m^3
- Dead load = 3.75 kN/m^2 (IS 875-1978 Part - 1)
- Live Load = 2 kN/m^2 (IS 875-1978 Part - 2)
- Floor load = 1 kN/m^2 (IS 875-1978 Part - 3)
- Total load = W = 6.75 kN/m^2

Load distribution on shorter span = [6.75 x 2.81/3] = 6.32 kN/m^2

Load distribution on longer span = [6.75 X 2.81/6] [3-(2.81/4.44)^2] = 8.22 kN/m^2

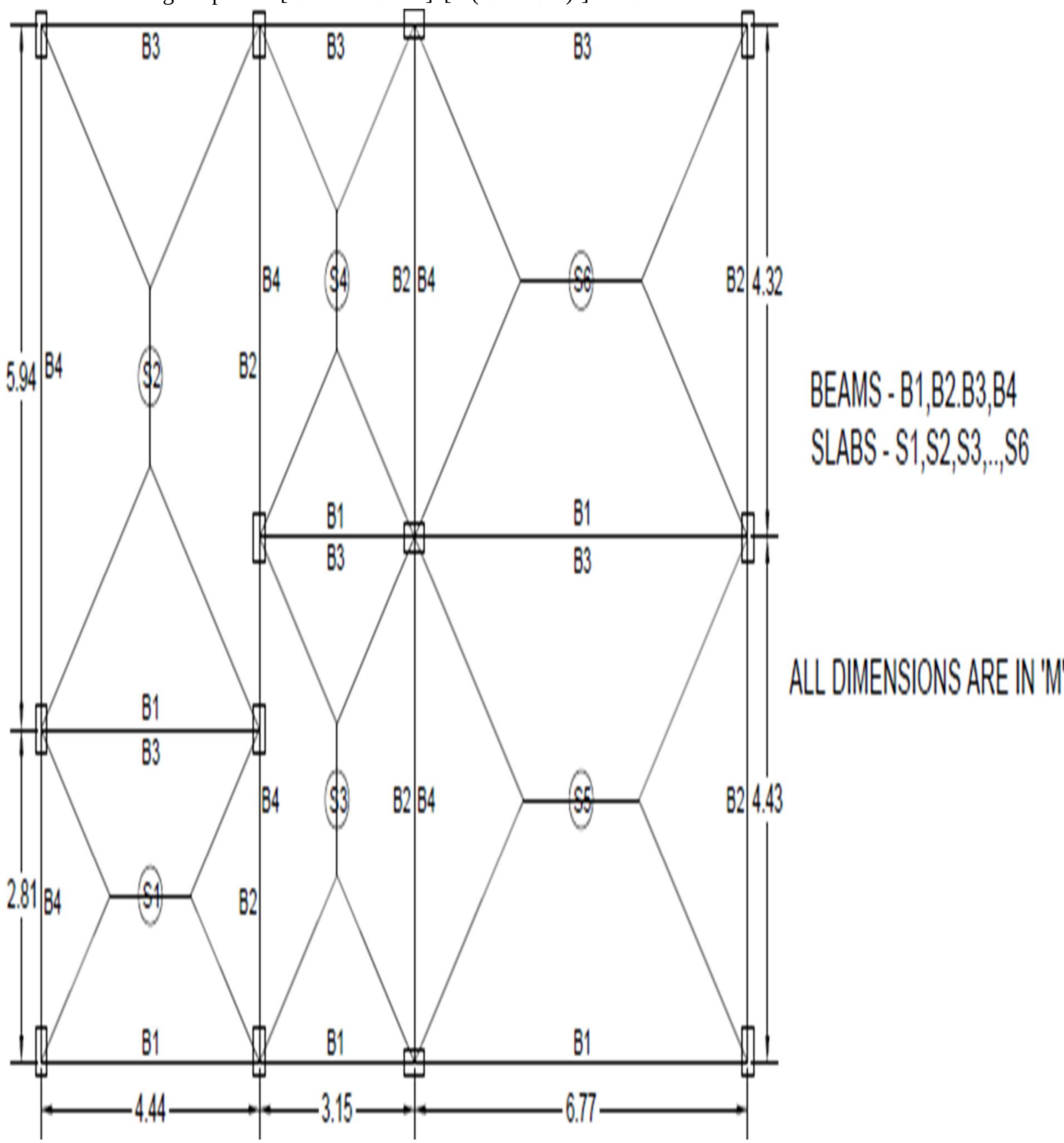

Figure 3.2: Load distribution on beams

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Table 3.1: Load Distribution on Beams for Ground floor For Ground Floor L0

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

Table 3.2: Load Distribution on Beams for First floor For First Floor L1

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

Table 3.3: Load Distribution on Beams for Second floor For Second Floor L2

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

Table 3.4: Load Distribution on Beams for Third floor for Third Floor L3

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

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Table 3.5: Load Distribution on Beams for Fourth floor for Fourth Floor L4

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

Table 3.6: Load Distribution on Beams for Fifth floor For Fifth Floor L5

Slab	Dead load	Floor load	Live load	Total load	Lx	Ly	B1	B2	B3	B4
S 1	3.75	2	1	6.75	2.81	4.44	6.32	8.22	6.32	8.22
S 2	3.75	2	1	6.75	4.44	5.94	9.99	12.19	9.99	12.19
S 3	3.75	2	1	6.75	3.15	4.43	7.09	8.84	7.09	8.84
S 4	3.75	2	1	6.75	3.15	4.32	7.09	8.75	7.09	8.75
S 5	3.75	2	1	6.75	4.43	6.77	9.97	12.82	9.97	12.82
S 6	3.75	2	1	6.75	4.32	6.77	9.72	12.60	9.72	12.60

D. *Wind load analysis*

Design of Wind loads
As per IS 875 (Part-3) - 1987 clause 5.3
Design Wind Speed (Vz) = (k1x K2 x K3 x Vb) Where,
K1 = Probability Factor = 1.0 (As per IS 875 (Part-3) - 1987 clause 5.3.1 Table 1, for Basic wind speed - 39 m/s and Design life of structure 50 years)
(Hence, Assumed Basic Wind Speed as 39 m/s for the location Kurnool from IS 875 (Part - 3) 1987 Fig 1)
K2 = Terrain and Structure size factor = 0.8
(As per IS 875 (Part - 3) - 1987 clause 5.3.3.2 Table 2 for Terrain Category 4 (Class A) Building and Height 20 m)
K3 = Topography Factor = 1.0 (Assumed)
Vb = Basic wind speed = 39 m/s
(As per IS 875 (Part - 3) - 1987 fig 1 Assumed Zone as Kurnool) Vz = 1.0 x 0.8 x 1.0 x 39 = 31.2 m/s
Design Wind Pressure Pd = 0.6 x $(Vz)^2$ Pd = (0.6 x (31.2)2)/1000 = 0.584 kN/m^2

IV. ANALYSIS OF BUILDING IN STAAD Pro V8i

A. *Introduction*

The design and analysis of building structures, especially high-rise buildings, is a complex process that involves understanding both the theoretical and practical aspects of structural engineering. While traditional hand calculations have been used for decades to analyse building frames, advancements in technology have transformed this process significantly.

Here's a more detailed look into how modern techniques have evolved from traditional methods, and the role that computer-aided tools play in designing and analysing high-rise buildings:

A building frame is typically made up of:

- Columns: Vertical elements that bear the load of the structure, transmitting it to the foundation.
- Beams: Horizontal elements that transfer loads from slabs and other parts of the building to columns.
- Slabs: Horizontal surfaces that form the floors of the building, supporting loads from people, furniture, and other materials.

The basic structural design considers these components working together as part of a three-dimensional system to resist forces such as gravity, wind, and seismic activity. As buildings get taller, their structural behavior becomes more complex, especially under lateral forces such as wind and earthquakes.

B. Analysis of Building

1) Step-1: Creation of nodal points. Based on the column positioning of plan we entered the node points into STAAD file.
2) Step-2: Representation of beams and columns. By using add beam command we had drawn the beams and columns between the corresponding node points.
3) Step-3: 3D view of structure. Here we have used the Transitional repeat command in Y direction to get the 3D view of a structure.
4) Step-4: Supports and property assigning. After the creation of structure the supports at the base of structure and specified as fixed. Also the materials were specified and cross sections of beams and columns members were assigned.
5) Step-5: Assigning of Dead loads
6) Step-6: Assigning of Live loads for every floor which are calculated manually using IS-875 PART2
7) Step-7: Analysis. After the completion of all the above steps we have performed the analysis and checked for errors

C. Building Data for Analysis

1	Type of Building	Residential Building (G+5)
2	No. of Stories	G+5
3	Floor height Ground Floor Remaining floors	3.5m 3.0m
4	Material	Concrete (M20) and reinforcement of steel (FE415)
5	Size of beam	230mm x 300mm
6	Size of column	230mm x 400mm
7	Size of wall	300mm

Table 4.1: Building data for Analysis

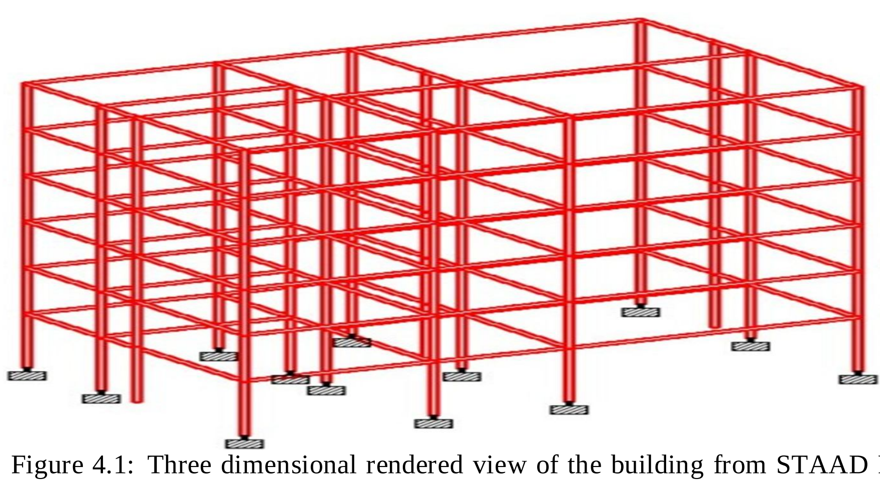

Figure 4.1: Three dimensional rendered view of the building from STAAD Pro

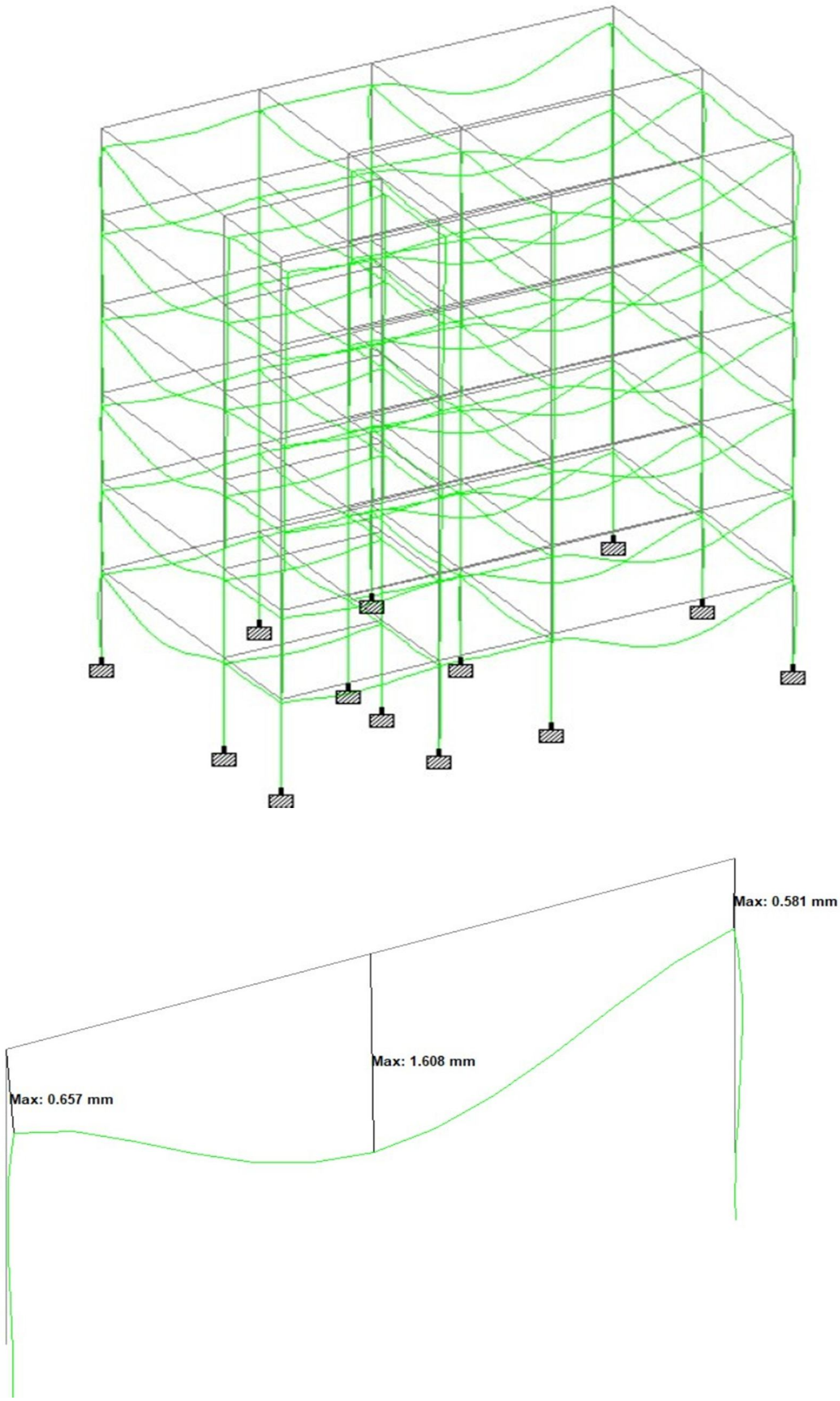

Figure 4.2: Deflection of Building

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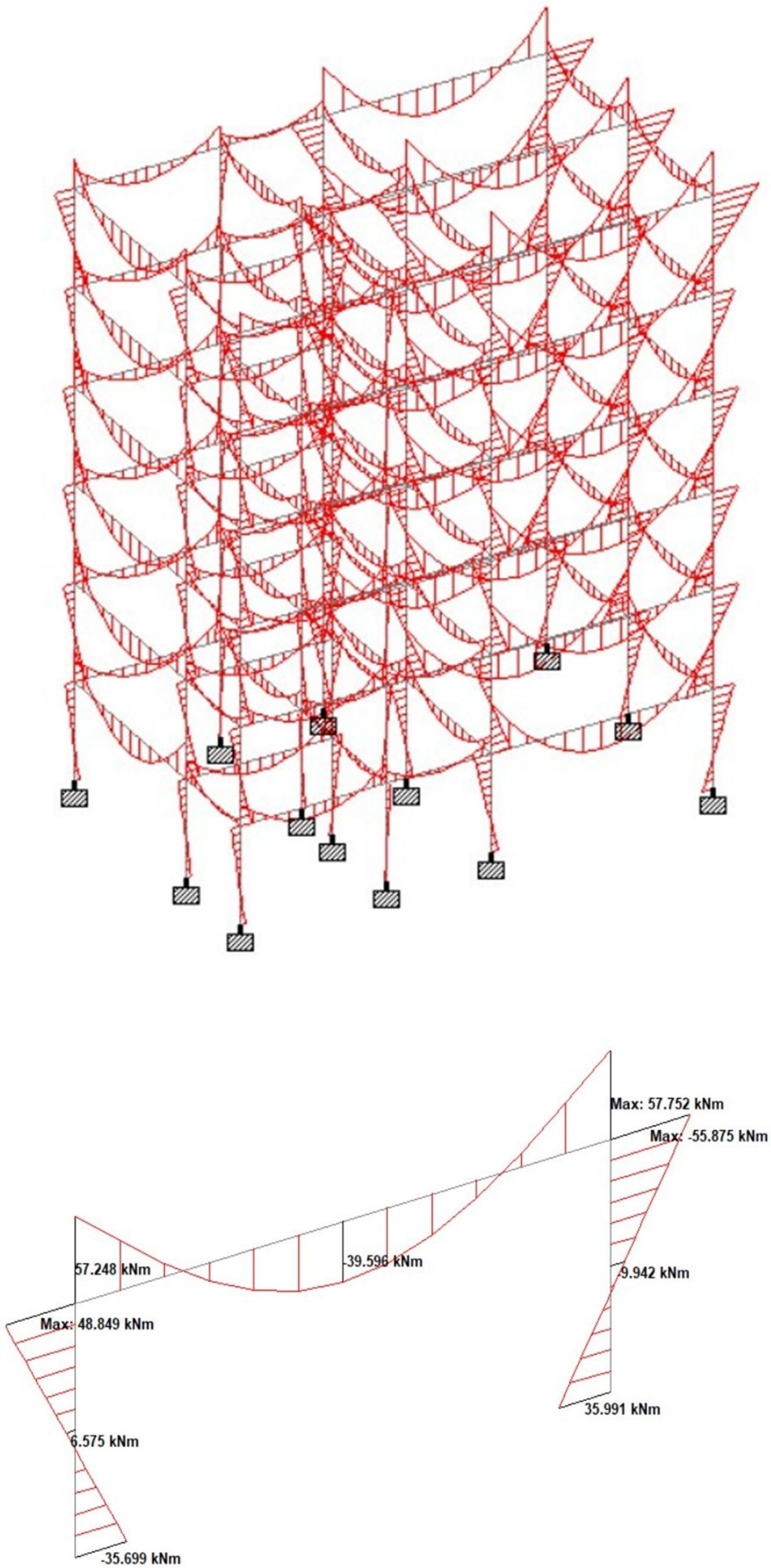

Figure 4.3: Bending Moment of Building

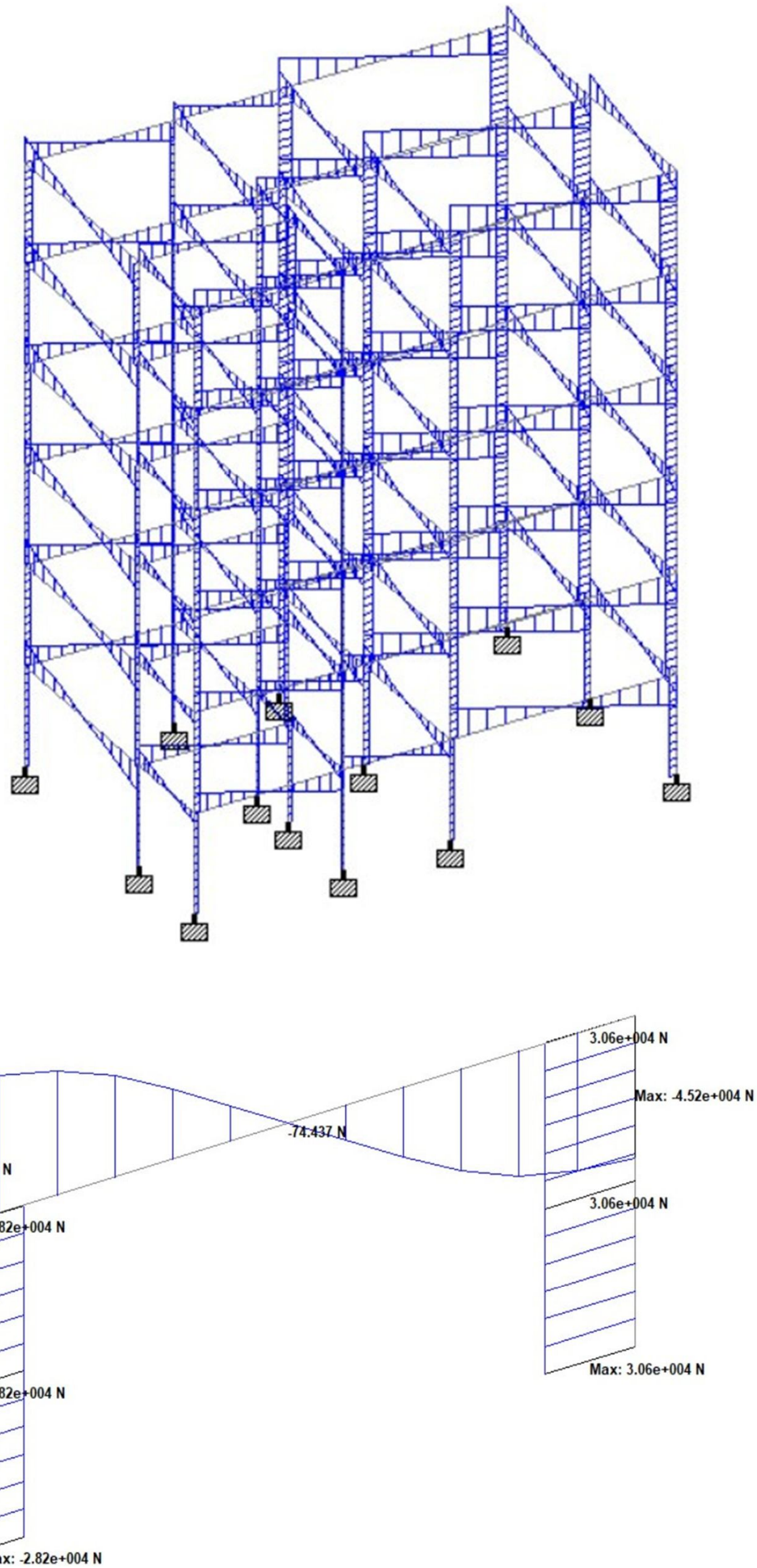

Figure 4.4: Shear Force of Building

V. DESIGN OF BUILDING

A. Design

Once the structural analysis of a building is performed using software, the next step is to design the individual components of the structure, such as beams, columns, slabs, and foundations. In the case of concrete structures, the design is typically carried out according to **IS 456:2000** (Indian Standard Code of Practice for Plain and Reinforced Concrete). Here's a breakdown of the design process based on the IS 456:2000 standard and how it is carried out using structural analysis software:

Before the design process begins, the structural model created during the analysis phase must be defined with precise details for each element (beams, columns, slabs, etc.). Each component will have its own set of design commands that direct the software to calculate and size the elements according to the required safety, strength, and serviceability criteria.

Key steps in defining components include:

- Material Properties**:** For concrete and reinforcement, define the grade of concrete (e.g., M20, M25) and steel (e.g., Fe415, Fe500).
- Cross-sectional Details: Define dimensions for beams, columns, slabs, and other components. This includes defining depth, width, and shape for each element.
- Loadings: Assign loads that the structure will experience, such as dead loads, live loads, wind loads, and seismic loads. These loads are typically generated from the earlier analysis or manually input by the engineer.
- Supports and Boundary Conditions: Define the type of supports (fixed, hinged, roller) and boundary conditions for each component to ensure realistic simulation of how the structure behaves under loading.

Once the structural model is defined, design commands are used to guide the software to perform the design of concrete components as per **IS 456:2000**. The design follows several key steps, including checking for strength, stability, and serviceability.

.

B. Design of Column

A vertical member whose effective length is greater than 3times its least lateral dimension carrying compressive loads is called as Column. Column transfers the loads from the beams or slabs to the footings and foundations. The inclined member carrying compressive loads as in case of frames and trusses called as struts. Pedestal is a vertical compression member whose effective length is less than 3 times its least lateral dimension. Generally the column may be square, rectangular or circular in shape. Columns can be designed in various shapes, depending on structural requirements, aesthetic considerations, and material efficiency. The most common shapes are:

- Square Columns: Equal dimensions in both directions. Often used in buildings with a regular layout.
- Rectangular Columns: One dimension (length or breadth) is greater than the other. These are often used when space constraints demand specific positioning.
- Circular Columns: Typically used in areas where circular symmetry is desired or when the column must resist uniform stress distribution.

1) Necessity of Reinforcement in Columns.

Even though concrete is strong in compression, longitudinal steel bars are placed in the column to reduce the size of the column or to increase the load carrying capacity and to resist any tension that might develop due to bending of column due to horizontal loads, eccentric loads or moments.

To resist any tensile stresses likely to develop, the reinforcement should be placed as near the surface as possible and should evenly distributed ensuring the minimum cover.

Transverse reinforcement in the form of lateral ties or spiral reinforcement are provided to resist longitudinal splitting of the column or splitting concrete due to development of transverse tension and to prevent buckling of longitudinal bars.

2) Types of columns

a) *Based on type of Reinforcement:* Depending upon the type of reinforcement used, reinforced columns are classified into

- Tied column: When the main longitudinal bars of the column are confined within closely spaced lateral ties, it is called as Tied column.
- Spiral column : When the main longitudinal bars of the columns are enclosed with in closely spaced and continuously wound spiral reinforcement, it is called as Spiral column

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b) Based on type of Loading: Depending upon the type of Loading used, columns are classified into

- Axially loaded column: When the line of action of the resultant compressive force coincides with the center of the gravity of the cross section of the column, it is called as axially loaded column.
- Eccentrically loaded column: When the line of action of the resultant compressive force doesn't coincide with the center of gravity of the cross section of the column. Eccentrically loaded columns have to be designed for combined axial force and bending moments.

c) Based on slenderness ratio **:** Depending upon the type of slenderness ratio used, columns are classified into

- Short column: When the ratio of effective length of the column to the least lateral dimensions is less than 12. A short column fails by crushing.
- Long column: When the ratio of effective length of the column to the least lateral dimensions is greater than 12. A long column fails by buckling.

3) Design of column

Size of column = 230mm x 400mm Length of column = 3000mm

Effective length = 0.65 x L = 0.65 x 3000 = 1950mm Slenderness ratio = l/b = 1950/230 = 8.47 >12 Hence, it may be designed as short column.

Minimum eccentricity, e = l/500 + D/30 = 3000/500 + 400/30 = 19.33 ¿ 20 Hence, e min = 20mm

Load = 23.32kN

Factored load (Pu) = 1.5 x 23.32 = 34.98kN Gross area Ag = 230 x 400 =92000mm^2

Ac = Ag - Asc

Pu = 0.4 x fck x (Ag - Asc) + 0.6 x fy x Asc

34.98 x 106 = 0.4 x 25 x (92000 - Asc) + 0.6 x 415 x Asc

Asc = 846 mm^2

Minimum reinforcement = 0.8/100 x 230 x 400 = 736 mm^2 Hence, provide minimum reinforcement = 846 mm^2 Provide 12mm dia of bars

No. of bars = 846/

[(Π/4)x12^2] = 8 no's

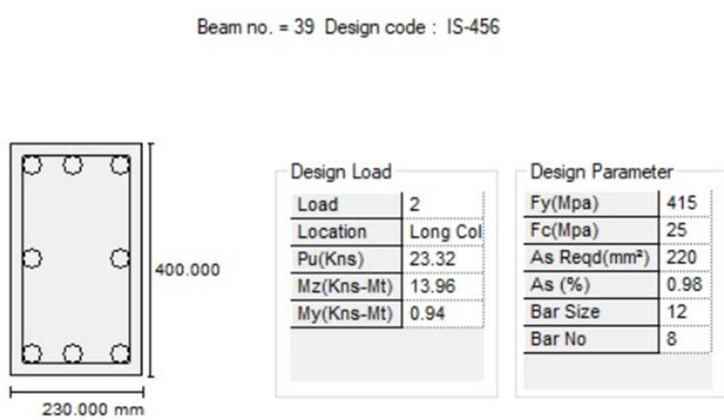

Figure 5.1: Reinforcement details of Column

C. Design of beam

In most of the reinforced concrete structures, beams and slabs are always cast monolithically. Form works are erected for beams and slabs together and concrete is poured in one operation form bottom of the beam to the top of the slab. Stirrups and bent up bars are also extended into the slab. Stirrups and bent up bars are also extended into the slab. Due to this, certain portion of the slab acts along with the beam in resting compression of the beam and it acts like a flange of the beam. The total resulting section is known as flanged section.

fck = 25 N/mm^2 fy = 415 N/mm^2

Support width = 300mm Length = 4440mm

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1) Depth of beam:
Selecting depth in range of (1/12) to (1/15) based on stiffness d = 4440/15 = 300mm
D = 350mm (cover 50mm) Width (b) = 230mm
Effective span = It is the least of c/c of supports = 4.44 + 0.23/2 + 0.23/2 = 4.67

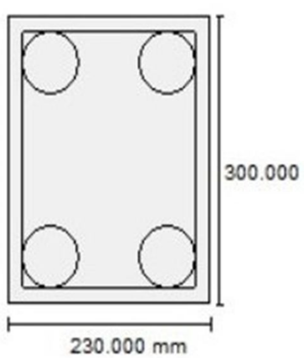
2) Loads:
Self-weight of beam = 0.23 x 0.35 x 1 x 25 = 2.127 KN/m^2 Imposed load = 6.75 KN/m^2
Total load = 8.877 KN/m^2
Factored load = 1.5 x 8.77 = 13.31 KN/m^2
Factored bending moment (Mu) = [(wu x l^2)/8] =36.28 KN-m

3) Depth required:
Minimum depth required (Mu) = 36.28 x 106 = 0.138 x 25 x 230 x x^2 X = 213.82mm <300mm
d = 300m
Hence, provide depth is adequate

4) Tension reinforcement:
Mu lim = 0.87fyAstd (1- fyAst/fckbd)
36.28 x 106 = 0.87 x 415 x Ast x 300 (1-415*Ast/25*230*300)
Ast= 329.49 mm^2 Provide 16mm Φ of bars
No of bars = 329.49/[(Π/4)x16^2] = 4 no's

5) Check for deflection (stiffness): For SSB basic value of l/d = 20
Modification factor for tension steel = 1.14
Stress in steel under service or working loads fs = 193.76 N/mm^2
From fig of IS456-2000 Modification factor = 1.15
Maximum permitted = l/d = 1.15 x 20 = 23 l/d provided ratio = 4440/350 = 12.68 ¡ 23 Hence deflection is safe.

Beam no. = 16 Design code : IS-456



Design Load

Load	5
Location	End 1
Pu(Kns)	-0.04
Mz(Kns-Mt)	0.49
My(Kns-Mt)	0.48

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	552
As (%)	1.16
Bar Size	16
Bar No	4

Figure 5.2: Reinforcement details of Beam

D. Design of slab
Slabs are constructed to provide flat surfaces, usually horizontal, in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls, by reinforced concrete beams usually cast monolithically with the slab, by structural steel beams, by columns, or by the ground.

1) *Flat slab:-*

Flat slab is a reinforced concrete slab supported directly by concrete columns or caps. Flat slab don't have beams. They are supported on columns itself. Loads are directly transferred to columns. In this type of construction a plain ceiling is obtained thus giving attractive appearance from architectural point of view. The plain ceiling diffuses the light better and is considered less vulnerable in the case of fire than the usual beam slab construction. The flat slab is easier to construct and require less formwork. The thickness of Flat slab is minimum 8
Inch or 0.2m. This is a one of the types of concrete slabs. Where it is used:

- To provide plain ceiling surface giving better diffusion of light.
- Easy constructability with economy in the formwork.
- Larger head room or shorter story height and pleasing appearance.
- This kind of slabs are provided in parking.
- Flat slabs are generally used in parking decks, commercial buildings, hotels or places where beam projections are not desired.

2) *Conventional slab:-*

The slab which is supported with Beams and columns is called conventional slab. In this kind of slab the thickness of slab is small wherea s depth of beam is large and load is transferred to beams and form beams to columns. It requires more formwork when compared with the flat slab. And there is no need of providing column caps in conventional slab. The thickness of conventional slab is 4 or 10cm.5 to 6 inches is recommended if the concrete will receive occasional heavy loads, such as motor homes or garbage trucks. Normally it is square in shape and has a length of 4m. Reinforcement is provided in conventional slab and the bars which are set in horizontal are called Main Reinforcement Bars and bars which are set in vertical are called Distribution bars. These types of slabs are used in constructing floors of multi storied building.
Based on length and breadth of the slab Conventional Slab is classified into two types

a) *ONE WAY SLAB:*

One way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction. The ratio of longer span (l) to shorter span (b) is equal or greater than 2, considered as one way slab because this slab will bend in one direction i.e., in the direction along its shorter span. However minimum reinforcement known as distribution steel is provided along the longer span above the main reinforcement to distribute the load uniformly and to resist temperature and Shrinkage stresses.
In general length of slab is 4m. But in one way slab one side length is 4m and other
Side length is more than 4m. So it satisfies the above equation. In one way slab main reinforcement is provided in shorter span distribution reinforcement is provided in longer span. Distribution bars are cranked to resist the formation of stresses.

b) *TWO WAY SLAB:*

Two way slab is a slab supported by beams on all the four sides and the loads are carried by the supports along both directions, it is known as two way slab. In two way slab, the ratio of longer span (l) to shorter span (b) is less than 2. The slabs are likely to bend along the two spans in this load is transferred in both the directions to the four supporting edges and hence distribution reinforcement is provided in both the directions.
In this kind of slab the length and breadth of slab is more than 4m. So distribution bars are provided at both the ends in two slab. To resist the formation of stresses.
These types of slabs are used in constructing floors of multi storied building.

Design of Slab:

- *Length to breadth ratio:*

Length of longer span of slab (Ly) = 2810 mm Length of shorter span of slab (Lx) = 4440 mm
(Ly/Lx) = 0.63 ¡ 2 = two way slab (from IS456-2000 ANNEX D 1.11)

- *Effective depth:*

Span to effective depth ratio's for span upto 10m, continuous slab is 26 as per IS 456-2000 clause 23.2.1

Longer span in slab (Ly) = 2810 mm (deff) = (span/26) = 108.077 mm
Assume 10mm dia of bar with 15 mm cover d = (deff - bar dia - cover) = 176 mm

- *Effective span:*

In Y-direction Ly(eff) = 2986mm (Ly+d) In X-direction Lx(eff) = 4576mm (Lx+d)

- *Calculations of loads:*

Dead load = 1 x 0.15 x 25 = 3.75 kN/m^2 Live load = 2 kN/m^2
Total load = 5.75kN/m^2
Factored load = 1.5 x 5.75 = 8.625 kN/m^2

- *Design bending moment (BM) and Shear force (SF): Maximum moment in both direction*

Mx = α_x x wl^2 , My = α_y x wl^2
For edge strip α_x = 0.055 , α_y = 0.037 For mid span α_x = 0.041 , α_y = 0.028
Maximum Bending Moments at edge strip in the both directions For shorter span = Mx = 0.055 x 8.65 x $(4440/1000)^2$
For longer span = My = 0.037 x 8.65 x $(2810/1000)^2$
Maximum Bending Moments at mid span in the both directions For shorter span = Mx = 0.041 x 8.65 x $(4440/1000)^2$
For longer span = My = 0.028 x 8.65 x $(2810/1000)^2$

- *Area of reinforcement:*

Take fe415 grade of steel for reinforcement In X-direction:
Mx = 0.87 x fy Ast d (1- fyAst /fck x b x d) = 660000 mm^2 Minimum reinforcement required is 0.12% = 792mm^2
Cross sectional area of a 8mm dia of bar = 50.26 mm^2 No.of bars = 16 No's
Spacing = 275 mm
Hence, use 16 no's of bars of 8mm dia @ 275mm spacing In Y-direction:
My = 0.87 x fy Ast d (1- fy Ast /fck x b x d) = 421500 mm^2 Minimum reinforcement required is 0.12% = 505.8 mm^2
Cross sectional area of a 8mm dia of bar = 50.26 mm^2
No.of bars = 11 No's Spacing = 281 mm
Hence, use 11 no's of bars of 8mm dia @ 281mm spacing

VI. ESTIMATION

A. Introduction

Before the start of any work for its execution, the owner of the builder should have a thorough knowledge of the volume of work. The minutest details can help him understand if the work can be completed within the stipulated time frame and budget. It also enables him to understand the probable cost that may be incurred to complete the proposed work. Therefore, it is necessary to list the probable costs or develop an estimate for the proposed work from its plans and specifications.

An estimate is prepared by calculating the quantities from the drawings for various items and multiplying them with the unit cost of the item concerned. To prepare an estimate one requires

1) Drawing: - The drawing is the basis from which quantities of various items for a work are calculated. The drawings consist of the plan, the elevations, and the sections through important points.
2) Specifications:-

- General Specification: - The general specification forms the general idea for the project. In this, the nature and class of work and the names of materials that should be used are described.
- Detailed Specification: - Detailed specification describes every item of work in the estimate. This specification of work serves as a guide to execute the work to the owner's satisfaction.
- Rates: - Rates for different items of works are vital factors to determine the estimated cost.

Standing circulars for taxes and insurance etc. are required to fix up rates of those item which are not in the schedule of rates.

B. Purpose of Estimation

Estimate for a work or project is necessary mainly for the following purposes:

1) To determine how much money the owner will need to finish the proposed project. Estimates are necessary for public construction projects in order to receive technical sanctions, administrative approval, and funding allocation.
2) Calculate the amounts of materials needed to schedule their prompt acquisition.
3) Determine how many employees will be needed to do the job by the expected completion date.
4) Evaluate the tools and equipment needed to finish the work in accordance with the program.
5) Determine the completion time based on the estimate's work volume.
6) Create a program and schedule for construction.
7) Justify the investment from the benefit-cost ratio.
8) Invite tenders and prepare bills for payment.
9) An estimation for an existing property is required for valuation.

```
TOTAL VOLUME OF CONCRETE =       107.7 CU.METER

          BAR DIA          WEIGHT
          (in mm)          (in New)
          --------         --------
              8               31643
             10                8404
             12               30788
             16               26025
             25                6141
                         ------------
       *** TOTAL=            103001
```

Figure 6.1: Weight of concrete and steel from the STAAD PRO

S.No	Name of the work	Nos	Length (m)	Breadth (m)	Height (m)	Quantity (m^3)	Rate (perm^3)	Amount (Rs)
1.	Earth work Excavation and depositing of soil banks with an initial lead of 10m. and lift of 3 m complete for column footings	13	2.02	2.02	2.12	112.46	550	61,853
2.	P.C.C.(1:1:2) for column footings	13	1.50	1.50	1.20	35.1	1750	61,425
3.	Filling Basement with sand including cost and conveyance of all materials and labour charges etc. a) Basement b) Under column footings	 1 13	 8.97 1.50	 16.7 1.50	 0.90 1.20	 134.81 35.1 T=169.91	 550	 93,451
4.	Brick masonry in CM (1:6) including and							

	labour charges etc., Super structurer charges etc. a) 9” walls b) 4” walls	 4 8	 8.97 16.7	 16.7 0.23	 3.0 3.0	 404.5 92.184 T=496.68	 550	 2,73,177
5.	Deductions Doors D1 D2 D3 Windows (W) Ventilator (V)	 1 1 8 11 4	 2.13 1.52 0.9 0.9 0.6	 0.23 0.23 0.23 0.23 0.23	 2.13 2.13 2.17 0.90 0.46	 1.04 0.75 3.60 2.05 0.27 T=7.71	1750	13,493
6.	20mm thick plastering with CM (1:5) including cost and conveyance of all materials and labour Inside of all rooms Outside building Ceiling	 1 1 1	 37.84 35.68 8.97	 - - 16.97	 3.00 3.20 -	(m^2) 113.52 121.08 149.80 T=384.4	per (m^2) 550	2,11,420
7.	Flooring with marble stones over 10cm thick PCC (1:5:10) including cost and conveyance of all material and labour of all rooms	1	8.97	16.7	-	149.80	3150	5,25,798

To Find Total Cost of Steel:-

We can estimate the cost of building by multiplying the weight of materials to cost of that material per kg.

“Total cost = weight of material in kgs x Rate of material”

- Total Weight Steel = 103001 N = 10503.17kg
- Rate of steel per Kg = Rs.54/-
- Total Cost = 10503.17 x 54
- Total cost of Steel = Rs.5,67,175/-
- Provision for Electrification arrangements = Rs.80,000/-
- Provision for Sanitary and water supply arrangements = Rs.1,50,000/-
- Provision for Cupboards = Rs.2,00,000/-
- Provision for RCC staircase with MS railing = Rs.1,20,000/-
- Provision for Compound wall, Gate Sump = Rs.2,50,000/-
- Provision for Painting, Varnishing = Rs.80,000/-
- Provision for interior works, Elevation works = Rs.2,00,000/-
- Provision for Safety Grills, Doors = Rs.1,20,000/-
- Estimation charges for 1 floor without excavation charges = Rs.35,58,734/-
- Total estimation cost = Rs.1,77,93,670/-

VII. RESULT AND DISCUSSION

In today's fast-paced world, the demand for housing can be met through the efficient utilization of land and thoughtful design. By constructing residential houses that use land effectively—such as through vertical growth, compact designs, and mixed-use developments—we can ensure that the land is used efficiently while still preserving valuable agricultural areas for future generations.

Furthermore, adhering to accurate design plans, meeting building codes, and satisfying owner requirements are essential to ensure the safety, functionality, and durability of residential buildings. These steps not only meet immediate housing needs but also contribute to the long-term sustainability and liability of urban areas. With proper planning and design, we can create homes that are both space-efficient and sustainable, making room for the growth of both urban and agricultural areas.

The Planning, Analysis, Design, and Estimation of a Residential Building is a comprehensive process that involves:

1) Planning: Understanding the site, setting goals for space usage, ensuring regulatory compliance, and defining the overall building concept. The planning phase lays the foundation for a functional, safe, and sustainable residential structure.
2) Analysis: The structural analysis phase ensures the design can withstand various loads, meets safety standards, and remains stable. It ensures that the building can bear the forces acting on it, including natural elements like wind and earthquakes.
3) Design: Translating the concepts into detailed construction documents, including architectural, structural, and MEP designs. The design focuses on making the building functional, aesthetic, and safe.
4) Estimation: Estimating the overall cost, including materials, labor, equipment, and other expenses. This phase helps ensure that the project is financially viable and stays within budget

Together, these phases result in the creation of a residential building that is safe, functional, cost-effective, and meets the needs of the owner. This structured approach ensures that the project is completed on time, within budget, and to the required standards.

VIII. SUMMARY & CONCLUSIONS

Based on the work carried out, the following conclusions were made:

1) In this project, PLANNING, ANALYSIS, DESIGNING AND ESTIMATION OF RESIDENTIAL BUILDING is carried out.
2) Studied how to plan a building using the National Building Code of India-2005. We learned how to use AUTO-CAD software to draft and draw building plans as a result of this project.
3) The bending moments are determined by a manual gravity load analysis carried out in accordance with IS code.
4) Using STAAD Pro software, the analysis has done as per IS codes. The design is safe in all aspects.
5) Finally, manually and software results are compared and observed that they are approximately equal.
6) The design of slab, beam, and column are design in limit state method, which is safe at control of deflection and in all aspects.
7) Finally, the structure is designed to withstand safely all loads liable to act throughout its life time, it shall also satisfy the serviceability requirements.
8) Steel, cement, aggregate, bricks, composite materials, equipment, electrical installations, plumbing, sanitary, and labour costs are the main factors.

IX. ACKNOWLEDGEMENT

I am profoundly grateful to everyone who has contributed to the successful completion of this project work "PLANNING, ANALYSIS, DESIGN AND ES- TIMATION OF A RESIDENTIAL BUILDING"

First and foremost, I dedicate this work to the loving memory of my Father, Late Dheer Singh, their constant struggles to get their children get the best of the Education and succeed continue to inspire me every day.

I would also like to express my sincere thanks to Prof. Vishnu Kumar for his invaluable guidance and constructive feedback, and to MANGALAYATAN UNIVERSITY for providing the necessary resources and support material as a base for this research. My gratitude also extends to my peers and colleagues for their support and collaborative spirit.

Finally, I thank all those who have directly or indirectly contributed to the successful completion of this project. This work is a testament to the collective effort and encouragement I have received from my loved ones and mentors.

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[9] IS 875, Part-3 - (1987) Wind loads for buildings and structures.
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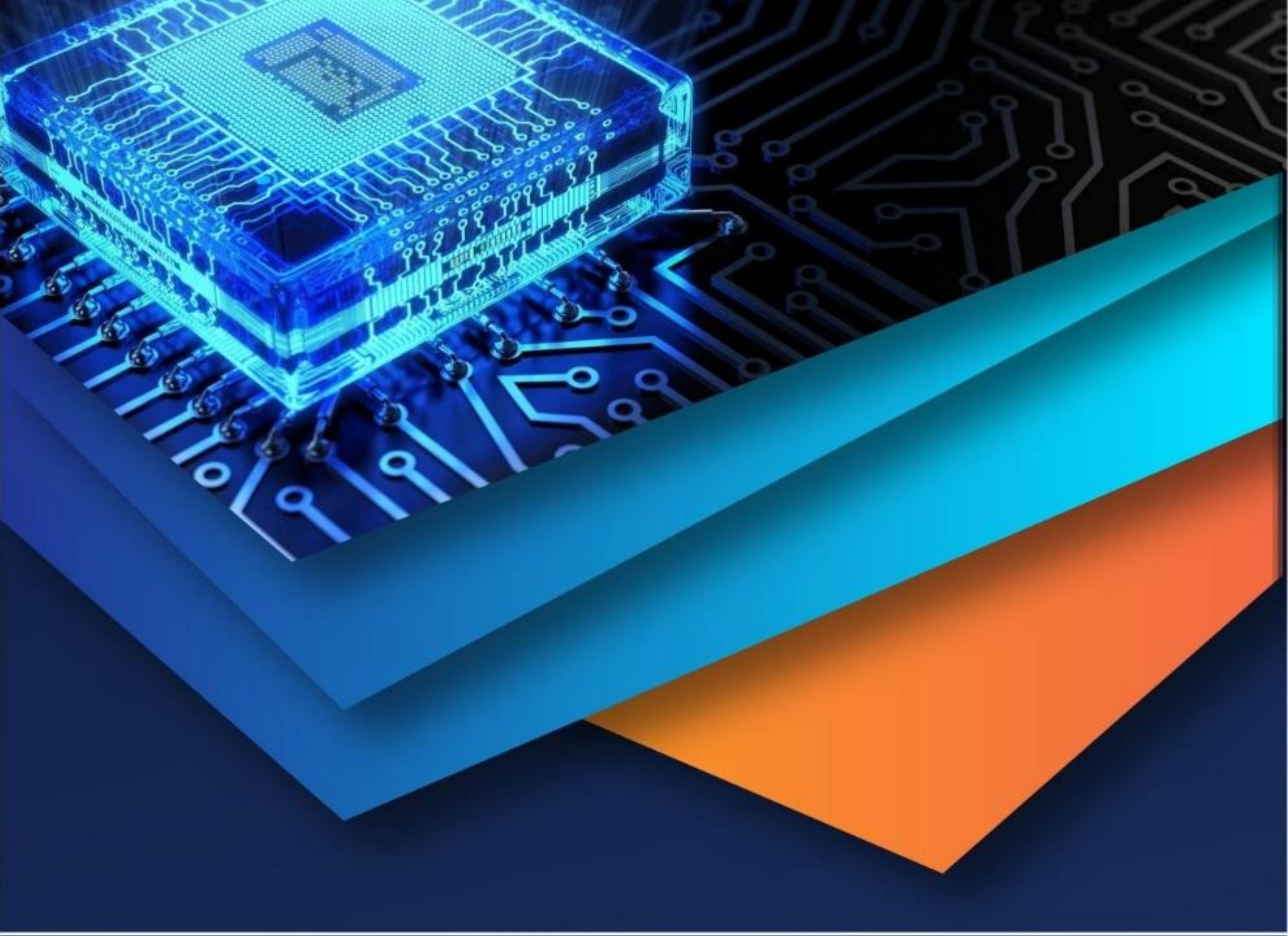

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