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Analysis And Design of Residential Building Based On Thermal Comfort

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ABSTRACT: The "Analysis and Design of Residential Building Based on Thermal Comfort" project report delves into the intricate realm of architectural design, focusing on the paramount significance of thermal comfort within residential spaces. In an era where sustainable construction and occupants' well-being take precedence, this project aimed to scrutinize, analyze, and propose design strategies that prioritize thermal comfort while emphasizing energy efficiency and environmental sustainability.

This project report comprises multiple phases, with the abstract encapsulating the findings and objectives of Phase 1. Phase 1 was dedicated to a comprehensive examination of various parameters that influence thermal comfort in residential buildings. It encompassed a thorough analysis of architectural design, building materials, insulation techniques, passive and active heating/cooling systems, ventilation strategies, and the integration of renewable energy sources.

The research methodology involved a blend of theoretical exploration, case studies, simulations, and evaluation of existing technologies and practices. Case studies provided practical insights into successful applications of thermal comfort principles, illustrating their impact on enhancing occupant comfort while minimizing energy consumption. The insights gleaned from this phase serve as a catalyst for the project's future stages, aiming to refine methodologies, integrate innovative solutions, and evolve strategies that actualize the vision of creating residential buildings where occupants' comfort is paramount, while upholding environmentally conscious design practices. Ultimately, this project aspires to contribute to the evolution of architectural paradigms by prioritizing human-centric design principles and fostering sustainable residential spaces that enhance occupants' quality of life.

KEYWORDS: Sustainable, Innovative, Design Ideas, thermal comfort, Energy efficiency, Climate resilience, Passive design strategies.

I. INTRODUCTION

In contemporary architectural discourse, the pursuit of both aesthetic appeal and inhabitant well-being stands as a fundamental tenet. With sustainable and energy-efficient construction practices emerging as imperatives in today's architectural landscape, the attainment of optimal thermal comfort within residential structures assumes paramount significance. This paper endeavors to dissect and evaluate the pivotal design principles essential for achieving optimal thermal comfort in residential constructions. Against the backdrop of escalating concerns regarding climate change and energy conservation, the synthesis of thermal comfort and energy efficiency emerges as a critical imperative. The primary objective of this paper is to delve into diverse methodologies, principles, and technologies pertinent to the

analysis and design of residential edifices, aiming to optimize thermal comfort. Through a meticulous examination of various parameters impacting the thermal performance of residential buildings—ranging from architectural design and building materials to insulation techniques, passive and active heating/cooling systems, ventilation strategies, and the incorporation of renewable energy sources—this study aims to furnish insights into the most efficacious strategies and exemplary practices. Moreover, the paper elucidates practical case studies and simulations showcasing the successful implementation of thermal comfort principles in residential architecture, thereby elucidating their tangible contributions in enhancing occupant comfort while curtailing energy consumption. The delineations and recommendations encapsulated herein serve as a comprehensive compendium for architects, engineers, and stakeholders engaged in the construction and refurbishment of residential structures. By advocating for the creation of living environments that prioritize occupant well-being while espousing environmentally conscious and sustainable design practices, this paper aspires to catalyze transformative shifts in contemporary architectural paradigms.

II. PURPOSE OF THIS IDEAS

Prioritizing occupant comfort and optimizing thermal conditions within residential buildings is the main objective. Through implementing design strategies that focus on thermal comfort, we aim to create living spaces that promote well-being and productivity for residents. Designing energy-efficient and sustainable residential buildings is of utmost importance. This project aims to explore how designing for thermal comfort can contribute to reducing energy consumption, lowering carbon footprints, and fostering environmentally responsible construction practices. The ideas acknowledges the need for adaptable design solutions that cater to varying climates across different geographical regions. This ensures that residential buildings remain comfortable and efficient irrespective of external temperature fluctuations. Incorporating thermal comfort considerations into the design process can significantly improve the overall performance of residential buildings. This includes factors such as reduced operational costs, increased market value, and improved occupant satisfaction. Adaptable and forward-thinking solutions are necessary to future-proof residential building designs against evolving environmental challenges and technological advancements.

III. OBJECTIVES OF THESE IDEAS

Assessing Thermal Comfort: Thoroughly evaluate the factors that influence thermal comfort in homes, from temperature and humidity to air movement and radiant heat, in order to gain a comprehensive understanding of their impact on occupants. Analyzing Building Design: Study how design elements like orientation, building shape, window placement, insulation, and materials selection contribute to creating optimal thermal comfort levels in residential spaces. Using Advanced Tools: Utilize cutting-edge simulation software or computational models to predict and analyze the building's thermal performance under various climatic conditions, ensuring a well-informed and optimized design approach. Implementing Passive Strategies: Propose passive design strategies, such as natural ventilation, shading devices, thermal mass utilization, and efficient building envelope design, to improve thermal comfort without relying heavily on mechanical systems. Considering Environmental Impact: Emphasize how the proposed design strategies can reduce the environmental impact of the residential building, with a focus on carbon emissions, resource consumption, and overall ecological footprint. Evaluating Economic Feasibility: Assess the cost-effectiveness of different thermal comfort strategies in residential buildings, taking into account initial investment, operational costs, and potential long-term savings.

3.1 APPROACH TOWARDS IDEAS

To design a building that responds effectively to its specific environmental context, it is important to conduct a thorough analysis of the local climate conditions, including temperature variations, humidity levels, solar radiation, wind patterns, and seasonal changes. This analysis forms the foundation for implementing various thermal comfort strategies, such as investigating and implementing passive design techniques like building orientation, natural ventilation, shading devices, thermal mass utilization, and proper insulation. It also involves utilizing advanced building energy simulation software to model and simulate different design scenarios, allowing for the prediction and evaluation of the thermal performance of the building design under various climatic conditions. Additionally, it includes analyzing and selecting building materials that offer optimal insulation properties, thermal inertia, and resistance to heat transfer, as well as optimizing the building envelope to minimize thermal bridging and air leakage, enhancing overall thermal performance. A life cycle cost analysis should also be performed to assess the economic feasibility of implementing various thermal comfort strategies, including evaluating initial investment costs, operational

expenses, maintenance, and potential long-term savings to justify the chosen design interventions. Moreover, exploring case studies and best practices from similar projects worldwide can draw insights, learnings, and successful approaches that have effectively enhanced thermal comfort in residential buildings. Finally, implementing an iterative design process allows for continuous evaluation, refinement, and optimization of design strategies based on simulation results, feedback, and emerging research findings.

IV. METHODOLOGIES

4.1 INITIAL BUILDING DESIGN:

- Define the architectural requirements and spatial layout of the residential building.
- Develop a preliminary building design considering structural elements, including floors, walls, columns, and beams

4.2 STRUCTURAL ANALYSIS USING STAAD:

- Import the architectural model or create a structural model in STAAD software.
- Analyze the structural elements to ensure they comply with building codes and safety standards.
- Perform structural analysis, considering loads, material properties, and design constraints to ensure structural stability and integrity.

4.3 INTEGRATION OF THERMAL COMFORT ANALYSIS IN REVIT:

- Transfer the finalized structural design from STAAD to Revit, maintaining accuracy and structural details.
- In Revit, incorporate thermal comfort analysis tools or plugins compatible with the software to simulate thermal behavior within the building.
- Utilize Revit's energy analysis features to assess factors influencing thermal comfort, such as building orientation, material properties, glazing percentages, and HVAC systems.

4.4 PERFORMANCE EVALUATION AND VALIDATION:

- Evaluate the results obtained from both STAAD and Revit simulations to ensure that structural stability aligns with thermal comfort goals.
- Validate the design by comparing the predicted thermal comfort levels against recognized standards or guidelines for residential buildings.

4.4 PERFORMANCE EVALUATION AND VALIDATION:

- Compile comprehensive documentation summarizing the design iterations, structural analysis, and thermal comfort assessment results.
- Present findings, recommendations, and any necessary design modifications to stakeholders or decision-makers for approval and implementation.

This methodology integrates the capabilities of STAAD for structural analysis with Revit's tools for thermal comfort analysis, allowing for a holistic approach to designing residential buildings that prioritize both structural soundness and occupants' thermal comfort.

V. HOW TO ANALYSE THERMAL COMFORT IN REVIT

In Revit, analyzing thermal comfort involves utilizing various tools and functionalities to assess factors that contribute to the overall thermal experience within a building. Here are steps to analyze thermal comfort in Revit:

1. Building Information Modeling (BIM) Setup:

Begin by setting up your project in Revit with accurate building geometry, including walls, windows, doors, and other relevant building elements. Ensure that the materials and construction details are correctly assigned to components.

2. Climate Data and Location Settings:

Input accurate climatic data and location-specific settings within Revit. This data influences the thermal performance analysis, considering factors like temperature, humidity, and solar radiation.

3. Energy Analysis and Thermal Performance:

Revit offers energy analysis tools that can help assess the thermal performance of the building. Use the energy analysis features to evaluate heating and cooling loads, energy consumption, and thermal behavior based on the building design.

4. Use Analytical Model:

Generate an analytical model within Revit to represent the building's thermal behavior. Ensure that the model is detailed enough to provide accurate thermal simulations.

5. Simulating Thermal Comfort Parameters:

Revit doesn't have direct tools for thermal comfort analysis, but it can facilitate the simulation of parameters that influence thermal comfort indirectly. Utilize tools to simulate temperature distributions, daylight analysis, solar heat gain, airflow, and ventilation paths to gauge potential comfort issues.

6. Add-ins and Plugins:

Explore available add-ins or plugins for Revit that specialize in thermal comfort analysis. Some third-party tools can integrate with Revit to provide more advanced thermal comfort assessments and simulations.

7. Evaluate Results and Iterative Design:

Analyze the results obtained from the simulations within Revit. Identify areas of potential discomfort or inefficiency in the building's thermal performance. Iterate the design by making adjustments to building elements, insulation, glazing, or HVAC systems to enhance thermal comfort while maintaining energy efficiency.

8. Documentation and Reporting:

Document your findings and analysis within Revit or export the results to other software for detailed reporting. Include diagrams, charts, and summaries that illustrate the thermal comfort parameters and proposed design modifications.

VI. SOFTWARE USED

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. AutoCAD first became notable because it was the first CAD program developed for PC use (instead of industrial computers) in the 1980s. With computer hardware becoming more capable, the company behind AutoCAD, Autodesk, wanted to make CAD accessible to more people. AutoCAD has remained the dominant program in many design industries because it's continuously updated. There's a new version released every year, and new features are always being added. 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 Auto-CAD 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 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 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.

STAAD PRO

Staad is powerful design software licensed by Bentley. Staad stands for structural analysis and design. It is widely used software for structural analysis and design from research engineers international it consists of following. It is a graphical user interface, (GUI) it is used to generate the model, which can then be analyzed using STAAD engine. After analysis and design is completed, the GUI can also be used to view results graphically. The STAAD

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

Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate SFD and BMD of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. Staad pro is a very powerful tool which does this job in just an hour's Staad is a best alternative for high rise buildings. Now a day's most of the high rise buildings are designed by Staad

which makes a compulsion for a civil engineer to know about this software. These software can be used to carry RCC, steel, bridge, truss etc according to various country codes.

Modeling:

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

Alternatives for STAAD:

Struts, Robot, SAP, ADDS pro which gives details very clearly regarding reinforcement and manual calculations. But these software's are restricted to some designs only where as Staad can deal with several types of structure

Staad Editor:

Staad has very great advantage to other software's i.e., Staad editor. Staad editor is the Programming For the structure we created and loads we taken all details are presented in programming format in Staad editor. This program can be used to analyze another structure also by just making some modifications, but this require some programming skills. So load cases created for a structure can be used for another structure using Staad editor.

REVIT

Revit offers a range of tools and features tailored for civil engineers to create detailed 3D models of infrastructure projects such as roads, bridges, tunnels, and drainage systems. With Revit, civil engineers can design, analyze, and visualize these projects in a collaborative environment. The software allows for precise modeling of terrain, grading, and site elements, as well as integration with other disciplines' models for comprehensive project coordination. Additionally, Revit facilitates the documentation and communication of design intent through detailed drawings, schedules, and reports, making it a valuable tool for civil engineering projects.

Analysis With advanced analysis engines and access to performance data, Revit users can optimize the functionality of their architectural design. Furthermore, Revit can run highly accurate cost estimates and monitor the performance over the lifecycle of a project or building. Visualization Another thing you can use Revit for is 3D building design visualization. Thanks to various rendering tools, you will be able to create construction documentation with cutaways, 3D views, and stereo panoramas. Furthermore, with Revit Interoperability and Autodesk's 3ds Max software, you can access your building model in virtual reality. Multidiscipline Coordination

Finally, seeing that Revit is a multidiscipline BIM platform, architects can share their Revit models with structural engineers and construction professionals in real-time. This feature will not only speed up the design process and make team members more efficient, but also significantly improve the final product.

VII. PLANNING

Building plans are a graphical representation of what a building will look after construction. They are used by builders and contractors to construct buildings of all kinds. Building plans are also useful when it comes to estimating how much a project will cost, and preparing project budgets. The creation of a set of building plans starts when an owner or developer approaches an architect with an idea for a new building, considering the detailing and complexity of a project, different types of drawings are issued by an architect for the easy understanding and smooth working of construction process.

NATIONAL BUILDING CODE OF INDIA (SP 7: 2016)

The National Building Code of India (NBC) is a national instrument providing guidelines for regulating the building construction activities across the country. The Code mainly contains administrative regulations, development control rules and general building requirements fire safety requirements, stipulations regarding materials, structural design and construction (including safety), and building and plumbing services. As per NBC for a residential building

- a) The plinth or any part of a building or outhouse shall be so located with respect to the surrounding ground level that adequate drainage of the site is assured. The height of the plinth shall be not less than 450 mm from the surrounding ground level.
- b) Parapet walls and handrails provided on the edges of roof terraces, balcony, Veranda, etc. shall not be less than 1.0 m and not more than 1.2 m in height from the finished floor level.
- c) Normally structures exceeding 45 m in length are designed with one or more expansion joints.
- d) The minimum width of staircase shall be 0.9 m.
- e) The minimum width of tread for the buildings shall be 250 mm. The maximum height of riser shall be 190 mm and these shall be limited to 12 per flight.

INDIAN STANDARD CODES

- IS 456 2000-Code of practice for plain and reinforced concrete.
- SP 16:1980-Design aids (for reinforced concretes) to IS 456.
- IS 875(Part 1, 2,):1987-Code of practice for design loads for buildings and structures

VAASTHU ADVICE FOR BUILDING

Building is a structure with multiple floors that can be used as either for commercial or residential 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 prosper life to the mankind. That is why Vaasthu is necessary for every building whether it is residential or commercial purpose.

VAASTHU TIPS FOR BUILDING DRAFTING

- Plot chosen for a building shall be particularly square or rectangle while avoid any irregular shaped building which can bring bad fate for inmates.
- Avoid buildings having extension in south or west whereas cuts in North or East shall also be avoid.
- 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.
- 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.
- The height of the building should be more on South and West. Stair case should ideally be placed in South-west.
- Kitchen in the building is best to be place in South-east.
- By adding all the doors, windows and ventilators of a building should be in an even number and it should not end with zero.
- Balcony should be made in East or North.

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

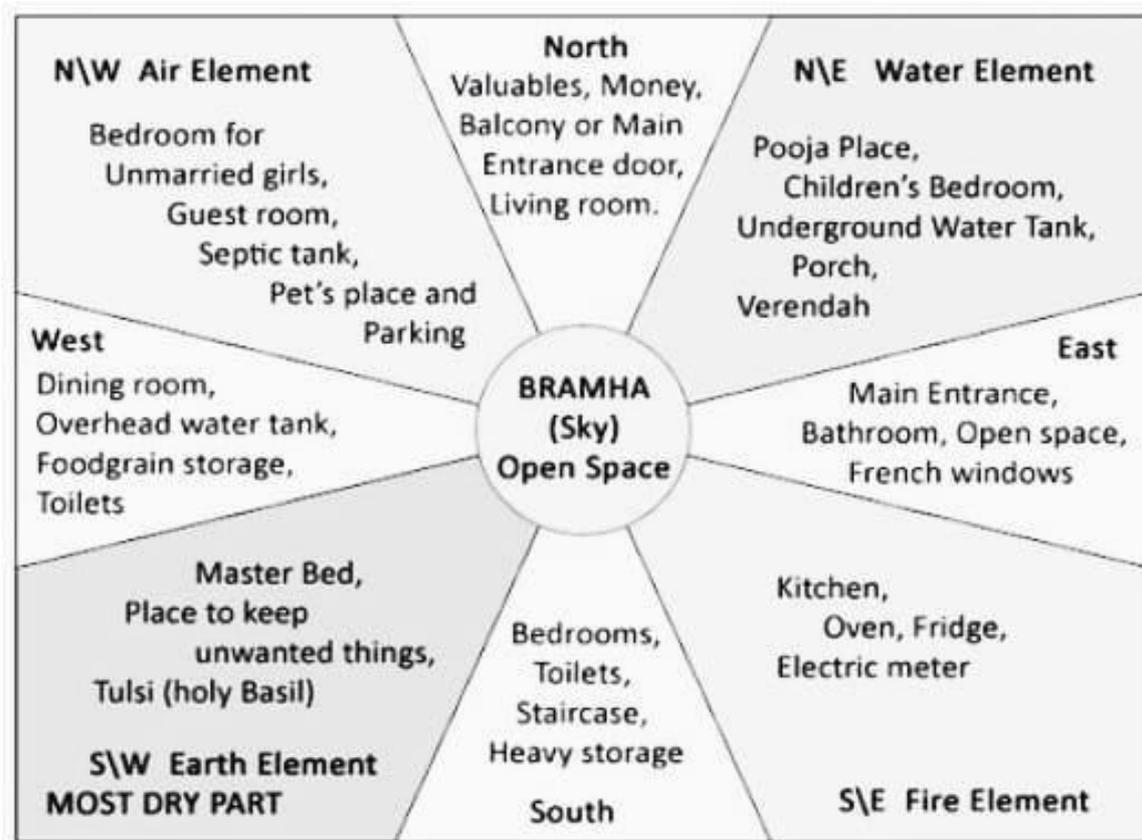
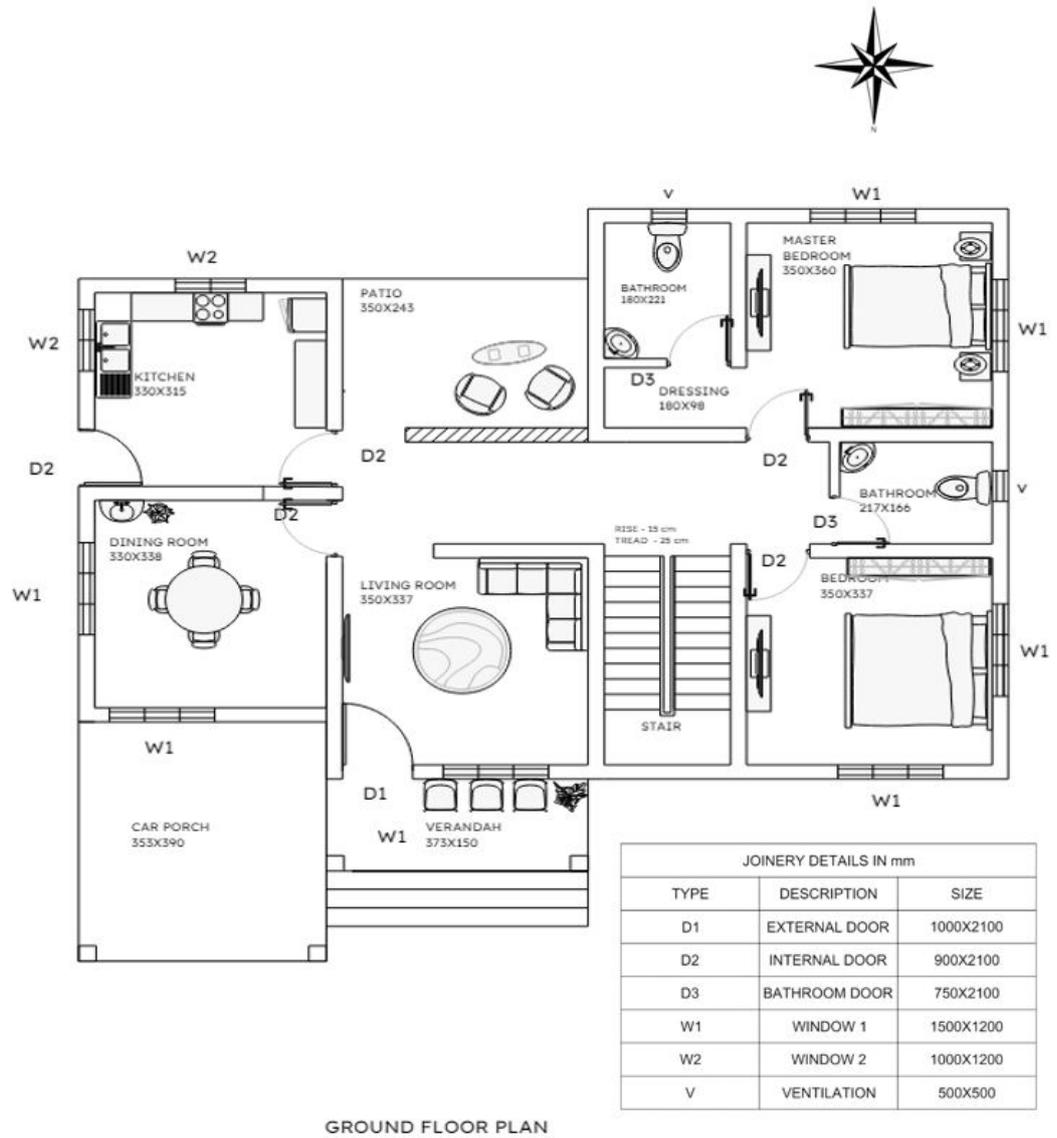
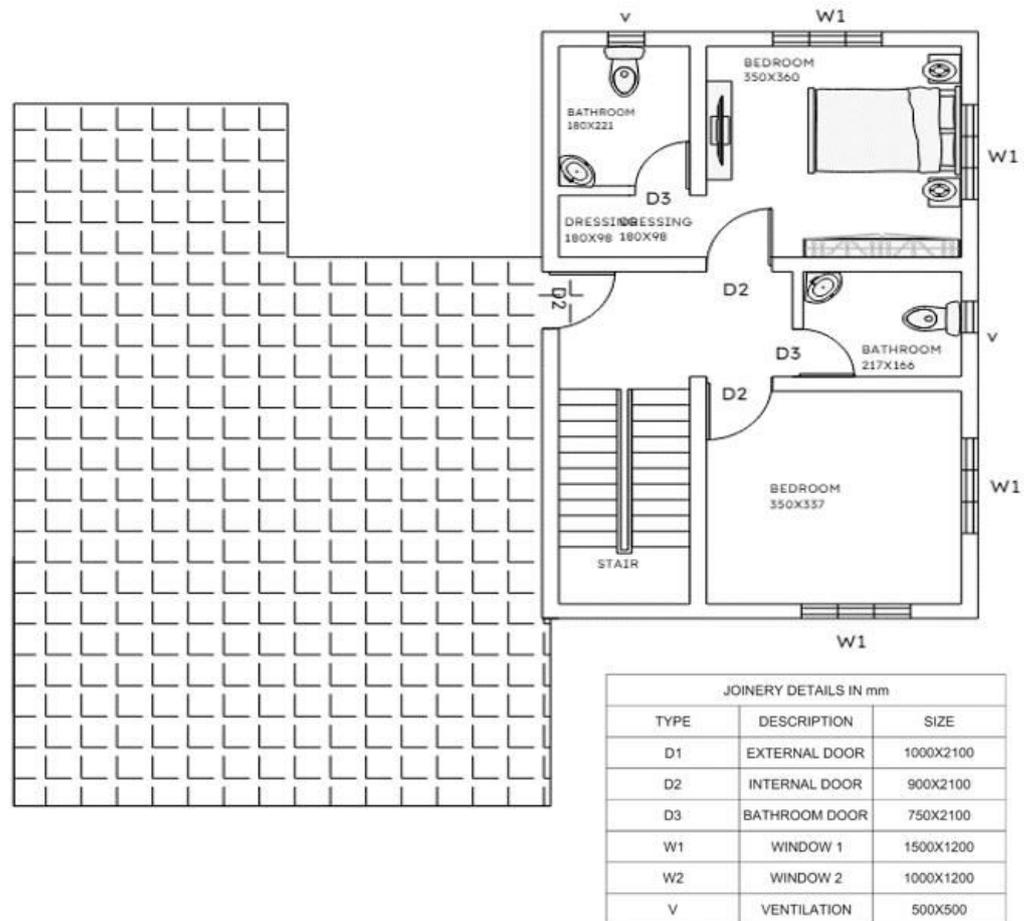


Fig. Brahma Sthana

VIII. STRUCTURE DETAILS

- TOTAL PLINTH AREA OF STRUCTURE = 1915 FT²
- GROUND FLOOR PLINTH AREA = 1316 FT²
- FIRST FLOOR PLINTH AREA = 599 FT²
- TOTAL FLOOR AREA OF STRUCTURE = 1397.2 FT²
- GROUND FLOOR FLOOR AREA = 911.4 FT²
- FIRST FLOOR FLOOR AREA = 485.8 FT²





FIRST FLOOR PLAN

IX. STAAD PRO ANALYSIS

The analysis of beams and columns in these framed structures are done using STAAD PRO V8i SS6.

We have already computed the loads acting on various beams in the structure. These loads are given as uniform force. The wind load is not considered as per IS code the height of the building is less than 10m. Also the seismic load is also not considered as its value gets negligible as when we consider the soil belongs to zone II as per IS Code.

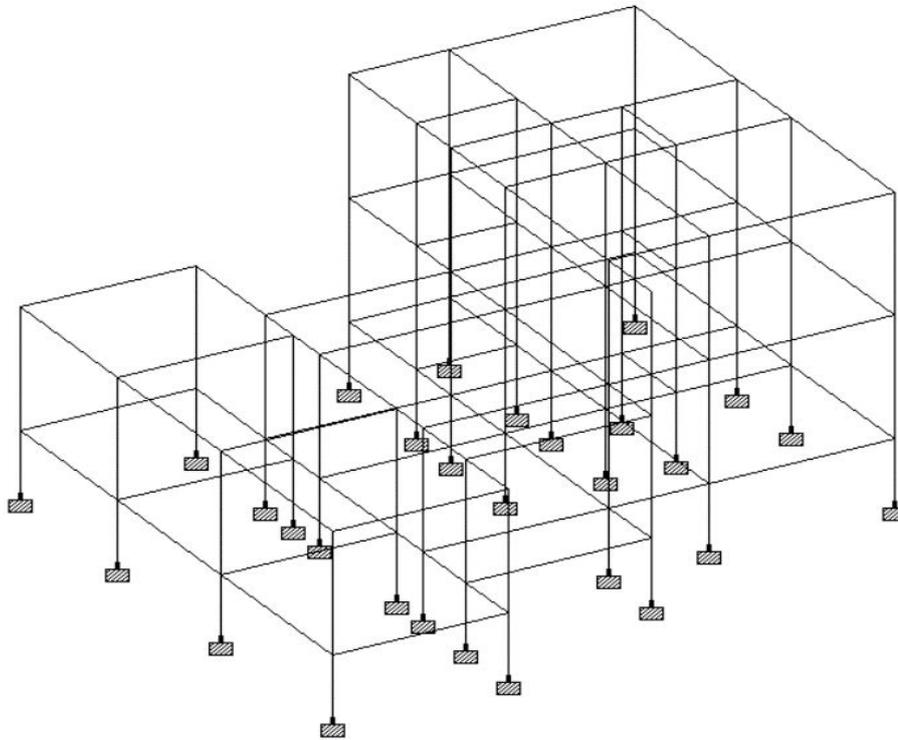


FIG 2 STAAD PRO Arrangement

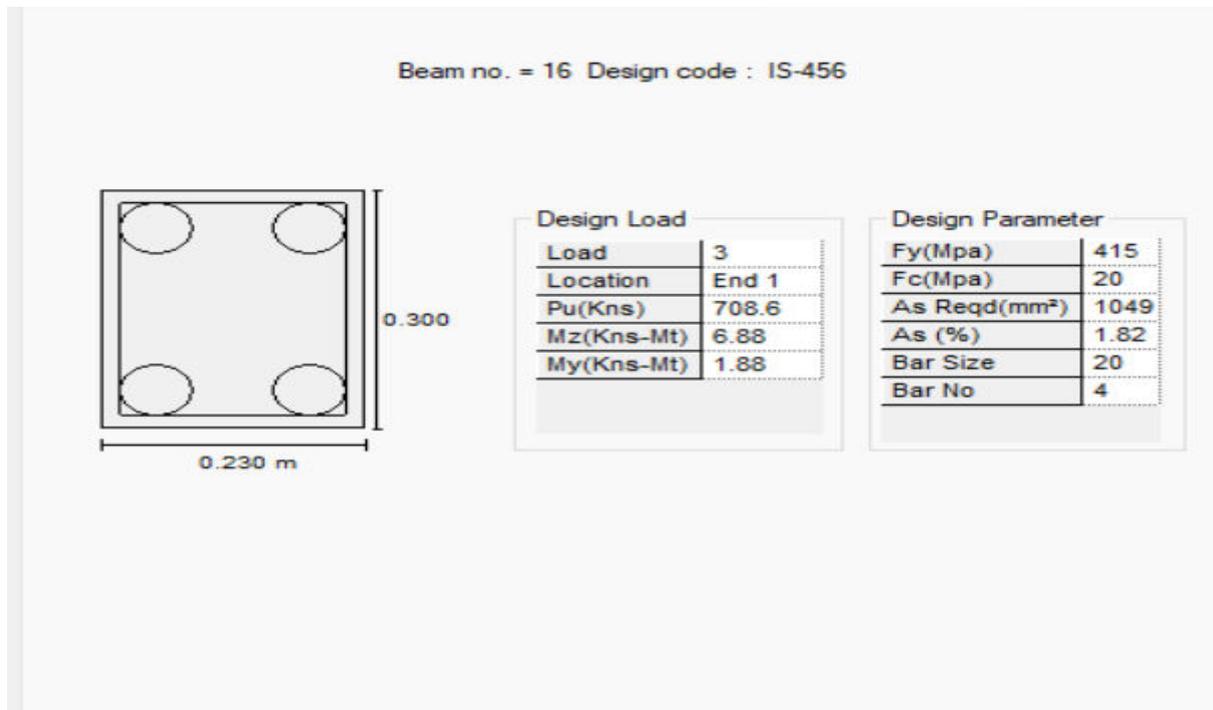


FIG 3 Reinforcement Detail in Column

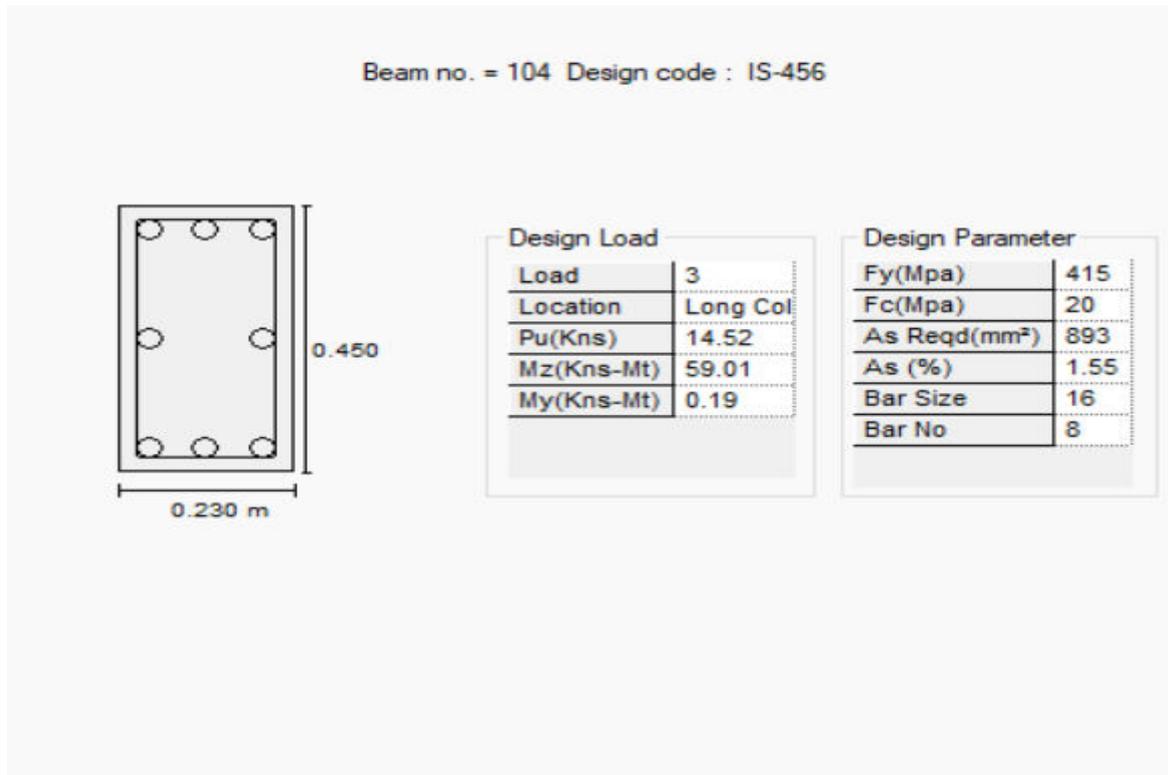


FIG 4 Reinforcement Detail in Beam

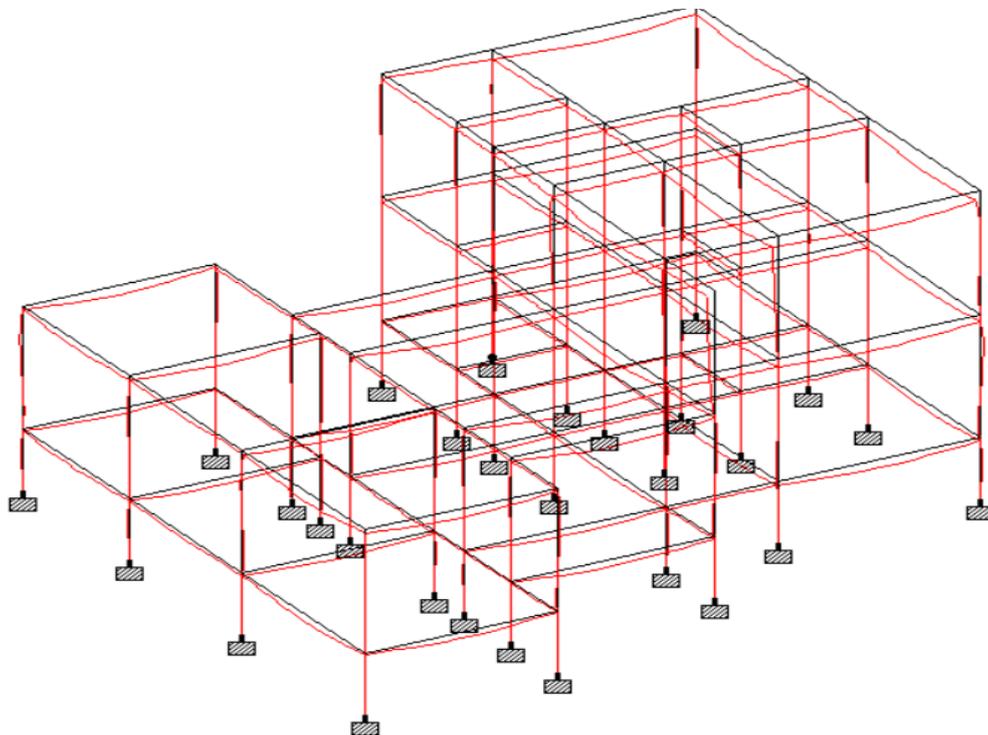


FIG 5 Deflections in Beam



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