THE SCIENTIFIC AND TECHNICAL SCRUTINY OF VASTU PRINCIPLES AND COMPARATIVE ANALYSIS OF PASSIVE SOLAR ARCHITECTURE FOR BETTER ADAPTABILITY IN ARCHITECTURE

Thesis Submitted For the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Architecture

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DECLARATION

I, hereby declared that the presented work in the thesis entitled “The Scientific and Technical Scrutiny Of Vastu Principles And Comparative Analysis Of Passive Solar Architecture For Better Adaptability In Architecture” in fulfilment of degree of **Doctor of Philosophy (Ph.D.)** is outcome of research work carried out by me under the supervision Late Dr. Mahendra Joshi, working as Professor, in the School of Architecture & Design of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigators. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph. D. thesis entitled "The Scientific and Technical Scrutiny of Vastu Principles and Comparative Analysis of Passive Solar Architecture for Better Adaptability In Architecture" submitted in fulfillment of the requirement for the reward of degree of **Doctor of Philosophy (Ph.D.)** in the School of Architecture & Design, is a research work carried out by Ar. Shanta Dash, 41900140, is a bonafide record of her original work carried out under my supervision and that no part of the thesis has been submitted for any other degree, diploma or equivalent course.

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ABSTRACT

Housing is the basic requirement of human beings, as is architecture. There are some parameters which have been followed during the designing and construction of the buildings since the time immemorial. Vastu Shastra is an ancient Hindu science of architecture whereas Passive Solar Architecture is a concept which is used in current times. In ancient times there was a lack of technology, and the Sun was used as a major source of energy. The energy requirements of the buildings in ancient India were fulfilled by the Sun. So the rotation of the Sun was mapped and structures were designed. Hence it can be said that the whole concept of Vastu Shastra is based on the rotation of the Sun.

The combination of growing population growth and increasing technological and industrial advances has resulted in massive increases in consumption of energy. Energy consumption is also rising at a rapid pace in the current times. According to International Energy Outlook IEO it is stated several times that the rising energy use in buildings is a global concern and it also harms the environment. So, there is a need for an approach that uses the energy of the sun and the surrounding climate to provide natural heating and cooling.

Passive Solar Architecture is a modern concept after the technology is introduced. Passive Solar Architecture means using solar energy for meeting the heating and cooling demands of any dwelling unit and reducing its energy consumption. It proves the solution to the problem of the energy crisis in the buildings to a certain extent.

Sun is the primary factor of design for both concepts. It has been observed from extensive literature study that there is almost no study done till date to establish the relationship between Vastu Shastra concepts and Passive Solar Architecture. Hence there is a need to compare both the principles of olden Vastu Shastra with the modern concept of Passive Solar Architecture so that the buildings must be designed efficiently in the current times. Therefore, this research is being carried out to integrate the Vastu Shastra and Passive Solar Architecture in terms of design principles.

The first chapter of this thesis introduces the key Vastu Shastra concepts and major principles that outline the entire ancient architectural science. Further, a brief overview of the Passive Solar Architecture framework has been provided along with a discussion of contemporary energy problems. Due emphasis has been made on the importance of Sun that plays an instrumental role in combining the principles of Vastu Shastra and Passive Solar Architecture for effective building design. After brief introduction of key concepts, problem statement, main objectives of research work, research methodology, research gap and expected outcomes of the proposed work have been outlined.

Within chapter 2, Vastu Shastra principles & designs during ancient and modern times have been studied in detail with proper framework and examples of buildings in both the periods. An extensive study and review of Passive Solar Architecture has been presented, including various strategies, elements, and architectural features. Examples of Passive Solar Architecture strategies in historical and contemporary buildings have been researched and reviewed. The chapter continues by outlining the research gaps in the body of existing literature. This section emphasizes the need for more research and analysis by highlighting topics that have been neglected or overlooked. Based on this literature review some broad conclusions have been drawn.

Chapter 3 consists of Methods and techniques in a form of structured plan that outlines the methodology for conducting a research study. It serves as a blueprint for collecting, analyzing, and interpreting data to answer specific research questions. This research design provides a systematic framework for comparing Vastu Shastra principles & Passive Solar Architecture, aiming to offer valuable insights for optimizing building design and improving environment performance.

Chapter 4 is divided into four parts, i.e. survey, analysis of traditional building, analysis of modern building and case study. To find out the preference for Vastu Shastra for the construction and renovation of residential buildings in Durg, Chhattisgarh, a survey was carried out among 384 respondents using the questionnaire method in part 1. Through the survey it was found that more than 50% of the respondents were positively inclined to incorporate Vastu Shastra principles in the construction and renovation of their house.

In part 2 of chapter 4, a detailed case study of the traditional dwelling unit located at village Dagania, District Durg, Chhattisgarh in a composite climate was carried out. Subsequently thermal performance analysis was performed for Original form of building (OFB) and Second transformation of Original form of building (ST – OFB) to compare the thermal comfort level with respect to structural transformations of the courtyard in the dwelling unit chosen for the study. Furthermore, Day lighting analysis was performed using IES-VE (Integrated environmental solutions – Virtual Environment) to see the effect of day lighting vis-à-vis different stages of courtyard transformation. The results and conclusions of the simulation showed that the courtyard transformation had a positive impact on thermal comfort level and had a negative impact on indoor lighting levels of dwelling units.

For the 3rd part of chapter 4, a modern building i.e. the CSERC Building (Chhattisgarh State Electricity Regulatory Commission) at Raipur, Chhattisgarh, which happens to be the first Passive Solar Building of Chhattisgarh was chosen for the study. A variety of energy-efficient features as well as passive and active solar design elements were objectively observed to determine the overall impact of the building design on energy consumption.

In the 4th part of chapter 4, detailed case studies of 10 traditional dwelling units located in four different villages at Chhattisgarh have been carried out. Various building design features according to Vastu Shastra principles and Passive Solar Architecture have been discussed and enumerated. Further analysis was carried out to assess their thermal environment and comfort levels using a questionnaire method. And based on the responses of the respondents' various conclusions have been drawn.

Chapter 5 of this thesis consists of three distinct sections. In the first section, a comparative study of Vastu Shastra between ancient and modern times was carried out and conclusions were drawn based on that study. In the second part, a comparative analysis was done between Vastu Shastra and Passive Solar Architecture, and broad inferences were drawn based on this analysis. In the third section, a comprehensive survey of applicability of comparative analysis was carried out to determine whether

the common principles of Vastu Shastra and Passive Solar Architecture contribute to the wellbeing of occupants in residential areas of Durg, Chhattisgarh.

In chapter 6, several conclusions have been drawn based on the review of literature, surveys, case studies, and comparative analysis that point out the similarities and overlap between Vastu Shastra and Passive Solar Architecture. For building more sustainable structures and energy efficient buildings, certain recommendations have also been laid out in this chapter.

As part of chapter 7, a design of Apartment has been proposed for the composite climate of Durg, Chhattisgarh based on the recommendations. To determine the viability of the proposed design, day lighting simulation has been done using Revit software.

An attempt has been made to understand and evaluate the scientific principles of Vastu Shastra. Then the suitability of Passive Solar Architecture has been explored for the climate of Durg, Chhattisgarh. The Sun is the common design factor in both concepts, so a brief comparison is made between the fundamental principles of Vastu Shastra and Passive Solar Architecture. Recommendations have been prepared based on the common parameters of both the ancient and modern concept of designing buildings. Based on the proposed recommendations, a residential unit is designed in Durg, Chhattisgarh. Day lighting simulation has been done to find out the viability of the design. The idea behind the study is to reduce the energy use in buildings following both the common parameters of Vastu Shastra and Passive Solar Architecture and hence the objective was achieved.

Keywords: Vastu Shastra, Passive Solar Architecture, Principles of Vastu Shastra, Vastu Purush Mandala, Buildings, Sun, Orientation, Passive Cooling Techniques, Passive Design Strategies, Day Lighting, Thermal performance, Courtyard.

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Dedicated to my grandmother Mrs. Yasoda Dash

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CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

Summary: This chapter serves as a comprehensive introduction to the research work, laying the groundwork for the study and providing essential context. It begins with a clear statement of the research problem, articulating the specific issue or challenge that the study aims to address. This section is crucial as it helps to define the scope of the research and highlights its significance in the broader field.

Following the problem statement, the chapter outlines the objectives of the research. These objectives specify what the study seeks to achieve, providing a roadmap for the research process. They are designed to be measurable and aligned with the identified problem, ensuring that the research is focused and relevant.

The methodology section details the approach and techniques that will be employed to conduct the research. This includes the research design, data collection methods, and analytical strategies, providing a transparent framework for how the research will be carried out. This section is vital for establishing the reliability and validity of the study.

Next, the chapter identifies existing research gaps within the literature. By highlighting areas that have not been adequately addressed, this section justifies the need for the current research and demonstrates its potential contribution to the field. It situates the study within the broader academic discourse, showcasing its relevance.

The expected outcomes of the proposed work are then discussed, outlining the potential implications and contributions of the research findings. This forward-looking perspective helps to convey the significance of the study and its potential impact on practice, policy, or further research.

Finally, the chapter concludes with a brief outline of the research structure. This overview provides readers with a clear understanding of the organization of the subsequent chapters, facilitating a smoother navigation of the entire research document. By encapsulating these elements, this chapter lays a solid foundation for the reader, preparing them for the detailed exploration of the research that follows.

1.1 INTRODUCTION OF THE PROBLEM

Vastu Shastra is a conventional Indian structural system that in a real sense means building science. Vastu comes from a Sanskrit that implies a dwelling place or constructed building. It emphasises on Site's location, the state of soil, the foundation of building, its surroundings, etc. (Shukla, 1993). Vastu Shastra unifies astrology, astronomy, physics, and art; therefore, this system of knowledge may additionally be interpreted as an antiquated science for creating and building man-made structures. Vastu Shastra is instrumental in changing the ways of human lives and protecting us from bad effects of unsound design.

The origins of Vastu Shastra can be dated back to 3000 BC. It finds mention in the ancient Indian scared treatise such as Mahabharata, Rig Veda and Bhagavat Gita (Patra, 2016). Vastu Shastra is primary based on illumination and thermal properties of the Sun. This also considers the earth's electromagnetic field and the biochemical effects on human body, in order to provide a stable and fruitful living for humans.

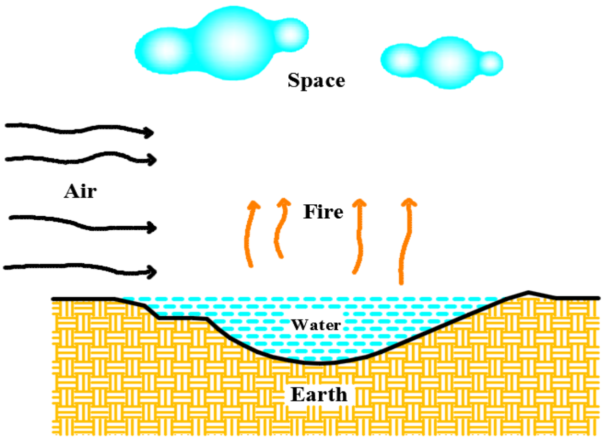


Fig. 1: The Five Elements of Vastu Shastra (Earth, Water, Fire, Air, and Space)

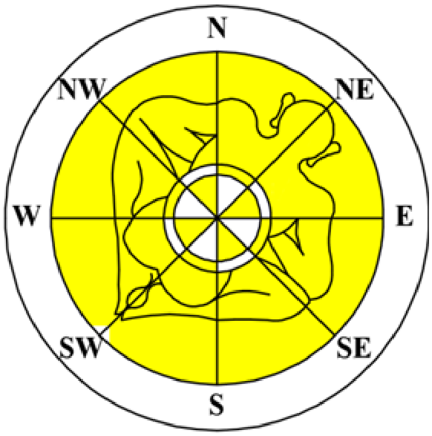


Fig. 2: Cardinal and Ordinal Directions

Vastu Shastra primary puts emphasis on the five fundamentals elements of nature that are Water, Air, Fire, Earth and Space (shown in Fig 1). The whole world around us, as indicated by the customary way of thinking, is made out of these five fundamental components. Moreover, coordinating the previously mentioned five components of nature with the five components of the human body is indispensable. This reconciliation is significant as this fits human connections. The directions found in Vastu Shastra, aside from these five essential elements, make up the majority of this age-old practise. Similarly, Vastu Shastra is referred to as "the art and science of directions" since it integrates the five elements of nature and strikes the proper balance between them and human requirements.

These directions have an instrumental significance in the science of Vastu Shastra. They can categorise into cardinal and ordinal directions as shown in Fig 2. east, west, north, south directions are referred to as cardinal directions and where these two directions meet at 45^o it is known as ordinal directions i.e. northeast, southeast, southwest and northwest. Ordinal directions are also known as inter cardinal directions. Constructing a structure as per Vastu Shastra is very important with proper knowledge of direction. In the olden days people used to see the shadow of the sun for checking the directions. Magnetic compass is used to check the directions in Modern times. Compass with its radius has 360^o in total. Each direction is allotted with 45^o. Having accuracy in terms of degrees is vital to ascertain every orientation.

The five fundamental canons of ancient science i.e., Vastu Shastra are the principles of orientation (Diknirnaya), site planning (Vastu Purush Mandala), the proportionate measurement of building (Maana), the six canons of Vedic architecture, and the artistic form of the building (Chanda) (Patra, 2009). While designing and constructing any building structure these five core canons should be followed to ensure good proportions, aesthetics, comfort and right orientation of any building. In simple words, Site orientation implies the accurate location of the house in relation to the cardinal and ordinal directions. In a site plan or layout, the side of the site which is oriented towards the main road shows its true orientation. Vastu Purusha Mandala means a plan consisting of squares with an imaginary Purusha. Purusha refers to cosmic man or soul and Mandal relates to chart or plan which represents cosmos. This metaphysical plan contains Vastu Purusha head in northeast direction and feet towards southwest direction. It has 81 squares (9X9) and it is believed that each square contains the position of different 45 Gods. In the external enclosure 32 Gods are placed whereas 13 Gods are placed internally with Vastu Purusha. According to the nature of God placed in that area, the rooms are designed for that site or house to ensure a perfectly balanced environment of the house that in turn results in good health, wealth and prosperity for the occupants of the constructed building. The third Vastu principle i.e. Maana

Proportions postulates aesthetically appealing proportions of the building by maintaining correct height to width ratio. It also means designing the buildings with the right proportions. The specific set of six formulas is known as Aayadi to work out the right dimensions of buildings in terms of length, breadth and height. The artistic form of the building –Chanda describes the different forms or elevation of the building. Chanda means beauty and refers to the aesthetic aspect of the buildings. Sometimes it also relates to the identification of buildings in ancient times. Thus, the implementation of Vastu fundamental Principles has brought happiness, peace and prosperity to many households and buildings since centuries (Patra, 2016).

The most important parameter of the science of Vastu Shastra is influence of Sun that must be carefully considered while designing and constructing a building. **The design of the house must consider the Sun's changing intensity from morning to evening, throughout the day, and throughout the seasons, so that the occupants can take advantage of the beneficial sunrays while carrying out their daily pursuits as indicated in fig 3**. As dwellers of that particular house carry out multifarious household activities at different times of the day in various rooms of the house and the influence of the Sun on the house keeps on changing. So, the main objective of the art of Vastu Shastra is to design the rooms according to aspect of the Sun in order to illuminate occupants of the habitat with beneficial sunlight even if inhabitants are within the habitat throughout the day.

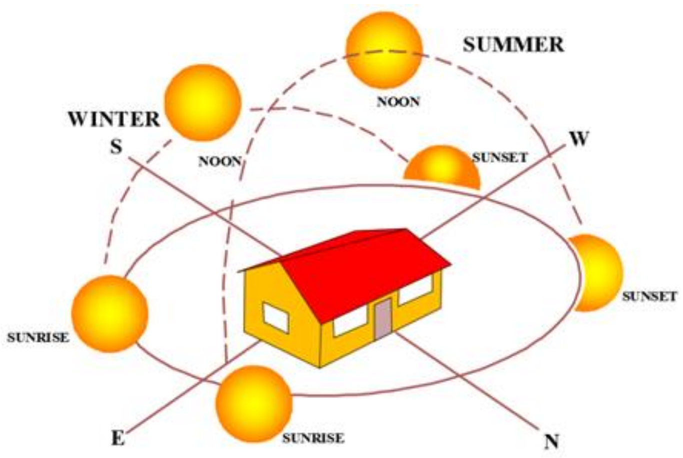


Fig. 3: Movement of Sun in Winter & Summer Season During a Day.

The term ‘Passive Solar Architecture’ describes the utilisation of thermal properties of Sunlight to meet building’s heating and cooling needs and also lowering its overall energy consumption. It excludes the use of mechanical or electrical equipment. Building’s site, climate, and materials are thought about to limit energy usage. Window placement and its size, type of glass, thermal insulation, thermal mass, and shading are the factors to be considered while designing. Passive Solar Architecture has two parts, i.e., passive solar cooling and passive solar heating. Based on the cooling or heating requirements of occupants, these techniques are used. Energy-efficiency strategies are deployed to lower the overall cooling and heating cooling energy needs of the house by utilising free solar energy.

For everything and everybody on the Earth, solar energy is a mighty source of energy, and sunlight is unquestionably the most important energy carrier that the world receives. Out of the total solar energy that falls on the surface of earth, about 50% falls under visible light spectrum, around 45% consists of infrared radiation, and the rest consists of ultraviolet rays and electromagnetic radiation. Hence, the solar energy from the sun can be utilised to produce heat, generate electricity, cause chemical reactions, etc. If adequately harnessed, this highly diffused source holds the ability to meet all energy related needs in the future.

The principles of Passive Solar Architecture are according to the movement of the sun during various seasons. Due to the geographical tilt of 23.5^{o} from the Earth axis, the Sun usually traces a lower path in winter than summer in the northern hemisphere. At the time of Winter Solstice, the Sun is at its zenith in the southern Hemisphere. Under the purview of the Passive Solar Architecture, the rooms of the house are meticulously designed to optimize utilisation of solar energy. A standard design orientation for residential buildings requires that the living areas are oriented facing solar noon and sleeping quarters are oriented towards the sunset. The factors that influence the performance of passive solar structures are climatic conditions, passive solar dwelling designs, and building size. As per studies, the energy consumption of passive buildings is 70% less than conventional buildings.

The internal temperature of the human body is 37° Celsius. We feel cold when our body temperature drops and hot when it increases. In a variety of ways, we maintain our body temperature at a safe level. The comfort level of a building is the temperature inside where we feel comfortable. So, to achieve comfortable conditions inside the buildings, passive solar designs are used based on climatic conditions of a particular area.

The combination of growing population growth and increasing technological and industrial advances has resulted in massive increases in consumption of energy. The high consumption of energy is a source of concern, and it also harms the environment. EIA's IEO 2017 (International Energy Outlook 2017) states that there will be the highest growth in energy use of buildings in India by 2040 as compared among all regions in the world. So, there is a need for an approach that uses the energy of the sun and the surrounding climate to provide natural heating and cooling. The Sun is giving away much more energy each day than we use to fuel anything on Earth. As energy prices rise, and the realities of global climate change become evident, widespread interest in passive solar design is rising.

Sun is the primary factor of design for both concepts, so a brief comparison is made between the core principles of Vastu Shastra and Passive Solar Architecture.

1.2 TITLE OF THE PROPOSED WORK

THE SCIENTIFIC & TECHNICAL SCRUTINY OF VASTU PRINCIPLES AND COMPARATIVE ANALYSIS OF PASSIVE SOLAR ARCHITECTURE FOR BETTER ADAPTABILITY IN ARCHITECTURE

1.3 STATEMENT OF THE RESEARCH PROBLEM

Vastu Shastra as an architectural design science was envisaged thousands of years back by learned scholars that postulated general principles for temple and construction of building. For centuries, using these principles various building structures have been constructed such as palaces, forts and temples. Vastu Shastra has remained an integral part of architecture system in India that relies on several important site aspects such as orientation, cardinal directions, location, main road, topography, adjoining built-up area, natural factors, movement of the Sun, and magnetic field of the Earth. In contrast, Passive Solar Architecture uses the Sun's energy to provide ambient heating and cooling for a dwelling unit while reducing its energy consumption. The buildings in the modern times consume much energy when compared with the structures of ancient India. Hence for an optimum architecture design there is a need to compare and integrate both the ancient principles of Vastu Shastra and the modern precepts of Passive Solar Architecture. In this research, first the principles of Vastu Shastra are scientifically evaluated and then a comparison is then made between schemes of Vastu Shastra and Passive Solar Architecture. And further, based on a comparison of both principles, conclusions are derived about the scientific framework behind a rational building design.

1.4 OBJECTIVES OF THE PROPOSED WORK

1. To evaluate the reality of key concepts of Vastu Shastra and its authenticity in application of residential buildings in the present times.

2. To explore the suitability of Passive Solar Architecture for the Climate of Durg, Chhattisgarh.

3. To propose recommendations in design by incorporating the similar concepts of Vastu Shastra and Passive Solar Architecture and applying these findings to residential units for improved performance.

1.5 WORK PLAN AND METHODOLOGY

1. Studying, understanding and evaluating the general principles of science of Vastu Shastra along with main principles of Passive Solar Architecture for residential dwelling units from various sources like ancient texts like manasar, research papers, journals, online texts etc. and documenting them.

2. Compiling and analysing the texts related to Vastu Shastra principles and Passive Solar Architecture.

3. Comparing both the principles of Vastu Shastra and Passive Solar Architecture considering Sun as the common component between them, for the climate of Durg, Chhattisgarh.

4. The result will be in the form of recommendations to be followed while designing residential buildings and preparation of Layout plans, sections, elevation & views considering specific plot areas and orientation preferably north or east for the climate of Durg, Chhattisgarh.

5. Day lighting analysis using simulation has been carried out for the validation of proposed design.

1.6 RESEARCH GAPS IDENTIFIED IN THE FIELD

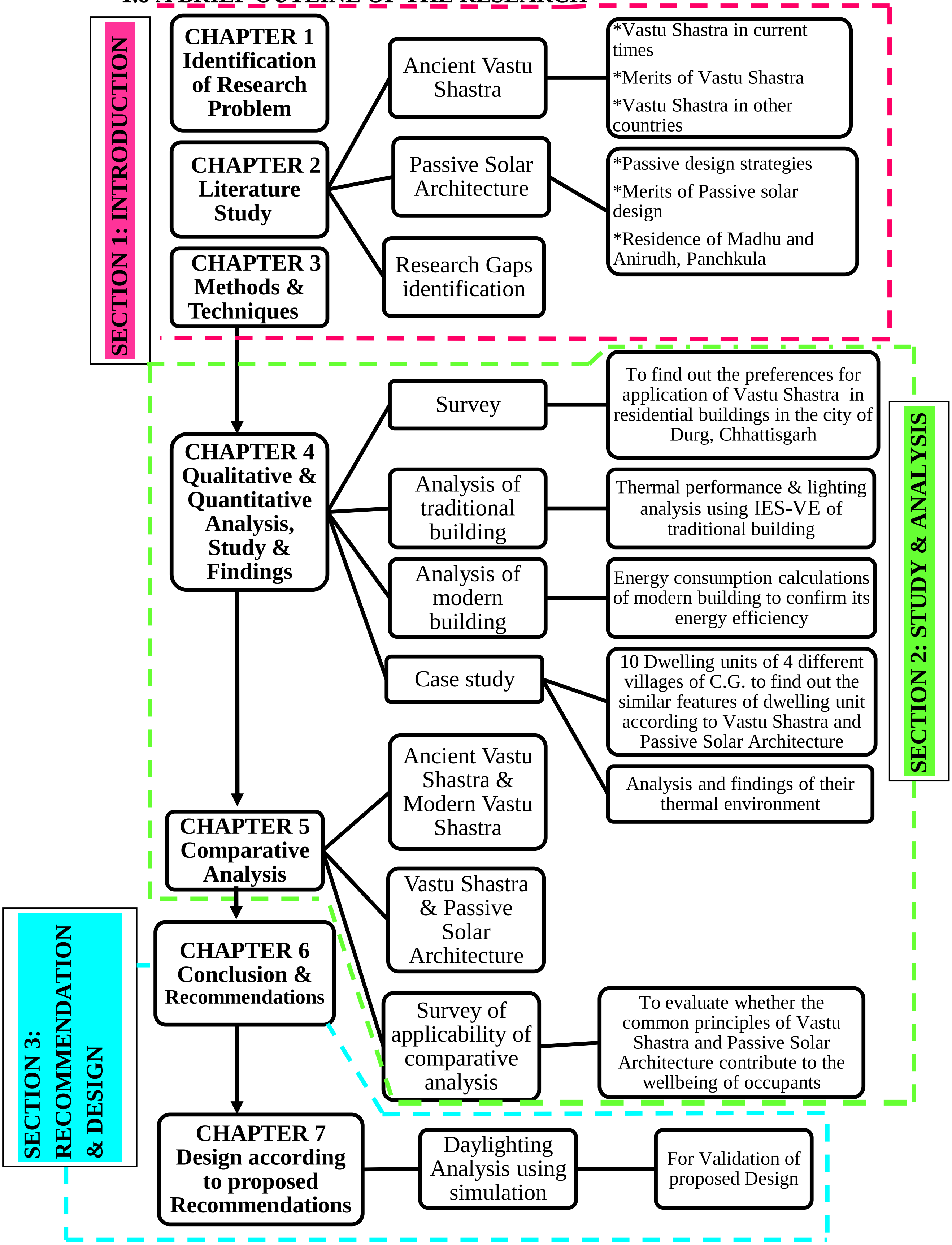
After extensive literature review as detailed in Chapter 2, it has been observed that there is almost no study done till date to establish the relationship between Vastu Shastra concepts and Passive Solar Architecture and therefore this research is being carried out to integrate Vastu Shastra and Passive Solar Architecture in terms of design principles.

1.7 EXPECTED OUTCOME OF THE PROPOSED WORK

1. Preparation of recommendations to be followed while designing residential buildings based on the research done on different concepts of Vastu Shastra and fundamentals of Passive Solar Architecture for the climate of Durg, Chhattisgarh region.

2. Preparation of layout plans, sections, elevation & views considering specific plot areas and orientation preferably north or east and incorporating all proposed recommendations in any live site in Durg, Chhattisgarh.

1.8 A BRIEF OUTLINE OF THE RESEARCH



CHAPTER 2

LITERATURE STUDY

CHAPTER 2: LITERATURE STUDY

Summary: This chapter provides a thorough literature review on the topic, systematically examining the existing body of knowledge related to Vastu Shastra and its contemporary implications. The study contains both a compilation as well as a critical examination of documents. This is a narrative presentation or reformulation of existing information on a topic derived from various sources. This consists of technical writing and data from previous scientific papers, journals, articles, books, reports and other thesis on the same subject. The chapter is organized into four distinct sections, each focusing on a specific aspect of the literature.

The **first section** delves into a detailed study of **ancient Vastu Shastra**. This part explores the historical origins, principles, and architectural guidelines established in ancient texts. It highlights how Vastu Shastra was developed as a holistic approach to design and spatial arrangement, emphasizing harmony with nature and the cosmic elements. By examining key texts and interpretations, this section sheds light on the philosophical underpinnings and cultural significance of Vastu, providing a foundational understanding of its practices.

The **second part** of the chapter investigates the **application of Vastu Shastra in current times**. It reviews contemporary interpretations and adaptations of ancient principles in modern architecture and urban planning. This section discusses how Vastu has been integrated into current architectural practices, addressing its popularity in residential design.

The **third section** focuses on **Passive Solar Architecture**, examining its principles and how they intersect with Vastu Shastra. This part discusses the significance of using natural resources for cooling and lighting in building design, emphasizing energy efficiency and sustainability. It explores case studies that demonstrate successful integrations of passive solar techniques with Vastu principles, highlighting the potential for synergy between these two approaches to create environmentally responsive and culturally sensitive architectural solutions.

Finally, the chapter identifies the **research gaps** that exist within the current literature. By pinpointing areas that have been under explored or overlooked, this section underscores the need for further investigation and analysis. It articulates the potential contributions that the proposed research could make to the academic community and practical applications in architecture, suggesting pathways for future study.

Overall, this chapter not only provides a comprehensive review of the existing literature but also establishes a critical context for the research by highlighting its relevance and the potential for innovative integration of ancient wisdom with modern architectural practices.

2.1 INTRODUCTION TO ANCIENT VASTU SHASTRA

Dagens (1985) defines "Vastu as anywhere where immortals or mortals live".

Shukla (1993) defines Vaastu Shastra as the "Science of Canons or principles related to site planning, its layout, building planning and architectural planning (shilpa) of ancient India".

According to Harlapur (1999) Vastu is derived from the word 'Vasati' which means 'Gruha' or a place of dwelling. It is basically a science of structures. In Sanskrit, Vastu means "To Dwell". An admixture of science art, astronomy and astrology, the system concerns itself to influence human kind to the sun, moon, light and force.

2.1.1 Origin and Concept of Vastu Shastra

According to Tiwari (1996) "Vastu Shastra, superficially means the science of building. If taken in a deeper sense, it creates unformidable layers of relationship between man, nature and the cosmos".

Babu (2003), states that the first and foremost link by which the vastu shastra came into this world is through 'Yajur veda'. It contains information on the design of houses, temples and buildings. It is a Science which dates to the ancient times. In ancient times Maya and Vishawakarma were the two Chief Architects known for their intelligent creations of Palace, Temples, Forts etc. Vishawakarma is mainly credited to have brought this knowledge from the cosmic mind. The eighteen sages namely, Bhrigu, Atri, Vasista, Vishwakarma, Narada, Nagnajeeth, Maya, Vishalaksha, Purandara, Brahma, Kumaraswamy, Nandesh, Shastra Bharage, Vasudeva, Aniruda, Shukra, Brahaspathi acted as divine link in the transfer of architectural and Vastu Shastra principles to the modem ages through the scripts.

Tarkhedkar (1999), states that Vastu Shastra refers to the field of vedic architecture. Vastu dates to the Pre-Ramayana and the Mahabharatha periods. The epics contain descriptions of cities with multistoreyed buildings with spacious balconies and porticos. It is said that the site plan of Ayodhya City was like the plan found in the great architectural text manasara. In the Mahabharata, mention is made of several houses that were built for the Kings, who were invited to Indraprastha for Rajusurya Yagna of King Yudhishtra. Sage Vyma says that those houses were as high as the peaks of Kailasa Mountains, perhaps, meaning that they stood tall and majestic. The houses were free from obstruction, had compounds with high walls, their doors were of uniform height and in lay with numerous metal ornaments.

References are also found in Buddhist Literature of buildings constructed based on Vastu. The Jatakas contain detached references to individual buildings. Lord Buddha is said to have delivered discourses on architecture and even told his disciples that supervising the construction of a building was one of the duties of the order.

Babu (2003), states that mention is made of (Viharas) or temples, buildings which are partly residential and partly religious (Ardhyayogas), residential storeyed building (Prasadas), multi-storeyed buildings (harmyas) and Guhas or residential buildings for middle class people.

A treatise known as Chullavagga with a commentary of Buddhaghosa is said to contain much material on the science of architecture.

Many puranas such as Skanda, Agni, Matsya, Oaruda, Narada, Vayu, Brahmananda and Linga deal with Vastu extensively.

Brihat Samhita is an excellent work on various aspects of natural phenomenon like weather forecasting, earthquake forecasting, transits of planets, rainfall, architecture, comets etc. This magnumopus is authored by the celebrated Varaharnihira who an astronomer-mathematician scientist of India was living in the sixth Century A.D. Certain chapters of Brihat Samhita exclusively deal with residential and temple architecture.

Manasara represents the universality of Vastu tradition and contains also the iconography of Jain and Buddhist images. The work in universally accepted all over India.

Manasara uses the term Manasara in three distinct ways, namely, the author of an unknown time and parentage, a class of sages or rishis who deal with the essence of measurement or mana-sara and lastly a treatise containing methods and rules of architectural and sculptural construction. Prof. P. K. Acharya who has exhaustively and painstakingly translated this classic work into English attempts to date Manasara to a few centuries earlier to the Christian era.

Samarangana Sutradhara is a remarkable legacy of King Bhoja. His rule was noted for splendour and grandeur. This great work not only deals with house architecture, town planning and temple architecture but also deals with the canons of painting and mechanical devices known as Yantras.

Mayamata of Maya, the work deals extensively and exhaustively with the subject of architecure with reference to dwelling sites, examination with reference to dwelling sites, examination of the soil, systems of measurement and orientation, villages and towns, the building of temples etc. It discusses the importance of doors, gateways and pavilions besides vehicles, beds and seats.

Mayamata has quite a few references to the postion of a well. Invariably these slokas recommend the placement of wells either in the north, northeast or east of the plot.

Mayamata occupies a very important place amongst the various treatises on Vastu. It is said to have originated from south India. It is best known among the ancient treatises dealing with architecture and iconography. Maya, the author, was not only an expert in Vastu but also in Jyothisha. The famous astronomical Surya Siddhanta is also authored by Maya.

Ancient Vastu Shastra principles include those for the design of Hindu Temple, Palaces and the principles for the design and layout of houses, towns, cities, gardens, roads, water works, shops and other public areas. Vastu shastra originated around 3000 BC. Most of the textual evidence is found in Rig Veda, Sama Veda, Yajur Veda, & Atharva Veda, Ramayana and Mahabharat, City of Indraprastra, Ayodhaya, Harappa and Mohenjo-daro (Dagens, 2010).

2.1.2 Origin and Concept of Vastu Purusha

Brihat Samita states that the concept of Vastu Purusha dates back to the Puranas when the battle between the Gods and demons were going on and a Rakshasa was born, who became very powerful and began to harass the Gods. The Gods then joined forces, pushed him into the underworld (Pathala) and sat on him, the Rakshasha then worshipped Lord Brahma, who was pleased with him and granted a boon, named him Vastu Purusha and ordained that any project on earth would be proper only if Vastu Purusha was appeased with prayers.

Reddy (1993), states that all that is represented on the earth is Vastu and spirit of energy of the earth is called Vastu Purusha. Vastu Purusha represents the five components of human beings namely five senses like touch, taste, smell, vision and hearing. Hence the five elements like earth, water, air, fire and sky have direct bearing on human constitution. Earth is related to site, water is related to existing water bodies, fire is related to fire element and open space to the sky element. The human body gets the energy from these five elements. Thus, the house or dwelling place must be in harmony with these elements to tap the positive energy.

2.1.3 Vastu Purusha Mandala

According to Rao (1996) Vastu means a surrounding, environment, matter or nature. Purusha means, energy, work power, vigour or soul. Mandala means, the astrological chart, which relates to the layout to orientation (Fig 4).

The Vastu Vidhana of Narada says that Vastu Purusha mandala is the magic diagram (Yantra) and the form (Roopa) of the Vastu Purusha. It is body (sharira) and its body device (Sharira Yantra) by which those, who have requisite knowledge attained the best result in the temple building.

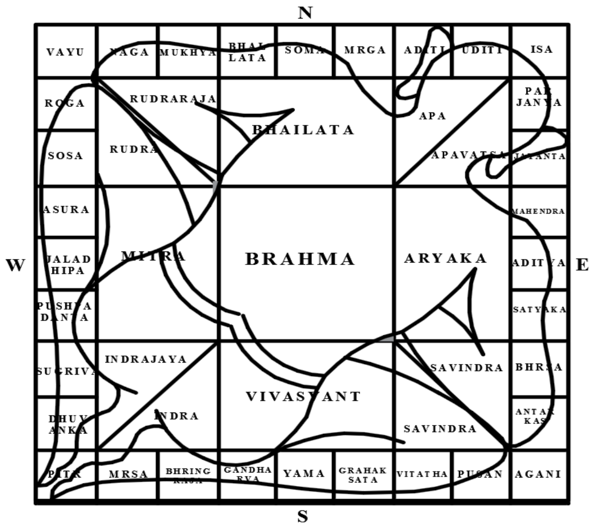


Fig. 4: Vastu Purush Mandala (Source: Patra, 2016)

While the mandrika mandala consisting of 64 square grids is the cosmic building, the paramasayika consisting of 81 square grid is the fully evolved form of the said geometric design.

Based on this view, Mandrika Mandala is called Nikshkalapada and the Paramasayika Mandala is called Sakalapada. All those mandalas with even number of rows are grouped under Nikshkalapada and those with odd number of rows are grouped under Sakalapada. So basically, there are only two Vastu Mandalas: Manduka and Paramasayi.

According to Kumar (2002), the principles of orientation of a building are intimately related to Vastu Purusha Mandala – the metaphysical plan of Vedic building, a temple or a site plan of a house. The Vastu Purusha, one with Mandala of 64 squares and legs in the southwest, right hand in the northwest, left hand in the southeast, and other parts of the body fill the square, forty five gods or deities are constituents of the body of Vastu Purusha. The Lord of Central Square is always the Lord of Cosmos, Brahma and the presiding deity of the whole site is called Vastu Purusha. The North is attributed to the Lord of Wealth (Kubera), south to the Lord of Death (Yama), the east to the Lord of Light (Sun), and the west to the Lord of Wind (Varuna). The Mandala generally fragmented into small cells numbering 49, 64, 81, 100 and 169 represent each cell for different applications.

2.1.4 Five Basic Elements of Vastu Shastra (Panchabhutas)

Pandarinath (1997) states, that the fivc basic elements i.e., panchabhutas are: jala (water), agni (fire), earth, wind, and the sky. Northeast is the Jalasthana or the place of water, if a well or an underground water storage facility (sump) is built here. The Southeast is the Agnisthana or the place of fire, hence the kitchen should be constructed here, and the fire should be lit facing the east, as fire should always be facing the east even while cooking, performing a yagna or while lighting the lamp for God. As the Southwest is the hardest part it can be compared to the earth. Northwest is Vayusthana or the place of the wind. Hence a door, window or ventilator is to be constructed in the west and northwest. The sky corresponds to the middle of the building and is the brahmasthana. It is very good if this place is built open to the sky.

2.1.5 Five Basic Principles of Vastu Shastra

The goal of Vastu Shastra is to restore the balance between buildings and universe so as to make the life of inmates better. For this, Vastu lays down some principles which are set, rigid rules and were originally meant for only temples and palaces. However, these principles were used for houses as well. Vastu principles are applicable even today, though ancient India has changed from a largely agriculture society to birth of many urban cities today (Patra, 2009). Few of the principles are discussed below:

- **Determination of Orientation (Diknirnaya):** Site orientation refers to the location or position of the site with respect to the cardinal directions. In earlier times, a procedure called Shankustaapana was followed. For the ancient Indians, Orientation played a very important role in their daily lives because the environmental factors that affect man and his buildings, like the Sun, the Earth's magnetic field and the direction of monsoon wind, were always taken reference to the cardinal direction i.e. the Sun rises in the east and sets in west, and there is constant light from north for countries in the northern hemisphere during Uttraraayana (Jan 14 – July 15) and vice versa during Dakshinaayana (July 16 – Jan 14) in the southern hemisphere. Similarly, the Earth is a huge magnet with a magnetic north pole close to the actual northpole and a magnetic south pole near the actual South Pole. Vastu Shastra considers these factors and orientation so that man can benefit from the positive and useful effects of these factors and is protected from harmful and negative factors.

According to Manasara (Ch.6 V87 – 88), Samaranganasutradhara (Ch.15) and Manushyalaya Chandrika (Ch. 3 V23) East as the most auspicious direction for the orientation of the building to perpetually receive benefic results. It is to be noted that all the texts strictly insist on the orientation of the buildings towards Cardinal directions only. Considering other three cardinal directions west seem to be the least preferred direction for orientation of the building.

At the Town Planning level, the allotment of residential plots to the respective Four Varnas is based on a social hierarchical order established in ancient time. According to the hierarchical order of Varnas Brahmins, Kashatrya, Vaisya and Sutra are assigned to east, south, north and west directions respectively (Mayamatham, Ch. 27 V40-54).

- **Site Planning (Vastu Purusha Mandala):** Vastu means surrounding, purush means energy and mandal means the astrological chart which relates to the arrangement as per direction. The Sun, the five fundamental elements (panchabhutaas), the magnetic field on Earth, the electromagnetism on Earth, and the eight directions are governed to create an environment advantageous to man. According to the Vastu Purush Mandala the different rooms are placed in such a way that proper orientation to the Sun, ventilation and lighting and privacy is ensured inside the building. To ensure that the habitants are regularly exposed to sunshine constantly, each room should be situated in such a way that it faces the Sun when it is most likely to be used during the day. For examination & selection of site - Shape of Site is important in current times. According to Vastu Shastra, the Site shape affects the wellbeing of the inmates. Some shapes have good effects while others have bad effects. Contour of land, Colour of soil, Odour of soil, Touch of soil, Taste of soil were also considered in the ancient times (Patra, 2009).

- **Proportion of the Building (Maana):** Proportion is a guide for designing and planning buildings with right proportions. It prescribes the perfect ratio of width to height to create a perfectly proportionate structure. Each ratio indicates a certain aspect of beauty and proportion (Chakrabarti, 1998). The structure is considered to be aesthetically proportionate if the ratio is 1. The structure is considered to have good stability if the ratio is 1.25. If the ratio is 1.5, then the structure is considered to have a pleasant appearance. The structure is good in every way and will appear to be both strong and beautiful, if the ratio is 1.75. The structure is gorgeous if the ratio is 2.
- **Building Measurement or Dimensions of the Building (Aayadi Shadvarga)**: Dimensions is a guide for designing and planning buildings with the correct dimensions. Aayadi constitutes six formulae Aaya, Vyaya, Yoni, Raksha, Vara and Tithi. The remainder obtained by using these formulae determines whether it is gain or loss. If it is a gain, then the structure is proportionate and stable, and the dimensions are right. Howeverif it is a loss, then it means the dimensions are not right and should be suitably corrected. So, this formula is a good guide to decide the correct proportions of the building.
    - Yoni is the reminder of Breadth X 3 divided by 8
    - Vyaya is the reminder of Breadth X 9 divided by 10
    - Aaya is the reminder of Length X 8 divided by 12
    - Raksha is the reminder of Length X 8 divided by 27
    - Vara is the reminder of Height X 9 divided by 7
    - Tithi is the reminder of Height X 9 divided by 30

    One can use Aayadi formulae to check whether the Length, Breadth and Height of the proposed building are in proportion. Accordingly, the dimensions of Length, Breadth and Height can be corrected (Shukla, 1993).
- **The Aesthetics of Building (Chanda):** It describes the different forms or elevations that building can have. A well-designed building not only serves its intended function but also enhances the environment around it. It also has a positive impact on the well-being of its inhabitants. Buildings that are designed with aesthetics in mind are more likely to attract people and create a sense of community (Patra, 2016).

These principles are a guide for designing and planning proportionate, aesthetically beautiful buildings.

In the past, it was believed that the traditional Indian Vastu had a significant meaning in the Indian setting, which was totally based on scientific principles and contained logical positivism, which is sometimes misunderstood by the public. The meaning of following and applying Vastu principles is somewhat propagated as religious or spiritual repercussions and benefits, so that individuals may be unable to violate the regulations and be compelled to make genuine decisions regarding the design of their home. Historically, formal architecture services were not available to the public; priests and astrologers were frequently the ones who preached the concepts of Vastu and helped individuals construct their residence layout. However, in the present environment, where formal architecture services are easily available in urban areas with factual knowledge, people still desire that Vastu principles be included in contemporary architecture (Rastogi & Kaushal, 2023).

The old Indian Vastu system was primarily intended to balance the energy of the residence's entire ecosystem with climate responsive architecture in order to provide the greatest possible passive thermal comfort (Pandey, 2020).

The concept of housing in ancient India is very wide and it is divided into four categories namely:

a) **The Earth / Site:** Bhoomi, the principal dwelling place on which everything else rests.
b) **Building:** the structure built on the earth, Prasada
c) **Conveyances** (Movable Objects): Yaana
d) **Furniture:** Sayana

The dwelling site must be chosen after the examination of the colour, odour, flavour, form orientation, sound and tactility. The dwelling site was different for each caste. It is of two types – first the principal site i.e. the earth and secondary site i.e. the village and like halls, houses, light buildings, pavilions with canopies and palaces are called buildings. Conveyances are litters, palanquins, carriages, war chariots and anika. Seats are thrones, divans, chairs, aviaries, benches, beds and cradles (Dagens, 2010).

Vastu Shastra in Vedic times focuses on:

a) **Dwelling unit**
b) **Temples**
c) **Palaces**

Table 1: Types of Structures Built in Ancient India

Dwelling unit	**Temples**	**Palaces**
Site	Temples with one and more storeys	Pavilions and halls
Examination of site	Base	Doors
Taking possession of site	Dimension of pillars and choice of materials	Vehicles
System of measurements	Entablature	Beds and seats
Orientations	Joinery	Iconography
Diagrams	Upper level of elevation and the consecration ceremony	
Offerings	Enclosures and attendants' shrines	
Village and other settlements: towns	Gateways	
The number of stories and dimensions	Doors	
The foundations deposit, socle	The linga	
Features of houses with four classes	Pedestals	
Doors		
Renovation works		

(Dagens, 2010)

2.1.6 The Site

The Site suitable for Brahmins is square, white, without defects, planted with udumbara trees, sloping towards the north, perfect and has an astrigent and sweet flavour. Such a site is a guarantee of good fortune. The length of the site suitable for Kings is one eighth more than its width, it is red in colour and bitter in flavour, it slopes towards east, is vast and planted with asvatta. Such a site invariably guarantees success. The length of site suitable for vaishya is one sixth more than its width, it slopes towards east, is yellow, of sour taste and planted with plaksa. Such a site is beneficial. The length of site suitable for Sudra is a one fourth more than its width, it slopes towards east, is black, has a pungent flavour and is planted with nyagrodha. Such a site is a source of abundant riches and grains (Dagens, 2010).

2.1.7 Examination of Site

According to Dagens (2010), the following points must be considered while selection of site:

- The shape of the site must be perfect.
- It must be compact, smooth and pleasing to touch and of uniform colour.
- It should be pleasing to the sight and to the mind.
- The ground must be free from pebbles, worms, ants and bones, it is free from holes
- It must be free from charcoal and every sort of pointed object and from sludge, dust, cavities and husk.
- Such a site is suitable for all castes and brings them success.

2.1.8 Unsuitable Sites

According to Dagens (2010), the characteristics of unsuitable sites are as follows:

- A site which has foul smells.
- A site which is too near a hall, a sacred place, a palace or a temple.
- One planted with thorn trees, one which is round, triangular, irregular, or shaped like a vajra and one raised or depressed in the centre.

- One on one, two, three or four roads along the site.
- Several roads give access, or which is crossed by one road.
- Large trees at the four corners, those planted with sacred trees and those whose four corners are indicated by a wall.
- A cremation ground or a place of retreat.

A building erected on such a site, even by mistake, is the source of great misfortune; this is always to be avoided.

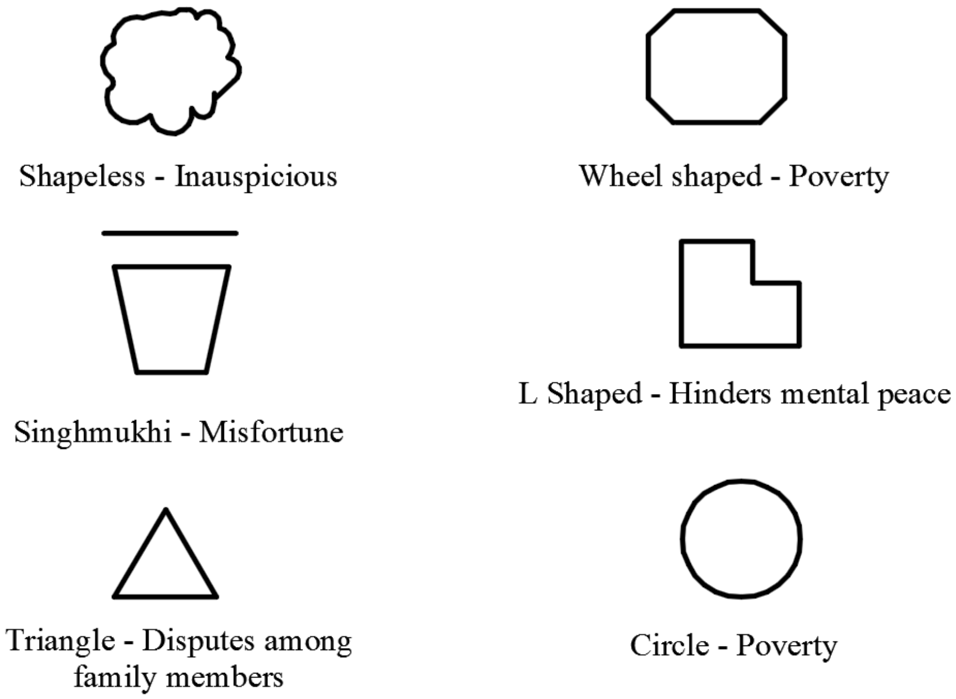


Fig. 5: Unsuitable Sites

2.1.9 Four Sorts of Builders

There are four sorts of builders each with their function:

a) **Architec**t (Sthapati): the master builder
b) **Sutragrahia:** the draftsman
c) **Taksaka**: carves stone, wood and clay.
d) **Vardhaki:** adds to the work of taksaka by joining parts and finishing their surfaces.

2.1.10 Taking Possession of Site

A square piece of land orientated to the cardinal points must be dug out to the depth of a cubit and filled with water. If a small residue of water is found after 12 hrs, then this is a guarantee of success. If the pit is damp, the building will be destroyed and if it is dry harvests and riches will disappear. When the hole is filled up with its own earth the site is of average quality if the pit is completely full. If it overflows with earth the site will prove excellent and if it is not packed full of earth it is of inferior quality (Dagens, 2010).

2.1.11 System of Measurements

- Eight barley grains make a digit angula.
- Twelve digits make a span (vitasti) twice which is a cubit (hasta)
- Twenty-five digits make a prajapatya, twenty-six a dhanurmusti and twenty-seven a dhanurgraha.
- For vehicles and seats the cubit (is used), for buildings the dhanurmusti and for villages and so on the dhanurgraha; the ordinary cubit however may serve for any building.
- Four cubits make a pole.
- Villages are to be measured in poles and houses in cubits.

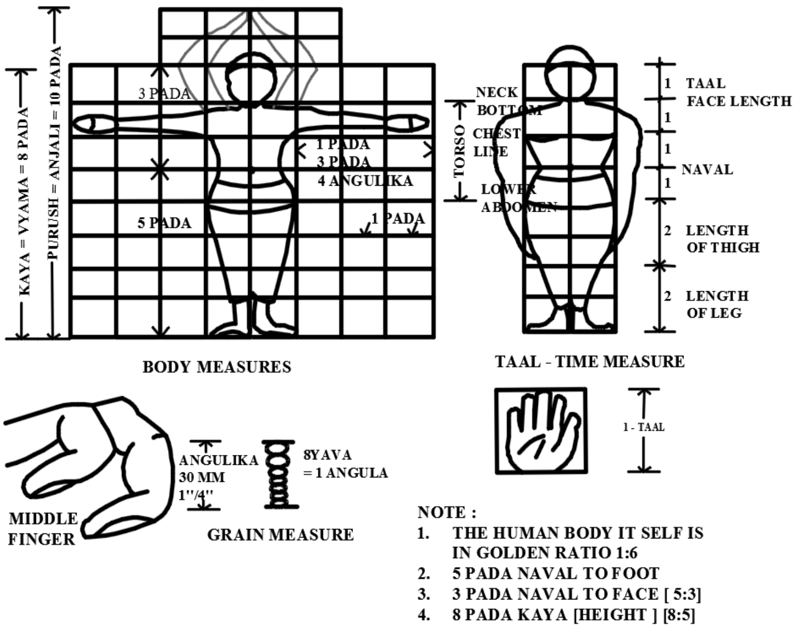


Fig. 6: System of Measurements (Source: Gupta, 2017)

2.1.12 Orientation

Cardinal points are determined with the help of agnomon. In the early days of astronomy, the gnomon was a common tool. The cardinal directions, the latitude of the observation site, the sun's celestial coordinates, and the observation time are all determined by the shadow of a vertical rod on a horizontal plane (Dagens, 2010).

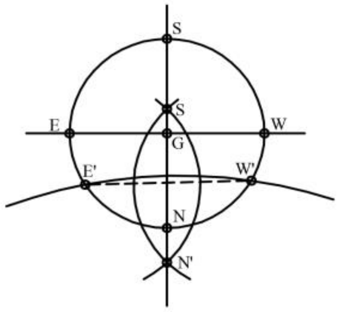


Fig. 7: Provides an Illustration of the Cardinal Points

G is the gnomon's foot. At W and E, the path of the shadow's end enters and exits a circle with centre G. The line EW is therefore pointing eastward and westward. Circular arcs are drawn with the centres at E and W, intersecting at N and S. The perpendicular bisector of EW, NS, is then in the north-south direction (Dagens, 2010).

2.1.13 Types of Sites

According to Dagens (2010), there are six types of sites with one, two, three, four, seven and ten main buildings in the site for all classes. All buildings are either separated or connected with each other in the form of blocks. The width, length and height are expressed in terms of even and odd numbers of cubits with specific arrangements. No building must be constructed at the centre of the site. Houses with a single main building have one or several storeys. East and north facing sites are considered auspicious for all classes.

- **Houses with a Single Main Building are:**
    a. Dandaka (Type 1 & Type 2)
    b. Sastika

Fig. 8: Traditional Dwelling Unit (Source: www.team-bhp.com)

a. Dandaka (Type 1)

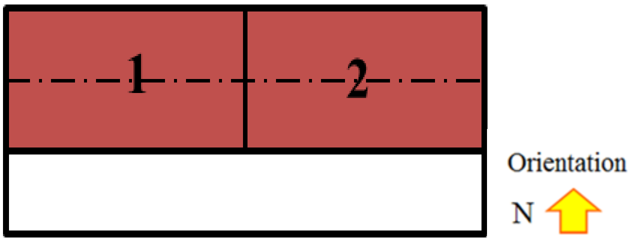


Fig. 9: Dandaka - Type 1(1 - Chamber, 2 – Gynaecium)

The main building is separated into two rooms by a median partition wall with a vaulted door. One room is reserved for women often called as gynaecium with pillars inside. There is a veranda in the front along its full length.

*** Dandaka (Type 2)**

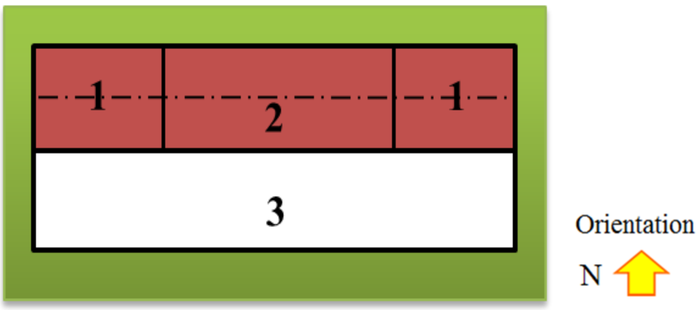


Fig. 10: Dandaka - Type 2 (1 - Chamber, 2 - Gynaecium, 3 - Front veranda)

The main building is surrounded by a gallery. It has two chambers with gynaecium in the middle. There is a veranda in the front along its full length. Pillars are arranged according to circumstances.

b. Sastika

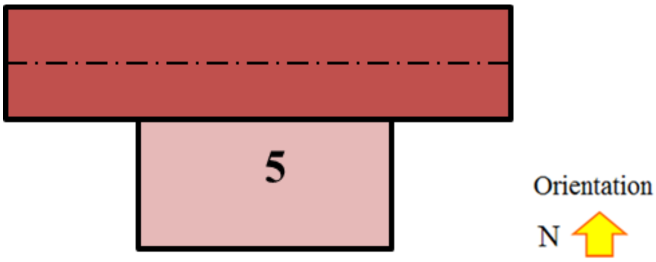


Fig. 11: Sastika (5 – Forepart)

The main building has a front forepart and three gables. This is suitable only for Gods, Brahmins and Kings and not for lower classes.

- **Houses with Two Main Buildings are:**
  a. Caturmukha
  b. Dandavaktra

a. Caturmukha

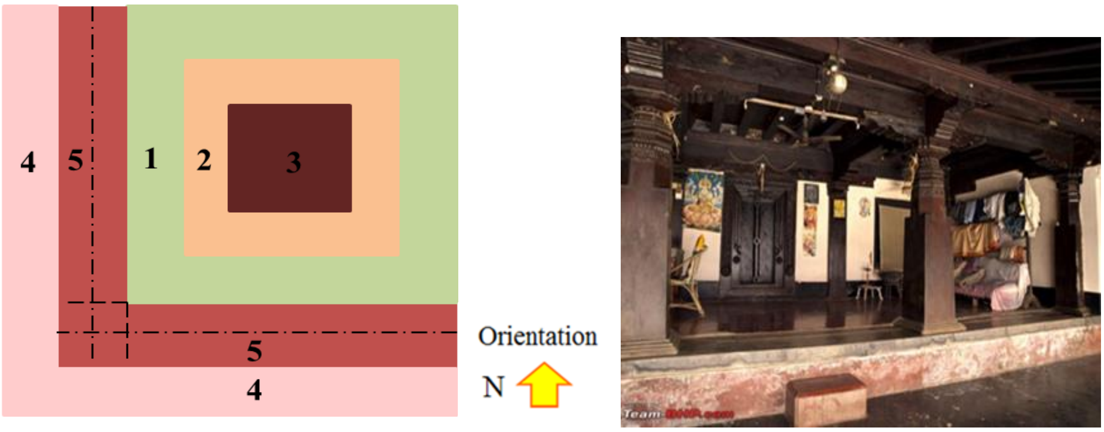
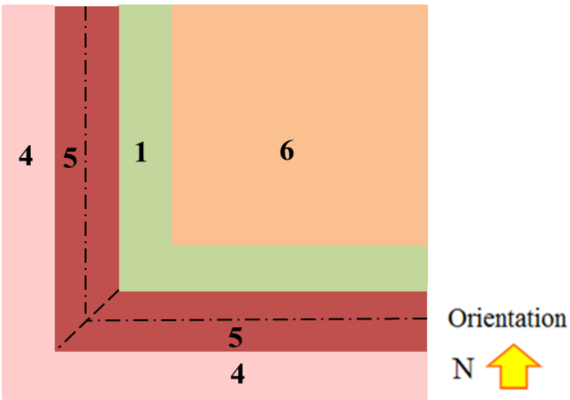


Fig. 12: Caturmukha (1 – Veranda, 2 - Portico, 3 – Pillared court, 4 – Gallery, 5 – Main Building)
(Source: www.team-bhp.com)

This house has two main buildings with galleries on two outer sides. The facades of the two main buildings are right angled to each other. The front inner court is made square. The principal main building comprises two chambers. There is a veranda in the front of the building. There is a square pillared court which is bordered by a portico.

b. Dandavaktra



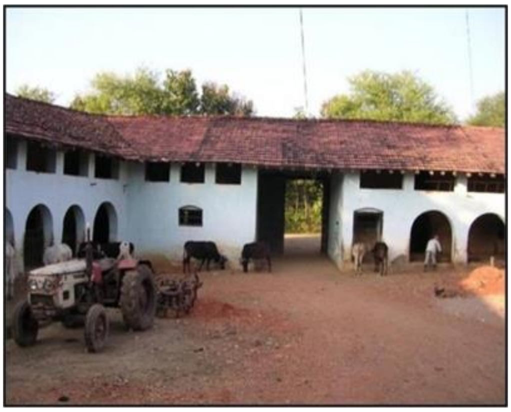


Fig. 13: Dandavaktra (1 – Veranda, 4 – Gallery, 5 – Main Building, 6 – Court)

(Source: www.archinomy.com)

It is the same as chaturmukha type with a little difference. It has only two gables. It has no pillar court. It will have a court open to the sky. This house may have multiple storeys.

- **Houses with Three Main Buildings are:**
  a. Merukanta
  b. Maulibhadra

a. Merukanta

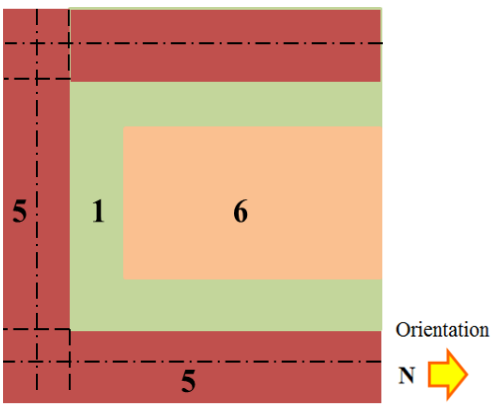


Fig. 14: Merukanta (1 – Veranda, 5 – Main Building, 6 – Court) (Source: www.team-bhp.com)

It has a central court and is surrounded on three sides by a veranda. This house has six gables, and its central court is covered**.** It has one or several storeys.

b. Maulibhadra

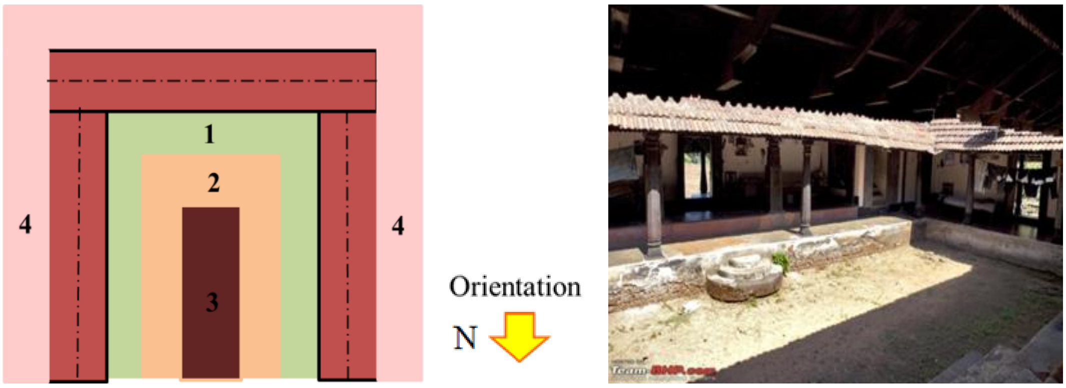


Fig. 15: Maulibhadra (1 – Veranda, 2 - Portico, 3 – Pillared court, 4 – Gallery)

(Source: www.team-bhp.com)

It is the same as the Merukanta type with an exterior gallery on three sides. It has a veranda on the front. It has a central court surrounded by a portico. It may or may not be covered. It will have four gables.

- **Houses with Four Main Buildings are:**

a. Sarvatobhadra

b. Vardhamana

c. Nandyavarta

d. Rucaka

a. Sarvatobhadra

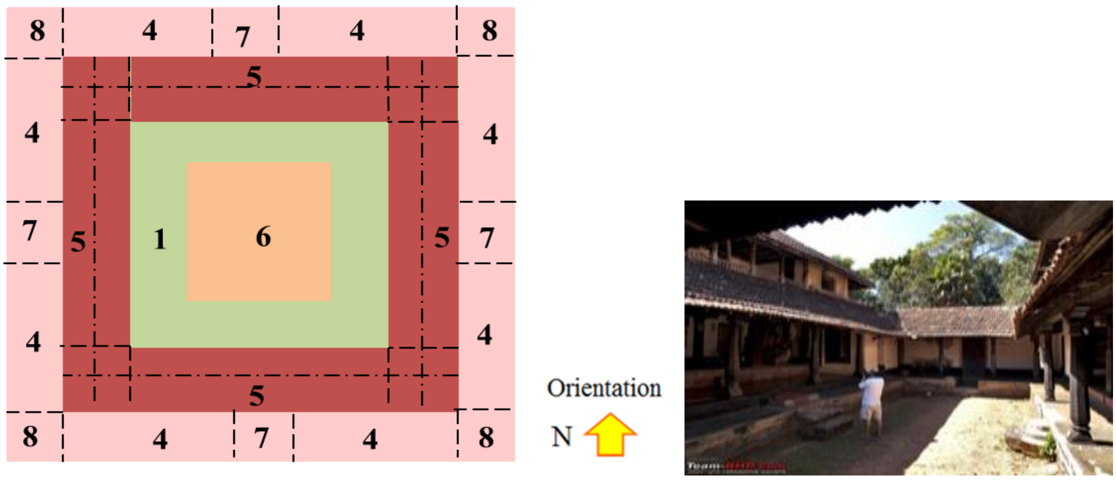


Fig. 16: Sarvatobhadra (1 – Veranda, 2 - Portico, 3 – Pillared court, 4 – Gallery, 5 – Main Building, 6 –Open court, 7 – Foreparts , 8 –Outward corner rooms) (Source: www.team-bhp.com)

There are four main buildings with a central courtyard. The central courtyard has a veranda all around. Exterior to the four corners of the square formed by the four main buildings there are square outward corner rooms, and the gallery extends on each side between these rooms. The master's chamber is in either the east or west main building. It is enclosed by walls and has a vaulted door. The walls have lattice windows on the outside and there are pillars along their interior face. The main house has an entrance from the east. It has a door with plain shutters on the exterior and one with latticed shutters on the interior. The ridge beam of the main building's crosses at right angles and thus there are eight gables, each of which has a porch roof. In the middle of the four faces of the house there is a forepart in the shape of a small hall. All around is a pent roof supported by consoles and there are eaves on the roof. The entablature is provided with small false dormer windows and with a frieze. The rafters, doors and ridge beam are to be of similar dimensions. There is one or several storeys and the arrangements are as for the temple. Such a house is always fit to be a dwelling unit of Gods, Bhramins and Kings. The gables which are at the ends of the four main buildings are at right angles. Above these eight gables are a second storey and an attic. There are finials on the ridge beam which are all at the same level. There are loggias above the foreparts, accessible from inside and with a gable on outside (Dagens, 2010).

b. Vardhamana

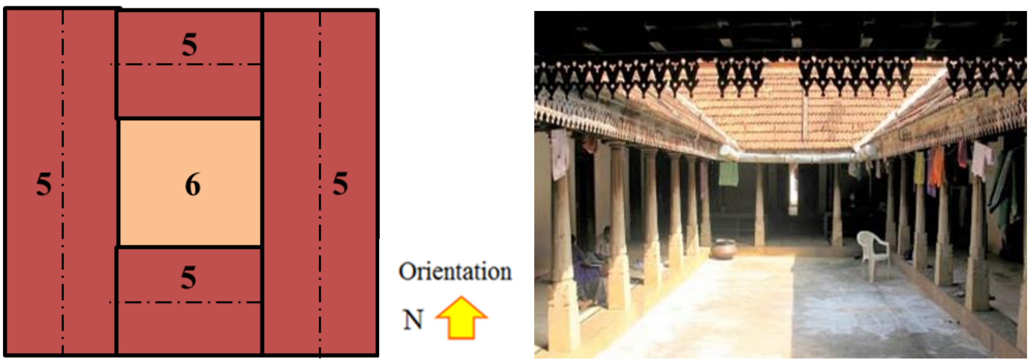


Fig. 17: Vardhamana (5 – Main Building, 6 – Court) (Source: www.team-bhp.com)

The main building has a central courtyard. There is a wall all around outside. There is a passage towards the east of the principal main building. It has a median partition wall and a vaulted door. The Western main building is elongated and has two gables. It is higher than the other. The eastern main building is a little less elevated than the western main building and it is elongated. The lateral main building has no gables and their ridge beams are lower than those of the other main buildings. Spiral staircase must be arranged at the corners. The house has a false dormer window, pillars, and a latticed window. The arrangement is suitable for temples. The house has one to three storeys. If it is intended for Kings, its door is not to be in the north (Dagens, 2010).

c. Nandyavarta

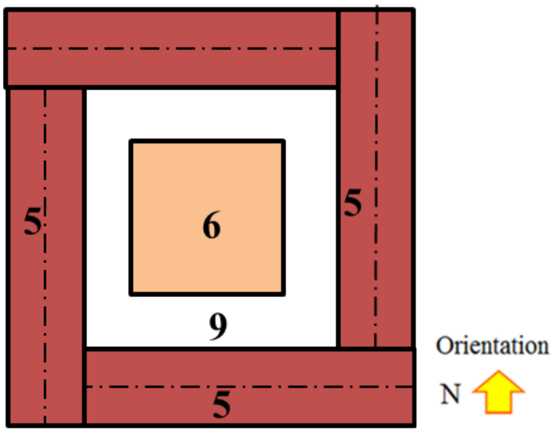


Fig. 18: Nandyavarta (5 – Main Building, 6 – Court, 9 – Walkway)

The main building has a central courtyard and passage all around this courtyard. It consists of an internal partition wall with a vaulted door. This house is suitable for all classes.

d. Rucaka

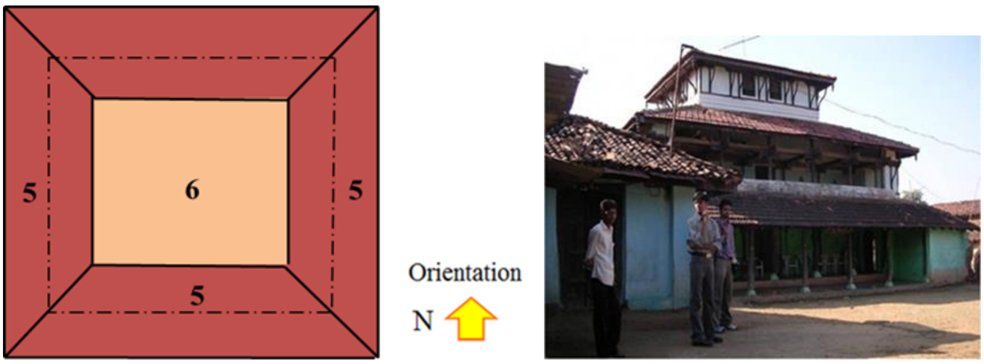


Fig. 19: Rucaka (5 – Main Building, 6 – Court) (Source: www.team-bhp.com)

The ridge beam of these buildings does not intersect and when there are rafters, there are stairways at the corners. There are decorative elements. There is no door in the north.

- **Houses with Seven Main Buildings:**

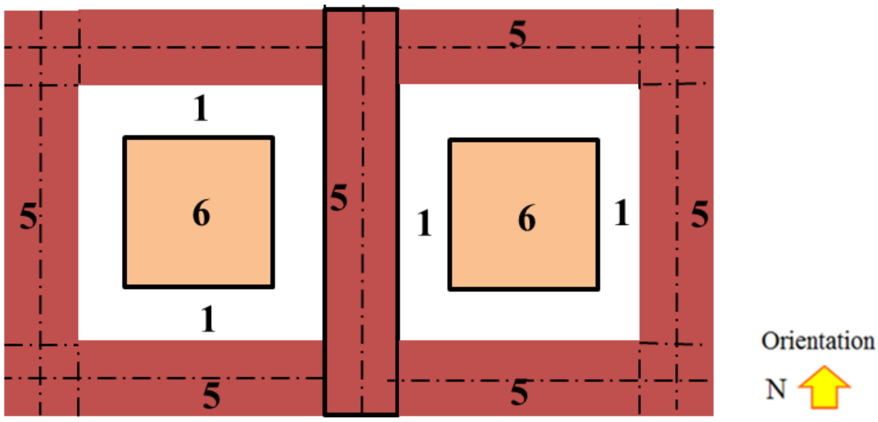


Fig. 20: Houses with Seven Main Buildings (1 – Veranda, 5 – Main Building, 6 –Court)

A royal palace with seven main buildings is twice as long as wide. It has two main entrances, ten gables, two interior courtyards as well as six joints between main buildings. It is decorated like a temple.

- **Houses with Ten Main Buildings:**

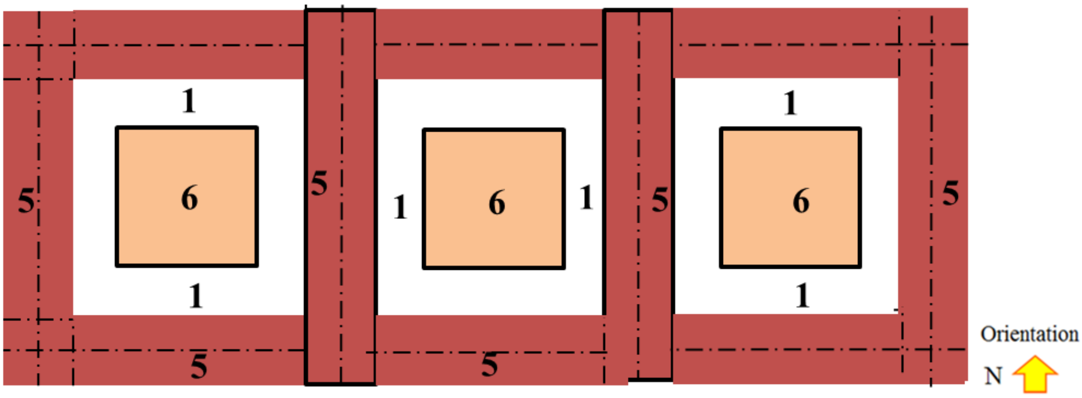


Fig. 21: Houses with Ten Main Buildings (1 – Veranda, 5 – Main Building, 6 –Court)

The edifice with ten main buildings is prescribed for Kings, it has twelve gables, three main doors, three interior courtyards and eight joints.

2.1.14 Houses

Dagens (2010), states that east is dedicated to women. The dining hall must be placed in YAMA i.e. south. Money must be stored in SOMA i.e. north. Granary must be placed in AGNI i.e. southeast. The room for cult ceremonies is on the square of ISA i.e. northeast. The well must be placed in ISA i.e. northeast and bath on the UDITI i.e. northeast. The sheds for goats and sheep on that of NIRRTI i.e. southwest. ISA i.e. northeast is dedicated to stables and the elephant shed. All vehicles are to the left of the doors placed at the cardinal points. There must be doors and gateways at each of four cardinal points. There is a moat beyond the wall equipped with every kind of defence. This is the description of the wall of the enclosure surrounding the house. Annexes may be built around the house in cob work or wooden framework with thatch or covering of that kind, they have a base and pillars. In the centre of site, the sages begin by constructing a pavilion with four of eight pillars. For Brahmins, Kings and Vaisya, the number of pillars is to be even and of Sudra to be uneven. Only for Brahmins, Kings and vaishya there must be a platform at the centre of the house. Offerings must be made three times a day. The pillar may be square, circular or octagonal. These pillars when for Brahmins and Kings are inn sami and khadira, for Vaisya in silindhra, pisita or madhuka woods, for Sudra in rajadana, nimba, silindhra, pisita or tinduka, bamboo is however appropriate for everyone. The pavilions with ornamentations are built of bricks joined by mortars when for Brahmins and Kings, it is in unbaked bricks when for vaishya and others. The passage must be left around the pavilion. This is suitable for all four classes. For Brahmins the enclosure is square. For ksatriya, vaishya and shudra the enclosure's length is greater than width.

2.1.15 Rules for the Order of Habitation for the Four Classes

- **Houses for Bhramins - Sukhalaya**

The saukhya i.e. the dwelling of Brahmins is to be built on the squares of Mahidhara, Indu, Bhallata, Mrga and Aditi. The overall height of the main building is to be equal to their greatest width. The height of the wall is equal to that of the pillars and their thickness is triple the diameter of the corresponding pillars. The diameter of the pillar is given on the basis of width of the building. The door is on the square of Mahendra and the drain pipe on Mukhya. A dwelling like this brings success to the Brahmins (Dagens, 2010).

- **Houses for Kings – Annalaya**

For Kings, a mahanasa is to be built on the squares of Mahendra, Arka, Aryaka, Satya and Bhrsa. The door is on the square of Grhaksata and the drain pipe on the Jayanta. A dwelling like this, situated in the east, is fitting for the Kings, to whom it will bring an increase in treasure (Dagens, 2010).

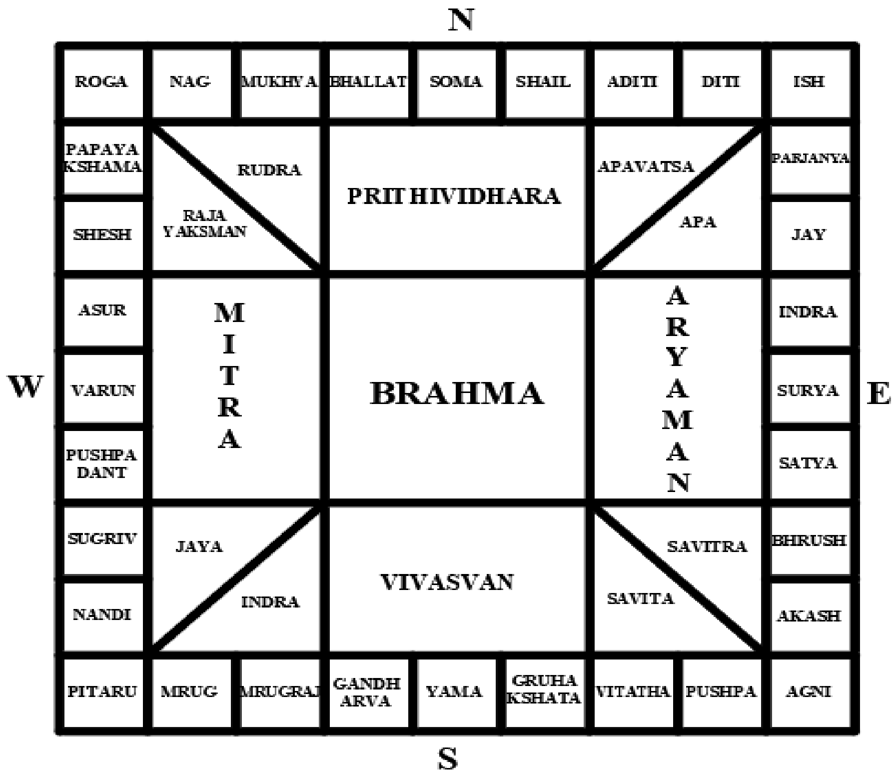


Fig. 22: Vastu Purusha Mandala Containing Different Gods in Each Square (Source: Pinterest, n.d.)

- **Houses for Vaisya – Dhanyalaya**

There is a Dhanyalaya for Vaisya on the squares of Grhaksata, Arkin, Gandharva, Bhrngaraja and Vivasvant. The door is on the square of Puspadanta and the drain course on that of Vitatha. This dwelling situated in the south brings wealth, rewards, and good fortune to Vaisya (Dagens, 2010).

- **Houses for Sudra – Dhanalaya**

A Dhanalaya is prescribed on the square of Puspadanta, Asura, Sosa, Varuna and Mitra similar to Dhanyalaya but a little smaller. This dwelling situated in the west brings good fortune to the Sudras. Its door is on the square of Bhallata and its drain course on that of Sugriva (Dagens, 2010).

2.1.16 General Rules

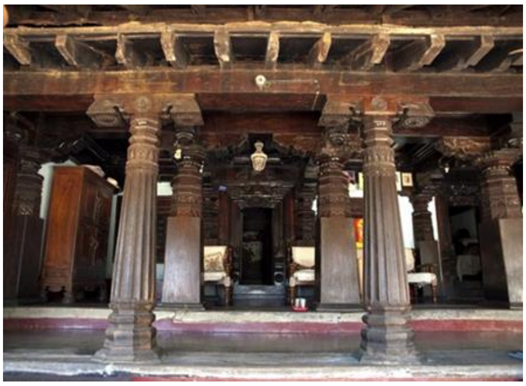


Fig. 23: Images Showing Different Parts of Ancient Dwelling Units (Source: www.team-bhp.com)

- The master's chamber is constructed inside the principal main building and there is a mandapa there.
- The bed must not be placed on the axis of the main building.
- It is said that the master's part is found on each storey of the building.
- Its walls are of bricks laid with mortar or of planks and when for the Kings are covered with gold, copper or other metals.
- The pillars, base and walls of the house must not be of stone for men.
- If the floor of the house is low, the entrance is to be a covered shed providing shelter from rain.
- The secondary main building of a designated house resembles its principal building.
- The vessel pot the salted water from boiled rice is placed at the northeast, the hearth is to be on the square of Antariksa and the mortar on Satya, an oven on the square of Isa.
- There are five types of hearths. For Kings the hearth is round, for Gods and Brahmins it is square, for vaishya it is rectangular and other forms are all fitting for the other classes.
- The study of Vedas takes place on the square of Vivasvant and marriage on that of Mitra.
- The women's confinement room is on the square of Sugala and Puspadanta, the cistern on that of Apavatsa, the tank on that of Apa, the millstone on Mahendra and the grindstone on Mahidhara.
- Door position– to be auspicious, the main entrance of the house must be on the square of Raksasa, Puspadanta, Bhallata or Mahendra. It is known that there is

an increase in wealth, lineage and cattle for the owner, the entrance of whose house is of auspicious proportions and it is placed between a pillar and a wall.

2.1.17 Number of Storeys

Fig. 24: Two Story Unit

Fig. 25: View of Entrance

(Source: www.team-bhp.com)

It is stated that buildings of up to twelve storeys are suitable for Sarvabhauma Gods, those with eleven at most are for Raksasa, Gandharva and Yaksa, those which have nine or ten are suitable for Brahmins, building with seven storeys are suitable for crown princes and for Kings, those which have three or four storeys are suitable for merchants and Sudra and lastly those with five storeys are for officers (Dagens, 2010).

2.1.18 Choice of Building Materials

Wood, stone, bricks are the materials to be used for horizontal and vertical elements such as pillars, architrave etc. The chosen trees must be perfect, hard and vigorous, they should neither be old nor should they be saplings. They should be growing in holy places, mountain or river banks. They should be pleasing to mind and eye. Stones must be of even colour, hard, perfect, pleasing to touch and are embedded in the earth with an eastward and northward orientation. Bricks must be compact and uniformly baked. It must be free from fissures and cracks. They must give a harmonious sound. Materials from forbidden localities must not be chosen. Stones should be used for temples and for dwellings of Brahmins and Kings and they are unsuitable for vaishya and shudra. A building constructed out of one material is said to be pure with two materials mixed and three mingled (Dagens, 2010).

2.2 VASTU SHASTRA IN CURRENT TIMES

The ancient body of knowledge known as Vastu Shastra provides guidance on how to design spaces based on the relationship between people and the places they live.

2.2.1 Contemporary Users of Vastu Shastra

Vastu Shastra is currently practised in a way that is completely disorganised and disarrayed. As it is applied and utilised randomly in parts without realising its full scope for solely creating the modern architectural style rather than utilising this ancient science as a whole architectural programme is indicative of this fragmentation. Its current rejection as an antiquated architectural programme has resulted in its utilisation in more peripheral sense, where it is subjected to personal interpretation by so called modern architectural experts. None of India's major architectural institutes and schools includes it in their curricula or discussions, and the only way to encounter its built expression is through contemporary standards of architectural evaluation. The league of professionals, whose valuable contribution is vital in the successful execution of entire Vastu Shastra programme of architecture from the ground up, has resorted to isolated and independent practises in addition to the modern architects. Such Vastu experts are also quickly vanishing, primarily because to the perception that they are irrelevant to the demands of contemporary architecture. Some Vastu Shastra fragments have taken on new meanings, with their original intent obscured by a sort of ritualism designed to hurriedly resolve an internal struggle without the corresponding architectural representation. All related building crafts and cosmetic operations are unnecessary as a result of this abject rejection of Vastu Shastra as an architectural programme, which throughout its incredible history has flourished with the prevailing climatic, geographic, social, political, and economic conditions of the different eras (Chakrabarti, 1998).

In the modern times, the practitioners who make some sort of reference to the principles of Vastu Shastra to some extent can be categorised as follows:

- **Indian architect:** who is in pursuance of self-identity sometimes draws inferences to the body of archaic building knowledge and terminology,

- **Vastu Pundit:** who strives to provide general guidelines with regard to the orientation and the layout of the building being constructed,
- **Astrologer:** who treats Vastu Shastra on the same plane as astrology,
- **Traditional craftsman:** who utilises limited knowledge of Vastu for the maintenance of old monuments and buildings,
- **Conservation architect:** who focuses on documentation and analysis of monuments for the sole purpose of restoration and preservation of them, and
- **Art historian:** who strives to analyse Vastu Shastra texts from historical perspective to develop a concrete knowledge base of history as a subject.

Further it has been witnessed that lack of strong educational foundations and chequered history of the architectural profession has led to the modern architect's identity crisis in India.

An opportunity to start over was presented by India's independence from British rule, in terms of the formulation of right guidance programme to shape indigenous architecture on modern lines. But this opportunity to restart sound architectural education based to tradition knowledge seemed to have remained unseized. This time around, architectural design philosophy seemed to have been fractured between the stern simplicity of a ‘traditional’ Indian building methodology on the one hand and ‘modern’ practical building design code adapting techniques of the west on the other. With the growth of contemporary India, the modern architects found their niche, fortified by new technology, vocabulary, and an overall sense of architectural sensibility. Contrastingly, the conventional builders and traditional craftsmen had no place in this endeavor as strong anchors in terms of architectural design were established at the time of independence. Architects regarded the classical architectural tradition like Vastu Shastra as obsolete and antiquated and they did not understand its principles, which hindered any attempt to explore it and promote it. This rift between these two architectural styles still continues till date resulting in fragmented building design philosophy and practice. Nonetheless, the Vastu Purusha Mandala principles are valued by western architects (Chakrabarti, 1998).

We posses secret wisdom, and there are still many misconceptions in the releam of Vastu Shastra. Because traditional knowledge is rarely adequately translated and utilized in contemporary culture, our knowledge and comprehension of it can be very restricted. We, as humans, are enabled with a sense of direction. The ‘place cells’ in our brain activate when we move into a specific location and they form a map of the environment. This demonstrates how sensitive our brain is to orientation and direction.

For billions of years, the earth has been in a geostationary orbit around the sun because of the magnetic effects of its rotation. Because of the earth's persistent magnetic qualities, which cause the magnetic needle of a compass to always point north, the application of Vastu principles also becomes permanently oriented with an inclination towards the north. Vastu principles are predicated on everlasting directions.

Eight components make up a single solar day's 24 hours, and these portions correspond to the eight cardinal directions. The Sun is in one of the cardinal directions during each of these eight periods. Given the significance of sunlight for human health, the primary goal of Vastu Shastra is to make sure that occupant of a house, even those who spend the entire day indoors, are unintentionally exposed to the beneficial solar radiation. But throughout the day, individuals engage in various activities in various rooms at various times, and the sun's position changes from dawn to dusk.

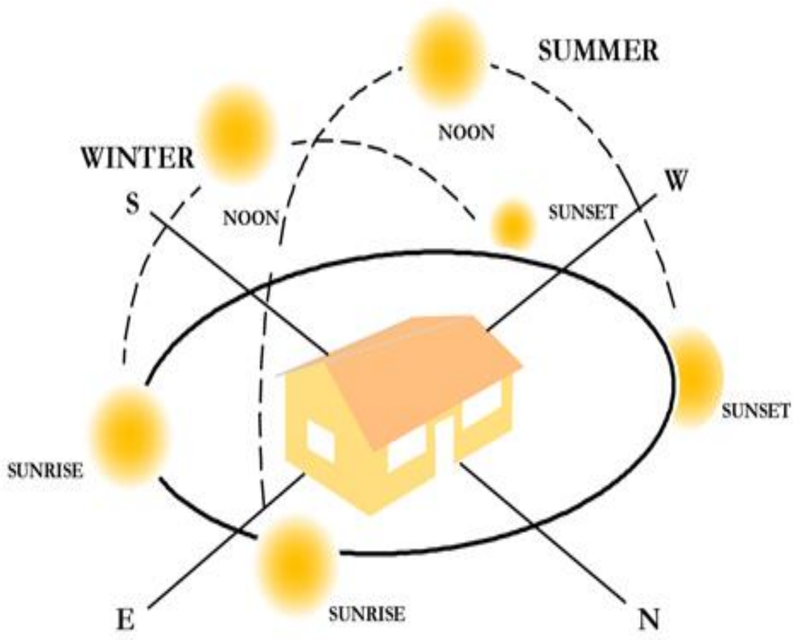


Fig. 26: Solar Path in Winter & Summer Season

- **3am to 7.30am: Northeast and North**

Morning rays are proven to be very beneficial for our health. Hence, it is advised to keep this area open without obstructions and let in as much sunlight as possible. Also, during this time, it is very quiet and peaceful. Therefore, it is to be allocated to wellness, may it be worship, meditation or even an open gym. Usually, this is the time we shower and prepare for the day. So, ideally, Bathrooms can be placed in this quarter. It also makes sense as it is adjacent to the wellness area.

- **7.30am to 12pm: Southeast and South**

Around this time, we prepare food and also leave for work. This is the reason why it is preferable to be in the south quarter of the building while at work. For those who do not go out to work, this is also a time to move into more personal spaces such as bedrooms or home offices. During work is when natural light is desired the most. So, make sure you place your home office in the south.

- **12pm to 6pm: Southwest and West**

Back in the day, it was common practice for the master of the house (the person who manages the household) to rest after lunch. This is the reason why the head of family's bedroom is preffered in the southwest corner. However, since the heat is extreme during this time, minimal openings and filtered light is preferable. To create obstruction to heat, heavy items such as wardrobes are placed. This is also the time when kids return from school, so having a children's bedroom and children's study in this quarter is favourable.

- **6pm to 3am: Northwest and North**

It's time to relax after and is therefore allocated for bedrooms. Usually guest bedrooms or rooms that are occasionally used are placed in this quarter as they don't receive a lot of sunlight. Also, every other quarter receives natural light throughout the day except for this one which is why it is best suited for safe-keeping and to hide valuables.

Table 2: Special Arrangement According to Vastu Shastra

S No.	Spaces	Directional arrangement
1.	**Bed room**	South, as it is attracted to opposite poles, just as human heads operate as north poles.
2.	**Kitchen**	Southeast, as morning sun from the southeast is therapeutic; its UV rays serve as a disinfectant, and when the body is exposed to the morning sun, vitamin D is produced through the skin.
3.	**Verandah**	North and east to provide uninterrupted electromagnetic flow from that direction. Provide a central courtyard that is exposed to the sky to create a stack effect.
4.	**W.C.**	Preferred in south and southwest.
5.	**Bathroom**	East because of the morning sun's sanitary effects.
6.	**Puja room/ Meditation room**	Northeast as mantra chanting and meditation yield greater effects when combined with the healing characteristics of the sun and the electromagnetic energy of the earth, which is present in the northeast.
7.	**Dining room**	Since the muladhar chakra, the body's first energy channel and a manifestation of earthly energy, is directly impacted by the setting sun in a positive way, its vibration serves as chromotherapy. In the west, the setting sun is typically red in color.
8.	**Drawing room**	Generally preferred in north or northest.
9.	**Study room**	Preferred in west and southwest

2.2.2 The Scientific Implication of Vastu Shastra

The Vastu science of building has numerous rules and concepts that relate to the environment, which was the initial manifestation of shelter. Vastu principles make it abundantly clear that the house orientation, spatial design, geometrical shape as well as the placement of vegetation and water features around the building construction are important for overall aesthetics.

Typically, a mandala is the initial geometric pattern used for a floor plan, from which all other ideas and designs are derived. It is believed that Mandalas have environmental origin, and graphically represent natural phenomena and their effects on constructed space in form of symbolic patterns (Akola, 2000).

The environmental factors such as sunlight, magnetic energy, energy grid lines and concentric spatial arrangement play an instrumental role in determining the spatial design and geometrical shape of the mandala patterns. Together, these factors have established specific guidelines for architectural design.

Vastu really bases its classification of each direction as either auspicious or harmful on the following ideas:

- **Sunlight**

This principle is based on the natural movement of Sun during the day in the sky. However, because of the earth's 23.5^{o} tilt from its vertical axis the northeast receives the sun's rays before the east. Because of this fact, kitchen is advised to be located in the southeast as it receives maximum light energy throughout the day (Kumar, 2005).

The apparent white light from the sun is made up of, visible light, invisible infrared and ultraviolet radiation. The influence of infrared rays, which are good for human health and have cleansing effects, begins at 6 am. As a result, water tank located in the north, east, or northeast becomes bacteriologically safe to drink without causing the nutrients to degrade. UV rays have a very strong effect from 11 am to 3 pm, which is bad for the body. The effect of infrared rays in terms heating quality grows from 3 pm to till evening.

Sunlight in the morning is typically cooler. The rays warm up with time. When moving through the southwest in the afternoon, the sun is at most strongest. While Southwest portion is the hottest and most damaging area, it is best to keep it closed and use the northeast, which is in the midst of the chilly zone, for praying or studying. Southwest was set aside in ancient times as an arsenal to store weapons (Kumar, 2005).

Generally, North is the coolest direction in the house based on the Sun's position in the sky during the day. The Northeast corner is ideally suited for daily prayer or meditation because it is the coolest area in the entire dwelling.

East brings the purifying rays of morning sun. The bathroom is constructed along this direction according to current Vastu. However, the bathroom was not even considered when building a house in the past. The Southeast corner of the house is considered well suited for the kitchen as it offers sufficient light energy throughout the day that has a sanitary effect (Akola, 2000).

Bedrooms should be oriented in the direction of the sun since the light and heat it emits in the southern hemisphere is overwhelming and damaging. Even if bedrooms are typically used at night, the habitats won't be disturbed by the dangerous rays coming from this angle. Keep this area elevated, dark, and closed.

During the day, the western part of the home also gets some negative sunlight. Since only a few hours a day are dedicated to dining activities, therefore it serves an ideal spatial location for dining area.

- **Magnetic Energy**

The basic structure of the Earth includes inner solid core and outer molten core. Due to high temperature, the Earth's liquid outer core happens to move and swirl creating magnetic field around the planet Earth. According to the electro-magnetic theory, as the Earth spins around its axis, the particles in molten outer core tend to swirl, due to this effect the planet acts like a giant dynamo – geo-dynamo. Metallic particles have some electrical charge that is free to move in the outer core and are capable of conducting electricity. Due to its rapid rotation and the high concentration of iron and nickel in its liquid core, the planet earth has an extremely strong magnetic field (Kumar, 2005).

In actuality, the earth possesses two magnetic poles that, when viewed through a compass, appear to be stable but are in fact continually shifting. Ephemeral undulations, often referred to as micro-pulsations, cause magnetic disturbances that can reach the ground and are both frequent and challenging to detect. The magnetic field of the Earth, often known as the Earth's aurora, acts like a protective shield against the sun's harmful radiation by deflecting solar flares. Thus providing a blanket of protection to all its inhabitants and allow all the lifeforms to survive and thrive.

According to science, this will deliver antibiotic characteristics that can control illness to the north geographic direction. As a result, the north direction is meant for purification, whereas the south direction is meant of warmth and contains energy-giving qualities. For this reason, the southern part of the plot will be barren or deficient while the northern half is filled with positive magnetic rays. The appearance of such a phenomenon was utilised to assess the auspiciousness of the directions and determine how best to utilise them in accordance with Vastu Shastra principles.

The stark reality is that the Earth behaves like a living being, seemingly sentient in its own right. According to biological research, the planet's oxygen content has essentially not changed over the millennia, and the Earth's tilt toward the northeast has contributed in absorbing the most positive cosmic energy. Any construction that is aligned with the axis of the Earth will naturally produce auspicious results. As a result, the north-eastern portion of the building will be replete with benevolent cosmic radiations whereas the south-western portion will be significantly devoid of these effects (Kumar, 2005).

- **Geopathic Zones**

A body of knowledge of contemporary research called geo biology studies various energy fields. Because it is based on patterns of sacred geometry, it frequently falls into the category of pseudoscience. The cosmic radiations come from celestial bodies such as the Moon and the Sun and the radiations that come from the Earth are known as “telluric radiations” or “terrestrial radiations”.

Earth’s energy grid is composed of precise geometrical patterns that adhere to predetermined symmetries. The grids overlap at numerous locations, forming a matrix that is highly reminiscent of the acupuncture sites on the human energy body. The study of the Earth's geometric grids is thought to have led to the development of the platonic solids, which include the cube, tetrahedron, octahedron, dodecahedron, and icosahedron.

Vastu's norms and principles are used while building any type of property, demonstrating the existence of this knowledge in traditional communities that scientists may not have fully found.

- **The Principles of Concentric Zones**

Since antiquity, it is an established fact that squares are the ideal shape for buildings. The symmetrical geometric pattern in form of concentric square according to the Vastu science is an exemplary design that, according to ancient teachings, creates a potent, energising, and beneficial effect (Silverman, 2007).

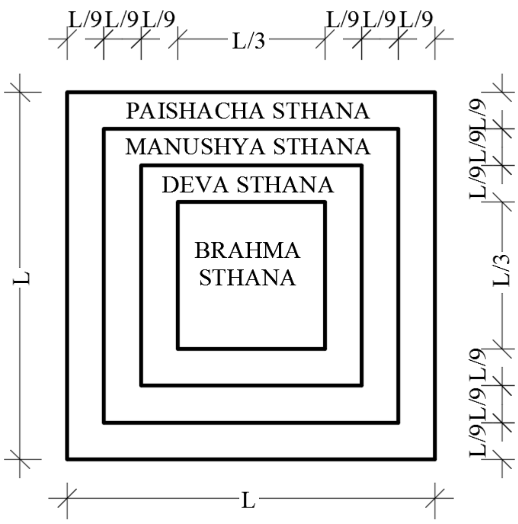


Fig. 27: The Concentric Zones (Source: Fazeli & Goodarzi, 2010).

There are different symbols used in Indian traditional geomancy to represent sacred entities and natural element. One such symbol is the sacred point, which represents the creator or God, ultimate unity, or limitless reality. The expression of this sacred idea is the navel, as shown by Bindu in the Vastu Purusha mandala's centre. In addition to its quantitative use, the yin-yang sign, which is used in Chinese Feng Shui, is a representation of creation's duality portrayed by two sacred points or dots. In the domain of geometry, a line is representation of the sacred duality represented by the masculine and female forces in the universe i.e. Shiva and Shakti (Silverman, 2007).

In addition to its symbolic value, the square, according to studies by Kumar, is the best geometric form for structural and economic reasons. The rectangle is the second best shape since it requires less material for building on its periphery while offering a larger interior space. According to mechanical structural theory, buildings with square and rectangular shapes can transfer the load safely even in locations where the earth carrying capacity is limited, whereas other irregular designs provide unnecessarily larger contact surface area more than they critically require for construction making them less than ideal choice for the purpose. Rectangular shapes' symmetrical design also offers resemblance of predictability in structural calculations and construction techniques that deal with problematic stress concentrations and load behaviour. As a result, symmetrical structures can withstand earthquake or wind effects better.

In other words, structural plan of the house can be likened to the human body. The least amount of pressure should be applied to the centrally located organs and portions because they happen to sensitive and delicate. Similarly, the evolution of courtyard homes in Iran, China, and Japan illustrates this concept architecturally.

In actuality, several principles in the Vastu Shastra science are primarily rooted in consideration of environmental factors. And due to general lack of awareness about its rich tradition and scientific principles involved, the current crop of architects accords it symbolic or ceremonial status at best without taking full advantage it offers as architectural science.

Archaeological studies established that architectural design forms across different civilisations was designed by keeping environmental factors into consideration The suitable use of Vastu compatible house layout and patterns may facilitate sustainability in architectural design that reduces ecological footprint by lowering the rate of energy consumption, at the same time creating a right micro climate aligned with human needs. Thus resulting in homes that are in complete harmony with the surrounding environment, even though modern technology makes it possible to adjust ambient temperature within the home by artificially cooling and warming any area regardless of its climate.

2.2.3 Merits of Vastu Shastra

Naik (2022) states that when an architectural construction incorporates the principles of Vastu Shastra, energy flows as it normally should, without any defects. Principles of Vastu Shastra combine with the element of nature and cosmos to balance with the man and material. A structure built in accordance with Vastu principles has an impact on people on a physical, psychological, and spiritual level. Vastu Shastra offers various advantages, thus it makes sense to design and construct living and work areas in accordance with its precepts. The following are some possible advantages of adhering to Vastu Shastra:

- **Good health**
- **Comfort**
- **Improve the flow of positive energy**
- **Brings harmony and fulfilment**

Vastu Shastra-inspired spaces can enhance general wellbeing, and support both mental and physical health. Vastu Shastra facilitates the flow of positive energy in a space by appropriately arranging rooms and furniture, employing specific colours and materials, and maintaining a clean and ordered environment. Vastu Shastra places a strong emphasis on the harmony and balance that exist between a built environment and its occupants. Balance can be attained by arranging the structure in relation to the surrounding natural elements and energy sources.

2.2.4 Vastu Shastra in Other Countries

According to the historical studies, the architectural system of India i.e. Vastu Shastra is thought to be similar to traditional Iranian architectural system since it has been established by the Indo-Aryan culture in ancient times and as a result of numerical cross-cultural exchanges in the past (Hojjat, Iranian Dwellings, 2009), (Shayegan, 2003), (Bausani, 1971). This notion is further strengthened by the fact that many of the words used in Iran’s traditional architecture and Indain architecture are identical. As shown in Table 3, this pattern was thought to enhance human health on all fronts (Ardalan & Bakhtiar, 1979).

Table 3: Comparing the Means of Creating Successful Dwellings in Vastu Shastra with the Iranian Teachings

S No.	Universal Concepts in Traditional Architecture	Concepts in Iranian Traditional Dwelling Architecture
1.	**Physiological Health** Many Many guidelines and precepts pertaining to the physical shelter were taken from the environment in order to create a microclimate that is conducive to human comfort. These topics are crucial to modern sustainable architecture.	**Concerning Jesm** In traditional Iranian architecture, jesm refers to the body, or the actual shelter, which has to be constructed using local materials, stabilized properly, and harmoniously integrated into the surroundings. The exterior surface of objects is actually Jesm.
2.	**Psychological Health** It examines the psychological effects on the human body of shapes, patterns, color, light, and vegetation—all of which were significant considerations in the design of traditional homes. The adage the house is a mirror of the self is well recognized as a symbolizing the significance of considering psychological elements in design.	**Concerning Ravan** When creating a structure, the psychological qualities of people hold greater significance. As a result, while building a home, one should take into account the psychological effects on the nervous system and brain of the human being. According to the theory of psychosomatic disorders, any shape, pattern, or component that adversely influences Ravan would cause health issues for the locals.
3.	**Spiritual Health** Every thing had an inner and an exterior aspect, with the latter being more significant and referred to as the soul in the minds of prehistoric man.	**Concerning Ruh** The most significant idea that links people to God is ruh. Ruh is the soul, and designing a home should prioritize this above anything else. Consequently, it was seen fortunate to employ any shape,

	Therefore, the soul should always come first when building anything.In this instance, the universe is viewed as a cohesive whole, in which each particle is interconnected with other elements that must be maintained and constructed in a way that complements the whole.	design, or symbolic ornamentation that transcends the human soul and promotes spiritual growth when building a home.

(Source: compliation from Alexander, 2004; Day, 2004; Salingaros, 1995; Sui, 2006; Shabanzadeh, 2009)

Although the architectural rules and systems of beliefs, together with the rituals associated with them are preserved in Indian culture among the sacred scripts of the Vedas and has introduced as the Vastu Shastra practices, the Persians have not preserved their traditional architectural knowledge as a set of written guidelines. The reason might be due to the invasions that Iran has faced throughout history, especially the conquest of the Mongols in which most of the ancient written documents were burnt or due to the traditional system of apprenticeship among the architects in Persia that used to confine the precious knowledge among the selected architects (Helli, 2009). The similar concepts, designs and symbolic ornaments are found in among Iranian and Indian houses that prove the fact that they both have originated from one belief system. For e.g. the buildings listed below shows similar characteristic features from both the concepts:

a) **Concentric Squares in Vastu Purusha Mandala and the idea of concentric squares in Abbasian House, Kashan.**

b) **The Vastu Purusha Mandala and the ornamentation on the Abbasian House roof in Kashan, Iran, which form a flawless mandala.**

c) **Swastikas can be found on the entrance gate of a Hindu temple in Delhi, India, and on the ornamental tiles of Yazd's Friday Mosque in Iran.**

d) **The design of arch in Taj Mahal in India and Abbasian house in Kashan, Iran.**

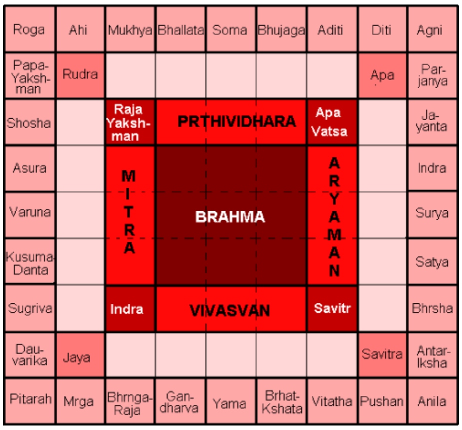


Fig. 28: Concentric Squares in Vastu Purusha Mandala (Source: Goodarzi & Fazeli, 2014)

Fig. 29: The Idea of Concentric Squares in an Abbasian House, Kashan (Source: Goodarzi & Fazeli, 2014)

Fig. 30: The Vastu Purusha Mandala (Source: Goodarzi & Fazeli, 2014)

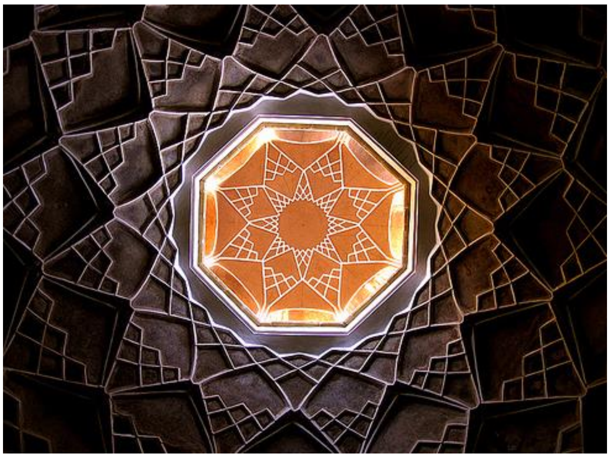


Fig. 31: Roof Decoration in Abbasian House, Kashan, Iran (Source: Goodarzi & Fazeli, 2014)

Fig. 32: Swastika in Decorative Tiles of Friday Mosque of Yazd, Iran (Source: Goodarzi & Fazeli, 2014)

Fig. 33: Hindu Temple Entrance Gate with Swastika Symbol in Delhi, India (Source: Goodarzi & Fazeli, 2014)

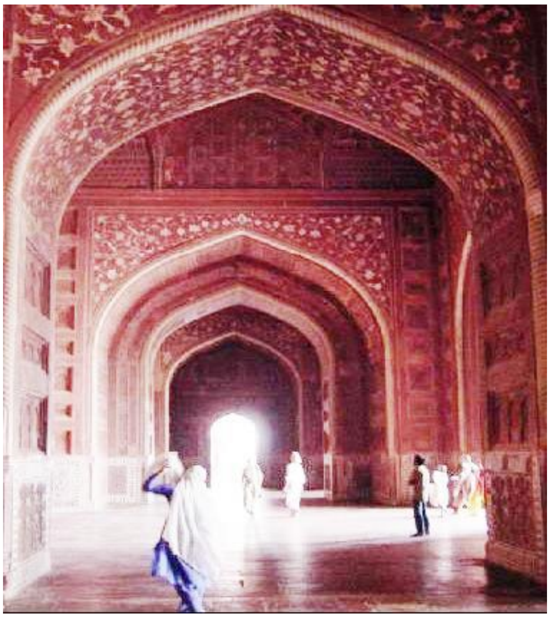


Fig. 34: The Arch Structure of Taj Mahal, India

(Source: Goodarzi & Fazeli, 2014)

Fig. 35: The Arch Design at Abbasian House, Kashan Iran

(Source: Goodarzi & Fazeli, 2014)

Vastu Shastra is practised in India same as Feng Shui in China. According to Saran and Shirodkar (2017) Feng Shui is a relatively new idea, having been around since approximately 960 BC while Vastu Shastra has been around since 6000 BC. There are many similarities between Feng Shui, the Chinese equivalent of Vastu Shastra, and other observations. With the exception of the latter's excessive emphasis on devices like fish tanks, flutes, mirrors, and lamps, both of them acknowledge the presence of positive and negative forces. Feng Shui is the ancient Chinese concept of living in harmony with one's environment. It means wind and water when translated literally. Feng Shui is sometimes referred to as the art of placement because so much of its focus is on figuring out the positive or negative directions for individuals, their homes, and their relationships. The entire Feng Shui system is based on the concept of yin and yang. Chinese philosophy holds that creation may only occur when two distinct forces come into contact. Since all creation in nature is the consequence of the interaction between yang and yin, the male and female opposites, we consider this to be true. In the kingdoms of animals and vegetables, it is the same. In Feng Shui, yang and yin stand for earth and heaven, respectively, as male and female. When heaven and earth interacted, creating the wind and water that lie between them, they also formed a cosmic power called chi. The core idea of Feng Shui is that every structure should be constructed with the intention of efficiently trapping chi, which is the symbol for all aspects of life. This is the same idea as universal life force, which the Japanese refer to as **Reiki**. It is also known as bio-plasma or bio-energy in the west, and it is the same as prana in Hinduism. Everything that is visible in the cosmos is said to release chi. The basis of Feng Shui's health philosophy is the human body's harmonious yin and yang balance. Five fundamental elements - wood, fire, earth, metal, and water - work together in different ways to create this balance. Table 4: shows the Comparative Analysis between Vastu Shastra and Feng Shui.

Table 4: Comparative Analysis between Vastu Shastra and Feng Shui

S No.	Feng Shui	Vastu Shastra
1.	Landscape has a significant role in feng shui. It is thought that the building's surroundings are quite significant.	Landscape is not that important. If the plot can be levelled it is considered sufficient.
2.	In Feng Shui, plain lands are not favoured.	Plain lands are considered as good.
3.	Human settlements are deemed unsuitable for mountain tops.	No such stipulation.
4.	Plain plots are considered as bad.	Plain plots are considered as good.
5.	For feng shui to work its magic, the owner's birth year is crucial.	No individual is so much crucial.
6.	Gadgets are used to correct defects.	No gadgets are used.
7.	Bagua is the design tool.	Vastu purush mandala is the design tool.
8.	Prefer windows in south.	Do not prefer windows in south

Based on five fundamental components, both sciences use a comprehensive approach in determining their rules based on their respective geographic locations and climatic conditions. Both rely on organic factors to maintain equilibrium in the prana Shakti, or chi, flowing through the structure. By combining tangible and intangible, or metaphysical and physical, elements, both are able to turn the building into a living system. The Feng-shui yin and yang and the prakiriti and purush of Samakhyas (Sanskrit: "Enumeration" or "Number") are the same. And there is no difference and both emphases to unit them to make the building complete and live. Fundamentally, there is no difference between Vastu Shastra and Feng Shui; both attempt to create harmonious energy systems within buildings. The Feng Shui concepts of yin and yang are essentially the positive and negative energies described in Vastu Shastra and both emphasize using their approach and philosophy to balance them. **Hence it can be said that aims of Vastu Shastra and Feng Shui are same but methodology is different.**

CONCLUSION

The review of related literature in sections 2.1 and 2.2 reveals that Vastu Shastra is a comprehensive framework integrating elements of scripture, religion, science, and architecture. Often regarded as the ultimate building science, Vastu emphasizes a harmonious blend of visible materials - such as bricks and wood - with invisible cosmic forces like energy, wind, and light. This perspective illustrates that the built environment is not just a collection of structures but is intricately connected to the natural world. Vastu Shastra is termed a Universal Science, making its principles accessible to all, regardless of caste or creed, with the aim of creating dwellings that promote health and harmony for their inhabitants.

Many fundamental concepts of Vastu remain relevant in modern sustainable design practices. For instance, contemporary Passive Solar Design techniques that focus on energy efficiency reflect Vastu’s emphasis on orienting buildings to harness natural energy. This connection enhances the functionality of spaces and fosters a bond between inhabitants and their environment. Additionally, modern sustainable architecture aligns with Vastu principles by integrating the five elements - earth, water, fire, air, and space - to create balanced living environments. Such synergies suggest that, although ancient ideas may not have been framed in scientific terms, they can effectively support contemporary environmental design goals.

Furthermore, Vastu Shastra’s architectural legacy provides valuable insights into spatial arrangement and design, combining empirical observations with cultural beliefs to optimize built environments for human use and sustainability. This integration enhances understanding of how ancient design principles can inform modern practices, validating Vastu's relevance today and encouraging a dialogue between tradition and innovation. By examining the intersection of Vastu with modern sustainable practices, we can see its potential to inspire innovative architectural solutions that respect cultural heritage while addressing environmental challenges. For example, principles of natural ventilation and daylighting derived from Vastu can guide designs that reduce reliance on artificial systems, promoting energy conservation and supporting local ecosystems.

Ultimately, this understanding of Vastu Shastra positions it as a dynamic framework for addressing the complexities of modern architecture and sustainable living. By recognizing Vastu as a vital resource, architects and builders can create environments that enhance quality of life for future generations, bridging traditional wisdom with contemporary design challenges. This interdisciplinary approach underscores the importance of preserving ancient knowledge while embracing innovative practices, paving the way for a more sustainable and harmonious future.

2.3 INTRODUCTION TO PASSIVE SOLAR ARCHITECTURE

Passive Solar Architecture refers to the use of the sun's energy for the heating and cooling of living spaces. Passive implies that energy-consuming mechanical components like HVAC, pumps, fans etc. are not used (Akshay et al, 2017).

As per the climatic classification of NBC 2005, though India has a large variety of climate types, it is predominantly a country with tropical climate. Approximately, 90% of the area has hot dry, warm humid and composite climate. Therefore climate responsive buildings, in this context, are designed to avoid the heat gain but at the same time allow adequate daylight into the living space. Some of the passive design strategies adopted to optimize building design that controls heat gain and allows maximum natural light are as follows:

- Optimum orientation
- Using the shape of the building (plan, section) to control air flow.
- Internal space arrangement (thermal buffer zone/buffer spaces)
- Using materials to control heat.
- Allocation of building openings.
- Sizing of openings (limitation of window wall ratio and skylight roof ratio).
- Appropriate shading design (facade shading and fenestration shading).
- Adequate day lighting (optimum day lighted area and daylight factor).

Passive Solar Architecture has two parts namely:

a) **Passive Solar Heating**
b) **Passive Solar Cooling**

a) Passive Solar Heating: The objective of passive solar heating systems is to maintain a pleasant interior temperature by storing solar heat inside the structure of the building and releasing it when the sun is not there. South-facing glass and thermal mass are the two main components of passive solar heating since they both collect, store, and disperse heat. The methods for putting such aspects into practice vary.

b) Passive Solar Cooling: In order to reduce unnecessary heat gain throughout the day, create non-mechanical ventilation, exchange heated interior air for cooler outdoor air when practical, and retain night time coolness to help regulate warm daytime temperatures, passive solar cooling systems must be installed. Simple passive solar cooling solutions include cross ventilation, shade trees, overhangs or coverings on south-facing windows, and thermal mass.

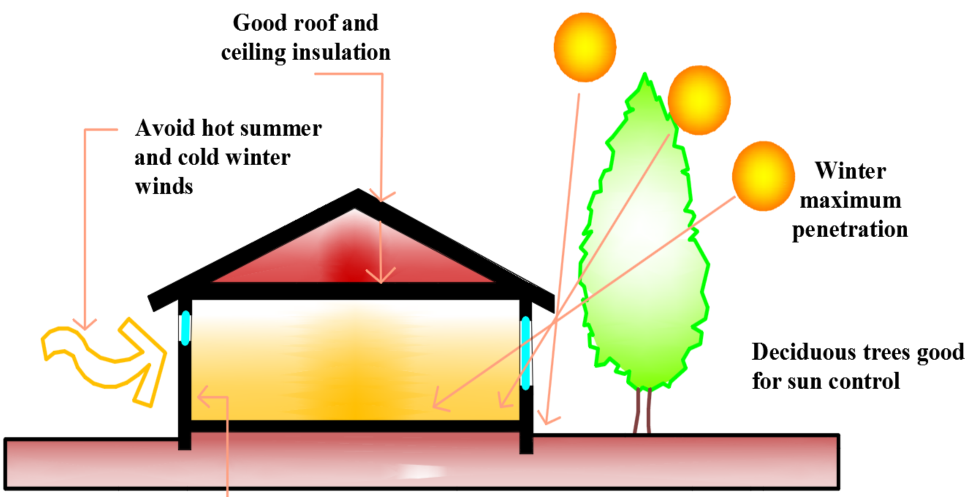


Fig. 36: Passive Solar Design

2.3.1 Passive vs. Active design

Passive Design results when a building is created and simply works on its own. The plan, section, materials selections and siting create a positive energy flow through the building and save energy.

Active Design uses equipment to modify the state of the building, create energy and comfort i.e.: Fans, pumps, etc.

Passive buildings require active users (to open and shut windows and blinds).

Passive solar heating and passive ventilation for cooling assist in creating sustainable buildings by reducing dependency on fossil fuels for heating and cooling buildings, as well as reducing the need for electricity to support lighting by using practices of day lighting in buildings.

2.3.2 Relationship between Passive Design and Sustainability

In LEED, Passive Design assists in gaining points in the Energy and Atmosphere category, as well as in Indoor Air Quality as Passive Design promotes natural ventilation and day lighting strategies.

However, not all Sustainably Designed buildings are strongly passive, and not all Passively Designed buildings are by default strongly sustainable (although this is more likely than the reverse).

Passive Buildings Require Active Users

Why Passive?

• Passive meets the minimum requirements.

• Active produces greenhouse gases such as (CO2).

• Active solar energy is expensive and more equipments are need for installation.

2.3.3 Description of Passive Systems

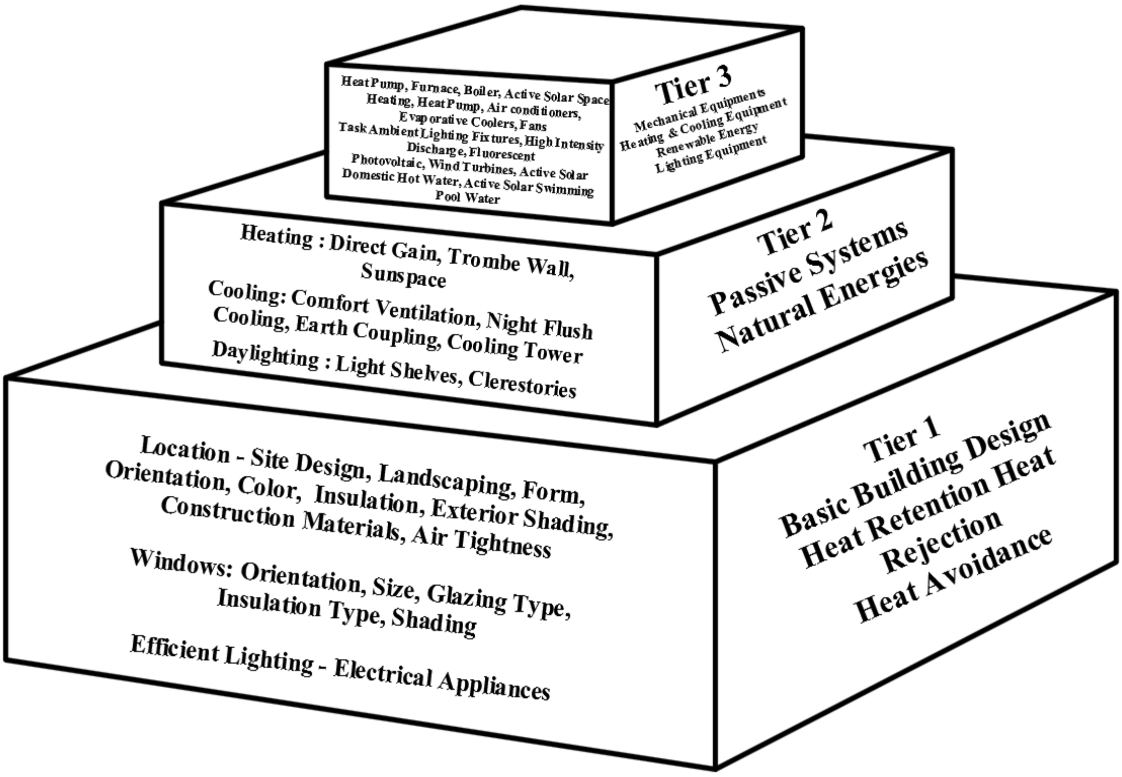


Fig. 37: The Three-Tier Approach to Sustainable Heating, Cooling, and Lighting of Buildings Passive Solar Design
(Source: Gunawardana, 2019)

2.3.4 Passive Solar Design (Thumb Rules)

1. The building should be elongated on an east-west axis.

2. The building's south face should receive sunlight between the hours of 9:00 A.M. and 3:00 P.M. (sun time) during the heating season.

3. Interior spaces requiring the most light and heating and cooling should be along the south face of the building. Less used spaces should be located in the north.

4. An open floor plan optimizes passive system operation.

5. Use shading to prevent summer sun entering the interior. Sun angles can help figure out the overhang calculations.

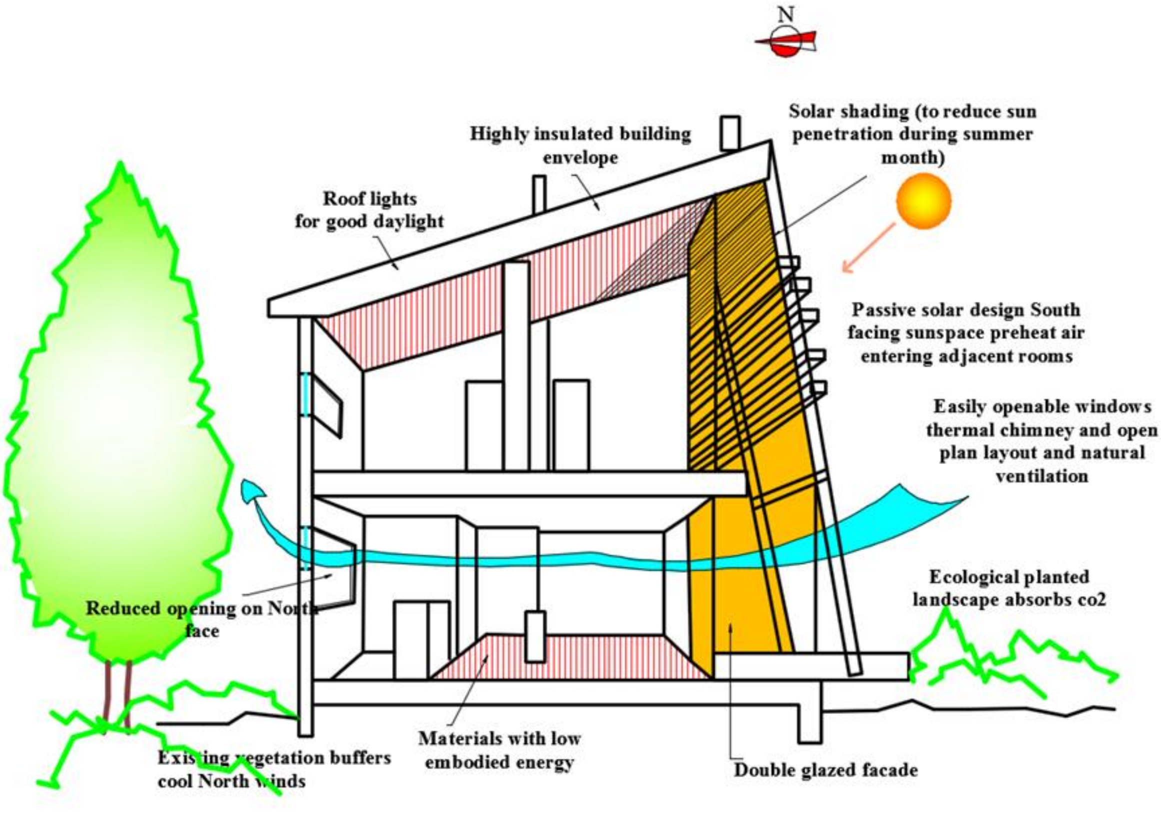


Fig. 38: Passive Solar Design Elements

2.3.5 Passive Solar Design Elements

- Landscaping
- Water bodies
- Orientation

- Site and Site Conditions
- Open spaces and built form
- Building envelope –Walls, Roof, Windows, Floor, Surface finishes
- Windows, Doors, Ventilators and other openings
- Sun Shades and chajjas
- Building structure
- Building material - Bricks, Stone, Timber, Lime, Sand stone, Jute fabric
- Load Distribution in Building

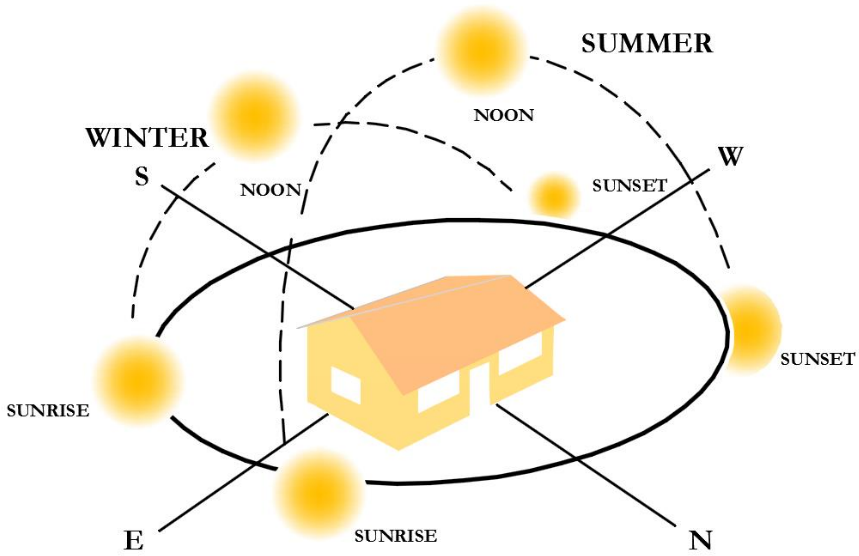


Fig. 39: Sun path During Summer and Winter

In passive solar homes, the low angled winter sun penetrates the south facing window to heat the home. During the summer, the high angled sun shines on the roofs of houses thereby reducing heat gain.

2.3.6 Passive Design Strategies: Legacy from the Past

Heritage buildings have various passive cooling strategies such as thick walls that have high thermal mass, high ceilings, courtyards and verandahs, solar shading devices like jaalis, canopies, still and moving water bodies for evaporative cooling, natural ventilation by means of wind induced flow to cool the indoor along with efficient day lighting and water management system (Hada, 2017).

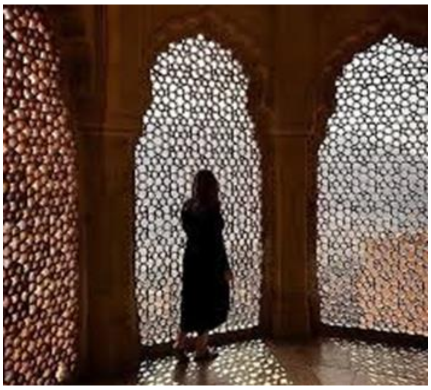


Fig. 40: Jaalis (Source: Pinterest, n.d.)

Fig. 41: Dense Clustering Layout at Jodhpur (Source: Pinterest, n.d.)

Fig. 42: Adalaj Ni Vav Famous Step Well in Ahmedabad (Source: Pinterest, n.d.)

Fig. 43: Fountain to Improve Air Quality (Source: Pinterest, n.d.)

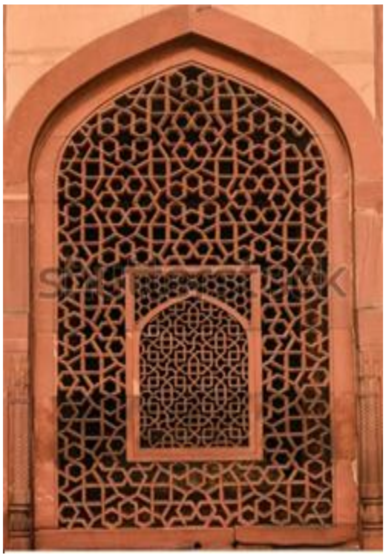


Fig. 44: A Water Body of Fatehpursikri (Source: Pinterest, n.d.)

Fig. 45: Ventilator (Source: Pinterest, n.d.)

2.3.6.1 Architectural Features in Historical Buildings

a. Jaali: in the wall eliminates direct sunlight, cuts glare but allows sufficient daylight to come in and also it maintains constant flow of air.

b. Ventilators: are openings usually located on the high end of the ceiling wall or on the top of windows which allows hot air to escape while maintaining cooler air inside and also lets light come inside the room.

c. Chowk: It is a centrally located open place surrounded by partly shaded places and/or fully shed places. It works chiefly as a source of sunlight and air for the activities occurring in the adjacent areas. The courtyard also serves as a microclimate modifier.

d. Parsal (Tibara): It is 4 partly shaded places surrounded on one side by the open place (courtyard) and on the other side by the fully shaded place Choubara/ Khadki. This place is shaded with low intensity of light. It has both “active” and “passive” activities and works as a “transitory” place and this is why it is the most “active” element of the dwelling (located between the fully shaded rooms and the open courtyard) it receives the light from the courtyard and takes it to the room.

e. Khadki (Choubara): It is a fully shaded place or rooms with Osari (a partly shade place) on one side, and either an open, or partly shaded place (Otala), on the other side.

Fig. 46: Carved Jharokha in Patwon ki Haveli Jaisalmer, Rajasthan (Source: Pinterest, n.d.)

Fig. 47: Veranda at Rambag Palace at Jaipur (Source: Pinterest, n.d.)

f. Jharokha/ Verandah: It is a projected place for shade, sun light, and breeze. A partly shaded or open place. However, Verandah is located on the ground floor, and Jharokha on the upper floors. Jharokha is meant to shade the lower storey and is exposed to the street for communication.

g. Otala (or Ota): It is the outermost place of a dwelling, either an open or a partly shaded place. At outdoor place attached to each dwelling, raised from the steer level and usually sheltered from above by a verandah or rooms.

Fig. 48: Indigenous Planning of Jodhpur
(Source: Pinterest, n.d.)

Fig. 49: Part of Domical Roof Is Always Shaded
(Source: Pinterest, n.d.)

Fig. 50: Courtyard at Rambag Palace at Jaipur
(Source: Pinterest, n.d.)

Indigenous planning layout was followed for palaces and simple small dwellings as seen in Shahjahanabad, Jaisalmer and many other cities in India. This type of a dense clustering layout ensured that the buildings were not exposed to the outer sun. The solar gain and the hot winds from entering the premises and also allows the cold wind to circulate within the building (Hada, 2017).

2.3.6.2 Planning Type and Thermal Mass

- A material that has thermal mass is one that has the capacity to absorb, store and release the sun's heat energy.
- The best way to cool a building is to build with thick stone or masonry.
- Thermal mass is measured in terms of 'Volumetric heat capacity'.
- When the outer temperature is lowered at night, the high emissive property of the walls allows cooling down the wall surfaces rapidly.
- Flat roofs get more radiation while vaulted and domed roofs prevent the absorption of heat of the summer's vertical sun.
- Thermal mass properties of some material are presented in Table 5:

Table 5: Building Materials with Their Conductivity and Heat Capacity

S No.	Material	Conductivity in W/m K	Vol. heat capacity in kJ/m3K
1.	Water	1.9	4186
2.	Cast concrete	1.4	2300
3.	Granite	2.1	2154
4.	Brick	0.72	1360

2.3.6.3 Evaporative Cooling and Landscaping

Evaporative cooling is extensively used in ancient architecture for example Amber Fort; Rajasthan, India comprises a garden which has been positioned just at the centre of the lake to modify the microclimate for comfortable outdoor sitting during summers.

The concept can be seen in Deegh Palace, Bharatpur, where the entire building has been surrounded by water body and landscaping or by a water garden. The small spaces were constructed to keep them sheltered from the sun by the neighbouring buildings. In case of large open spaces, plantation and water pools were used as landscaping elements to protect them from the solar gains (Gupta, 2017).

Fig. 51: Passive Cooling of Amber Fort in Rajasthan
(Source: Pinterest, n.d.)

Fig. 52: Deeg Palace, Bharatpur
(Source: pinterest, n.d.)

Fig. 53: Taj Mahal, Agra
(Source: Pinterest, n.d.)

The Taj mahal uses a number of passive cooling techniques to keep the interior part well lit and airy. There are jaalis, huge domes, walls with high thermal mass, cross ventilation, the use of green spaces and water bodies around the built form, etc. All these features help the building become cooler especially in the summer months.

2.3.6.4 Radiative Cooling and Courtyard Planning

Fig. 54: Haveli, Shekhawati, Rajasthan (Source: Pinterest, n.d.)

Fig. 55: Courtyard with Vegetation and Water Body Enhances Humidity (Source: Pinterest, n.d.)

Courtyard planning is visible in havelis and forts of Rajasthan, India for cooling effect. Courtyards were the main architectural element used in planning generally integrated with water bodies, vegetation and usually open to sky to enhance evaporative cooling, provision of shade and infuse maximum daylight in the buildings. The lower floors are used to spend the hot days while the nights are spent on the terrace taking advantage of the radiative cooling and the rooftops are sprinkled with water for evaporative cooling effect. There was no provision of a parapet wall towards the courtyard and solid parapets were constructed towards the street. Large openings are provided towards the courtyard to take advantage of radiative cooling so that the cool air is passed through the interiors. Due to incident solar radiation in a courtyard, the air gets warmer and rises. Cool air from the ground level flows through the louvered openings of rooms surrounding a courtyard, thus producing air flow. At night, the warm roof surfaces get cooled by convection and radiation. If this heat exchange reduces roof surface temperature to wet bulb temperature of air, condensation of atmospheric moisture occurs on the roof and the gain due to condensation limits further cooling (Gupta, 2017).

2.3.6.5 Openings and Ventilation

Fig. 56: Different Types of openings / jharokhas (Source: Pinterest, n.d.)

Outdoor breezes create air movement through the house interior by the push-pull effect of positive air pressure on the windward side and negative pressure (suction) on the leeward side. In order to have good natural ventilation, openings must be placed at opposite pressure zones. With openings near the top of stacks, warm air can escape whereas cooler air enters the building from openings near the ground (Gupta, 2017).

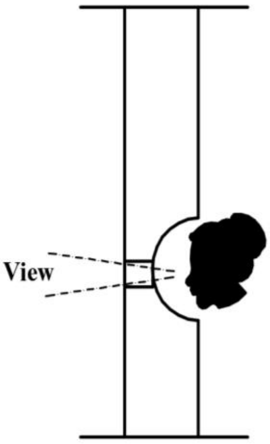


Fig. 57: Small Openings For Visual Connection

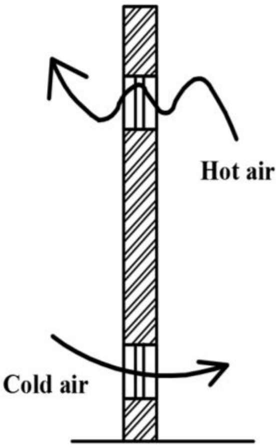


Fig. 58: Openings near Floor and Roof for Ventilation

Fig. 59: Junagarh Fort, Bikaner, Rajasthan (Source: Pinterest, n.d.)

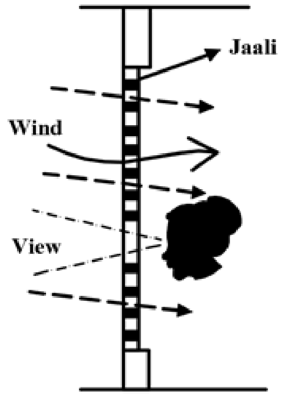


Fig. 60: Ventilation and Visual Connection with Jaali

Fig. 61: Junagarh Fort, Bikaner, Rajasthan (Source: Pinterest, n.d.)

The windows play a dominant role in inducing indoor ventilation due to wind forces. Exhausting the warm air quickly can be a problem. With the design of high ceilings throughout the breeze zone combined with clerestory windows at the 14’ ceiling height on three walls, the rising hot air is allowed to escape which in turn does two things.

2.3.6.6 Natural Cooling System - example of Hava Mahal Jaipur

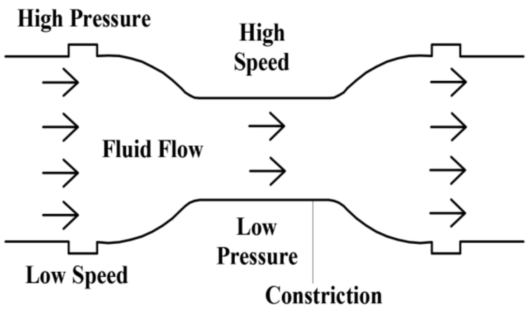


Fig. 62: Hava Mahal Jaipur (Source: Pinterest, n.d.)

Fig. 63: Venturi Effect

Hawa Mahal in Jaipur has 953 windows, known as jharokhas that maintain air ventilation and also keeps temperature low. The Hawa Mahal in its fundamental design resembles a honeycomb structure. The Hawa Mahal was designed by architect Lal Chand Ustad for Maharaj Sawai Pratap Singh. The original function of the building was to allow women to watch processions on the streets below, through the intricate jharokhas, without a threat to their modesty. It is designed like a natural cooling system, based predominantly on the ‘Venturi Effect’ in Physics. The 953 perforations in the facade serve as a device that generates wind for those who stand; inside at its ramping corridors. The fractal design, with its self- Venturi Effect repeating pattern at every scale - is scaling up to the fourth floor. The air blown through is compressed, very similar to the ordinary laws which govern a modern day air-conditioner and is reflected through its curvy linear bay windows. Hawa Mahal makes it a very climate responsive building, to the point where it is dubbed as a 'natural air-conditioner' (Sarswat & Kamal, 2015).

2.3.6.7 Solar Shading Devices

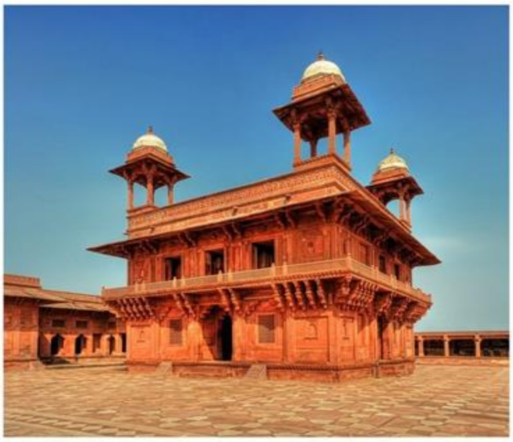


Fig. 64: Fatehpur Sikri, Agra (Source: Pinterest, n.d.)

Fig. 65: Courtyard at Jahangiri Mahal, Agra (Source: Pinterest, n.d.)

Solar shading devices is another control medium for solar heat gains in form of horizontal (canopies, awnings, horizontal louvers, and overhangs), vertical (vertical louvers, projecting fins), screening (movable insulations, vegetation etc.) or egg crate devices (jalis, grills). These devices reduce the heat gains and thus provide comfortable indoor temperature, reducing the cooling costs and also act as an aesthetic element. Mughal architecture used inclined and deep shades to cover more surface area with deep carvings which creates a self-shading effect. Horizontal shading devices are best suited for south oriented whereas vertical for east and west facing facades. This chart demonstrates the variation in solar energy received on the different facades and roof of a building set at 42 degrees latitude. A horizontal window (skylight) receives 4 to 5 times more solar radiation than the south window on June 21. East and west glazing collects almost 3 times the solar radiation of the south window. Little winter heating can be expected from east and west windows, shading devices on those orientations can be designed purely on the basis of the summer requirement (Gupta, 2017).

2.3.6.8 Shading Strategies for East and West Elevations

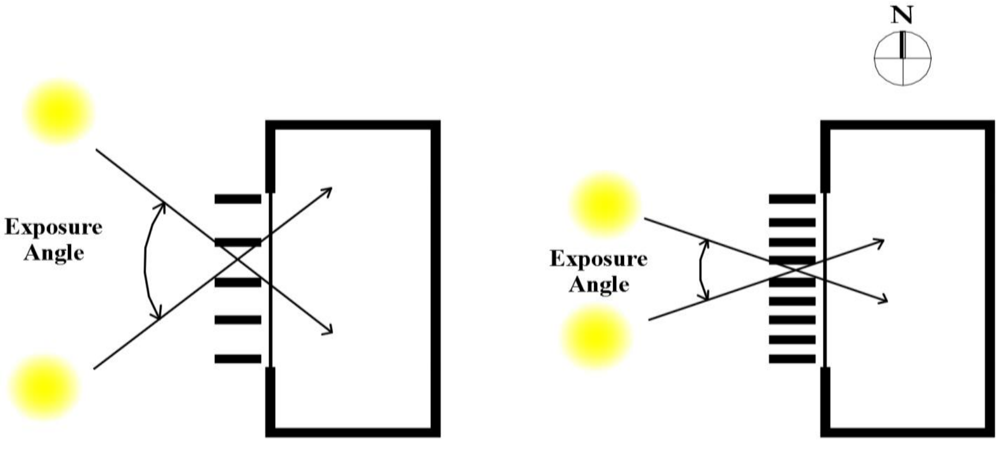


Fig. 66: Solar Penetration Is Reduced by Moving Fins Closer Together, Making Them Deeper, or Both

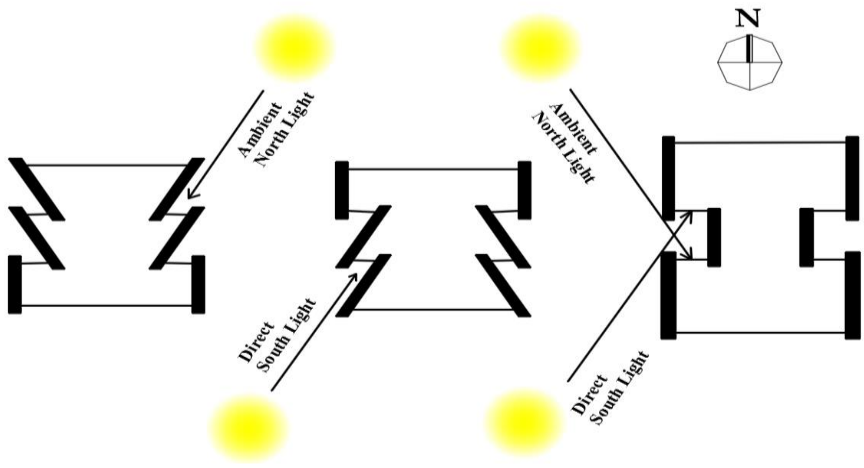


Fig. 67: Shifting East and West Side Windows to Face North and South

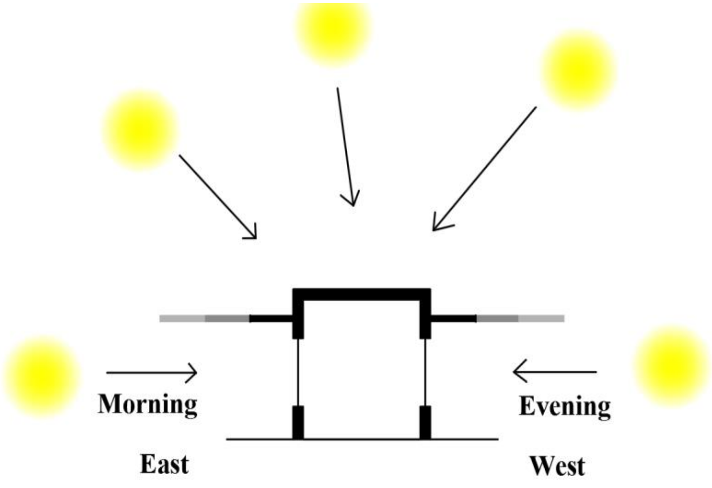


Fig. 68: Horizontal Overhangs (They Do Not Work on East and West Facades)

The best solution by far is to limit using east and especially west windows (as much as possible in hot climates)**.** Next best solution is to have windows on the east and west facades facing north or south**.** Use Vertical Fins.

2.3.6.9 Shading Strategies for the North Elevation

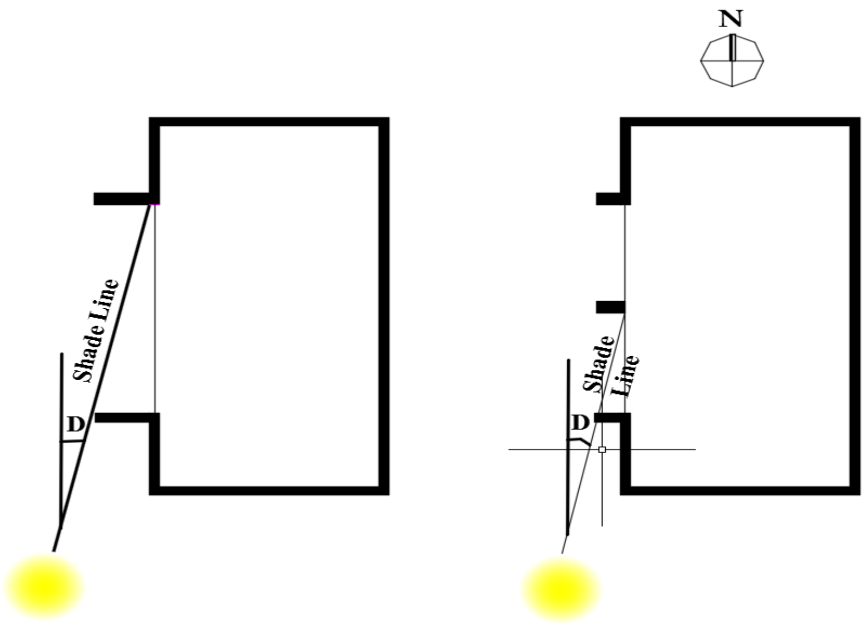


Fig. 69: The Shade Line at Angle D Determines Fin Spacing and Depth

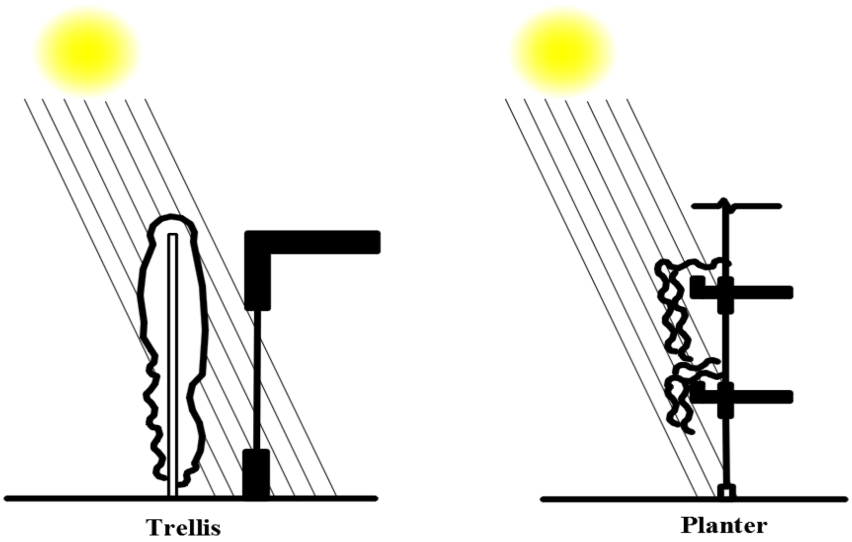


Fig. 70: Shade Option

The Sun also hits the facade from the northeast and northwest during the summer. Fins can be used to control this oblique light as well. It is a function of the latitude, window size and fin depth/frequency. Living Awnings such as deciduous trees and trellises with deciduous vines are very good shading devices. They are in phase with the thermal year – gain and lose leaves in response to temperature changes.

2.3.6.10 Comfort Cooling: Wind Towers

Fig. 71: Wind Tower in Jodhpur Hostel to Catch Favourable Cool Wind from Southwest for Passive Cooling

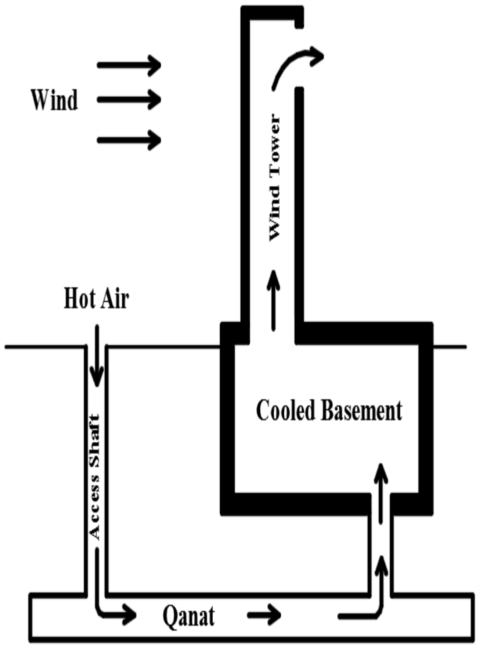


Fig. 72: A Wind Catcher and Qanat Used for Cooling

(Source: Pinterest, n.d.)

The tower walls absorb heat during daytime and release it at night, warming the cool night air in the tower. Warm air moves up, creating an upward draft, and draws cool night air through the doors and windows into the building. The system works effectively in hot and dry climates where fluctuations are high. A wind tower works well for individual units, not for multi-storeyed apartments. In dense urban areas, the wind tower has to be long enough to be able to catch enough air. Also, protection from driving rain is difficult. The windows play a dominant role in inducing indoor ventilation due to wind forces. Other passive cooling techniques that induce indoor natural ventilation and are used by architects to achieve passive cooling.

2.3.7 Merits of Passive Solar Design

Sharma (2024) states that passive design concepts hold significant value in projects even where active design strategies are employed. This is due to the fact that they offer dependable, reasonably priced, and energy-efficient building design solutions. They contribute to better indoor comfort, increased energy efficiency, aesthetics and sustainable qualities.

- Indoor Comfort
- Health and wellbeing
- Energy efficiency
- Durability and longevity
- Affordability
- Sustainability

By maximizing natural ventilation and reducing direct light exposure, passive design techniques can produce a cozy indoor atmosphere. This can result in an indoor environment free of drafts, hot spots, and indoor air pollution that is more comfortable and healthy. Passive design strategies can improve health and well-being by promoting natural ventilation, reducing indoor air pollution, and providing access to natural light. Passive design techniques can drastically lower a building's energy usage because they rely on natural sources for lighting, ventilation, heating, and air conditioning, whereas active design relies on mechanical operations. Lower energy costs and a smaller carbon impact may result from this. The use of basic, low-maintenance systems and long-lasting materials in passive design strategies can extend the life of a structure and lessen the need for regular replacements or repairs. Passive design techniques can minimize the original cost of construction as well as ongoing operating costs by lowering the reliance on mechanical systems, which opens up the possibility of developing sustainable buildings at a cheaper cost to a wider variety of individuals. Passive design strategies align with the principles of sustainability by reducing the use of non-renewable resources and minimizing the environmental impact of the building.

2.3.8 Example of a House Based on Passive Solar Architecture and Vastu Shastra Principles in Composite Climate

Residence of Madhu and Anirudh, Panchkula

Fig. 73: Residence of Madhu and Anirudh, Panchkula (Source: TERI Bookstore)

A tiny residence in the composite zone has adapted to the needs of the climate through easily implementable, affordable solutions. The city of Panchkula is located in a diverse climate backdrop in the plains at the base of the lower Himalayas.

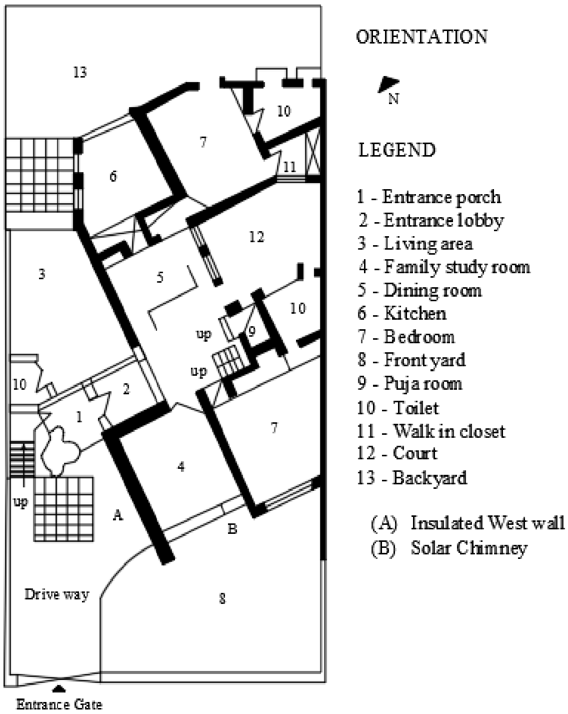


Fig. 74: Building Plan with an Angular Shape to Give the Majority of the Room's Southern Exposure(Source: TERI Bookstore)

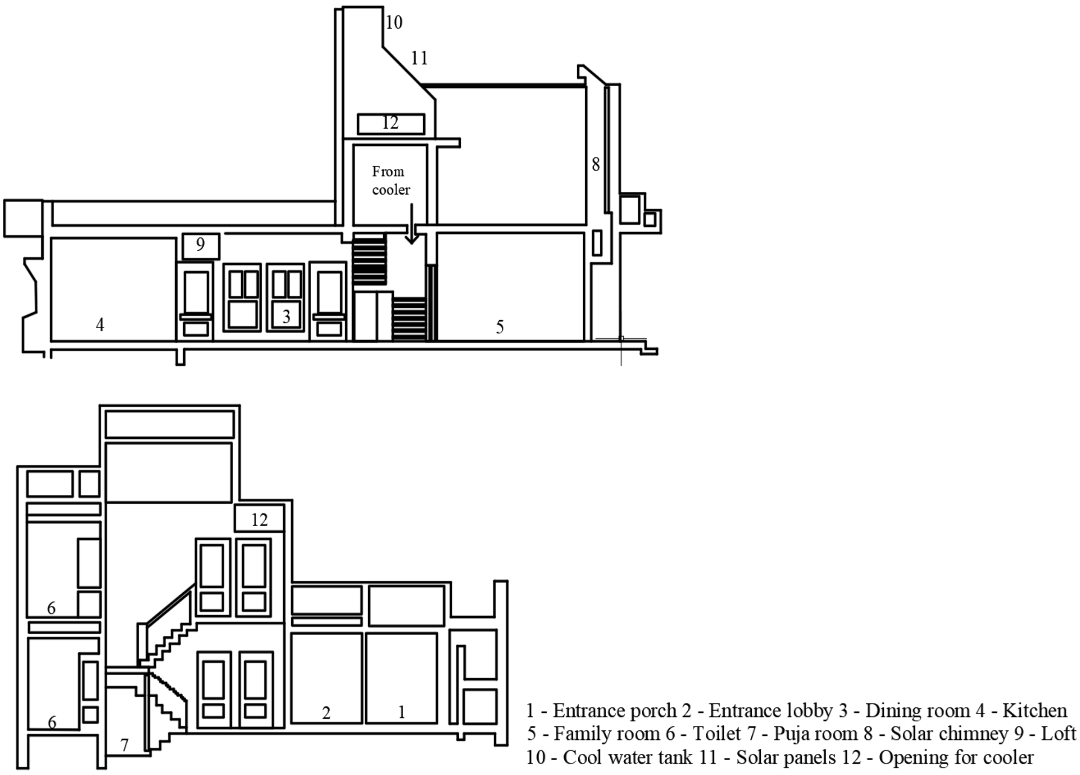


Fig. 75: Building Section Displaying the Rooms' Centralized Evaporative Cooling System (Source: TERI Bookstore)

Wide climatic fluctuations occur throughout the year in Panchkula, including a very hot and dry period lasting approximately two and a half months (highest DBT 44°C), and a very chilly one lasting a shorter time (minimum DBT 3°C). After the hot, dry season, a hot, humid monsoon season lasts for about two months (maximum DBT 38°C and highest relative humidity 90%), with cooler weather in between. As a result, it is imperative that building designs adapt to the extremes: eliminate or minimise heat gain in hot and dry periods, maximise ventilation from zones/areas built as heat sinks in hot and humid periods, and maximise heat gain in cold periods.This compact home is situated on a 245 m^2 rectangular site with a southwest facing entrance. The master bedroom and the study/family room face the south and are situated around a courtyard. While the second bedroom on the ground floor opens to the north and receives direct sunlight from the court, the living room faces north. The dining area is situated near the courtyard as well. The building is made of load-bearing brick and an RCC slab. Sheesham wood is used for the woodwork on the doors and windows, and brick and polished stone make up the floors (Majumdar, 2001).

Remarkable Features

To properly manage the sun, the main structure was pointed due south. The South facade is determined by properly constructed south blinds combined with light shelving. The dining room and the back bedroom both have wonderful lighting receiving from the courtyard. The orientation meant that the rooms would receive enough light and the winter sun (while blocking the summer). The nearby structure blocks the east sun, and 50 mm of polystyrene is used to insulate the west wall (Majumdar, 2001).

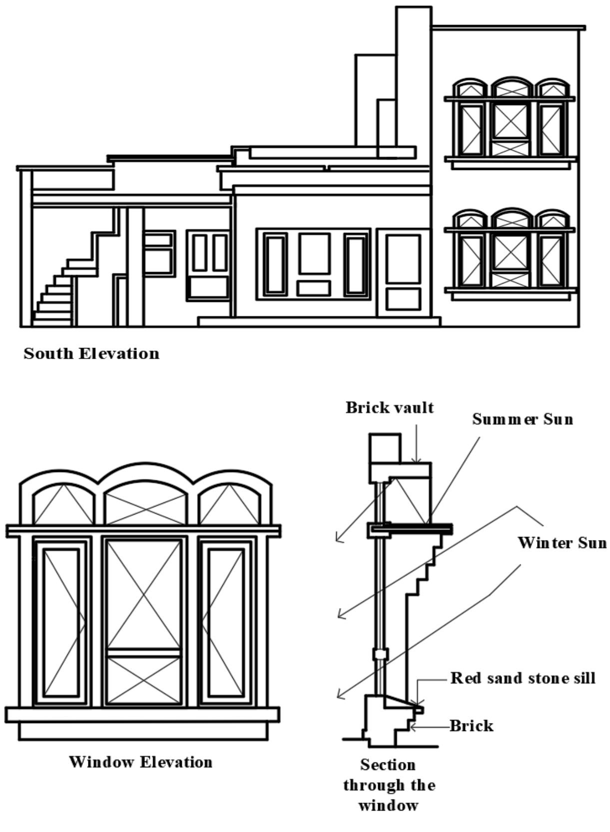


Fig. 76: Windows Let in Winter Sunlight While Blocking Summer Heat (Source: TERI Bookstore)

The rooms have enough day lighting due to their white ceilings and light shelves. Over the stairwell, there is a central evaporative cooler. An additional air current is produced by a solar chimney that draws air from the living room. Even when the doors are closed, airflow is maintained by louvers in the doors (Majumdar, 2001). Solar water heating or solar photovoltaic panels, depending on the situation, may be architecturally integrated into the slab that slopes upward above the stairs. More light is reflected down the stairs from the well's north face.

- **Solar chimney** has been provided to enhance ventilation.
- The building is oriented in such a way that it catches the sun in winter and avoids it in summer.
- Western wall is properly insulated.
- Proper day lighting and shading is induced in the building.

Systems Installed Inside the Building:

- Central evaporation cooling would be provided by an evaporative cooler with a 24” fan size and 2.5m^2 pad area.

Renewable Energy Systems Installed in the Building:

- Solar photovoltaic system
- Solar hot water system

The building incorporates several key features of Vastu Shastra, which is reflected in its thoughtful design aimed at maximizing harmony and functionality. One of the most notable aspects is the arrangement of rooms around a central courtyard. This layout not only facilitates an aesthetic appeal but also ensures that each room benefits from abundant natural light and ventilation, enhancing the overall living experience. The central courtyard serves as a vibrant focal point, allowing sunlight to penetrate deep into the interior spaces, creating a warm and inviting atmosphere throughout the day.

In terms of specific room placements, the kitchen is strategically located in the southeast corner of the dwelling. This positioning aligns with Vastu principles, as it is believed that having the kitchen in the southeast enhances the cooking experience and promotes positive energy flow. The placement allows for optimal natural light, which is essential for food preparation and contributes to the overall health and well-being of the inhabitants.

The master bedroom, on the other hand, is situated in the southwest corner of the house. This placement is in accordance with Vastu guidelines, which suggest that the master bedroom should be located in this direction to foster stability and a sense of security. The Southwest orientation is associated with strength and is thought to enhance restful sleep and tranquility, making it an ideal space for relaxation and rejuvenation.

Furthermore, the central area of the dwelling is intentionally left open, which is a fundamental principle of Vastu Shastra. This open space not only serves as a communal area but also acts as a vital breathing space within the home. It promotes a sense of connection among the inhabitants and allows for the circulation of fresh air, further enhancing the overall comfort and livability of the house. This openness can also facilitate various activities, such as family gatherings or outdoor relaxation, thereby fostering a strong sense of community and well-being.

Overall, the incorporation of these Vastu Shastra features reflects a commitment to creating a harmonious living environment that balances aesthetics with functionality. By prioritizing natural lighting, thoughtful room placements, and open communal spaces, the design embodies the principles of Vastu, ultimately contributing to the health, happiness, and well-being of its residents.

The building posses few of the features of Vastu Shastra like all the rooms are placed around the central courtyard through which natural ligting is achieved in the rooms. The placement of kitchen is in southeast whereas master bedroom is placed in southwest. The centre part of the dwelling is left open.

CONCLUSION

From the review of literature presented in the third section (section 2.3), it can be concluded that for the next few decades, passive solar building design will stay the same based on the materials and techniques that are currently accessible. In a composite climate, designing a passive solar building can be more challenging and requires careful planning to balance the needs for thermal comfort all year round. To optimize passive solar energy benefits, the strategies and approaches currently in use will be repeated in different ways based on the area and availability. The advancement of passive solar energy necessitates the creation of new techniques, technologies and more suitable, effective resources. Simple procedures can greatly enhance comfort and reduce energy consumption over time, leading to improved living environments.

2.4. RESEARCH GAPS IDENTIFIED

In order to find research gap, various research papers for the concepts of Vastu Shastra and Passive Solar Architecture has been studied and presented as following:

According to the aforementioned study, Vastu Shastra was contrasted with other key ideas in psychology (Karni, 2014), philosophy (Patra, 2017), seismic design (Singh et al., 2011), modern building science (Gupta, 2016), and feng shui (Saran et al., 2017). It was discovered that efforts have been made to look at the parallels and discrepancies among each of these principles. The main goal was to identify commonalities between all the concepts in order to better understand the relationship between humans and the built environment, the influence of nature on human life, the psychology of architecture, how to improve a building's seismic performance, create a built environment that is compatible with its occupants, improve the psychological well-being of both owners and users, find a practical and efficient method of integrating science and technology into design, and address the issue of sick building syndrome.

Surveys were also done in order to find out the choices and preferences in constructing and renovating their residences as per the principles of Vastu Shastra. Location of kitchen, puja room and underground water tank were the major concerns for the purpose of investigation (Batra et al., 2018).

Settlement designs based on Vastu Shastra planning concepts were also studied (Sinha, 1998). Some of the major cities like Jaipur, Varanasi and Chandigarh have been chosen for this purpose. The articles tried to find out the background of Settlement design as it was mentioned in the ancient treatises of medieval India. The basic objective of this study was to examine the structure of Vastu-designed cities.

The principles of Vastu Shastra were often considered as a traditional architectural belief system which deals with the principles designed to make the most use of the environment and more specifically climate as one of its dominant factors. It was stated that based on the knowledge of the Sun Rays, the Earth’s Magnetic Poles and the Geopathic Zones, many rules have been implemented in ancient Indian architecture dealing with environmental requirements which are now considered superstitions. It was found that the proper use of Vastu Shastra principles along with its environmental criteria may lead to sustainable design and hence the energy consumption of the building is reduced thereby creating an enhanced micro climate with increased human comfort (Fazeli et al., 2010).

According to historical studies, the Indian architectural method based on Vastu Shastra had an influence on the construction of traditional Iranian houses. It is found that the most of the patterns available in traditional Iranian houses are the evolutionary models of the traditional architectural system of Indo-Aryan culture or Vastu Shastra (Goodarzi et al., 2014).

In ancient texts it was found that Vastu Shastra has its astrology logic and still it fulfils all the concepts of advanced engineering of the modern day. The study explained examples related to earliest surviving astronomical architecture. It also described that there exists a direct relation between architecture and astronomy. In the midst of opportunistic trends and consequent chaos on the socio-political and even religious fronts the legacy of ancient wisdom lost its originality and grasp on the life of people. The influence of western culture, the greed of builders and contractors, limitation of space and growing population ruins the importance of Vastu Shastra in modern times (Gupta, 2015).

A study was carried out to explain the value of sustainable planning in the life of today by listing the environmental problems that sustainable architecture can minimize. It further explained the relevance of Vastu Shastra in the world of sustainable development. The main purpose of this paper was to study those design principles of Vastu Shastra which leads to the concept of sustainable development of the society (Soni et al., 2019).

It was also found that Solar Passive Architecture is the best choice particularly for the construction sector for sustainable development and to reduce the environmental pollution. Solar energy is a very attractive energy resource because of its pollution free nature, virtually inexhaustible supply and global distribution. The Solar Passive Architecture is called to make a building suitable for human occupancy with minimal use of energy (Hada, 2017).

Much work is carried out by world-wide studies on passive architecture methods and specific techniques are implemented to minimize the temperature and conserve energy (Borzooeian, 2014). As we know, the rapid growth of pollution and environmental degradation can harm the human body. The use of more passive strategies can aid recycling resources and help to preserve the world (Pitroda et al., 2016).

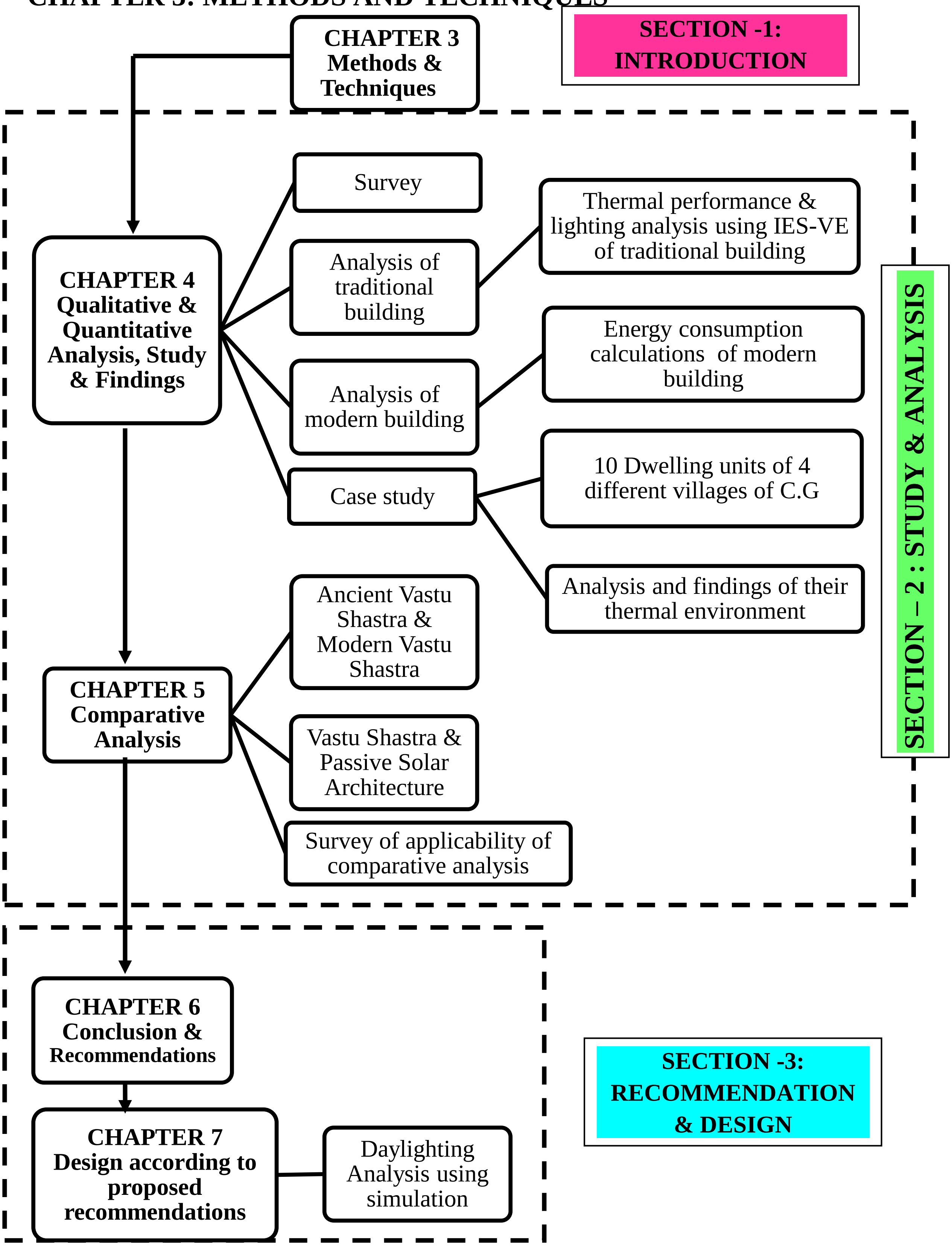
Based on the above summary of literature review, it is understood that Vastu Shastra is scientific and can be applied to the construction of modern times. **Moreover the basic concepts of Vastu Shastra are dependent on the movement of sun and its effects.**

There is almost non exientence of study related to establish the relationship between Vastu Shastra concepts and Passive Solar Architecture till date and therefore this research is being carried out to integrate the Passive Solar Architecture and Vastu Shastra in terms of design principles.

CHAPTER 3

METHODS AND TECHNIQUES

CHAPTER 3: METHODS AND TECHNIQUES



The first chapter after Methods and Techniques is the Qualitative and Quantitative analysis and study and findings and it consists of four parts namely Survey, Analysis of traditional building, Analysis of modern building and Case study.

A survey has been carried out in the first part. To find out how Vastu Shastra principles were applied and preferred in residential building design, construction, and renovation in Durg, Chhattisgarh, a thorough assessment was carried out. The respondents were specifically chosen from the Durg area and planned to build or modify their homes within the following two years. The purpose of concentrating on this particular region was to assess how well the concepts of Vastu Shastra were being adopted and applied in a regional setting.

For the investigation, a multistage purposive cum random sampling approach was used. The Probability Proportion to Size (PPS) approach was used to pick 384 respondents in total from five wards in Durg city. A systematic questionnaire was used in conjunction with observation and interviewing techniques to obtain data. To make sure the questions were reliable and clear, pretesting was done. Furthermore, two specialists in the domain examined the questionnaire to verify that it attained an acceptable degree of content validity. To confirm the questionnaire's efficacy, twenty non-sampled respondents were also given it.

This analysis investigates respondents' knowledge, comprehension, perception, belief, and application of Vastu Shastra concepts. To quantify these preferences, statistical metrics such as mean, median, variance, standard deviation, and Chi-Square Test were computed. Formulae for Statistical Analysis

Mean Calculation

$$\text{Mean} = \sum_{i=1}^{25} \frac{x_i}{\text{n}}$$

Where:

- x_i = Individual response
- n = Total number of respondent

Standard Deviation Calculation

S.D. $= \frac{\sqrt{\sum_{i=1}^{n}(x_i - Mean)^2}}{n-1}$

Where:

- x_i = Individual response
- n = Total number of respondent
- M = mean of the responses

Variance Calculation

Variance $= \frac{\sum(\boldsymbol{x_i} - \boldsymbol{\bar{x}})^2}{\boldsymbol{N}}$

Where:

- x_i = Individual response
- $\bar{x}$ = Total number of respondent
- N = mean of responses

Chi-Square Test: In order to acertain whethere a statistically significant disparity exists among the responses to various inquiries it is feasible to conduct a Chi-square test.

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

O_i = Observed Frequency

E_i= Expected Frequency

The analysis was carried out to find out awareness and perception of Vastu Shastra among respondents.

A comprehensive investigation of the traditional dwelling unit in the small village of Dagania, District Durg, Chhattisgarh, was carried out by visiting the site in the second part. The plan was looked over and recorded with the other characteristics of the residential unit. After speaking with the owner, it was discovered that the courtyard of the dwelling unit had undergone two transformations. The thermal comfort level of the dwelling unit was evaluated using thermal performance analysis of the Original form of building (OFB) and Second transformation of Original form of building (ST-OFB) in comparison to the structural modifications made to the courtyard. Furthermore, a day lighting analysis was carried out using IES-VE (Integrated Environmental Solutions-Virtual Environment) to ascertain the influence of day lighting on the different stages of the courtyard makeover.

The third investigation of the first Passive Solar Building in the state, namely the Chhattisgarh State Electricity Regulatory Commission (CSERC) Building in Raipur, Chhattisgarh was performed. A variety of energy-efficient elements and passive and active solar design elements were objectively observed in order to determine the building's overall impact on energy consumption. The total energy generation, consumption and transmission to Chhattisgarh State Electricity Board (CSEB) Grid for consecutive three year starting from 2011 to 2014 has been collected, observed and evaluated.

Site visits were carried out to perform case studies of ten traditional dwelling units spread across four distinct villages in Chhattisgarh: Kodia, Borsi, Chhattarpur, and Mohradih in the fourth part. The typical dwelling units that have the central courtyard were specifically chosen for the Case study. Many architectural design features that adhere to the concepts of Vastu Shastra and Passive Solar Architecture have been noticed, discussed and mentioned. More research was conducted using a questionnaire approach to assess their comfort levels and surroundings temperature. The questionnaire was administered to two subject experts for pilot testing to confirm its content validity. The feedback on question clarity, length and relevance was collected and necessary adjustments were made based on feedback of the experts to improve the questionnaire. The questions were asked to the home owner alongwith the family members and a collective answer was noted using likert scale. Moreover, many conclusions have been drawn in light of the replies provided by the respondents.

In chapter 5, a comparative analysis of Vastu Shastra between ancient and current times was conducted by studying the literature from various texts, research papers, online contents and books in the first portion, and conclusions were formed from the analysis. The above represents the first section of the study.

The second portion included a comparison of Passive Solar Architecture with Vastu Shastra, from which some general conclusions were reached based upon the observations.

Subsequently, in the third segment, a comprehensive survey of applicability of comparative analysis was administered to elucidate the practical correlation between the principles of Vastu Shastra principles and Passive Solar Architecture. In the study, a random purposive sampling approach was used. Using the Probability Proportion to Size (PPS) method, 384 respondents in total were selected from five wards of Durg city. A systematic questionnaire was used in conjunction with observation and interviewing technique to obtain data. A Likert scale was chosen for measuring the respondents' responses. To make sure the questions were reliable and clear, pretesting was done. Two subject matter experts examined the questionnaire to make sure its content validity was appropriate. The questionnaire was administered to 20 non-sampled respondents to confirm the questionnaire's efficacy. The study is limited to residential buildings and does not explore commercial or industrial buildings. The questionnaire has five sections namely Knowledge and Understanding, Advantages of Vastu Shastra, Advantages of Passive Solar Architecture, Combined Impact of Vastu Shastra and Passive Solar Architecture on Wellbeing, and Satisfaction and Preferences. Each section consists of different set of questions.

Formulae for Stalistical Analysis

Chi-Square Test: In order to acertain whethere a statistically significant disparity exists among the responses to various inquiries it is feasible to execute a Chi-square test.

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where:

- O_{ij} = Observed Frequency
- E_{ij} = Expected Frequency

The primary goal of the Survey is to establish that these principles are closely related and beneficial, particularly in the context of composite climate of Durg, Chhattisgarh region.

Based on the literature study, surveys, case studies, and comparative analysis, a number of conclusions have been made that highlight the parallels and overlaps between Vastu Shastra and Passive Solar Architecture, in Chapter 6. Additionally, some recommendations for the construction of energy-efficient and more sustainable buildings have been outlined for city of Durg, Chhattisgarh for heighted residential dwellings.

In chapter 7, an Apartment design based on the ideas has been suggested for composite climate of Durg, Chhattisgarh. Various design features common to Vastu Shatra and Passive Solar Architecture like placement of rooms, courtyard, placement of windows, and shading devices was incorporated in the design. Using Revit software, day lighting simulation has been performed to assess the practicality of the proposed design. The chapter highlights the research's contribution to architecture, blending traditional and modern techniques to address climate challenges, and suggests areas for future research to improve residential design in India's diverse climates.

This study examines the scientific foundations of Vastu Shastra and evaluates the suitability of Passive Solar Architecture for Durg, Chhattisgarh's climate. It briefly compares the principles of both, focusing on the shared element of the Sun, and uses common guidelines from each to generate design recommendations. A residential unit in Durg is designed based on these guidelines, and daylight simulation is conducted to assess the feasibility of reducing energy consumption while adhering to Passive Solar Design and Vastu Shastra principles.

CHAPTER 4

QUALITATIVE & QUANTITATIVE ANALYSIS, STUDY & FINDINGS

CHAPTER 4: QUALITATIVE AND QUANTITATIVE ANALYSIS, STUDY AND FINDINGS

Summary: This chapter is organized into four distinct parts, each addressing critical aspects of Vastu Shastra and its application in residential construction and renovation, particularly in the context of Durg, Chhattisgarh. The four parts are as follows:

1. **SURVEY**
2. **ANALYSIS OF TRADITIONAL BUILDING**
3. **ANALYSIS OF MODERN BUILDING, and**
4. **CASE STUDY**

In the **first part**, a comprehensive survey is conducted to assess the preferences for applying Vastu Shastra in the construction and renovation of residential buildings in Durg. This survey aims to gather insights from local residents, architects, and builders regarding their understanding and prioritization of Vastu principles. It explores how these preferences influence decision-making in design and construction processes, revealing the extent to which traditional practices are integrated into modern building methods. The findings from this survey not only highlight community attitudes towards Vastu but also provide a valuable context for understanding the relevance of these principles in contemporary residential architecture.

The **second part** of the chapter focuses on the **analysis of traditional buildings in India**. This section involves a detailed examination of the thermal performance and daylighting characteristics of traditional structures. By utilizing simulation tools and empirical measurements, the chapter assesses how traditional architectural designs optimize natural light and thermal comfort, thereby enhancing energy efficiency. This analysis serves to demonstrate the environmental benefits of traditional practices rooted in Vastu Shastra, providing evidence of their effectiveness in creating sustainable living spaces. It also highlights how these buildings respond to local climatic conditions, offering insights into their resilience and adaptability.

In the **third part**, the chapter shifts its focus to the **analysis of modern buildings in India**. This section evaluates the energy consumption patterns of modern residential structures over a three-year period, aiming to ascertain their energy efficiency. By collecting data on energy usage and comparing it with benchmarks, the chapter identifies trends and challenges in the contemporary architectural landscape. This analysis underscores the importance of integrating sustainable practices in modern design and highlights areas where Vastu principles could potentially enhance energy performance, bridging the gap between traditional wisdom and modern technological advancements.

The **fourth part** presents **case studies of existing dwelling units** across four different villages in Chhattisgarh. This section provides a comparative analysis of these dwellings, focusing on their thermal environments and overall performance. By examining factors such as ventilation and orientation, the chapter evaluates how these homes function in their specific climatic contexts. The insights gained from these case studies illustrate the practical implications of Vastu Shastra in everyday living conditions, demonstrating its relevance in rural settings and the potential for improving thermal comfort and energy efficiency through thoughtful design choices.

Overall, this chapter not only investigates the application and impact of Vastu Shastra in residential architecture but also provides a nuanced understanding of how traditional and modern practices can coexist and inform one another. By examining preferences, performance, and real-world examples, the chapter contributes valuable insights to the discourse on sustainable building practices in India, highlighting the importance of integrating cultural principles with contemporary architectural solutions.

4.1 SURVEY

A comprehensive survey was conducted to evaluate the inclinations and utilization of Vastu Shastra principles in the design, construction, and renovation of residential buildings in Durg, Chhattisgarh. The respondents, who were either planning to construct or renovate their homes within the next two years, were purposely selected from Durg region. The rationale for focusing on this specific geographic area was to gauge the acceptance and implementation of Vastu principles in a localized context.

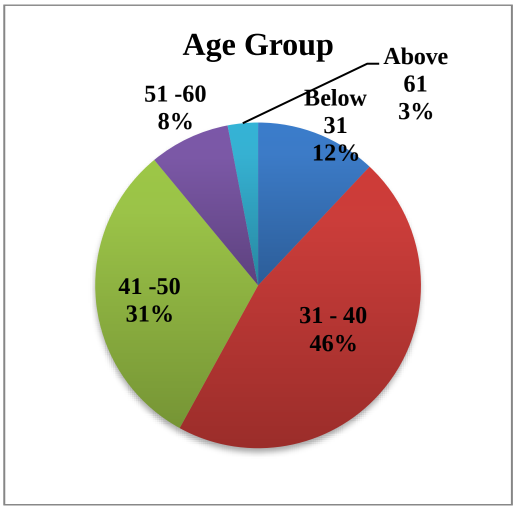
A multistage purposive cum random sampling methodology was utilized for the research investigation. A total of 384 respondents were selected from five wards of Durg city using the Probality Proportion to Size (PPS) method. Data collection involved both observation and interview techniques, utilizing a structured questionnaire. Pretesting was conducted to ascetain the clarity and dependability of questions. Additionally, the questionnaire was reviewed by two subject experts in the field to confirm that it achieved a satisfactory level of content validity. The questionnaire was also administered to 20 non-sampled respondents to further validate its effectiveness.

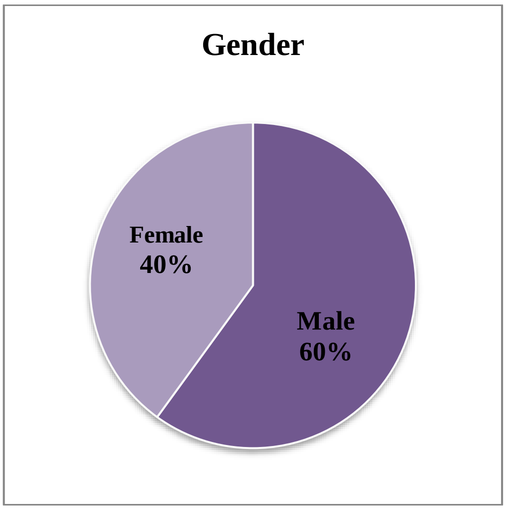
This analysis explores the awareness, understanding, perception, belief, and application of Vastu principles among respondents. Statistical measures including mean, median, standard deviation, variance and Chi-Square test were calculated to quantify this preferences.

4.1.1 Demographic Profile of Respondents

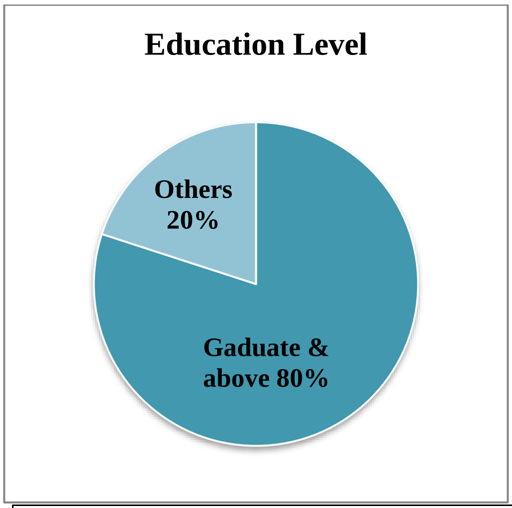
The demographic analysis revealed the following:

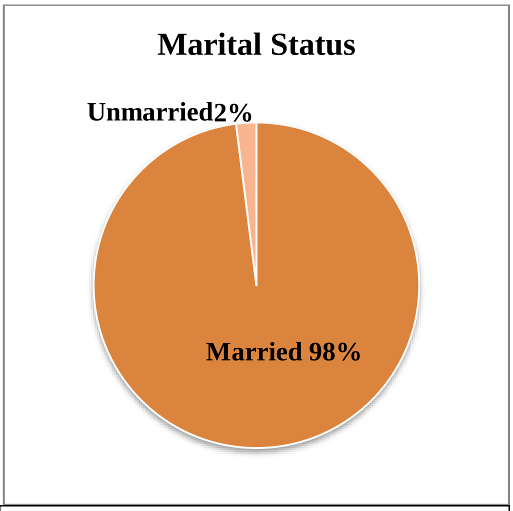
Table 6: Demographic Analysis of Respondent



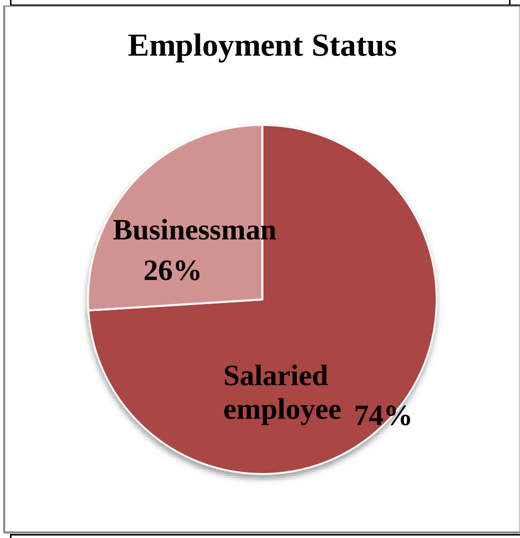


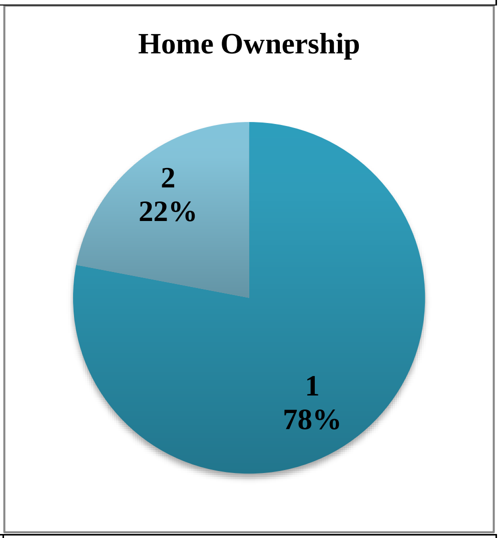
Age Group: 46% of respondents were aged 31-40 years, while only 3% were above 61 years.	**Gender:** 40% of respondents were female, and 60% were male.





Education Level: Approximately 80% of respondents were graduates or had higher qualifications	**Marital Status:** 98% of respondents were married.





Employment Status: The majority of respondents were salaried employees, with an average annual income of 6.0 lakhs.	**Home Ownership:** About 78% of respondents lived in their own houses.

4.1.2 Assessment of Preferences for Vastu Shastra Principles

This section examines the preferences for Vastu Shastra principles across three areas: awareness and understanding, perception and belief, and the placement of spaces according to Vastu Shastra principles. Each section includes various questions aimed at evaluating the respondents' choices and preferences, allowing for a nuanced analysis of how these principles are integrated into daily life. By gathering insights from a diverse range of respondents, the study seeks to identify patterns and trends in attitudes toward Vastu Shastra, ultimately shedding light on its relevance in modern architectural practices and individual living environments.

The data is summarized from Table 6, which shows responses to 25 questions categorized into three types: YES, NO, and MAYBE.

4.1.2.1 Data Summary

Table 7: Distribution of Responses for Each Question

SECTION – 1: Awareness and Understanding of Vastu Shastra			
Question No.	**YES**	**NO**	**MAYBE**
Q1. Are you familiar with Vastu Shastra concepts?	65	13	22
Q2. Do you feel Vastu Shastra is scientific?	66	10	24
Q3. Do you know any basic principle of Vastu Shastra?	73	13	14
Q4. Do you think that your house must be designed according to Vastu Shastra?	56	19	25
Q5. Do you think you will be benefited by residing in a house constructed according to Vastu Shastra?	60	8	32
Q6. Have you constructed your house according to Vastu Shastra?	38	40	22

SECTION – 2: Perception and Belief			
Question No.	**YES**	**NO**	**MAYBE**
Q7. Do you believe that following Vastu guidelines can affect your well-being and success?	85	8	7
Q8. Do you think following Vastu Shastra in your home makes you psychologically satisfied?	60	14	26
Q9. Do you feel more relaxed and pleasant after renovation of your house according to Vastu Shastra?	44	11	45
Q10. Do you feel kitchen and puja room are major areas of concern while constructing a house?	52	20	28
SECTION – 3:Placement of spaces according to Vastu Shastra principle's			
Question No.	**YES**	**NO**	**MAYBE**
Q11. Do you have a rectangular plot?	72	19	9
Q12. Do you have a basil plant (Tulsi) at northeast corner of the house?	57	36	7
Q13. Do you have a small garden with highly fragrant flowering plants in front of the house?	47	46	7
Q14. Is the bore located at the northeast corner of your house?	43	45	12
Q15. Do you have heighted plants in the southern and western parts of the house?	31	58	11
Q16. Is your Kitchen located at the southeast corner or according to Vastu	48	38	14

Shastra?			
Q17. Is your interior of the kitchen like a platform, washbasin, burner, storage, place for keeping utensils and drinking water according to Vastu Shastra?	27	48	25
Q18. Is your Puja room placed at the northeast corner in your house?	57	32	11
Q19. Have you made arrangements inside the Puja room like placement of deity, lamps, colour and material of floor according to Vastu Shastra?	31	49	20
Q20. Is your Master bedroom located at the southwest corner of the house?	49	37	14
Q21. Do you keep your head in the south or west direction while sleeping?	59	26	15
Q22. Is your toilet seat alignment in the north-south direction?	54	31	15
Q23. Have you painted your rooms, kitchen and toilets according to Vastu Shastra?	14	63	23
Q24. Is there ample supply of natural light and ventilation in your house?	92	6	2
Q25. Do you feel comfortable temperature in your house?	81	10	9

4.1.2.2 Awareness and Understanding of Vastu Shastra:

This section of the survey aimed at assessing the awareness and understanding of Vastu Shastra which helps in gauging current knowledge and beliefs. It helps establish the level of awareness and familiarity people have with Vastu Shastra principles and concepts. It explores whether individuals believe in the efficacy of Vastu principles in enhancing well-being and harmony in living environment.

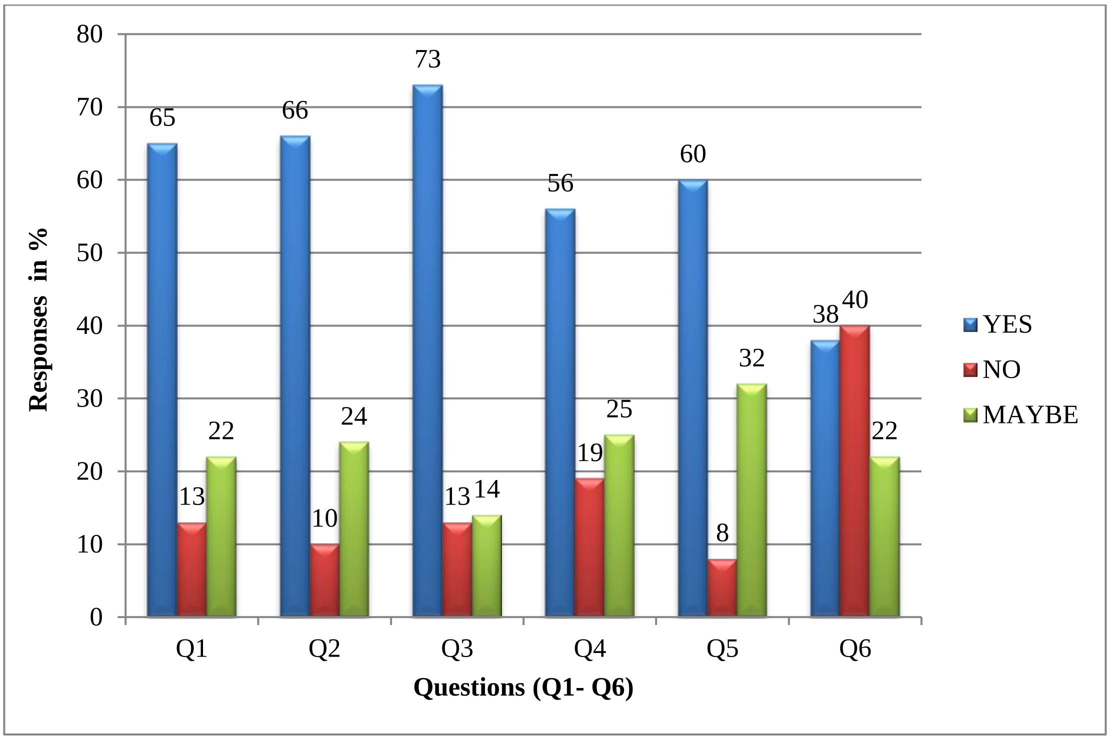


Fig. 77: Shows the Respondents Responses of Q1 - Q6

- **Familiarity:** 65% of respondents were familiar with Vastu Shastra, 22% were unsure, and 13% were unfamiliar.
- **Scientific Perception:** 66% felt Vastu Shastra is scientific, 24% were unsure, and 10% disagreed.
- **Knowledge of Basic Principles:** 73% knew the basic principles of Vastu Shastra, 13% did not, and 14% were unsure.
- **Design Preferences:** 56% wanted to design their house according to Vastu Shastra, 19% did not, and 25% were unsure.
- **Perceived Benefits:** 60% believed they would benefit from residing in a house constructed according to Vastu Shastra, 8% did not, and 32% were unsure.
- **Implementation:** 38% had constructed their house according to Vastu Shastra, 40% had not, and 22% were unsure.

4.1.2.3 Perception and Belief:

Belief in Vastu Shastra is deeply rooted in cultural, traditional and spiritual beliefs. It reflects a rich cultural legacy and a holistic approach to create a harmonious living environment. In order to ascertain the respondents' psychological pleasure and belief in the benefits of wellbeing, questions about perception and belief were asked in this part.

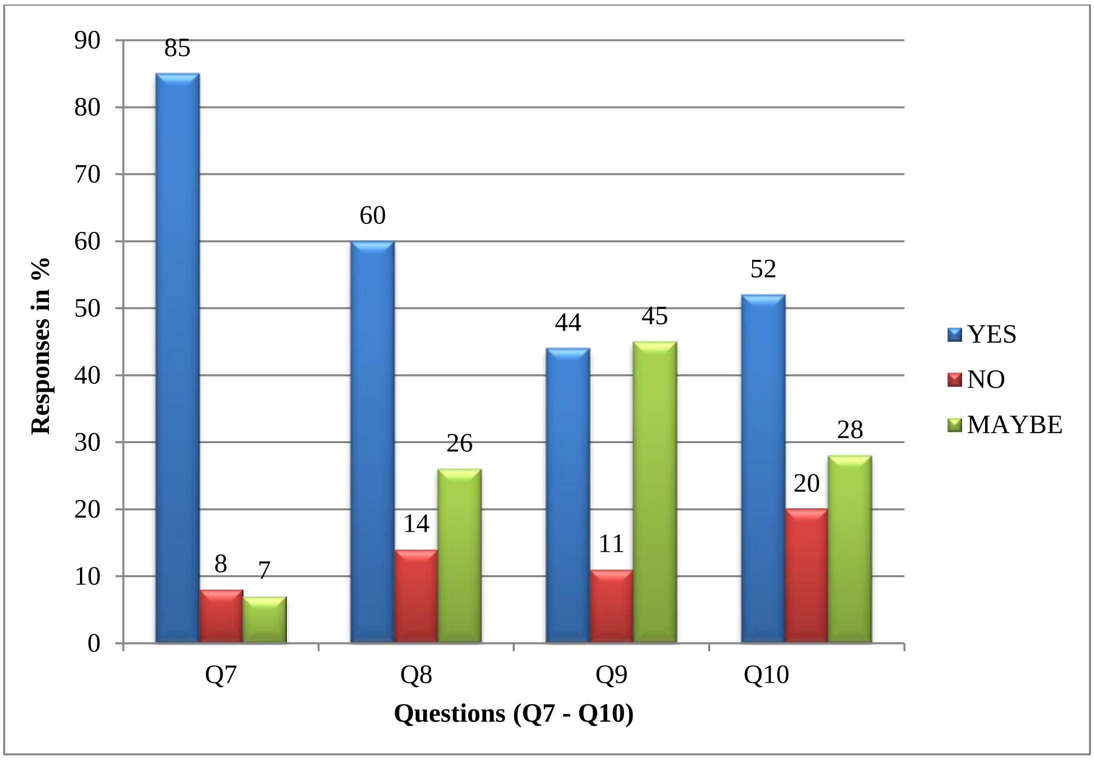


Fig. 78: Shows the Respondents Response from Q7- Q10

- **Impact on Well-being and Success:** 85% believed Vastu guidelines could affect their well-being and success, 8% did not, and 7% were unsure.
- **Psychological Satisfaction:** 60% felt that following Vastu Shastra in their home provided psychological satisfaction, 14% did not, and 26% were unsure.
- **Renovation Experience:** 44% felt more relaxed and pleasant after renovating their house according to Vastu Shastra, 11% did not, and 45% were unsure.
- **Major Areas of Concern**: 52% considered the kitchen and puja room as major areas of concern, 20% did not, and 28% were unsure.

4.1.2.4 Placement of Spaces According to Vastu Shastra Principles:

Vastu Shastra emphasizes the importance of directional alignments, spatial arrangements, and the use of natural elements to create harmonious living spaces. This section of the survey provides insight into the extent to which people adhere to specific Vastu guidelines for designing or renovating any building.

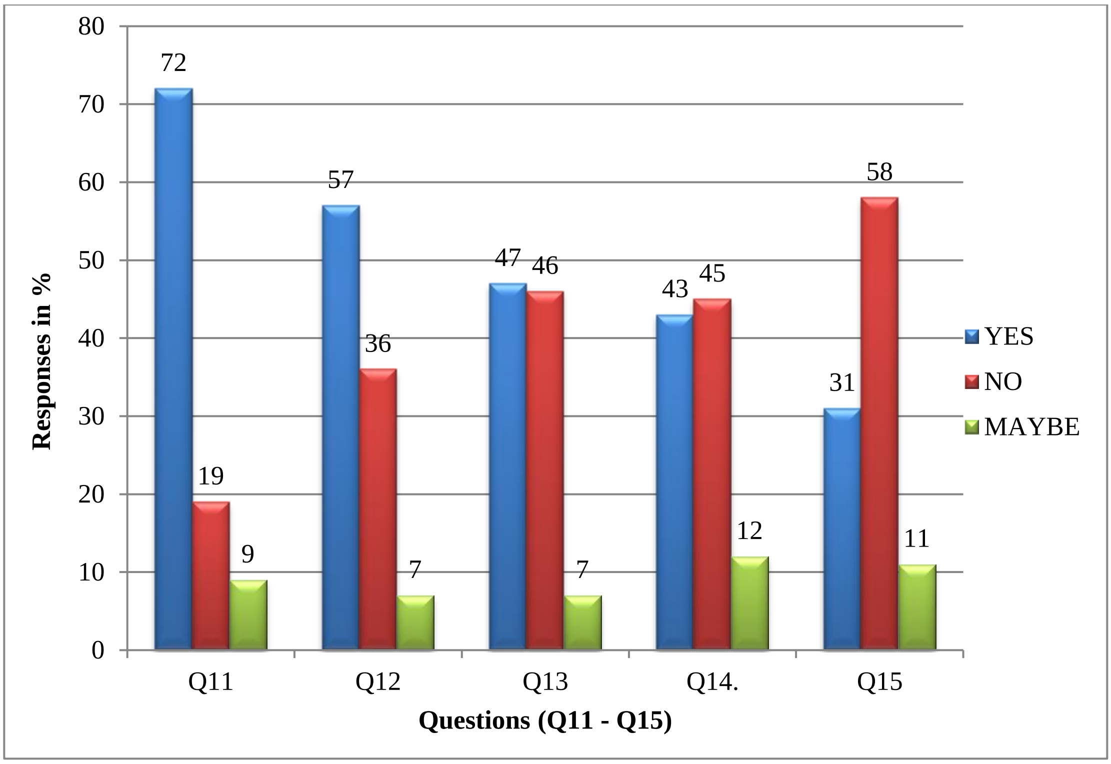


Fig. 79: Shows the Respondents Response from Q11- Q15

- **Rectangular Plot:** 72% had a rectangular plot, 19% did not, and 9% were unsure.
- **Basil Plant (Tulsi):** 57% had a basil plant at the northeast corner of their house, 36% did not, and 7% were unsure.
- **Garden with Fragrant Plants:** 47% had a small garden with highly fragrant flowering plants in front of the house, 46% did not, and 7% were unsure.
- **Borewell Location:** 43% had a borewell at the northeast corner of their house, 45% did not, and 12% were unsure.
- **Heighted Plants:** 31% had heighted plants in the southern and western parts of the house, 58% did not, and 11% were unsure.

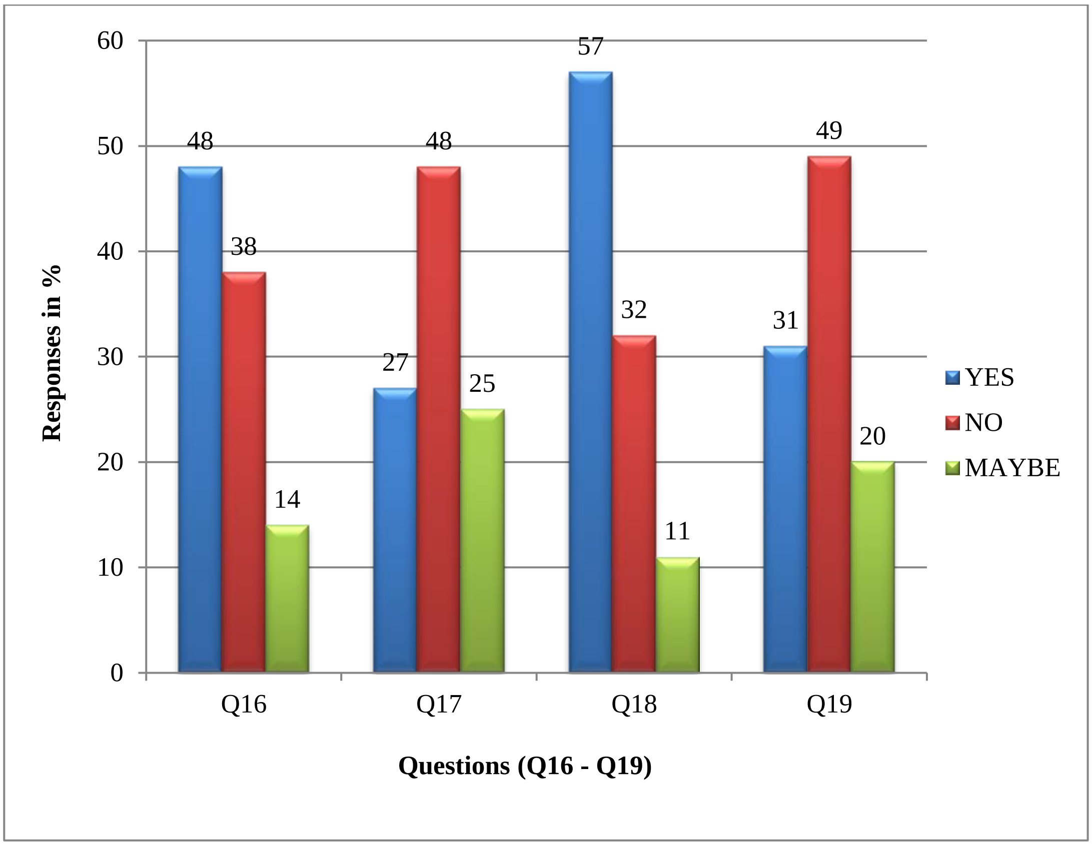


Fig. 80: Shows the Respondents Response from Q16 - Q19

- **Kitchen Location:** 48% had their kitchen according to Vastu Shastra, 38% did not, and 14% were unsure.
- **Interior of Kitchen:** 27% had the interior of the kitchen designed according to Vastu Shastra principles, 48% did not, and 25% were unsure.
- **Puja Room Placement:** 57% had a puja room in the northeast corner, 32% did not, and 11% were unsure.
- **Arrangements Inside Puja Room:** 31% had made arrangements inside the puja room according to Vastu Shastra, 49% had not, and 20% were unsure.

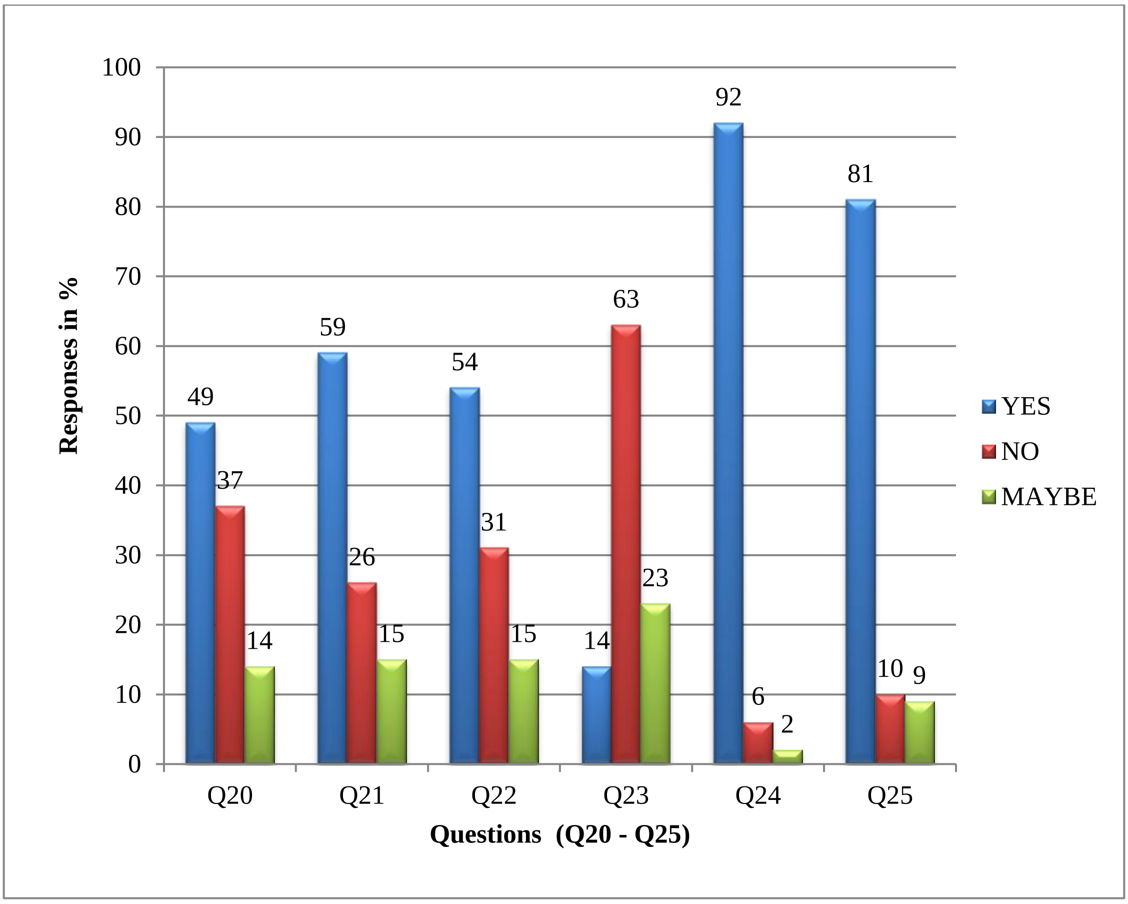


Fig. 81: Shows the Respondents Response from Q20 - Q25

- **Master Bedroom Location:** 49% had their master bedroom at the southwest corner, 37% did not, and 14% were unsure.
- **Sleeping Direction:** 59% kept their head in the south or west direction while sleeping, 26% did not, and 15% were unsure.
- **Toilet Seat Alignment:** 54% had toilet seats aligned in the north-south direction, 31% did not, and 15% were unsure.
- **Painting According to Vastu Shastra:** 14% had painted their rooms, kitchen, and toilets according to Vastu Shastra, 63% had not, and 23% were unsure.
- **Natural Light and Ventilation:** 92% felt they had ample supply of natural light and ventilation, 6% did not, and 2% were unsure.
- **Comfortable Temperature: 8**1% felt comfortable with the temperature in their house, 10% did not, and 9% were unsure.

4.1.3 Statistical Analysis

Formulae for Mean, Standard Deviation, Variance Calculation, Chi-Square Test has already been described in Chapter 3.

4.1.4 Descriptive Statistics

Table 8: Mean, Median, Standard Deviation, and Variance of Responses

Responses	Mean Responses	Median Responses	Standard Deviation	Variance
YES	55.08	54	18.82	354.14
NO	25.84	26	16.78	281.77
MAYBE	19.08	15	10.56	111.53

4.1.5 Inferential Statistics

Chi-Square Test: To determine if there is a significant difference among the responses pertaining to various questions, we can conduct a chi-square test.

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

- O_i = Observed Frequency
- E_i = Expected Frequency

Hypothesis:

- **Null Hypothesis (H0):** There is no significant difference in the responses for different questions.
- **Alternative Hypothesis (H1):** There is a significant difference in the responses for different questions.

Calculation: The chi-square value calculated based on the Table data 7.

Degrees of Freedom (d*f*): (*n*-1) x (*k*-1) = (25-1) x (3-1) =48

P-Value Calculation and Hypothesis Significance

Chi-Square Test for Independence

To determine the p-value, we calculate the chi-square statistic based on the observed frequencies of YES, NO, and MAYBE responses across the 25 questions.

Step-by-Step Calculation:

1. Observed Frequencies (O):

   The data from Table 7 provides the observed frequencies for each response type (YES, NO, MAYBE) for each question.

2. Expected Frequencies (E):

   The expected frequency for each cell can be determined by applying the formula:

   $$E_{ij} = \frac{\left(\text{Row Total}_{\text{i}} \times \text{Column Total}_{\text{j}}\right)}{\text{Grand Total}}$$

3. Chi-Square Statistic ($\chi 2$):

   The chi-square statistic is performed by utilising the following formula:

   $$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

4. Degree of Freedom (d*f*):

   For this test, the degrees of freedom are calculated as:

   d*f* = (*Number of Rows* – 1) x (*Number of Columns* – 1)

   Since we have 25 questions and 3 response types,

   d*f* = (25-1) x (3-1) = 24 x 2 = 48.

5. **P-Value:** Using the chi-square distribution table, we compare our calculated chi-square statistic to find the corresponding p-value.

Hypothesis Testing

Null Hypothesis (H0): There exists no noteworthy disparity in the distribution of responses (YES, NO, MAYBE) across the questions. This implies that the respondents' answers are independent of the questions asked.

Alternative Hypothesis (H1): There exists noteworthy disparity in the distribution of responses (YES, NO, MAYBE) across the questions. This implies that the respondents' answers are dependent on the specific questions asked.

Interpretation

Significance Level (α): When doing a hypothesis test, a significance level of 0.05 (5%) is typically employed. This means we are willing to accept a 5% chance of incorrectly rejecting the null hypothesis.

P-Value Interpretation:

- **If p-value ≤ 0.05:** the null hypothesis (H0) is rejected. This suggests that the distribution of replies differs in a way that is statistically significant, suggesting that the respondents' answers are influenced by the specific questions asked.
- **If p-value > 0.05:** the null hypothesis (H0) cannot be rejected. This suggests that the distribution of replies does not differ in a way that is statistically significant, suggesting that the respondents' answers are not influenced by the specific questions asked.

Example Calculation Result: Assuming a hypothetical chi-square statistic value of 60.1, the p-value can be looked up in a chi-square distribution table for 48 degrees of freedom.

For this example:

- **Calculated χ^2 = 60.1**
- **Degrees of Freedom = 48**
- **P-Value (approximate) = 0.1**

Since the p-value of 0.1 is higher than 0.05, **the null hypothesis cannot be rulled out**.

If the computed p-value is larger than the predetermined significance level of 0.05, we would draw the conclusion that the distribution of answers to the several questions is not significantly different. Therefore, the null hypothesis (H0) would be considered valid. This implies that the variability in responses is likely due to chance rather than the influence of the specific questions.

The alternative hypothesis (H1) would be supported if the p-value was less than or equal to 0.05, which would indicate that the responses differ significantly depending on the questions. In this case, the null hypothesis would be rejected.

4.1.6 Findings and Interpretation

Questions 1-6 reveal that a majority are aware of Vastu Shastra with an average YES response of 59.67%.

- High YES responses for questions about familiarity (Q1), perceived scientific basis (Q2), and knowledge of basic principles (Q3).
- Indicates a good level of awareness but variability in deeper understanding and application.

Questions 7-10 show a strong belief in Vastu Shastra's impact on well-being with an average YES response of 60.25%.

- High YES responses to questions about psychological satisfaction (Q8) and belief in well-being effects (Q7).
- Suggests that belief in Vastu Shastra is tied to perceived personal benefits.

Questions 11-25 indicate varying levels of compliance, with a lower average YES response of 51.53%, suggesting room for increased awareness and adoption.

- High compliance in aspects like natural light and ventilation (Q24) and having a rectangular plot (Q11).

- Lower compliance in specific detailed practices, such as the location of gardens and boreholes (Q13, Q14).

4.1.7 Significance for Chhattisgarh:

High YES responses in key areas (Q7, Q11, and Q24) indicate a positive perception and importance of Vastu Shastra.

- Specific aspects like natural light (Q24) and psychological satisfaction (Q8) are highly regarded, indicating areas of focus for promoting Vastu practices.

CONCLUSION

The analysis indicates a significant awareness and positive perception of Vastu Shastra among respondents, suggesting that many individuals recognize its importance and potential benefits in creating harmonious living spaces. Respondents generally express a favorable attitude toward the principles of Vastu, acknowledging its cultural significance and the role it plays in enhancing comfort and well-being within their environments.

However, the application of Vastu principles in practical scenarios reveals variability, indicating that while awareness exists, the translation of these principles into everyday practice is inconsistent. Some respondents actively incorporate Vastu guidelines into their home or workspace designs, while others may only partially apply them or remain unaware of how to implement specific recommendations effectively. This highlighting the need for increased awareness and structured implementation.

This report synthesizes data-driven insights to guide strategic initiatives for promoting Vastu Shastra practices, particularly in Chhattisgarh, aiming for a harmonious and beneficial living environment by 2047.

4.2 ANALYSIS OF TRADITIONAL BUILDING

Traditional buildings provide practical examples of how Vastu principles were applied in architectural designs, including spatial organization, orientation, and use of natural elements. By analyzing their layouts and features, the effectiveness of Vastu principles in achieving desired outcomes such as spatial harmony and environment sustainability can be assessed. Understanding how traditional buildings promote wellbeing through natural light, airflow and spatial harmony informs strategies for creating healthier indoor environment in modern constructions.

A detailed study was conducted on the traditional dwelling unit in the small village of Dagania, Chhattisgarh's District Durg to find out its thermal performance and day light analysis.

4.2.1 Analysis of Traditional Residence at Village Dagania, Distt – Durg

Fig. 82: Rear Facade of Dwelling at Village Dagania, Dist. – Durg

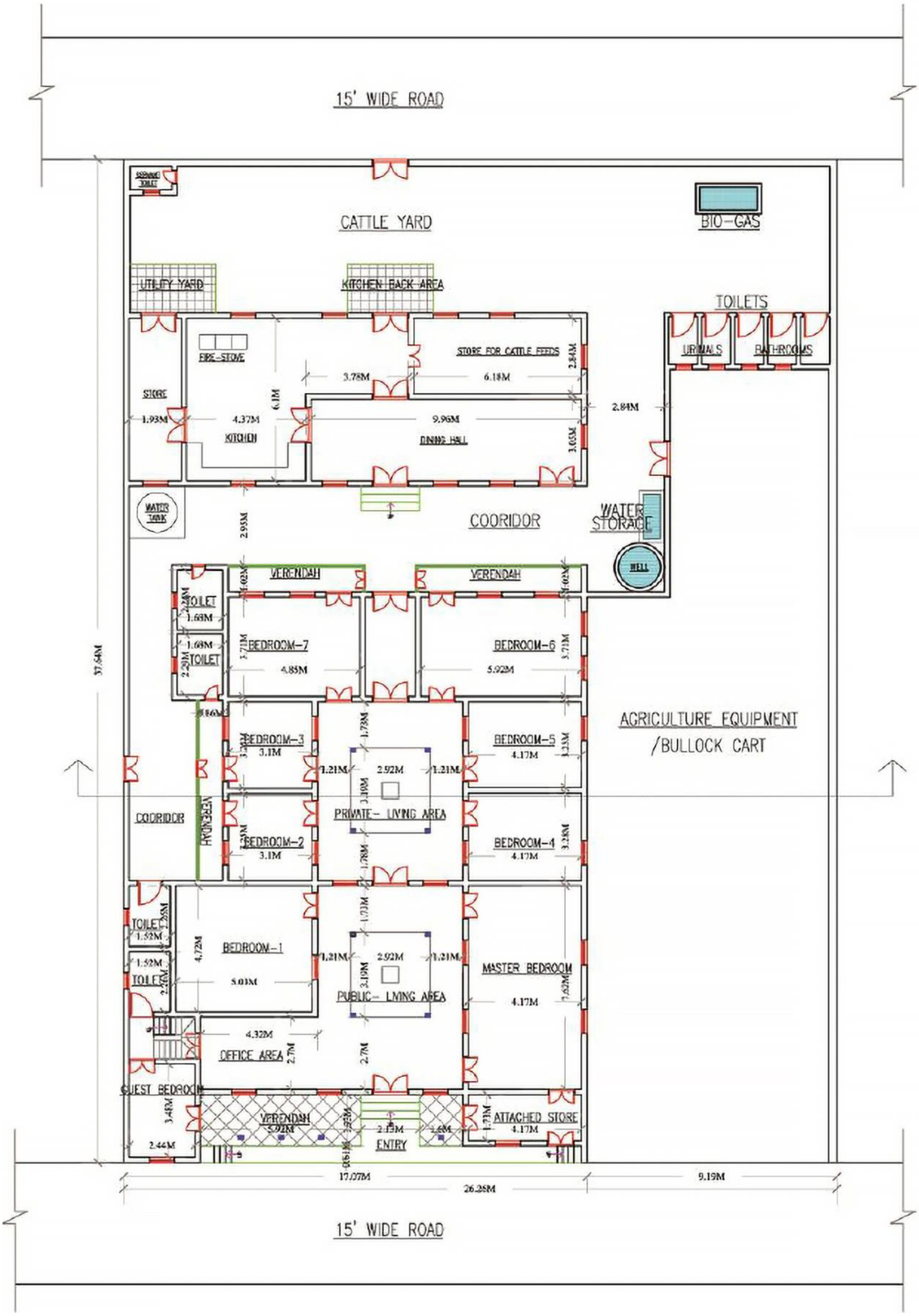


Fig. 83: Plan of Residence at Village Dagania, Dist. – Durg
(Source: Chadalavada et al., 2017)

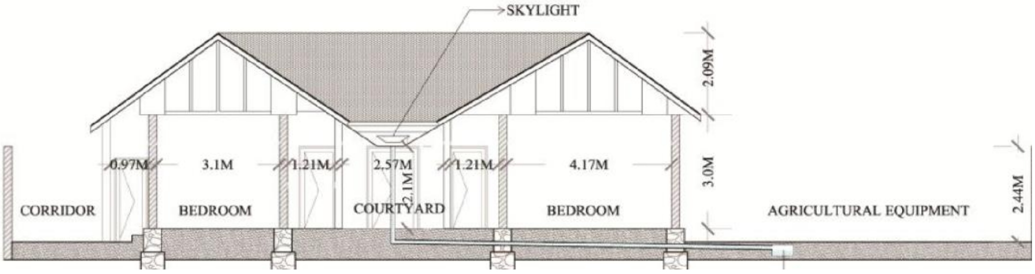


Fig. 84: Section of Dwelling Unit (Source: Chadalavada et al., 2017)

The selected building typology is about 100 years old dwelling which extends up to 982.0 Sq. M. with 47.65% of ground coverage. This dwelling belongs to an agro based family with the total number of occupants extending up to 30 people. Roof structure of the dwelling is treated with traditional terracotta tiles and the whole dwelling has a raised plinth of 0.8 meters above the natural ground level. The whole dwelling has been divided into two separate structures i.e. 355 Sq.M and 110 Sq.M respectively, one is used for living and the other is dedicated to the kitchen. The living area consists of 8 bedrooms, one private living area, one public living area and a guest room. The kitchen has been segregated into cooking, dining and storage areas. Raised semi covered platform in front of the dwelling which connects the exterior and interior, thus enhances interactions at family and community level. Front side of the building opens into a wide street where the main entrance exits to enter into the dwelling. Dwelling consists of a backyard of 142 Sq.M which caters space for cattle, toilets and bio-gas plant and eventually opens into a 4.5M wide road. southern side of the dwelling is allocated for storing agricultural equipment.

Fig. 85: View from South

The present case study is a composite structure which has a combination of wooden columns and load bearing brick walls. All the external and internal walls possess an identical thickness of 350mm and are constructed by the burnt clay bricks (100mm x 55mm x 33mm) dressed with lime mortar which provides thermal insulation. The roof is made of Teak and Neem tree wood in which three layers of terracotta tiles have been placed to increase the thickness of the roof i.e. 300mm which increases the heat gain lag from the solar radiation. The incidence of the solar beam radiation on an angled surface of the pitched hip roof reduces its intensity due to the possessing roof angle of 35^o. Hip roof has a projection of 1.8 m externally which helps in shading the building from harsh east and west sun. The projection of rooms on either side of the west facade prevents the laterally inclined solar beam radiation during the thermal discomfort period of day. Total numbers of windows in the case study are 24 and similarly sized (900mm X 1200mm). Out of 9 windows in east west axis 7 windows are completely shaded with the help of roof projections.

4.2.1.1 Transformation of Structure (1909 to 2017)

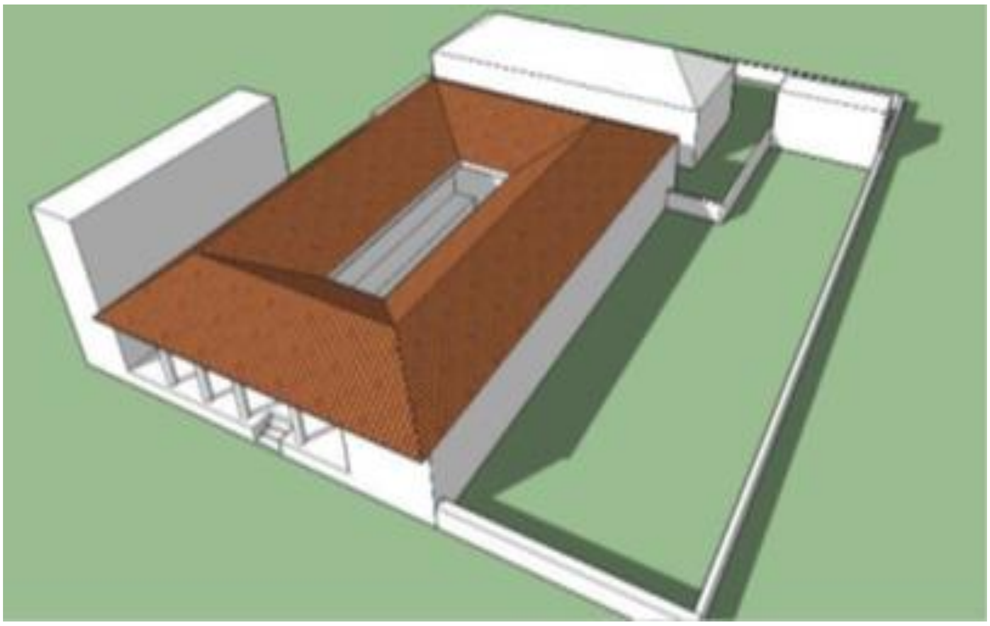


Fig. 86: Original Form of Building (OFB); 1909-48.
(Source: Chadalavada et al., 2017)

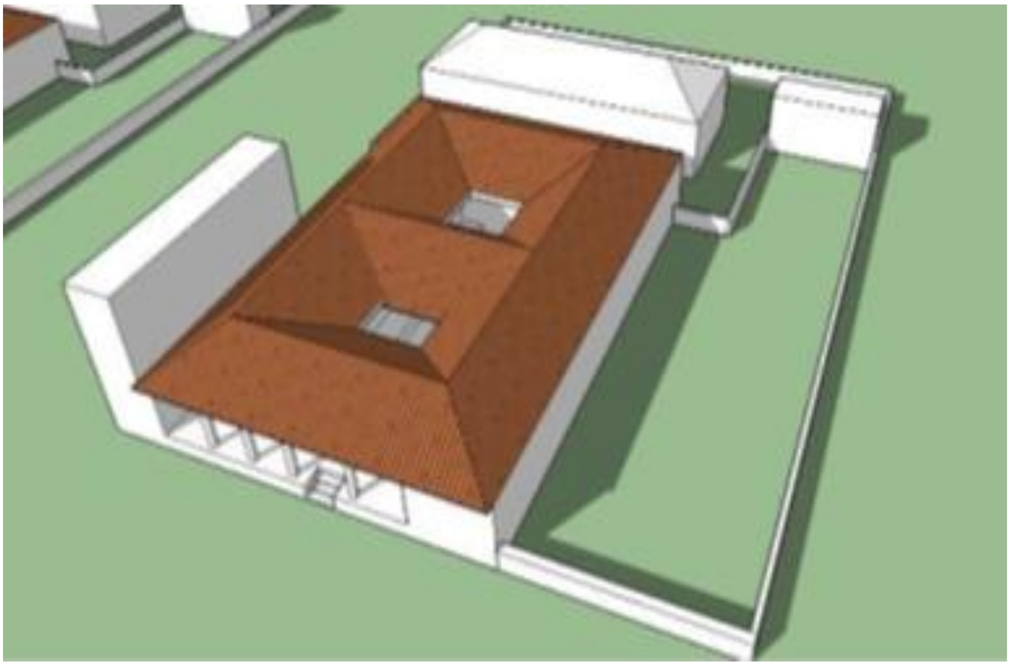


Fig. 87: First Transformation of Original Form of Building (FT-OFB); 1948-69.
(Source: Chadalavada et al., 2017)

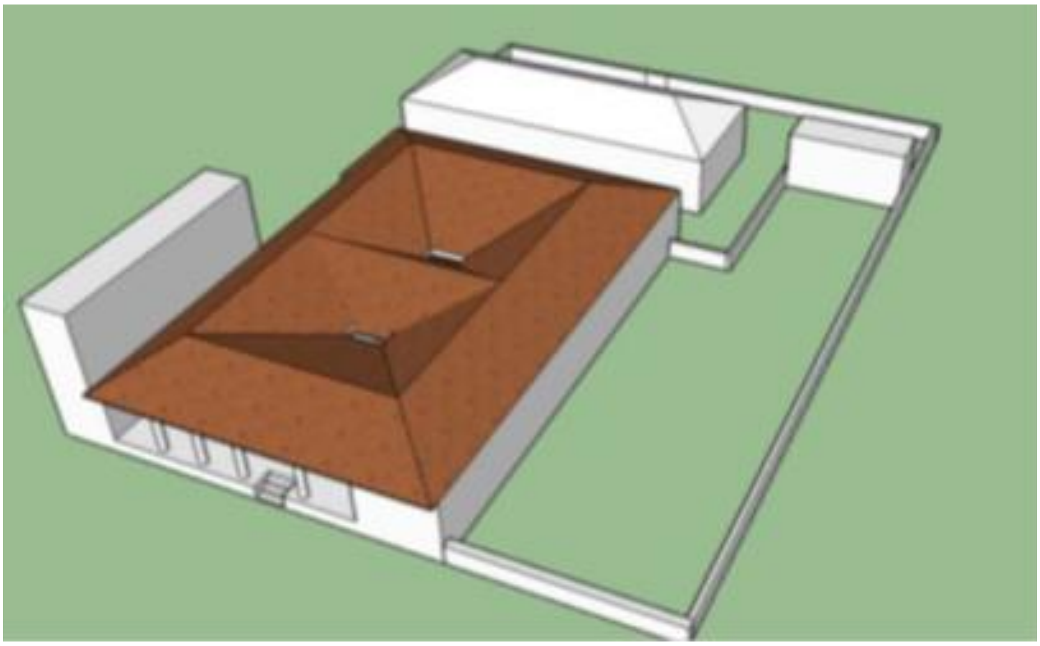


Fig. 88: Second Transformation of Original Form of Building (ST-OFB) 1969-2017.
(Source: Chadalavada et al., 2017)

Central courtyard has been fragmented into two spaces as living and private living spaces and space to draw light has been reduced to 1.2mx0.8m affecting the indoor lighting profile of the house. The Initial form of the building during the year 1909-1948 may be called 'Original Form of Building' (OFB). Eventually the demand for space has been increased with the demand and need of occupants. Hence the additional space has been acquired from segregating the central courtyard into two more enclosed spaces namely living space and private living spaces. This is the first transformation of a building that took place during 1948-1969 which may be called the First-transformation of Original form of building (FT-OFB). After the first transformation the courtyard size was further reduced to a size of 1.2M X 0.8M and covered by extending the tiled roof. Also the floor level of the courtyard has been increased to the surface level of other rooms.

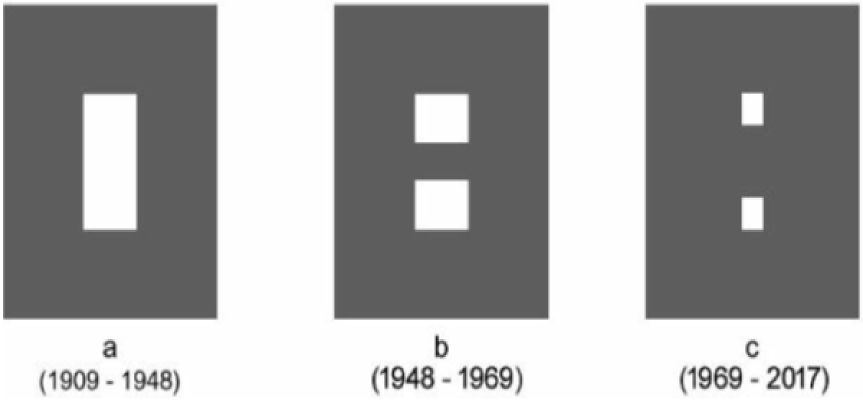


Fig. 89: Ground of Dwelling's Roof Showing the Transformation of Courtyard since OFB: 1909 (15m x 5m) – FT-OFB: 1948 (5m x 5m) – ST-OFB: 1969 (1.2m x 0.8m)
(Source: Chadalavada et al., 2017)

4.2.1.2 Comparative Analysis of OFB, FT-OFB and ST-OFB Using IES-VE.

- **Thermal performance and Lighting analysis was performed using IES-VE.**
- **Thermal analysis was performed for OFB and ST-OFB to compare the thermal comfort levels of before and after transformation.**

Table 9: Parameters Considered for the Thermal IEV-ES Analysis

S No.	Building Component	Quantity	U-Value
1.	External wall	350mm Thick	1.5W/Sq.m
2.	Internal wall	350mm Thick	1.5W/Sq.m
3.	Sloped roof with tiles (3 layer mud singles)	600mm Effective Thickness	1.26W/Sq.m
4.	Windows with no insulation	900x1200mm	NA
5.	Doors	1200mmx2100mm	NA

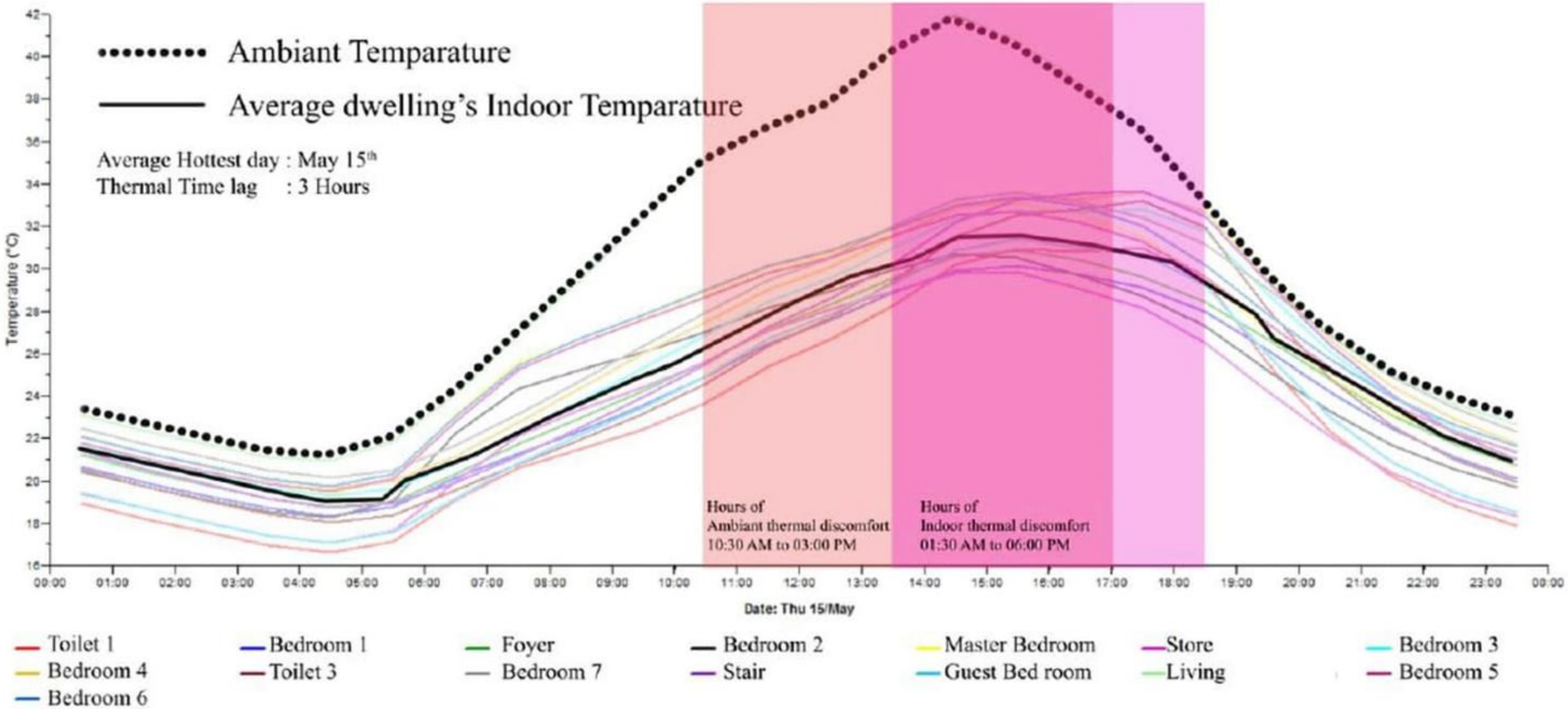


Fig. 90: Thermal Performance Analysis of the Dwelling during the Hottest Day (15th May) calculated through IES-VE

Hours of ambient thermal discomfort – 10:30 am to 3:30 pm

Hours of indoor thermal discomfort – 1:30 pm to 6:00 pm

(Source: Chadalavada et al., 2017)

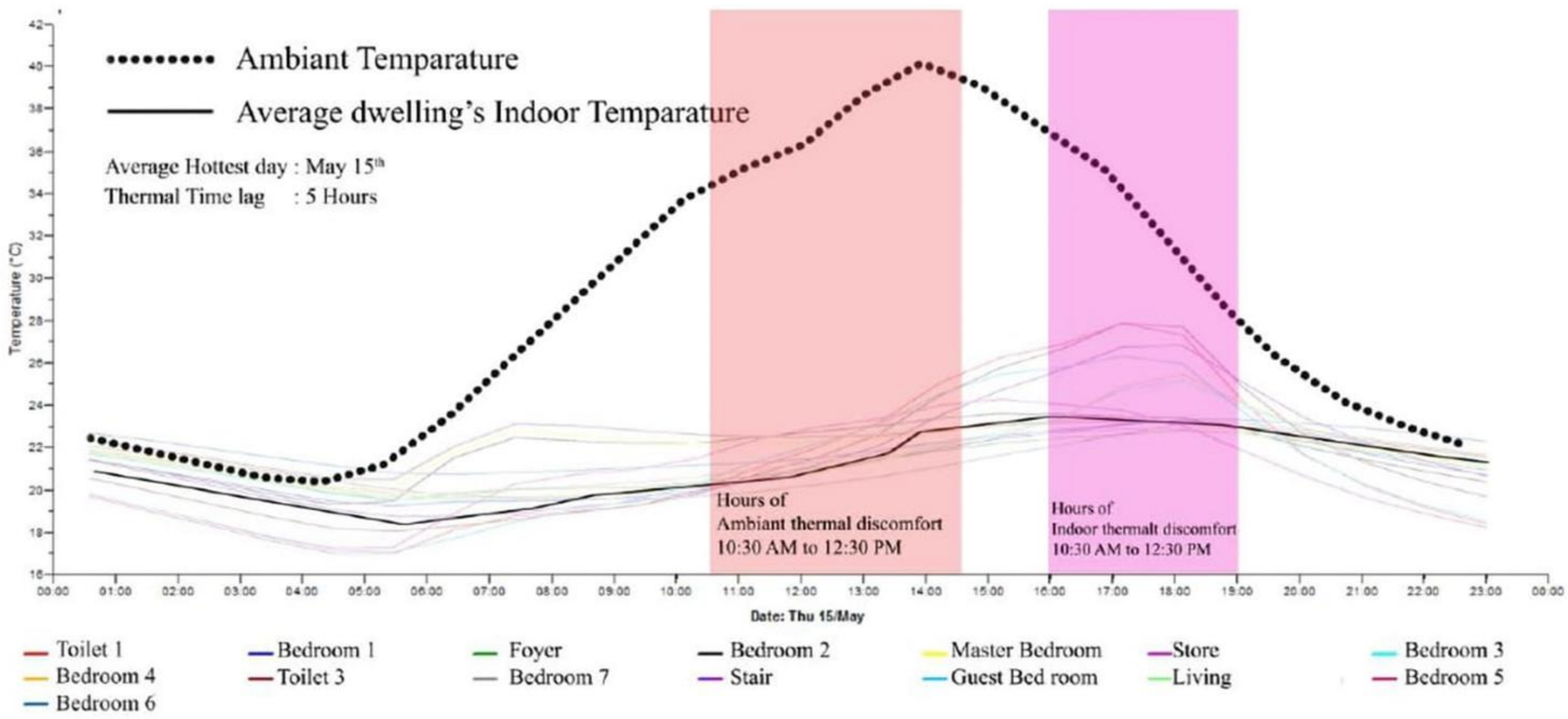


Fig. 91: Thermal Performance Analysis of the Dwelling during the Hottest Day (15th May) calculated through IES-VE

Hours of ambient thermal discomfort – 10:30 am to 12:30 pm

Hours of indoor thermal discomfort – 10:30 am to 12:30 pm

(Source: Chadalavada et al., 2017)

4.2.1.3 Results of Thermal Performance Analysis

From the analysis it is evident that OFB has a significant 7^o to 9^{o}C temperature difference between indoor and ambient air temperature levels during discomfort hours of average hottest day (May 15th). Whereas ST-OFB has achieved a temperature difference of 9^o to 14^{o}C. By comparing both the cases (OFB and ST-OFB) there is a significant 33% improvement of thermal performance by attaining 5^{o}C reduction in indoor temperature during discomfort hours. It has been found that a pitched roof and 350mm thick wall resulted in improving the thermal time lag of the whole structure by up to 5hours.

4.2.1.4 Day Lighting Analysis

For performing the lighting simulation external daylight levels have been determined as 8700 Lux (Energy Conservation Building Code, 2007), India. The main building excluding the kitchen and dining part has been analysed. Openings such as doors, windows and roof voids have been introduced as per existing conditions. Day lighting simulation has been carried out on the average hottest day i.e. 15th May to analyse natural lighting levels in terms of daylight factor for all the three transformations (OFB, FT-OFB and ST-OFB).

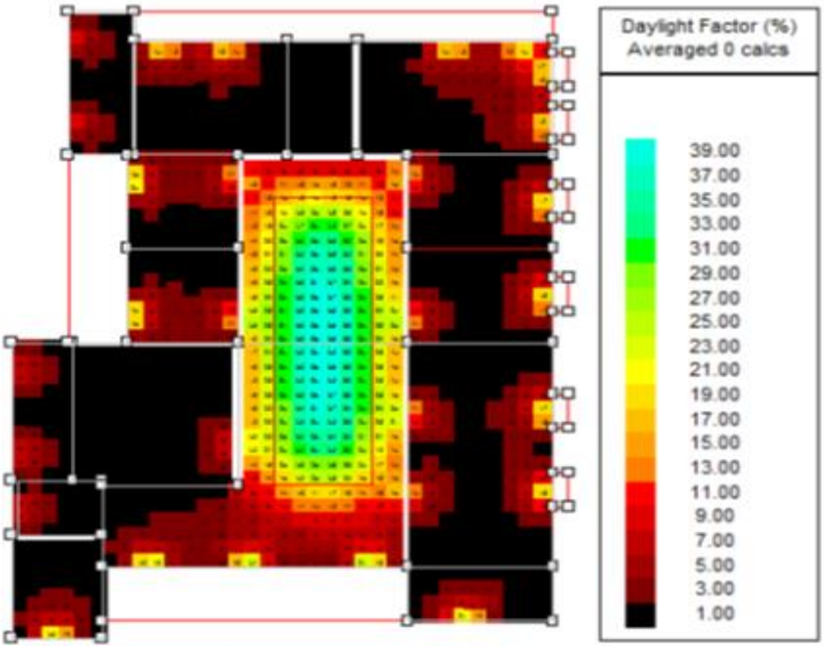


Fig. 92: IES-VE Lighting Analysis of Dwelling OFB (1909-1948)
(Source: Chadalavada et al., 2017)

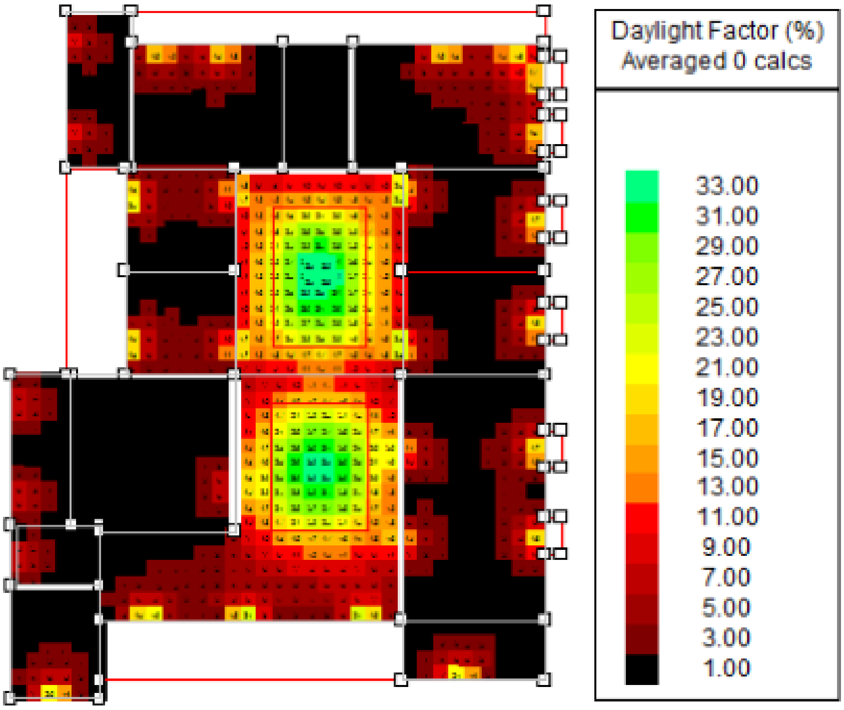


Fig. 93: IES-VE Lighting Analysis of Dwelling FT-OFB (1948-69)
(Source: Chadalavada et al., 2017)

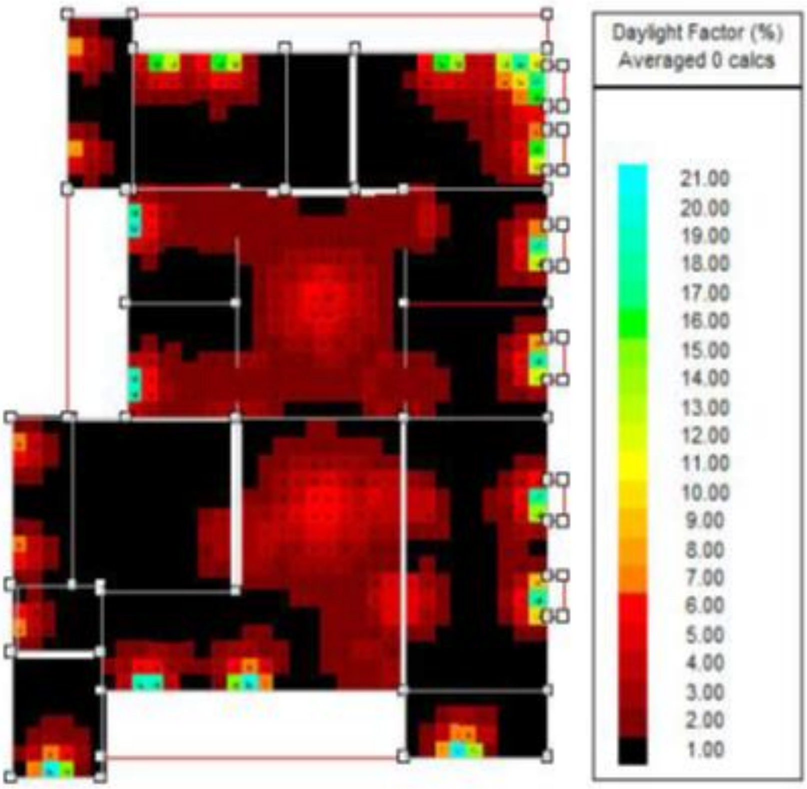


Fig. 94: IES-VE Lighting Analysis of Dwelling ST-OFB (1969-2017)
(Source: Chadalavada et al., 2017)

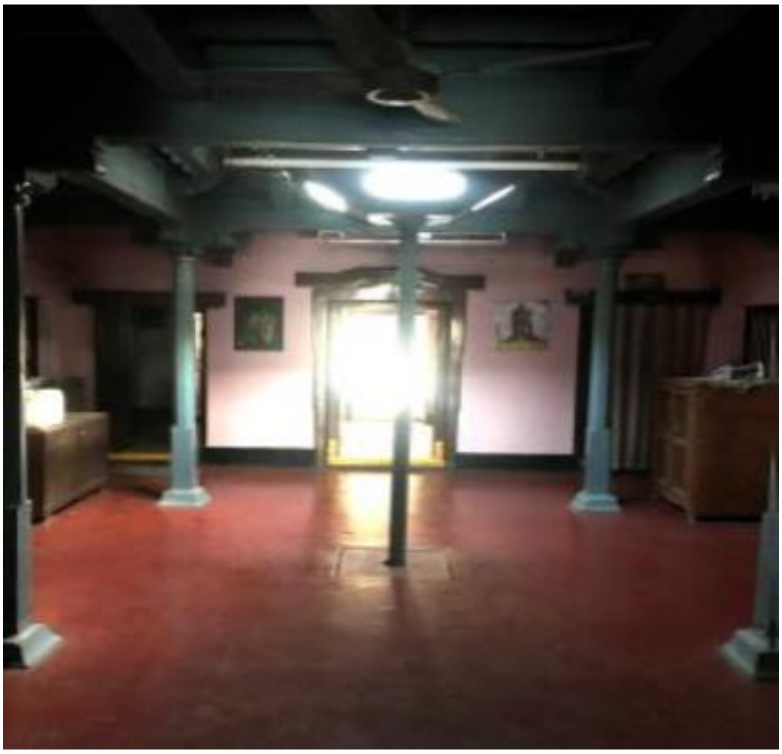


Fig. 95: Showing Skylight at the Centre of Courtyard after Transformation (1969)
(Source: Chadalavada et al., 2017)

Table 10: IES-VE Simulation Results of Indoor Daylight Factor

S No.	Stage of Transformation	Maximum Daylight Factor
1.	OFB	39
2	FT – OFB	33
3.	ST – OFB	6

Table 11: Percentage of Dwelling's Indoor Floor Space under Natural Lighting

S No.	Stage of Transformation	% of indoor floor space under natural lighting		
		High (>25 Daylight Factor)	Medium (10 to 25 Daylight Factor)	Low (<10 Daylight Factor)
1.	OFB	21%	28%	51%
2.	FT – OFB	13%	41%	51%
3.	ST – OFB	0%	6%	94%

CONCLUSION

In this work, the indoor thermal and natural daylight levels of typical traditional dwellings in Chhattisgarh have been analyzed using IES-VE simulations. The findings of the thermal performance research show that there is a 7-9 degree Celsius variation in indoor temperature. With a 9-14 degree differential in temperature between the outside and inside, indoor thermal comfort has grown by up to 33% since the courtyard renovation at ST-OFB (1948-1969). On the other hand, following the courtyard alteration of the residence from the Original form of Building (OFB) 1909 to the Second alteration of the Original form of Building 1969, internal lighting levels have severely fallen by 54%.

Therefore, the current study of courtyard transformation process improves thermal comfort levels but degrades the dwelling's interior lighting levels.

4.3 ANALYSIS OF MODERN BUILDING

Passive solar buildings are designed to maximize thermal comfort and minimize energy consumption for cooling and lighting through natural means. They serve as examples of sustainable design that reduce reliance on non-renewable energy sources. These buildings often incorporate innovative design elements to maximize natural light, heat and ventilation.

The State's first Passive Solar Building, the Chhattisgarh State Electricity Regulatory commission (CSERC) Building in Shanti Nagar, Raipur, was inaugurated in 2010. A thorough analysis of CSERC Building's architectural characteristics and its energy production, consumption and transmission has been done in order to determine its potential for energy efficiency.

Chhattisgarh State Electricity Regulatory Commission (CSERC) Building

Fig. 96: Chhattisgarh State Electricity Regulatory Commission (CSERC) Building at Raipur, Chhattisgarh

Fig. 97: View from Entrance

Fig. 98: View from Northwest

Fig. 99: View from Southwest

Fig. 100: Tower at Entrance

4.3.1 Building Summary

The CSERC building is located at Shanti Nagar, Raipur, Chhattisgarh. It was designed by Ar. Tara Prasad Desai and implemented by the Chhattisgarh State Housing Board between 2007 and 2010.

The project covers a site area of 2400 m^2 with a builtup area of 2072 m^2 and includes 3 floors. The Gross carpet area of the building is 1675 m^2 with 670 m^2 Air conditioned and 563 m^2 non-conditioned service spaces. The most remarkable feature of this building is the southwest umbrella. Its cooling option is evaporative type and a 59.5 TR conditioning capacity. The renewable energy system installed at site is 80KW SPV Power plant and its Net Energy Performance index (EPI) is (-) 15KWh/m^2/annum.

Fig. 101: Site Plan of CSERC Building at Raipur, Chhattisgarh

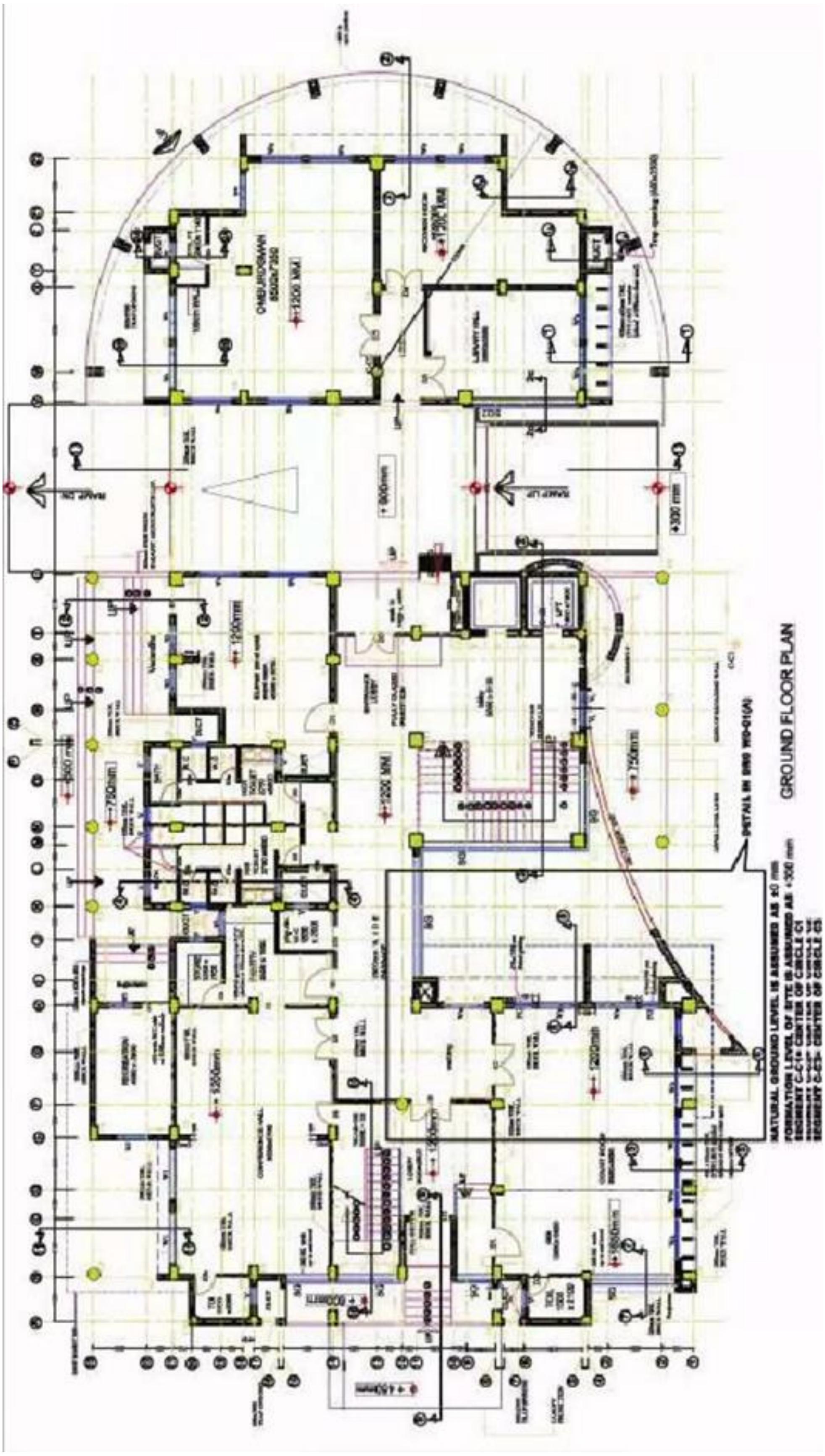


Fig. 102: Ground Floor Plan - Floor Area – 659.0 Sq.Mts

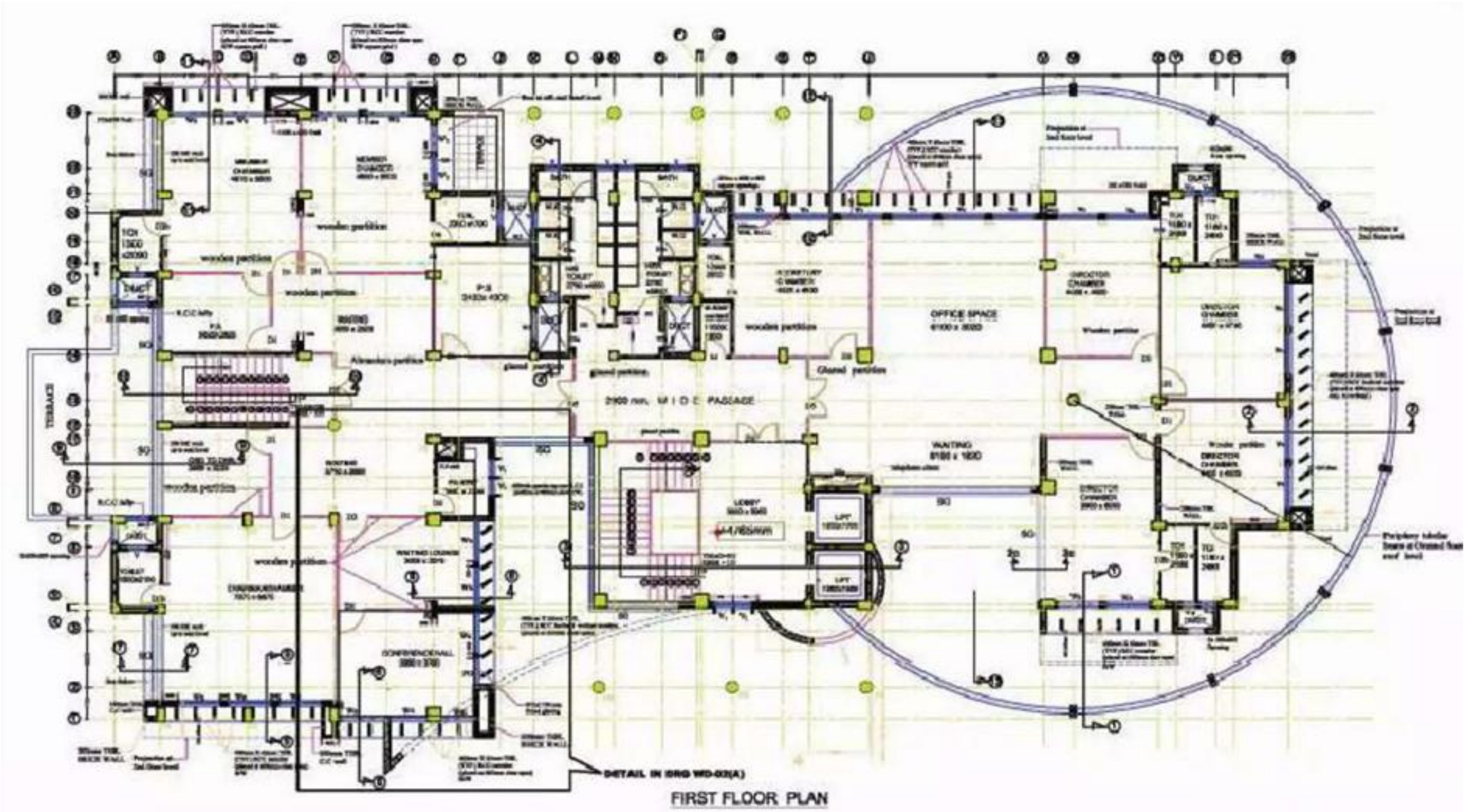


Fig. 103: First Floor Plan - Floor Area – 687.0 Sq.Mts

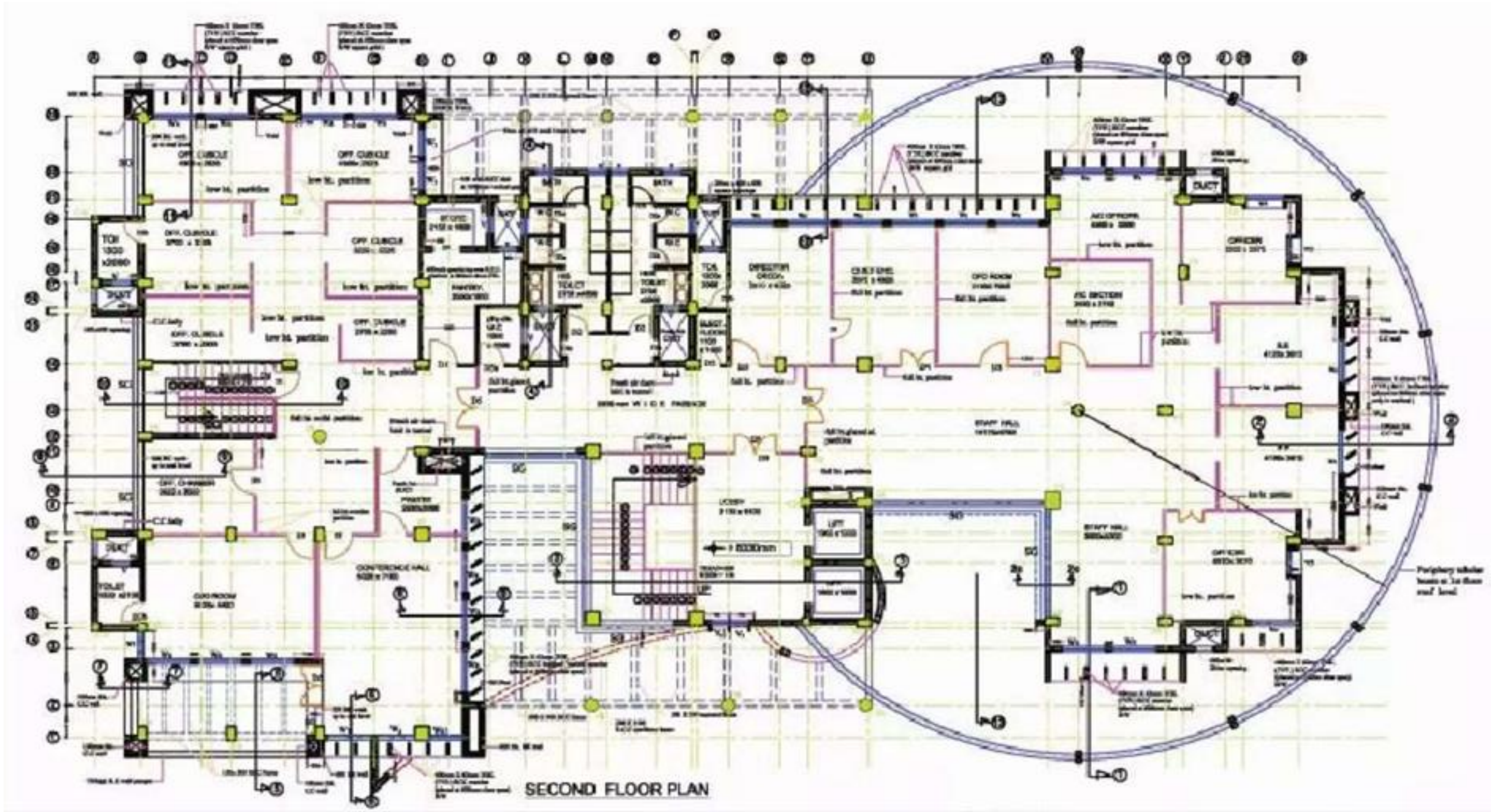


Fig. 104: Second Floor Plan - Floor Area – 726.5 Sq.Mts

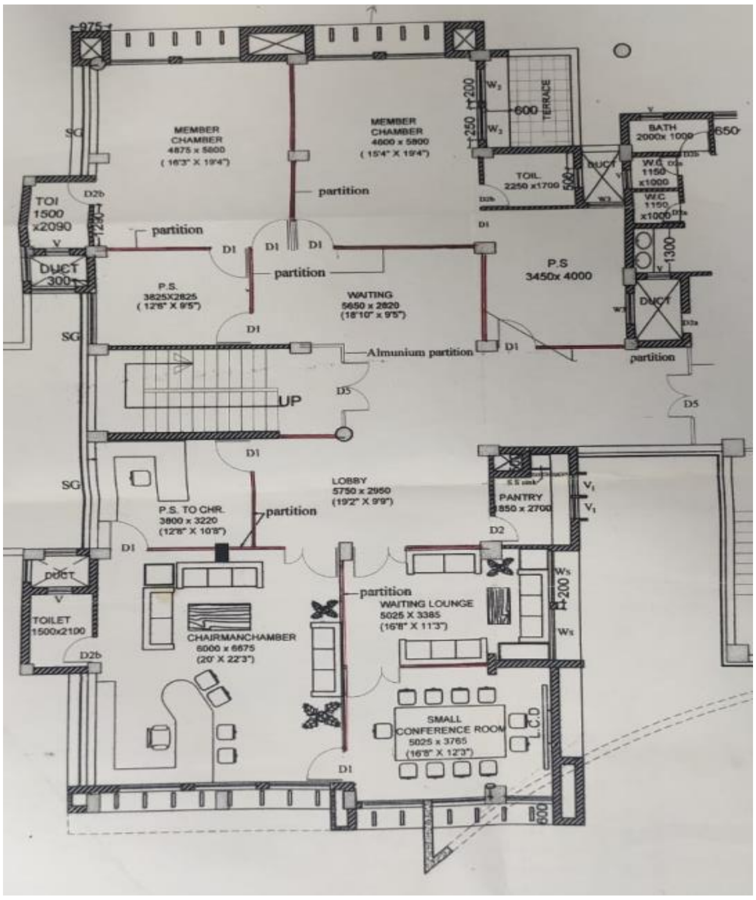


Fig. 105: Plan near Staircase of Central Passage

Fig. 106: Front View from West during Construction

4.3.2 Salient Features of CSERC Building

The energy efficiency movement in non-domestic buildings like offices, schools, and factories gets underway with the CSERC building, Solar Passive Complex. The structure has the following standout design elements:

- **Optimisation of building envelope:** The wall area exposed to outside - 28 Sq. M
- **Modulation of orientation:** Orientation of building made north-south for larger energy efficiency.
- **Air conditioned & non-air conditioned spaces** distributed effectively to rationalize heat gains for energy efficiency.
- **Solar Passive Techniques:** were incorporated in the building like wall and roof insulation, shading, landscaping, natural day lighting, conductive and evaporative cooling, solar power plant, unique southwest umbrella, cavity walls, energy-efficient lighting system
- **Wall insulation:** double wall, air gap & thermocol (cavity insulated).
- **Shading:** Projections, overhangs, pergolas, trees and solar panels were positioned in such a way that the direct rays of the sun did not strike the building envelope.
- **Landscaping:** Trees, shrubs, and grass have been used in the design of the area surrounding the structure, both within and outside of the boundary wall, as well as a large lawn in the west and south directions. Large trees around the border wall serve as a curtain to reduce noise pollution, air pollution, and to filter and chill incoming air.
- **Natural day lighting:** Room spaces designed to day lit with daylight.
- **Conductive and evaporative cooling:** Ferro cement baffles given in critical areas of façade to hinder unwanted conductive & transmitted heat gain. Evaporative duct able cooling facility for cooling non-ac spaces.
- **Unique Southwest Umbrella:** An Umbrella has been designed consisting of solar panels in the southwest position of the building which serves multiple

purposes like shading of external walls, providing aesthetics to the building and at the same time collecting solar energy from the southwest direction.

- **Energy-efficient lighting system.**
- **Use of low energy/ waste for construction.**
- **Installation of energy efficient (star rated) gadgets and equipments.**
- **Grid interactive Solar PV Power Plant 80 KW.**

Fig. 107: Southwest Umbrella as Shading Device

Fig. 108: Egg Crate Shading Device

Fig. 109: Hollow Projection in Wall

Fig. 110: Solar Panels *Fig. 111: Electrical Room* *Fig. 112: External Shading*

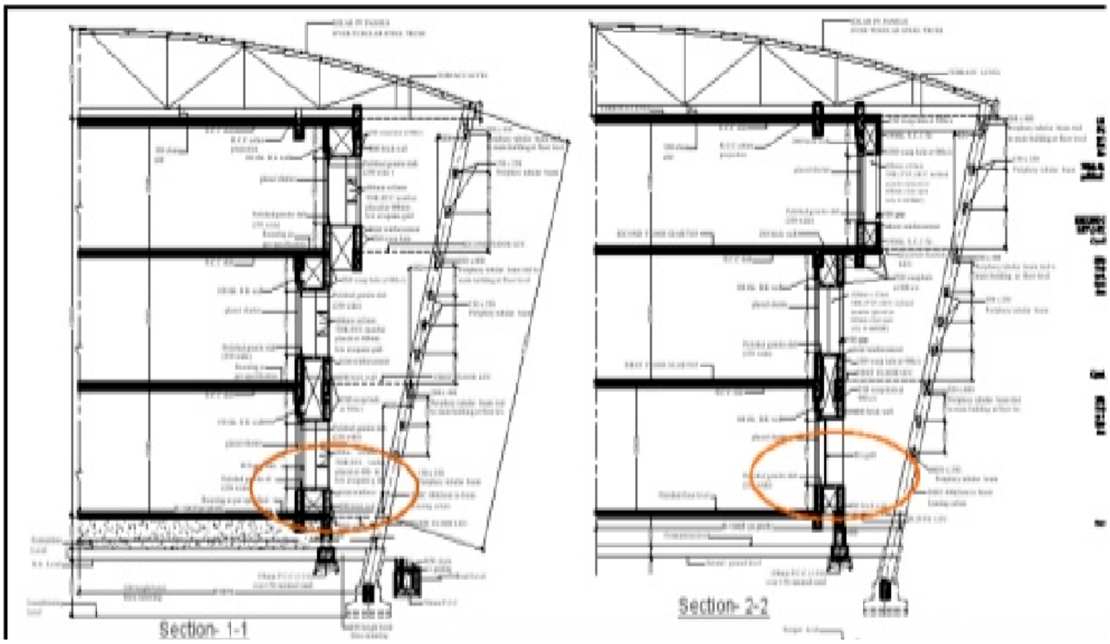


Fig. 113: Typical Sections

Fig. 114: View from Entrance

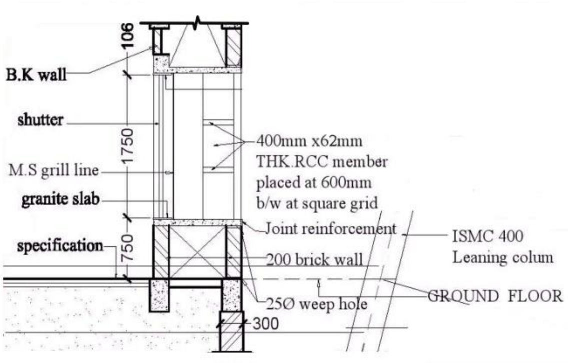


Fig. 115: Cavity Wall Details

Fig. 116: Egg Crate Shading Device

Fig. 117: Window Fins during Construction

Fig. 118: West Elevation during Construction

Fig. 119: Permanent Shading Device in the Form of RCC Pergola

Fig. 120: Thermal Insulation in Wall

Fig. 121: Egg Crate Devices during Construction

Fig. 122: Front Elevation from Approach Road

4.3.3 SPV PP Configuration

- PCU Based rooftop off grid systems of 80 KWp
- Total number of modules - 372
- Module configuration:
  -192 modules of 225 Wp
  -180 modules of 230 Wp
- Battery bank capacity - 240 V, 300AH

Fig. 123: Truss Support for Solar Panels

Fig. 124: Power Generation Room

4.3.4 Consumption Data of CSERC Building

Table 12: Consumption Data of CSERC Building (July 2011 - June 2012)

Month	**Total Solar Generation (KWh)**	**Total Solar units export to CSEB (KWh)**	**CSEB Consumption in building (KWh)**	**Solar consumption in building (KWh)**	**Total Consumption in building (KWh)**
A	**B**	**C**	**D**	**E=(B-C)**	**F=(D+E)**
July 11	7039	2400	4954	4639	9593
Aug 11	6311	2565	5016	3746	8762
Sept 11	6217	2646	4342	3571	7913
Oct 11	7384	3052	3890	4332	8222

Nov 11	7061	3635	2974	3426	6400
Dec 11	6478	3082	2948	3396	6344
Jan 12	6826	3546	3020	3280	6300
Feb 12	7805	4170	2562	3635	6197
Mar 12	9304	3305	4606	5999	10605
Apr 12	8682	2965	6079	5717	11796
May 12	8030	2194	7074	5836	12910
Jun 12	5512	1683	5481	4929	11410
Total	**87749**	**35243**	**53946**	**52506**	**106452**

Table 13: Consumption Data of CSERC Building (July 2012 - June 2013)

Month	Total Solar Generation (KWh)	Total Solar units export to CSEB (KWh)	CSEB Consumption in building (KWh)	Solar consumption in building (KWh)	Total Consumption in building (KWh)
A	**B**	**C**	**D**	**E=(B-C)**	**F=(D+E)**
July 12	5598	1055	4425	4543	8968
Aug 12	5322	1553	3578	3769	7347
Sept 12	7214	2193	4054	5021	9075
Oct 12	6975	3190	3689	3785	7474
Nov 12	6461	3255	3086	3206	6292

Dec 12	7028	3691	2869	3337	6206
Jan 13	7427	3856	2702	3571	6273
Feb 13	7484	3350	2045	4134	6179
Mar 13	8337	2874	3465	5463	8928
Apr 13	9371	2241	5391	7130	12521
May 13	8397	1055	10666	7342	18008
Jun 13	7638	1531	8389	6107	14496
Total	**87252**	**29844**	**54359**	**57408**	**111767**

Table 14: Consumption Data of CSERC Building (July 2013 - June 2014)

Month	Total Solar Generation (KWh)	Total Solar units export to CSEB (KWh)	CSEB Consumption in building (KWh)	Solar consumption in building (KWh)	Total Consumption in building (KWh)
A	**B**	**C**	**D**	**E=(B-C)**	**F=(D+E)**
July 13	6317	1282	6438	5035	11473
Aug 13	6234	2202	4846	4032	8878
Sept 13	6977	2045	5094	4932	10026
Oct 13	4474	1587	4897	2887	7784
Nov 13	6086	2722	3248	3364	6612
Dec 13	7279	3376	2363	3903	6266

Jan 14	6825	2574	2397	4251	6648
Feb 14	7549	3639	2304	3910	6214
Mar 14	8431	3104	3791	5327	9118
Apr 14	8412	2812	6436	5600	12036
May 14	8377	2385	9937	5992	15929
Total	**76961**	**27728**	**51751**	**49233**	**100984**

(Source: Slideshare)

4.3.5 Energy Savings

a) Period July 2011 - June 2012

- Total generation from SPV Power plant - 87749 kWh
- Solar units exported to CSEB Grid - 35243 kWh
- Total units imported from CSEB Grid - 53946 kWh/ year
- Total floor area of the building - 2072 m^2
- **Net EPI - 26.04 kWh/ M^2**

b) Period July 2012 - June 2013

- Total generation from SPV Power plant - 87252 kWh
- Solar units exported to CSEB Grid - 29844 kWh
- Total units imported from CSEB Grid - 54359 kWh/ year
- Total floor area of the building - 2072 m^2
- **Net EPI - 26.24 kWh/ M^2**

c) Period July 2013 - June 2014

- Total generation from SPV Power plant - 76961 kWh
- Solar units exported to CSEB Grid - 27728 kWh
- Total units imported from CSEB Grid - 51751 kWh/ year
- Total floor area of the building - 2072 m^2
- **Net EPI - 24.98 kWh/ M^2**

4.3.6 Advantages of the CSERC Building

- Saving in overall energy consumption
- Reduction in lighting consumption
- Considerable reduction in recurring expenditure
- Clean and pollution free environment
- Considerable thermal comfort
- High Productivity

CONCLUSION

Form the above quantitative analysis of energy consumption of CSERC Building for 3 consecutive years starting from July 2011 to June 2014, was found that the net EPI to increase with 0.20 kWh/m^2 and then decrease with 1.26 kWh/m^2. Hence, it can be assumed that the energy consumption in the building can be reduced to a certain extent by the use of active and passive systems in the building. This will further leads to save non renewable energy.

Building energy efficiency is critical to improving energy security in developing nations because of the current rate of urbanization and the resulting increase in energy consumption. Because the cost of energy is rising along with the complexity of new energy sources, governments should share the burden and expense of ensuring supply security with end users through energy efficiency. The design of buildings and appliances has benefited technologically, creating new chances for energy reduction. Furthermore, there is a great potential for savings because many of these technologies have not yet been adopted by poor nations. Without a legislative and regulatory framework in place, it is doubtful that anything will change because of resistance to change and the expense of achieving energy savings. Lack of understanding about building energy usage patterns and potential opportunities is one of the main challenges. Thus, when designing a building, it's critical to understand and take energy efficiency into account.

4.4 CASE STUDY

Vastu Shastra and Passive Solar Architecture both emphasises principles that enhance natural light, ventilation and thermal comfort within buildings. By studying traditional buildings influenced by these principles, common design strategies can be identified that optimize energy use and human comfort. They also provide a rich source of knowledge for developing environmentally friendly and culturally responsive building solutions.

The case studies of 10 traditional dwelling units located in four different villages in Chhattisgarh, namely Kodia, Borsi, Chhattarpur, and Mohradih were conducted by onsite visits. Case study of courtyard type of buildings, particularly those influenced by Vastu Shastra and Passive Solar Architecture, were conducted to identify and understand their shared features. In addition, a questionnaire was used to inquire the occupants about their comfort levels and the surrounding temperature.

4.4.1 CASE STUDY 1

A. **Location:** Kodia, Chhattisgarh.
B. **Orientation:** East
C. **Description:** The building, approximately 100 years old, has undergone renovations over the years to meet the evolving needs of its residents. It is accessed via a 40 feet wide road, enhancing its visibility and accessibility.

Fig. 125: Front Facade of House at Kodia Chhattisgarh

At the entrance of the dwelling unit, two shops are situated on the right side, while a room featuring two double-leaf doors is positioned on the left, creating a welcoming and functional entryway.

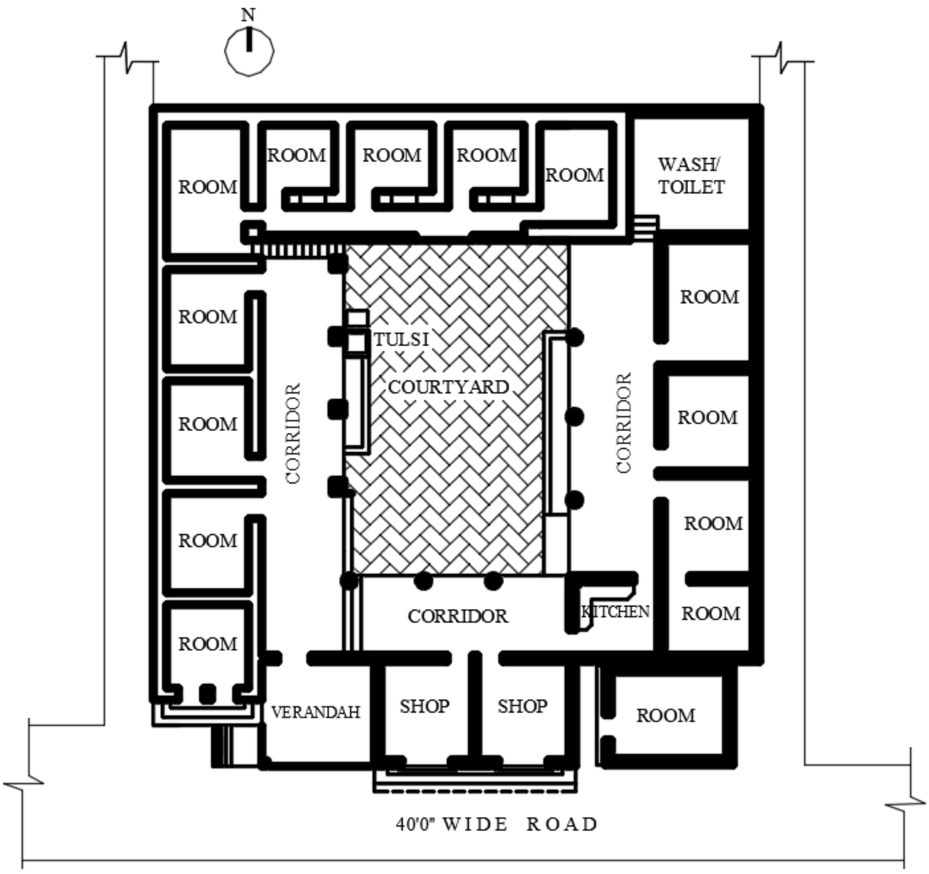


Fig. 126: Typical Floor Plan

D. Plan & Layout: Courtyard Type

At the entrance, there is a shaded raised platform that stands 2 feet above the road level, providing a welcoming transition into the dwelling. Centrally located is a traditionally designed double-leaf entrance door, leading into the heart of the home. The central courtyard is surrounded by rooms, with a shaded corridor encircling it, seamlessly connecting all the spaces. The dwelling is designed as a two-storeyed structure on the north and south sides of the courtyard, while the east and west sides feature a single storey. On the ground floor, the Southern side houses four rooms along with a staircase, while the northern side includes four additional rooms, a kitchen, and a washing area, creating a functional and harmonious living environment. The Eastern, southern, and northern sections of the building have been thoughtfully renovated, while the western part retains its original character, with only minor alterations made to the roofing sheets.



Fig. 127: Entrance Door Fig. 128: View from Entrance Fig. 129: View of Courtyard



Fig. 130: Dwelling Unit on West *Fig. 131: View of Courtyard from the Top* *Fig. 132: Slate Flooring at Passage*



Fig. 133: View of North *Fig. 134: 6'0" High Roof* *Fig. 135: Tulsi Plant at Courtyard*

The Western part of the building features five rooms with a ceiling height of 6 feet and door height of 4 feet, characterized by small doors and windows that open toward the corridor and courtyard. The corridor floor is adorned with slate tiles, adding a touch of elegance to the space. As the oldest section of the structure, its roof has been updated with galvanized iron sheets. The rooms on this side have retained their original mud flooring, while all other rooms in the dwelling have been recently upgraded to tiled floors. The walls are constructed from mud, boasting a thickness of 2 feet, providing a sturdy and traditional feel. The toilets are conveniently located in the northwest corner of the house. Additionally, the courtyard is covered with clay tiles, and the Tulsi plant has been thoughtfully relocated to the southern part of the courtyard, enhancing the overall ambiance.

Fig. 136: Decorative Square Column

Fig. 137: Space for Washing

Fig. 138: Door with Fanlight & Multi Panel Door

Fig. 139: Rooms on First Floor

The corridor is elegantly designed with decorative round and square columns, measuring 1 foot in diameter and 1.5 feet by 1.5 feet, featuring a subtle horizontal projection at the lintel and slab level that extends toward the courtyard. On the Southern side, flat lintels are supported by square columns, while the northern side showcases graceful arches built between two circular columns. The Southern portion of the building has a wall thickness of 1 foot 4 inches and is constructed from a mix of mud, bricks, and cement. Five years ago, the original mud flooring was replaced with stylish tiles, and a reinforced concrete (RCC) roof was added. At the Southwest corner of the dwelling unit, a small staircase of 12 steps, 2 feet wide, leads to the first floor. Here, new rooms were constructed on both the south and north sides, while the east side remains open. The first-floor doors are 6 feet high, featuring double-leaf designs with traditional aesthetics, complete with hollow portions above the frame that serve as windows for natural light and air circulation within the rooms.

E. Vastu Features Observed:

- **Entry Orientation**: The main entry is located in the northeast direction.
- **Welcoming Entrance**: A shaded lobby features a double-leaf wooden door, providing an inviting entrance.
- **Courtyard Planning**: The layout incorporates a central courtyard, promoting natural light and ventilation.
- **Room Placement**: Rooms are strategically arranged along all four cardinal directions.
- **Height Variation**: The building is elevated from the southern side, enhancing its overall design.
- **Staircase Location**: The staircase is situated in the southeast corner, facilitating efficient movement within the dwelling.
- **Toilet Placement**: Toilets are conveniently located in the northwest corner of the house.
- **Thermal Insulation**: Thick walls on the southern and western sides improve thermal insulation and energy efficiency.
- **Architectural Projections**: Projections are incorporated at the lintel and slab levels, adding to the aesthetic appeal.
- **Design Aesthetics**: Efforts have been made to enhance beauty through the use of circular and square columns with plaster designs, flat and multi-centered arch openings, and a vibrant color wash.

F. Passive Solar Features Observed:

- **Courtyard Planning**: The design incorporates a central courtyard, enhancing natural light and ventilation.
- **Maximized Surface Area**: The building features more surface area on the south and north sides, optimizing exposure to sunlight and airflow.

- **Architectural Projections**: Projections are included at the lintel and slab levels, adding depth and visual interest to the structure.
- **Buffer Spaces**: Passageways or corridors serve as buffer spaces, reducing heat penetration into the rooms.
- **Thermal Insulation**: Thick walls on the southern and western sides significantly improve thermal insulation.
- **Limited Openings**: There are no openings in the exterior walls on the south and west sides, minimizing heat gain.
- **Mutual Shading**: The design effectively achieves mutual shading, enhancing comfort and energy efficiency.
- **High-Quality Materials**: The use of materials with high thermal insulation properties contributes to the overall energy efficiency of the dwelling unit.

4.4.2 CASE STUDY 2

A. Location: Borsi, Chhattisgarh

B. Orientation: East

C. Description: The dwelling unit is situated 60 feet away from the main road, and the open space at the entrance serves as a designated area for keeping animals.

Fig. 140: Front View of Dwelling Unit at Borsi, Chhattisgarh

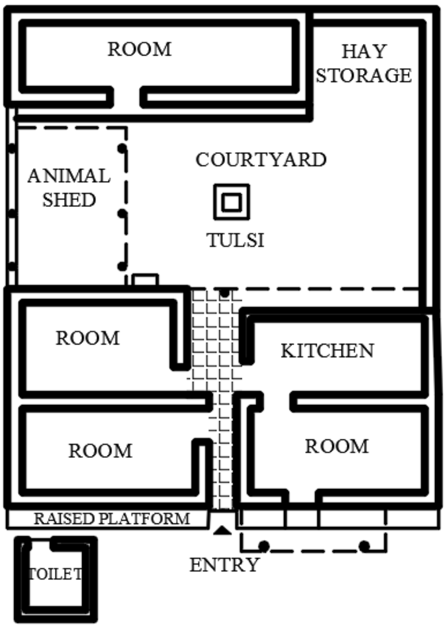


Fig. 141: Typical Floor Plan

Fig. 142: Timber Roof Supported by Wooden Post

D. Plan & Layout: Courtyard Type

At the entrance, a raised platform is designed for daily activities. Centrally located, the doorway opens into a small passage measuring 2 feet wide, featuring a floor made of slate stone and broken tiles. The entrance door stands 5 feet 6 inches high, while the passage reaches a height of approximately 7 feet. Adjacent to the entrance, a room includes a small exterior projection supported by two wooden posts, with a roof made of bamboo and polythene sheets. A string is conveniently tied between the wooden posts for drying clothes, adding functionality to the space.

Fig. 143: Raised Platform at the Entrance

Fig. 144: Entrance Door Highlighted with Lime Wash

Fig. 145: Central Courtyard with Tulsi at Centre

Fig. 146: Narrow Passage with Broken Tiles Flooring

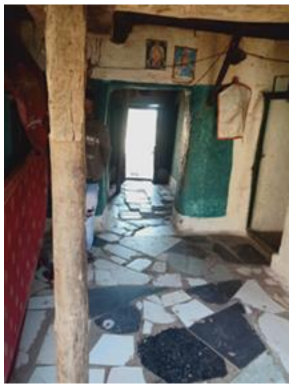


Fig. 147: Timber Column

Fig. 148: Kitchen Walls Covered with Cloth

Fig. 149: Storage Space for Animal Food

Fig. 150: Hut on West

Fig. 151: Timber Trusses in Roof

Fig. 152: Informal Sitting Area

The passage leads to a small courtyard, featuring a Tulsi plant at its centre. Flanking the passage are two rooms: one with an entrance from the roadside and the other accessible from within the passage on the south side. The walls are adorned with a mud wash, while the entrance doors are highlighted with lime wash on both sides. The courtyard includes a designated space for keeping animals on the south side, as well as a hut on the west side with a door that stands 4 feet high. This courtyard serves as a private sitting area with mud flooring and features a northwest corner for storing food, such as hay for the animals. The mud walls are impressively thick, measuring 2 feet, and the roof is constructed from a combination of bamboo, sticks, clay tiles, and corrugated cement sheets. The kitchen opens into the courtyard, with its walls on two sides made of cloth, creating a unique aesthetic. Additionally, toilets are located outside near the entrance, separated from the main dwelling unit by a 2-foot-wide passage for privacy

E. Vastu Features Observed:

- **Central Entry**: The entrance is positioned at the center of the dwelling unit.
- **Shaded Platform**: A shaded platform or *ota* with a double-leaf wooden door enhances the entrance area.
- **Courtyard Planning**: The design features a courtyard layout, with rooms arranged at the front, sides, and rear of the unit.
- **Tulsi Plant**: A Tulsi plant is prominently located at the center of the courtyard, adding to the aesthetic and cultural significance.
- **Natural Light and Ventilation**: The rooms benefit from ample light and ventilation provided by the courtyard.
- **Utilized Space**: The Western side of the unit is designated for less frequently used space.
- **Cow Shed Location**: A cow shed is conveniently situated in the southern corner of the dwelling unit.
- **No Indoor Toilets**: There are no toilets present inside the dwelling unit, emphasizing a traditional layout.
- **Use of Local Materials**: The construction incorporates locally available materials such as mud, timber, and bamboo, utilizing traditional techniques.
- **Aesthetic Enhancements**: The entrance is beautified with a color wash, enhancing the overall appearance of the dwelling.

F. Passive Solar Features Observed:

- **Courtyard Planning**: The design incorporates a courtyard layout, enhancing the spatial organization of the dwelling.

- **Natural Light and Ventilation**: Rooms benefit from ample light and ventilation provided by the courtyard.
- **Eaves Projections**: Projections in the form of eaves from the sloping roof add character and functionality.
- **Heat Retention**: A small passage, thick walls, and roof projections effectively reduce heat penetration into the rooms.
- **Thermal Insulation**: Thick mud walls contribute to improved thermal insulation, maintaining a comfortable indoor climate.
- **High-Quality Materials**: The dwelling features materials with excellent thermal insulation properties, enhancing energy efficiency.
- **Sustainable Roofing**: The sloping roof is constructed using sticks, timber, tiles, and waste materials, promoting sustainability.

4.4.3 CASE STUDY 3

A. Location: Chhattarpur, Chhattisgarh

B. Orientation: East

C. Description: The building, approximately 80 to 90 years old, is complemented by a spacious open area at the front, providing a welcoming approach.

Fig. 153: Front View of East-Facing Dwelling Unit at Chhattarpur, Chhattisgarh

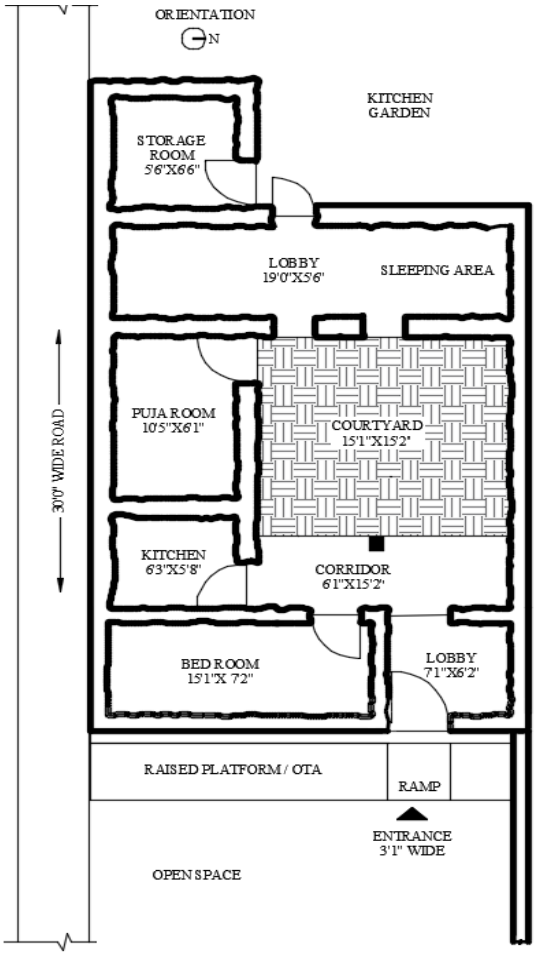


Fig. 154: Typical Floor Plan

Fig. 155: Raised Platform at the Front

Fig. 156: Space for Keeping Bicycle

Fig. 157: Shaded Passage

D. Plan & Layout: Courtyard Type

At the entrance, a raised platform stands 1 foot high above road level, providing a space for seating, gatherings, and daily activities. The entrance features a beautifully crafted multi-panel double-leaf door, situated in the northwest corner of the dwelling, adorned with elegant floral plaster designs. A small passageway adjacent to the entrance is designated for bicycle storage. In the centre of the home lies a charming courtyard, surrounded by rooms on the south, east, west, and northwest sides. The room closest to the entrance is accessible via a shaded passage with projected eaves, offering a pleasant transition into the space. The bedroom, though cozy and designed solely for sleeping, has a low ceiling height of 7 feet and lacks windows, emphasizing its intimate character.


Fig. 158: View of Courtyard from Passage


Fig. 159: Cement Flooring in Courtyard


Fig. 160: Brick Corbelling


Fig. 161: Kitchen


Fig. 162: Small Void for Ventilation


Fig. 163: Cement Flooring with Level Difference


Fig. 164: Brick Pier Supporting Roof


Fig. 165: Sloping Roof


Fig. 166: Shade at Lintel Level

The kitchen is in the southeast corner of the dwelling unit, featuring a small void in the external wall that serves as a ventilator, allowing smoke to escape. The bedroom, kitchen, courtyard, and entrance passage all have cement flooring, which was once mud. The brick walls are 15 inches thick, and a sturdy pillar, measuring 1 foot 3 inches by 1 foot 3 inches, supports the sloping roof of the passage, with eaves extending 2 feet toward the courtyard.

The courtyard measures 15 feet by 15 feet, adorned with a Tulsi plant on the north side and sparse vegetation on the opposite side. A dedicated Puja room is situated to the south and can be accessed through the courtyard. On the West side of the courtyard, there is a covered lobby featuring two openings, with brick corbelling as lintels and an additional room to the south. A small door leads from the lobby to the west.

The rear section of the dwelling unit boasts a spacious garden used for growing vegetables and fruits, complemented by a small storage room in the southwest corner. The entire dwelling appears to be part of a larger unit, separated by a boundary wall to the north. Please note that there are no toilets or bathrooms within the dwelling unit.

E. Vastu Features Observed:

- **Northeast Entry:** The dwelling features an entryway positioned in the northeast.
- **Courtyard Design:** The layout follows a courtyard planning style, promoting natural light and ventilation.
- **Room Placement:** Rooms are thoughtfully arranged on the south, west, and east sides.
- **Single Storey:** The unit is designed as a single-storey structure, enhancing accessibility.
- **Buffer Spaces:** Passageways and a lobby serve as buffer spaces, reducing heat penetration into the building.
- **Landscaped Open Space:** The open area to the west is beautifully planted with trees and various plants.
- **Storage Room:** A small storage room is conveniently located in the southwest corner of the dwelling unit.

- **Absence of Toilets:** There are no toilets within the house itself.
- **Eave Projections:** The design includes projections in the form of eaves, adding to the architectural character.
- **Aesthetic Appeal:** Aesthetics are enhanced through the use of colorful plaster designs on both external and internal walls.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design follows a courtyard-type layout, promoting natural light and ventilation.
- **Eave Projections:** Architectural projections in the form of eaves enhance both aesthetics and functionality.
- **Buffer Spaces:** Passageways and a lobby serve as buffer areas, effectively reducing heat penetration into the building.
- **Thick Walls:** The use of thick walls contributes to superior thermal insulation.
- **South Wall Design:** There are no openings in the external south walls, enhancing privacy and energy efficiency.
- **Landscaped West Side:** The West side is dedicated to planting trees, creating a green, shaded environment.
- **Thermal Insulation Materials:** High thermal insulation materials are utilized throughout the dwelling unit for improved energy efficiency.
- **Elegant Sloping Roof:** The sloping roof not only adds visual appeal but also ensures structural stability.

4.4.4 CASE STUDY 4

A. Location: Chhattarpur, Chhattisgarh

B. Orientation: North

C. Description: It is approached by a front road.

D. Plan & Layout: Courtyard Type

Fig. 167: Front View of North-Facing Dwelling Unit at Chhattarpur, Chhattisgarh

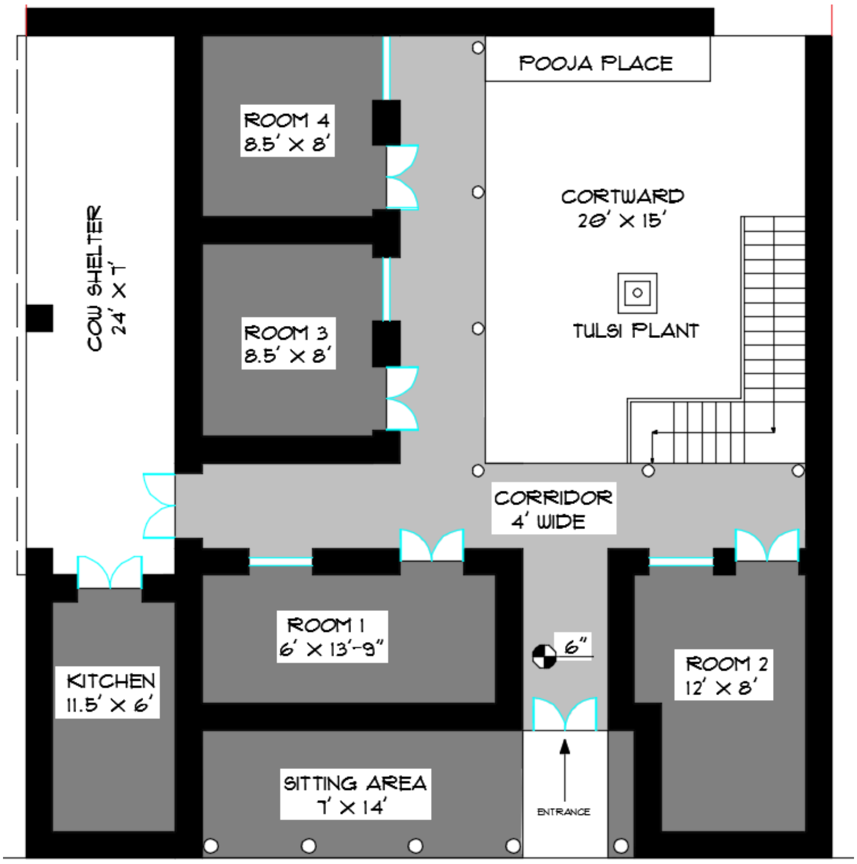


Fig. 168: Typical Floor Plan

Fig. 169: Raised Platform *Fig. 170: Decorative Entrance* *Fig. 171: Panel Door*

At the entrance, a raised platform rises 2 feet above road level, creating an inviting first impression. The outer façade of the house features elegant, rounded columns that enhance its visual appeal. The entrance door is exquisitely ornamented, adding a touch of charm. A narrow passageway leads from the entrance to the central courtyard, around which the rooms are thoughtfully arranged.

Fig. 172: View of Courtyard *Fig. 173: Shaded Passage in Front of Rooms*

A shaded corridor, 4 feet wide, runs along two sides of the courtyard, connecting all the rooms and elevated 6 inches above the ground. The dwelling comprises four rooms in total, with a staircase located on the western side. On the Northern side, you'll find two rooms along with the kitchen, while the eastern side features a washing space and a cow shelter. Each room is equipped with small doors and windows that face the corridor and courtyard. The walls, constructed from mud, bricks, and cement, have a thickness of 1 foot 3 inches, ensuring both durability and insulation.

Fig. 174: Rooms on Southeast

Fig. 175: 4'0" Wide Passage

Fig. 176: Multi Centred Arch

The space designated for performing puja is situated in the southeast corner of the courtyard, which features mud flooring and a central planter. The southern area of the dwelling unit is reserved for planting, discreetly enclosed by a boundary wall, yet accessible from the courtyard. The walls, doors, windows, lintels, roof, and columns are beautifully adorned with intricate plaster designs and vibrant colour washes, adding a touch of elegance to the overall aesthetic.

Fig. 177: Staircase on West

Fig. 178: Void for Ventilation

Fig. 179: Cow Shed

Fig. 180: Multipurpose Courtyard

The columns of the dwelling are octagonal, with each side painted in a different colour, contributing to the vibrant aesthetic. Overall, the dwelling unit takes on a square shape, featuring open spaces in the southwest and west parts for the courtyard. The kitchen is positioned on the northeast side of the house, separate from the rooms and courtyard. A small window in the kitchen, facing east, allows smoke to escape without overlooking the road. Additionally, an animal shelter is in the southeast corner, attached to the rear of the rooms, helping to reduce heat penetration into the bedrooms. Notably, there are no toilets or bathrooms within the dwelling unit.

E. Vastu Features Observed:

- **North Side Entry:** The dwelling unit features an entrance from the north side.
- **Shaded Lobby:** A spacious, shaded lobby with a double-leaf wooden door greets visitors at the entrance.
- **Courtyard Planning:** The design follows a courtyard-type layout, promoting natural light and ventilation.
- **Room Placement:** Rooms are thoughtfully arranged on the east and north sides of the dwelling.
- **Openings for Light:** Each room has openings directed toward the courtyard to enhance light and airflow.
- **Vegetation Reserve:** The Southern part of the dwelling unit is dedicated to vegetation, creating a green buffer.
- **Absence of Toilets:** There are no toilets present inside the house.
- **Plantation Area:** The rear area facing south is utilized for plantation activities.
- **Aesthetic Design Elements:** The design is enriched by circular and square columns with plaster details, decorative doors adorned on three sides, floral ceiling designs, multi-centered arch openings, and vibrant color washes.
- **Cow Shed Location:** A cow shed is situated in the southeast corner of the property.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design incorporates a courtyard-type layout, enhancing natural light and airflow.
- **Increased Surface Area:** The dwelling has more surface area on the south and north sides, promoting energy efficiency.
- **Buffer Spaces:** Lobby, passage, and corridor areas serve as buffer spaces, effectively reducing heat penetration into the building.
- **Thick Walls:** Thick walls are utilized for superior thermal insulation, maintaining comfortable indoor temperatures.

- **Southern Plantation:** The Southern side is dedicated to plantation, adding greenery to the environment.
- **Ventilation and Light:** Windows and doors in the rooms are oriented toward the courtyard to maximize ventilation and natural light.
- **High Thermal Insulation Materials:** The dwelling features materials with excellent thermal insulation properties for enhanced energy efficiency.
- **Aesthetic Enhancements:** The ornamented lobby and passage serve not only as beautiful design elements but also function as effective shading devices.

4.4.5 CASE STUDY 5

A. Location: Chhattarpur, Chhattisgarh

B. Orientation: South

C. Description: It is approached by a front road. There is a raised platform with a ramp at the entrance to enter inside the dwelling unit.

Fig. 181: Front View of South-Facing Dwelling Unit at Chhattarpur, Chhattisgarh

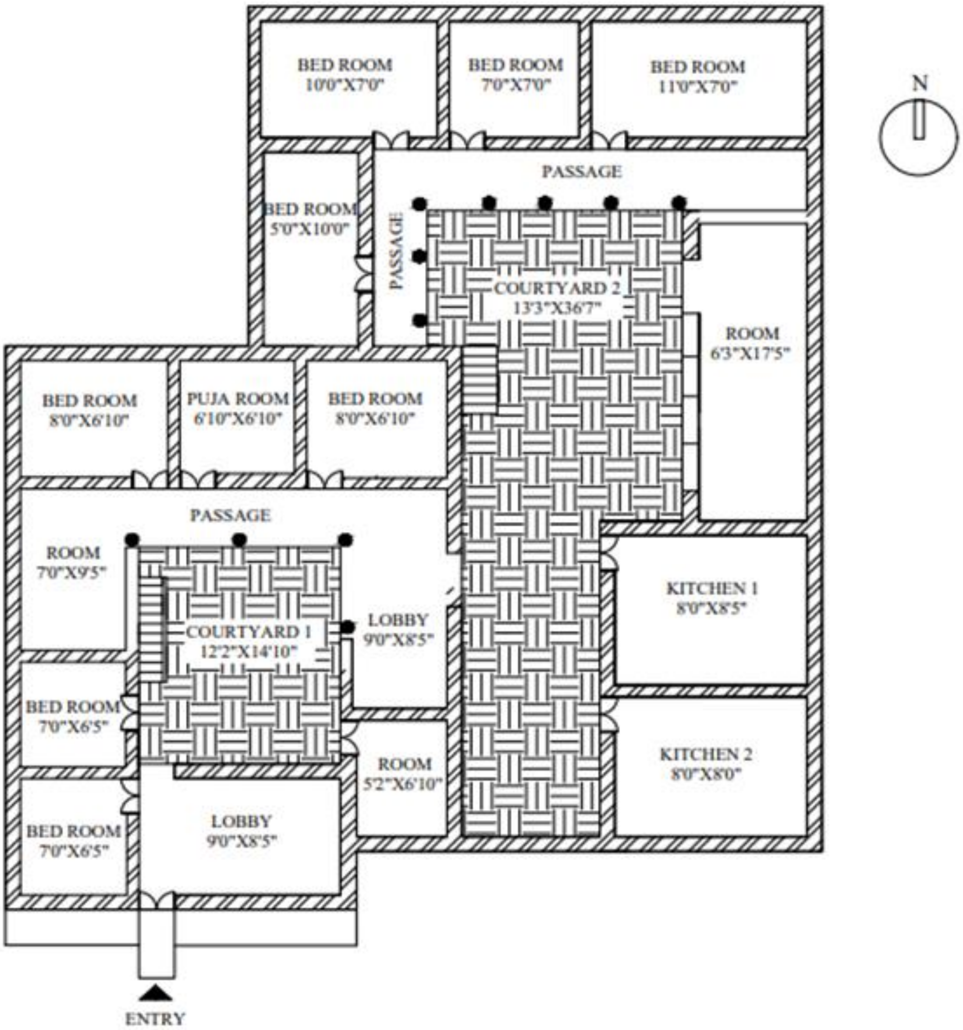


Fig. 182: Typical Floor Plan

D. Plan & Layout: Courtyard Type

This two-story unit features a granary on the first floor. The Southeast and southwest portions include a lobby and a room. In total, the house comprises 12 rooms. There are two courtyards within the dwelling; one is smaller, while the other is larger and separated by a covered lobby. Both courtyards are adorned with slate flooring. The smaller courtyard includes stairs leading up to the granary. Thanks to the granary's height of 4 feet on the first floor, the dwelling unit remains pleasantly cool throughout.

Fig. 183: Decorative Entrance

Fig. 184: Multi Panel Door

Fig. 185: View of Courtyard from Entrance

Fig. 186: Round Column with Square Base

Fig. 187: Granary of 4’0” High

Fig. 188: Straight Staircase

Fig. 189: Lobby with Cement Flooring and Timber Roof

Fig. 190: Ventilator for Ventilation

Fig. 191: Slate Flooring in Courtyard

The windows and ventilators are oriented toward the courtyard, enhancing natural light and ventilation. Small, prefabricated cement ventilators are installed in both the rooms and the granary. The walls are adorned with various floral designs, finished in a range of vibrant colours. The structure features circular and square columns with intricate plaster designs, decorative doors painted on three sides, and both flat and multi-centred arch openings, all complemented by a colourful wash. The South, west, and east sides showcase sloping roofs made of timber and clay tiles, while the northern side of the larger courtyard boasts a flat roof constructed from RCC.

Fig. 192: View of Second Courtyard

Fig. 193: Stairs Leading to First Floor

Fig. 194: Decorative Columns with Passage, Rooms, Courtyard and Parapet Wall

Fig. 195: Adjoining Old Structure of Dwelling Unit

E. Vastu Features Observed:

- **Central Entry:** The dwelling features an entrance positioned at the center.
- **Double-Leaf Wooden Door:** A beautifully crafted double-leaf wooden door greets visitors at the entrance.
- **Courtyard Planning:** The design follows a courtyard-type layout, enhancing light and airflow.
- **Room Placement:** Rooms are thoughtfully arranged on the south, west, east, and north sides of the unit.
- **Puja Room and Kitchen:** The puja room is located on the north side, while the kitchen is situated in the southeast corner.
- **Absence of Toilets:** There are no toilets present inside the house.
- **Use of Local Materials:** The dwelling incorporates locally available materials such as mud, timber, bamboo, slate stone, and traditional construction techniques.
- **Projected Eaves:** The roof features projected eaves, with a lobby and passage connecting the rooms and courtyard.
- **Aesthetic Design Elements:** The design is enhanced by circular, octagonal, and square columns with plaster details, flat and multi-centered arch openings, floral decorations on walls and parapets, and vibrant color washes.
- **Floor Slope:** The floor is designed to slope toward the rear of the dwelling unit, specifically toward the north.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design follows a courtyard-type layout, enhancing natural light and ventilation.
- **First-Floor Granary:** A granary on the first floor surrounds the small courtyard, helping to keep the ground floor cool.
- **High Ventilators:** Small ventilators are installed high on the walls to improve air circulation throughout space.
- **Flat Projections:** The design features flat projections at the lintel level and eaves at the roof level.
- **Buffer Spaces:** Lobby, passage, and corridor areas serve as buffer spaces, effectively reducing heat penetration into the building.
- **Thick Walls:** Thick walls are utilized for superior thermal insulation, contributing to energy efficiency.
- **No Openings on Sides:** There are no openings on the east and west side walls, enhancing privacy and insulation.
- **Mutual Shading:** The design incorporates mutual shading, optimizing comfort and energy efficiency.
- **High Thermal Insulation Materials:** The dwelling unit is constructed using materials with excellent thermal insulation properties.

4.4.6 CASE STUDY 6

A. Location: Chhattarpur, Chhattisgarh

B. Orientation: West

C. Description: The dwelling unit has approach road on its north side.

D. Plan & Layout: Courtyard Type

Fig. 196: Front View of West-Facing Dwelling Unit at Chhattarpur, Chhattisgarh

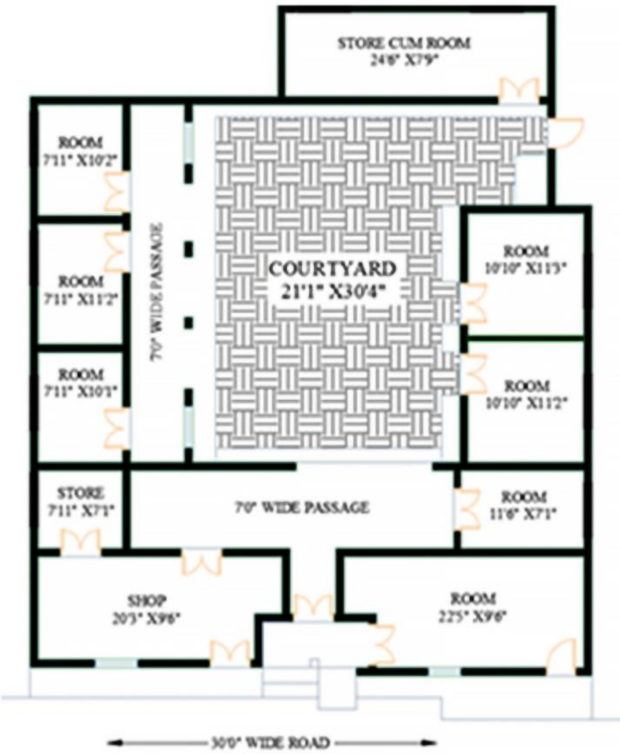


Fig. 197: Typical Floor Plan

Fig. 198: View from Entrance *Fig. 199: Roof Supported by Battens & Purlins* *Fig. 200: Multi Panel Entrance Door*

The dwelling unit features two entrances: a main entrance from the west and a rear entrance from the north. At the front, there is a spacious area designated for storing hay and drying clothes. The boundary wall is constructed from dried stems, supported by sturdy posts with thin horizontal stems tied together. The rear entrance leads to a narrow passage with a mud floor, while the apron of the dwelling unit is elevated by six inches above the mud floor. The courtyard is beautifully paved with slate and serves multiple purposes, including vehicle storage, seating, washing utensils, and serving as a gathering space.

Fig. 201: Rear Entrance from North *Fig. 202: View of courtyard* *Fig. 203: Rear Entrance Door*

Fig. 204: Rooms with Double Leaf Door *Fig. 205: Projected Roof* *Fig. 206: Kitchen with Small Void for Ventilation*

Fig. 207: Dwelling Unit on North *Fig. 208: 6'0" High Door* *Fig. 209: Storage Space in Walls*

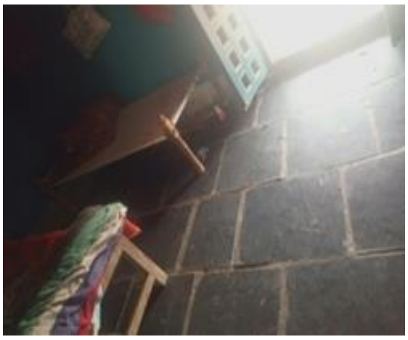


Fig. 210: Dining Area *Fig. 211: Timber Roof Supported by Purlins* *Fig. 212: Slate Flooring*

The walls of the dwelling unit are 15 inches thick, built from bricks and mud plaster. The doors and room heights are intentionally low, creating a cozy atmosphere. These rooms serve various purposes, including sleeping, dining, and storage. The kitchen is situated in the northwest corner and features a small vent to allow smoke and hot air to escape. Each entrance is accompanied by a lobby that helps to minimize the direct entry of heat into the interior spaces. There are no toilets inside the unit, and multi-panel timber doors with frames on all sides enhance the structure's charm. Slate flooring is found throughout the rooms and kitchen, while notches in the walls provide convenient storage for everyday items. The sloping roof is constructed from timber, sticks, hay, plastic, and tiles. Decorative plaster designs in rich colours adorn the walls, adding to the character of the home.

E. Vastu Features Observed:

- **Central Main Entrance:** The dwelling features a main entrance positioned at the center of the west side.
- **Double-Leaf Wooden Door:** A large projection showcases a beautifully crafted double-leaf wooden door at the entrance.
- **Courtyard Planning:** The design follows a courtyard-type layout, promoting natural light and ventilation.
- **Room Arrangement:** Separate dwelling units are thoughtfully placed on the east, west, south, and north sides around the central courtyard.
- **Kitchen Location:** The kitchen is conveniently located in the northwest corner of the dwelling unit.
- **Heat Management:** Buffer zones, such as foyers and large projections at each entrance, effectively slow heat penetration.
- **Absence of Toilets:** There are no toilets present inside the house, adhering to traditional Vastu principles.
- **Architectural Projections:** Projections in the form of eaves and lintels enhance the entrance of each dwelling unit.
- **Aesthetic Design Elements:** The beauty of the design is achieved through decorative plasterwork on columns and walls, finished with rich dark colors.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design follows a courtyard-type layout, enhancing natural light and airflow.
- **Strategic Unit Placement:** Each dwelling unit is positioned on the east, west, south, and north sides around the central courtyard, with minimal gaps that restrict heat transfer.

- **Architectural Projections:** Projections at the lintel level take the form of chajjas and eaves, providing shade and protection.
- **Heat Management Buffers:** Buffer spaces, including lobbies and large projections at each entrance, help to retard heat penetration into the units.
- **Thermal Insulation:** Thick walls contribute to better thermal insulation, maintaining comfortable indoor temperatures.
- **Small Openings:** The design incorporates small openings, which help reduce heat gain while allowing for ventilation.
- **Mutual Shading:** The layout promotes mutual shading among the units, enhancing comfort during warmer months.
- **High-Insulation Materials:** The dwelling unit utilizes materials with high thermal insulation properties, ensuring energy efficiency and comfort.

4.4.7 CASE STUDY 7

A. Location: Chhattarpur, Chhattisgarh

B. Orientation: West

C. Description: The dwelling unit has open space at the front.

D. Plan & Layout: Courtyard Type

Fig. 213: Front View of West-Facing Dwelling Unit at Chhattarpur, Chhattisgarh

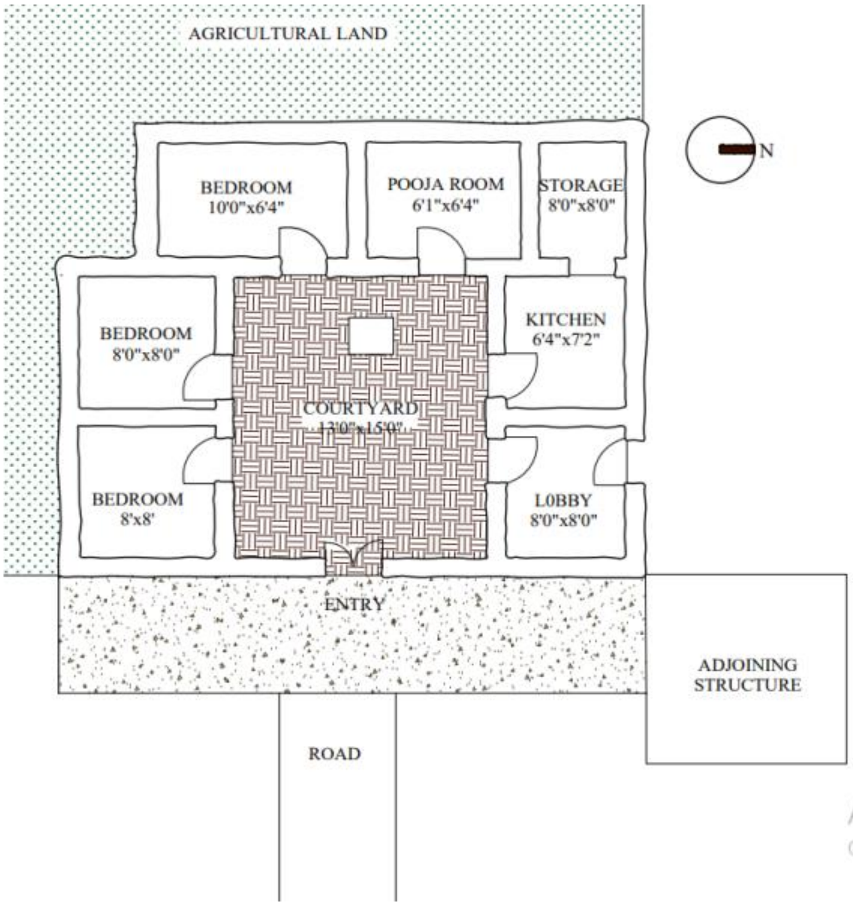


Fig. 214: Typical Floor Plan

Fig. 215: View from Entrance

Fig. 216: View of Courtyard with Mud Flooring

Fig. 217: Rooms on East

The entrance lacks shaded coverage, featuring a centrally placed double-panel door. At the heart of the house lies a courtyard measuring 13 feet by 15 feet, with a Tulsi plant positioned in front of the puja room. The puja room is in the east, while the rooms surrounding the courtyard are shaded by projecting eaves. The courtyard has a mud floor, providing access to all the adjacent rooms.

Fig. 218: Rooms on North

Fig. 219: Sloping Roof Supported by Wooden Post

Fig. 220: Puja Room

Fig. 221: 15" Th. Brick Wall with Cement Plaster

Fig. 222: Storage in Wall

Fig. 223: Wooden Lintel

Fig. 224: Passage towards South

Fig. 225: View of Roof from Inside

Fig. 226: Projecting Eaves

Rooms are positioned on the east, north, and south sides of the dwelling. The kitchen, located in the south, connects to an interior storage area. Adjacent to the kitchen is a poultry area, accessible via an external gate. The walls are constructed from bricks, finished with either cement or mud plaster, and feature recessed sections for storing daily use items. Ledged, battened, and braced wooden doors are framed on all four sides, adding to the home’s functionality and charm.

E. Vastu Features Observed:

- **Central Entry:** The dwelling features an entry positioned at the center, accessed through a double-leaf wooden door.
- **Courtyard Planning:** The layout follows a courtyard-type design, enhancing natural light and airflow.
- **Room Placement:** Rooms are thoughtfully arranged on the south, east, and north sides of the unit.
- **Kitchen Location:** The kitchen is situated in the south, equipped with a small void serving as a ventilator that opens towards the agricultural land.
- **Puja Room:** The puja room is centrally located on the east side, accompanied by a small Tulsi plant in front within the courtyard.
- **Absence of Toilets:** There are no toilets present inside the house, adhering to traditional Vastu principles.
- **Architectural Projections:** Projections take the form of eaves, extended with dried stems and covered with plastic sheets for protection.
- **Aesthetic Enhancements:** The beauty of the design is further enhanced by a color wash that reaches up to the lintel level.

F. **Passive Solar Features Observed:**

- **Courtyard Planning:** The design follows a courtyard-type layout, fostering natural light and ventilation.
- **Increased Surface Area:** The dwelling has more surface area on the south and north sides, enhancing exposure to natural elements.
- **Architectural Projections:** Projections are present at both the lintel and roof levels, adding depth and character to the design.
- **Thermal Insulation:** Thick walls are incorporated for improved thermal insulation, ensuring a comfortable indoor environment.
- **Shading Features:** The design effectively achieves shading, helping to regulate indoor temperatures.
- **High-Insulation Materials:** The dwelling utilizes materials with high thermal insulation properties, contributing to energy efficiency and comfort.

4.4.8 CASE STUDY 8

A. Location: Mohradih, Chhattisgarh

B. Orientation: East

C. Description: The dwelling unit has entry from 30’0” wide road.

Fig. 227: Front View of Dwelling Unit at Mohradih, Chhattisgarh

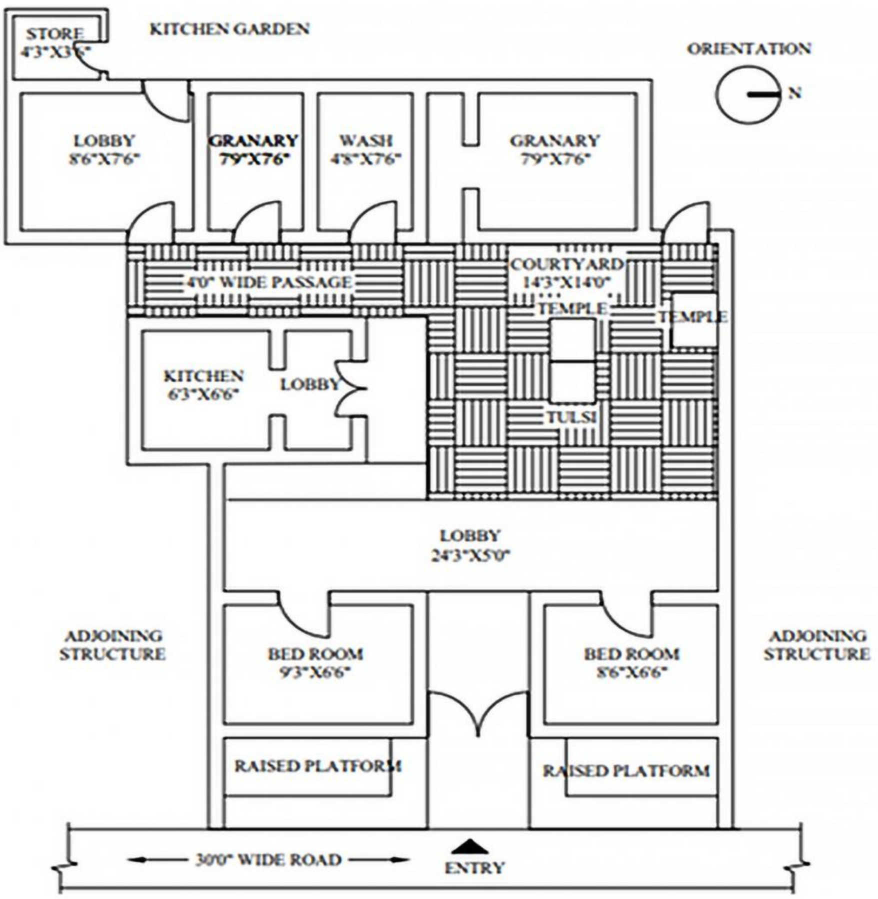


Fig. 228: Typical Floor Plan

Fig. 229: Shaded Entry from Centre with Floor Made of Composite Material of Tyre

Fig. 230: Raised Platform at the Entrance

Fig. 231: Double Panel Door

Fig. 232: Raised Platform

D. Plan & Layout: Courtyard Type

The entrance features a raised shaded area with a centrally positioned entry. A cozy sitting area is created with timber seats, and visitors are welcomed by a double-leaf door. At the heart of the house lies a spacious courtyard, where a Tulsi plant stands prominently at the centre. Behind the Tulsi plant is a Shiv temple, while a Hanuman temple can be found in the northeast corner, enriching the spiritual atmosphere of the home.

Fig. 233: Timber Roof

Fig. 234: View of Courtyard

Fig. 235: Courtyard is used for Keeping Vehicles

Fig. 236: Front View of Kitchen at South

Fig. 237: View of Kitchen Roof

Fig. 238: Passage

Fig. 239: Door of Kitchen *Fig. 240: View of Rear Passage* *Fig. 241: King Post Timber Truss Roof*

Fig. 242: Timber Post Supporting Overhangs *Fig. 243: Door Frame* *Fig. 244: Tyre Flooring*

A shaded corridor extends from the passage, connecting two bedrooms located on the east side, separated by a corridor that faces the courtyard. The kitchen is situated in the south, near the courtyard, featuring a traditional design with highly ornamented doors and windows that set it apart from the adjoining structures. At the rear, the courtyard connects to a passage that provides access to the bathroom, granary, lobby, and entry to the backyard. The floor of the shaded corridor and foyer is crafted from burnt tire and straw, while the kitchen boasts slate tile flooring. The courtyard and other rooms are finished with mud flooring covered in cow dung paste. Each wall is 15 inches thick, constructed from a combination of mud and bricks, and the sloping roof is made of sarai wood and country tiles.

E. Vastu Features Observed:

- **Eastern Entry:** The dwelling unit features an entrance oriented towards the east.

- **Shaded Lobby:** A wide, raised shaded lobby at the entrance serves as a welcoming meeting and sitting area.
- **Ornate Entrance:** The entrance is adorned with a highly ornamented double-leaf wooden door.
- **Courtyard Planning:** The design follows a courtyard-type layout, with rooms positioned around the courtyard in all directions.
- **Kitchen Placement:** The kitchen is located on the south side, showcasing intricate ornamentation on the exterior and accessed via a shaded lobby.
- **Thick Walls:** The walls are constructed with a thickness of 2 feet for enhanced stability and insulation.
- **Local Materials:** The dwelling unit prominently features locally available materials such as mud, timber, bamboo, and traditional construction techniques.
- **Roof Projections:** Roof projections are present at the entrance, providing shelter over the raised platform and lobby.
- **Aesthetic Design:** The kitchen exhibits extensive ornamentation on its walls, doors, windows, and columns, while simplicity is achieved in the exterior design through plain facades and thoughtfully chosen wall colors.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design incorporates a courtyard-type layout, enhancing natural light and ventilation.
- **Increased Surface Area:** The dwelling boasts more surface area on the east, south, and north sides, optimizing exposure to natural elements.
- **Architectural Projections:** Projections are present at both the lintel and roof levels, adding character and functionality to the structure.
- **Heat Management Buffers:** Buffer spaces in the form of passages and lobbies effectively retard heat penetration into the building.
- **Thermal Insulation:** Thick walls are utilized for improved thermal insulation, maintaining a comfortable indoor environment.
- **Small Openings:** The design includes small openings facing the courtyard, which help reduce heat gain while allowing for ventilation.

- **Mutual Shading:** The layout promotes mutual shading among the units, enhancing comfort during warmer months.
- **High-Insulation Materials:** The dwelling unit employs materials with high thermal insulation properties, ensuring energy efficiency and comfort.

4.4.9 CASE STUDY 9

A. Location: Mohradih, Chhattisgarh

B. Orientation: East

C. Description: The dwelling unit has entry from center.

D. Plan & Layout: Courtyard Type

Fig. 245: Front View of Dwelling Unit at Mohradih, Chhattisgarh

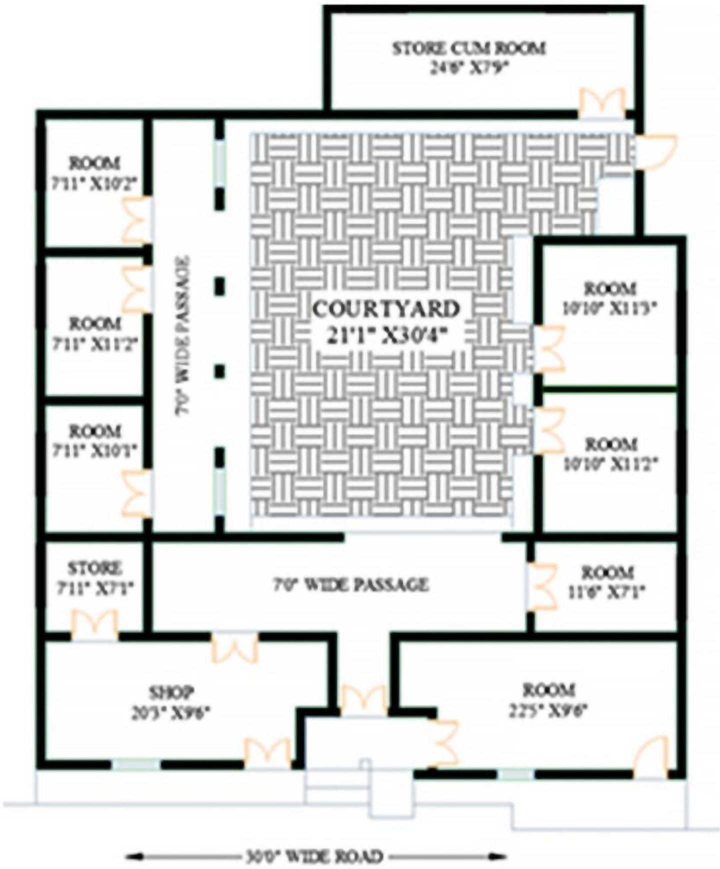


Fig. 246: Typical Floor Plan

Fig. 247: Space for Keeping Vehicles at the Front *Fig. 248: Steps and Ramp at Entrance* *Fig. 249: Front Door*

At the entrance, there is a raised shaded area complete with steps and a ramp, along with an unshaded raised area in the northeast corner designated for vehicle parking. The entrance features a double-panel door that opens into a passage with slate flooring. Centrally located in the house is a courtyard, adorned with a Tulsi plant. Following the passage, a shaded corridor connects the shop and bedroom from the inside. The bedroom and shop are positioned on the east side, separated by a passage and corridor that face the courtyard.

Fig. 250: Lobby at Entrance

Fig. 251: Post Supporting Roof

Fig. 252: Passage

Fig. 253: Lobby for Keeping Vehicles

Fig. 254: Slate Flooring and Wooden Column

Fig. 255: View of Courtyard towards South

Fig. 256: Passage in Front of Dwelling Unit

Fig. 257: Dwelling Unit on South

Fig. 258: Timber Roof

Fig. 259: Dwelling Unit on North

Fig. 260: Exit from North

Fig. 261: Animal Shelter

The rooms are situated on the south and north sides of the courtyard. The South side rooms feature a lobby at the front, while the north side rooms do not have a lobby. An animal shelter is located on the west side, with a small open passage to the northwest allowing animals to enter the dwelling unit. The courtyard and passage are paved with slate flooring, while the rooms and lobby on the south side have cement flooring, elevated by six inches above the courtyard floor level. The walls are constructed from a combination of mud, bricks, and mud plaster, with a thickness of 15 inches. The sloping roof is made of tiles, sticks, bamboo, and sarai wood. All the rooms maintain a comfortable temperature, eliminating the need for a cooler.

E. Vastu Features Observed:

- **Eastern Entry:** The dwelling unit features an entry located at the center on the east side.
- **Shaded Entrance:** A shaded area with a double-leaf wooden door welcomes visitors at the entrance.
- **Courtyard Planning:** The design incorporates a courtyard-type layout, enhancing light and ventilation.
- **Room Placement:** Rooms are thoughtfully positioned on the south, west, north, and east sides of the unit.
- **Absence of Toilets:** There are no toilets present inside the house, adhering to traditional Vastu principles.
- **Architectural Projections:** Projections in the form of eaves are supported by a tie beam from the roof, providing additional shade and protection.

- **Aesthetic Design:** The design features square columns, along with finishes of mud, lime, and color wash to enhance visual appeal.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design incorporates a courtyard-type layout, promoting natural light and airflow.
- **Roof Projections:** Projections are present at the roof level, enhancing the architectural character and providing shade.
- **Increased Surface Area:** The dwelling has more surface area on the south and north sides, optimizing exposure to sunlight and ventilation.
- **Heat Management Buffers:** Buffer spaces in the form of passages or corridors effectively retard heat penetration into the building.
- **Thermal Insulation:** Thick walls are utilized to provide better thermal insulation, ensuring a comfortable indoor climate.
- **Mutual Shading:** The design facilitates mutual shading among the rooms, improving comfort during warmer months.
- **High-Insulation Materials:** The dwelling unit employs materials with high thermal insulation properties, contributing to energy efficiency.

4.4.10 CASE STUDY 10

A. Location: Chattarpur, Chhattisgarh

B. Orientation: South

C. Description: The mud building is approximately 60 years old and has undergone renovations on the front side, enhancing its appearance while preserving its traditional charm.

D. Plan & Layout: Courtyard Type

Fig. 262: Front View of Dwelling Unit at Chhattarpur, Chhattisgarh

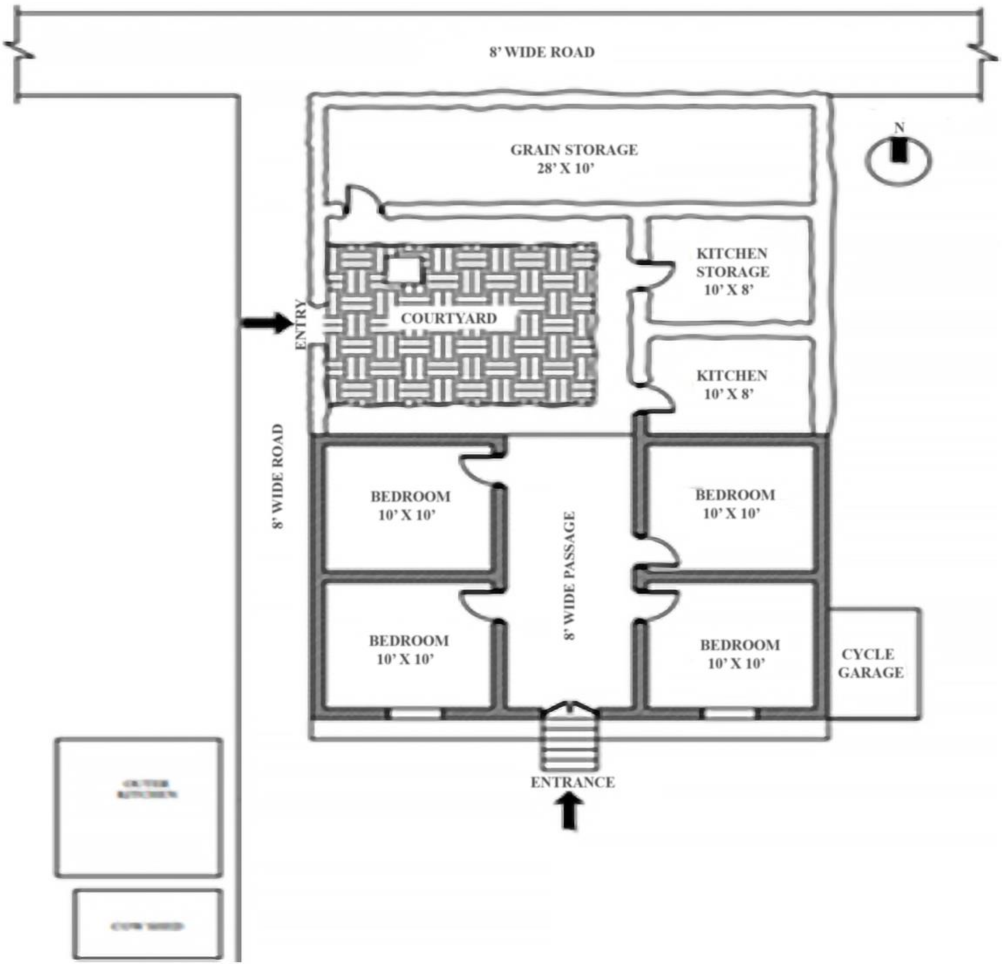


Fig. 263: Typical Floor Plan

Fig. 264: View of Dwelling Unit from Southeast Fig. 265: View of Courtyard

Fig. 266: Steps and Ramp at the Entrance *Fig. 267: Mud Flooring* *Fig. 268: Post Supporting Roof*

Fig. 269: Colour Wash in Walls *Fig. 270: King Post in Sloping Roof*

In front of the house, there is an otta measuring 3 feet by 2 feet on both sides of the entrance, featuring stairs and a ramp for accessibility. The hall or passage beyond the entrance door is 7 feet wide and has cement flooring. On the Southern side, there are three bedrooms along with a storage room. At the centre of the house lies a courtyard, which is adorned with a Tulsi plant in the northwest corner.

Fig. 271: Animal Shelter Made of Waste Materials

Fig. 272: Ridge Supported by Timber Post

Fig. 273: Use of Curtains for Hiding

Fig. 274: Colour Wash in Walls

Fig. 275: Puja Space in Courtyard

The house features two entrances: one from the south side and another from the west side. The front portion of the unit is constructed with brick walls and cement plaster, topped with an RCC slab, while the rear consists of an older mud house. On the east side, there are two kitchens along with a storage room to the north, both of which open into the central courtyard. The kitchens and storage room are built with mud walls, and the floors are covered with roof tiles. In the northwest corner of the courtyard, there is a small puja space. The courtyard itself is one level lower than the kitchens and other rooms, featuring mud flooring. Additionally, there is an outer kitchen and a cow shade near the entrance, which are detached from the main dwelling unit. Waste materials have been repurposed as building materials for the cow shade, and garbage is disposed of in the open field. Water is sourced from a bore well and a hand pump.

E. Vastu Features Observed:

- **Central Entry:** The dwelling unit features an entrance located at the center.
- **Raised Platform:** A raised platform, or otta, is present at the entrance, adding to the functionality of the space.

- **Courtyard Planning:** The design follows a courtyard-type layout, with rooms arranged at the front, sides, and rear of the property.
- **Tulsi Plant:** A Tulsi plant is thoughtfully placed in the courtyard, enhancing the spiritual ambiance.
- **Absence of Toilets:** There are no toilets present inside the house, in line with traditional Vastu principles.
- **Material Use:** The dwelling incorporates locally available materials such as mud, timber, bamboo, alongside modern construction materials like cement, bricks, plaster, and RCC, blending traditional and contemporary techniques.
- **Aesthetic Enhancements:** Aesthetics are achieved through plaster designs and color washes applied at the entrance and on the rooms facing the courtyard.

F. Passive Solar Features Observed:

- **Courtyard Planning:** The design incorporates a courtyard-type layout, promoting natural light and ventilation.
- **Architectural Projections:** Projections are featured in the form of extended slabs and eaves from the sloping roof, enhancing protection from the elements.
- **Heat Management:** The lobby, thick walls, and roof projections work together to retard heat penetration into the building.
- **High-Insulation Materials:** The dwelling unit utilizes materials with high thermal insulation properties, ensuring a comfortable indoor climate.
- **Sloping Roof Construction:** The roof is constructed with sticks, timber, tiles, and waste materials, reflecting a sustainable approach to building design.

CONCLUSION

From the case study, it is evident that each dwelling unit is aligned in a specific direction relative to the road. At the entrance, most units feature raised platforms for daily activities. The main entrance door is a double-leaf design made of local timber, such as Sarai, Bija, and Babool. The door frame consists of two vertical and two horizontal members, which help prevent water from entering and create level differences.

Almost every dwelling unit has a courtyard located at its centre, surrounded by small, covered passages. These passages provide access to various rooms facing the courtyard. Most doors and windows can be opened through the passage and courtyard, allowing for proper airflow and natural lighting. This layout reduces the reliance on artificial cooling systems like air conditioners and coolers, both during the day and at night.

A small Tulsi plant is often found at the centre of the courtyard. Room sizes typically range from 6’0” x 6’0” to 10’0” x 10’0” and are primarily used for sleeping and storage. The walls are generally 15 inches thick, providing better thermal insulation and keeping the structure cool. One room is typically reserved for performing rituals in nearly every dwelling unit.

Kitchens are equipped with small openings in the external walls near the top to allow smoke and fumes to escape without entering the main rooms. Toilets are placed outside the dwelling unit to maintain hygienic conditions. Some units feature a straight flight staircase leading to the first floor. Small projections at the lintel and roof level provide shade at the entrance and the passage facing the courtyard.

There are no openings on the exterior walls, and mutual shading is achieved in most structures. The roofs are generally sloping, low in height, and constructed using local techniques. This sloping design ensures that direct sunlight does not fully reach the roof throughout the day. Local building methods and materials, such as mud, bamboo, and wood, are employed in the construction of the dwelling units.

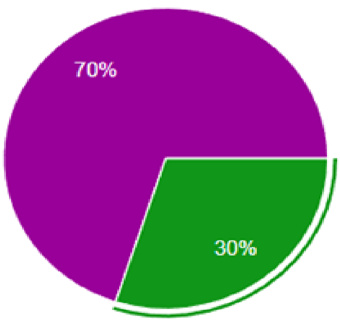
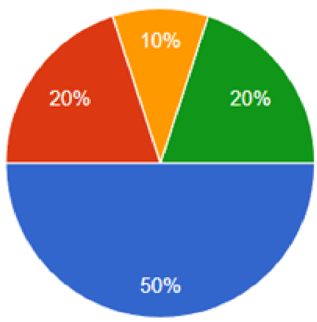
The aesthetic appeal of the dwelling is enhanced by circular and square columns adorned with plaster designs, flat and multi-centred arch openings, and vibrant colour washes. A large open area is reserved in the backyard for planting both fruits and vegetables. Some backyards include small toilets. Since keeping animals at home is a common practice in India, provisions for animal sheds are found in a few dwelling units.

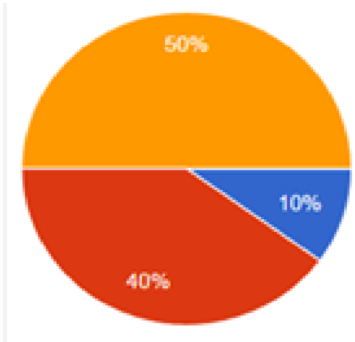
In conclusion, the dwelling unit harmoniously integrates Vastu Shastra and Passive Solar Architecture, promoting a sustainable and comfortable living environment. Key features, such as the northeast entry and central courtyard, enhance natural light and ventilation. Strategic room placement and thick walls improve thermal insulation and energy efficiency, while architectural projections add both aesthetic appeal and functionality. Overall, this design exemplifies the coexistence of Vastu principles and passive solar features, creating a beautifully efficient home.

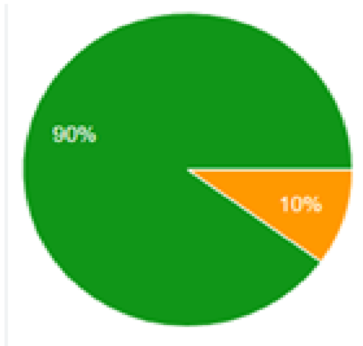
4.4.11 Analysis and Findings of Their Thermal Environment

Some questions were asked to the occupants during the case studies of their thermal environment to know how people respond to their environment. By asking question about temperatures, it was assessed whether the actual temperature matches the occupants' preferred or comfortable temperature scale. Overall asking occupants about their thermal comfort and temperatures during case study provide crucial insights into how to create healthier, more comfortable and more energy-efficient indoor environments. Responses of occupants are as follows:

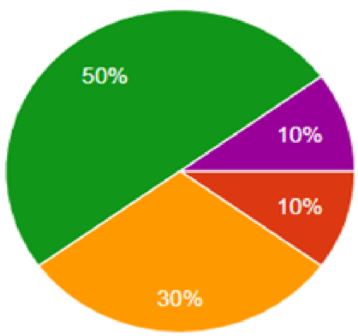
Table 15: Questions Asked and Responses of Occupants during Case Study

Q1. How long have you been living in this building?	Q2. What is the orientation of your house?
a) Less than 1 year	a) East
b) 1 – 3 year	b) West
c) 4 – 6 year	c) North
d) 7 – 10 year	d) South
e) More than 10 years	e) Not Sure
	
During the case study it was found that	50% of the occupants' house faced East,

<table>
<tr>
<td>about 70% of occupants lived in their house for over a decade, while only 30% had resided for between 7 and 10 years.</td>
<td>20% each faced west and south, and 10% faced north.</td>
</tr>
<tr>
<td>Q3. How do you feel about the temperature in the room at this moment?
<table>
<tr><td>a) Cold</td><td></td></tr>
<tr><td>b) Slightly cool</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Slightly warm</td><td></td></tr>
<tr><td>e) Hot</td><td></td></tr>
</table>


</td>
<td>Q4. Do you feel comfortable now?
<table>
<tr><td>a) Very uncomfortable</td><td></td></tr>
<tr><td>b) Uncomfortable</td><td></td></tr>
<tr><td>c) Just right</td><td></td></tr>
<tr><td>d) Comfortable</td><td></td></tr>
<tr><td>e) Very comfortable</td><td></td></tr>
</table>


</td>
</tr>
<tr>
<td>40% of the occupants'felt slightly cool, 50% felt neutral whereas 10% felt cold.</td>
<td>90% of the occupant felt comfortable, while 10% felt that their environment was just right.</td>
</tr>
<tr>
<td>Q5. In Summer season, the temperature is?
<table>
<tr><td>a) Always too hot</td><td></td></tr>
<tr><td>b) Occasionally too hot</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Moderately hot</td><td></td></tr>
<tr><td>e) Slightly hot</td><td></td></tr>
</table>
</td>
<td>Q6. In Winter season, the temperature is?
<table>
<tr><td>a) Always too cold</td><td></td></tr>
<tr><td>b) Occasionally too cold</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Moderately cold</td><td></td></tr>
<tr><td>e) Slightly cold</td><td></td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr>
<td>


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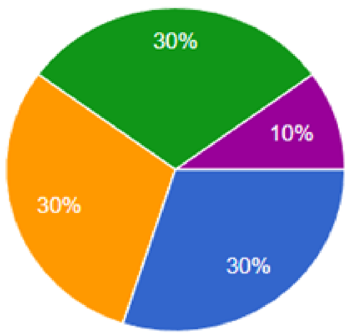
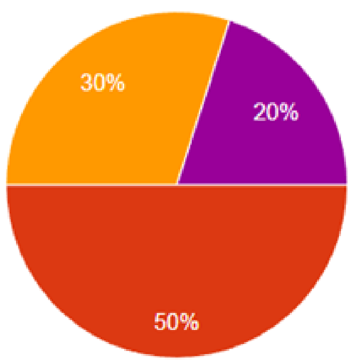
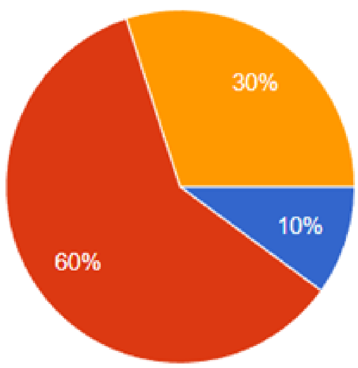
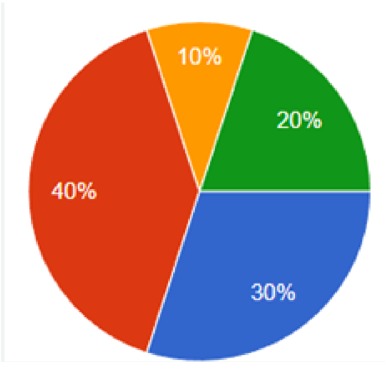
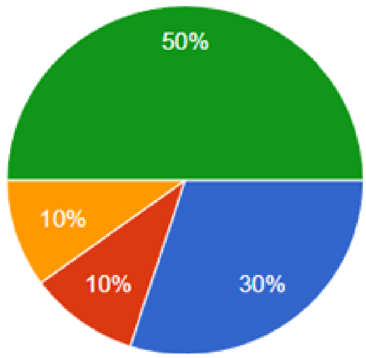


</td>
</tr>
<tr>
<td>50% of the occupants felt moderately hot during summer, 30% felt neutral, while 10% each experienced occasional heat and slight warmth.</td>
<td>30% of the occupants felt always too cold, moderately cold and neutral while 10% felt slightly cold.</td>
</tr>
<tr>
<td>Q7. In Rainy season, the temperature is?
<table>
<tr><td>a) Extremely humid</td><td></td></tr>
<tr><td>b) Humid</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Moderately humid</td><td></td></tr>
<tr><td>e) Slightly humid</td><td></td></tr>
</table>


</td>
<td>Q8. What is the temperature state that you expect?
<table>
<tr><td>a) Cooler</td><td></td></tr>
<tr><td>b) Slightly cooler</td><td></td></tr>
<tr><td>c) No change</td><td></td></tr>
<tr><td>d) Slightly warmer</td><td></td></tr>
<tr><td>e) Warmer</td><td></td></tr>
</table>


</td>
</tr>
<tr>
<td>During the rainy season 50% of the occupants felt humid, 30% felt neutral and 20% felt slightly humid.</td>
<td>60% of the occupants expected slightly a cooler temperature, while 30% required no change and 10% anticipated a cooler temperature in summer season.</td>
</tr>
<tr>
<td>Q9. How satisfied are you with the</td>
<td>Q10. How satisfied are you with the day</td>
</tr>
</table>

<table>
<tr>
<td>current living environment by consideration of space and structural safety?
<table>
<tr><td>a) Extremely satisfied</td><td></td></tr>
<tr><td>b) Satisfied</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Dissatisfied</td><td></td></tr>
<tr><td>e) Extremely dissatisfied</td><td></td></tr>
</table>


</td>
<td>lighting inside your dwelling unit?
<table>
<tr><td>a) Extremely satisfied</td><td></td></tr>
<tr><td>b) Satisfied</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Dissatisfied</td><td></td></tr>
<tr><td>e) Extremely dissatisfied</td><td></td></tr>
</table>


</td>
</tr>
<tr>
<td>40% of the occupants were satisfied with the current living environment, 30% were very satisfied, 20% were dissatisfied and 10% were neutral.</td>
<td>50% of the occupants were dissatisfied with the day lighting inside their dwelling unit, 30% were very satisfied and 10% each were satisfied and neutral.</td>
</tr>
<tr>
<td>Q11. Your assessment of the air in the room?
<table>
<tr><td>a) There is no air</td><td></td></tr>
<tr><td>b) There is a slight air sensation</td><td></td></tr>
<tr><td>c) There is a distinct air sensation</td><td></td></tr>
<tr><td>d) There is strong air feeling</td><td></td></tr>
<tr><td>e) Undecided</td><td></td></tr>
</table>
</td>
<td>Q12. How satisfied are you with the indoor thermal environment for a whole year?
<table>
<tr><td>a) Extremely satisfied</td><td></td></tr>
<tr><td>b) Satisfied</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Dissatisfied</td><td></td></tr>
<tr><td>e) Extremely dissatisfied</td><td></td></tr>
</table>
</td>
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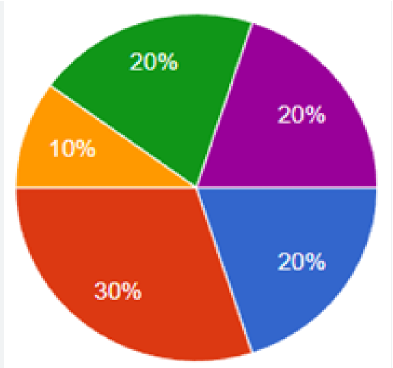
<table>
<tr>
<td>
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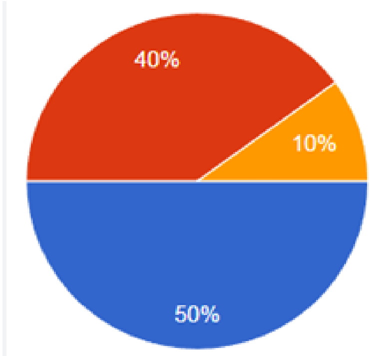
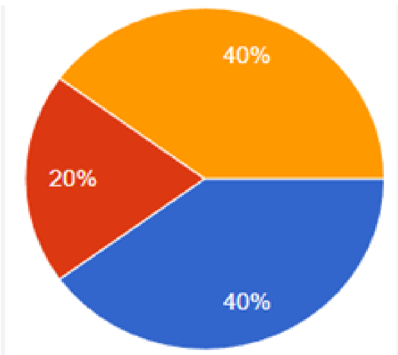
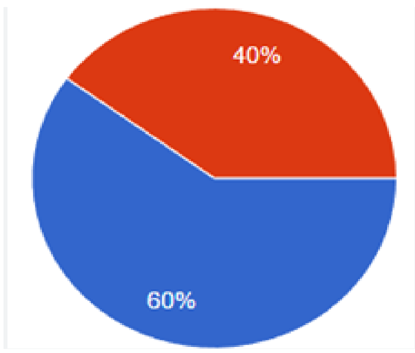
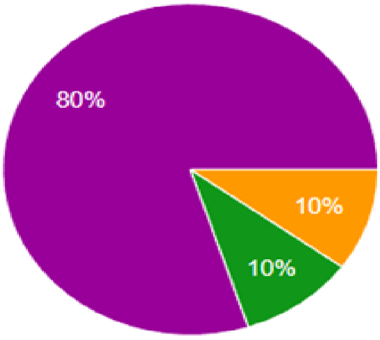
<td>
</td>
</tr>
<tr>
<td>30% of the occupants felt a slight air sensation inside room, 20% each experienced a strong air feeling, felt there was no air or were undecided, while 10% noticed a distinct air sensation.</td>
<td>For an entire year, 50% of the residents expressed great satisfaction with the interior thermal environment, 40% were satisfied and 10% were neutral.</td>
</tr>
<tr>
<td>Q13. What measures are you using now to improve your comfort level?
<table>
<tr><td>Fan</td><td></td></tr>
<tr><td>Cooler</td><td></td></tr>
<tr><td>Both fan and cooler</td><td></td></tr>
<tr><td>Air conditioner</td><td></td></tr>
<tr><td>None</td><td></td></tr>
</table>

</td>
<td>Q14. How satisfied are you with the overall living environment of your village (air quality, facility convenience, neighbourhood relationship)?
<table>
<tr><td>a) Extremely satisfied</td><td></td></tr>
<tr><td>b) Satisfied</td><td></td></tr>
<tr><td>c) Neutral</td><td></td></tr>
<tr><td>d) Dissatisfied</td><td></td></tr>
<tr><td>e) Extremely dissatisfied</td><td></td></tr>
</table>

</td>
</tr>
<tr>
<td>To make better their comfort level 40% of the occupants used a fan or a combination</td>
<td>Of the residents, 40% were pleased and 60% were extremely satisfied with their</td>
</tr>
</table>

of both a fan and a cooler, while 20% used cooler.	village's overall quality of life.
Q15. In your opinion, how acceptable is the current thermal environment overall? a) Very unacceptable b) Unacceptable c) Neutral d) Acceptable e) Very acceptable	
80% of the occupants rated the thermal environment as very acceptable, while 10% each rated it as acceptable and neutral.	

4.4.12 Responses Received from the Occupants for Their Thermal Environment:

- About 70% of occupants were found to live in their dwelling unit for more than 10 years.
- 50% of the dwelling units considered for the study were east facing.
- 40% of the occupant felt slightly cool about the current temperature of the room.
- 90% of the occupant felt comfortable inside their room.
- About 50% of occupants felt moderately hot during the summer season.
- In the winter season most of the occupant felt moderately cold, always too cold and neutral.
- 50% of the occupant felt humid in the rainy season.
- 30% of occupants expect no change in temperature whereas 60% of the occupants expect slightly a cooler temperature.
- About 40% of occupants were very satisfied with the current living environment, considering space & structural safety.
- 50% of occupants were dissatisfied with the day lighting inside the rooms.

- 30% of the occupant felt that there was a slight air sensation inside the room.
- Throughout the entire year, 50% of the residents expressed great satisfaction with the indoor thermal environment.
- About 40% of occupants were using fans to improve their comfort level.
- About 60% of residents expressed high satisfaction with the village's overall living conditions, including the neighbourhood relationships, convenience of the facilities, and air quality.
- Most inhabitants gave the current thermal environment an overall approval rating of 80%.

CONCLUSION

Eighty percent of occupants are very satisfied with their thermal environment. During the case study, most of them reported that their dwelling units are cooler compared to contemporary buildings made of bricks, cement, and concrete. They are also highly satisfied with the indoor temperature, as there is no need for coolers or air conditioning in any room, and they feel very comfortable inside.

In the summer, they find the rooms cool in the morning and afternoon, but they feel hot at night. As a result, they often sleep on the terrace when the temperature drops. During the rainy season, occupants feel humid, with little change in temperature. In winter, the temperature inside the rooms remains cold throughout the day and night, but this does not affect their comfort level. Nights are slightly cooler than days, yet the rooms remain comfortable.

There is little airflow inside the rooms unless the fan is on. Daylight is limited due to the absence of windows on the external walls, and windows facing the passage and courtyard are usually kept closed. Small openings in the kitchen allow smoke to escape.

Additionally, they express a need for better infrastructure facilities, such as concrete roads.

CHAPTER 5

COMPARATIVE ANALYSIS

CHAPTER 5: COMPARATIVE ANALYSIS

Summary: This chapter is organized into three sections, each examining important aspects of Vastu Shastra and its contemporary relevance. The **first section** compares Vastu Shastra as practiced in ancient times with modern interpretations, highlighting its historical significance in promoting harmony through the alignment of structures with natural forces. It illustrates how ancient architects used principles like orientation and material selection to enhance well-being, while contemporary architects adapt these principles to modern construction techniques and sustainability, showcasing the enduring relevance of Vastu in today's architectural practices.

The **second section** explores the connection between Vastu Shastra and Passive Solar Architecture, both aimed at enhancing occupant well-being while minimizing environmental impact. This section emphasizes their shared goals of optimizing natural light and ensuring thermal comfort, presenting case studies that demonstrate successful integration of Vastu principles with passive solar design strategies.

The **third section** features a survey assessing the impact of these integrated approaches on occupant well-being, focusing on thermal comfort and overall satisfaction. By synthesizing insights from the survey, the chapter highlights the potential of combining ancient wisdom with modern sustainability practices to create healthier living environments.

In conclusion, this chapter emphasizes the relevance of Vastu Shastra in contemporary architectural discourse, particularly in the context of sustainability and occupant health. By exploring the intersections of traditional wisdom and modern design, the chapter illustrates the potential for creating environments that are not only functional and aesthetically pleasing but also promote well-being. Through the insights gained from the survey, the chapter reinforces the notion that integrating ancient architectural principles with modern techniques can lead to innovative and sustainable living spaces.

5.1 COMPARATIVE ANALYSIS BETWEEN ANCIENT VASTU SHASTRA AND CURRENT ARCHITECTURAL PRACTICES ACCORDING TO VASTU SHASTRA

The ancient Vastu Shastra and current architectural practices according to Vastu Shastra has been compared based on the basic five principles of Vastu Shastra. Few aspects which are observed during the literature review are also considered during the study.

Table 16: Comparative Analysis between Ancient Vastu Shastra and Current Architectural Practices According to Vastu Shastra

S No.	Ancient Vastu Shastra	Current architectural practices according to Vastu Shastra
1.	**Basic five Principles of Vastu Shastra** **Determination of orientation (Diknirnaya)**	
	A practice known as Shankustaapana was used in the past for finding orientation. Using this technique, a gnomon is placed in the middle of the plot. The bottom of the gnomon is used as the centre of the circle, and its radius is double its length. Where the gnomon's shadow intersects the circle's circumference in the morning and afternoon are designated as two points. The east-west line is the line that connects these two places. At the east-west positions where their distance is equal to a radius, two circles are drawn. The North and south points are where they intersect.	Nowadays we use a compass to ascertain the orientation. Finding the north requires standing with the compass in the middle of the plot, which is regarded as the Vastu purusha's navel. Then identify the direction of the road. Accordingly, that is the orientation of Site. 1. Orientation is determined by using a compass. 2. The finest direction are said to be north and east. 3. South and west are not preferred. 4. Orientation is the positioning of a building in relation to seasonal

	1. Orientation is determined by the movement of sun and gnomon. 2. East as the most auspicious direction for benefice results. 3. West seems to be the least preferred direction. 4. Large cardinal directions are preferred more than the ordinal directions (Shukla, 1960).	variations in the sun's path as well as prevailing wind patterns. Good orientation can increase the energy efficiency of home, making it more comfortable to live in and cheaper to run. In mixed or heating climates, it is beneficial to have the longer walls of a house facing north to minimize exposure to the sun in summer and maximize it in winter (BEE, 2017).
2.	**Site planning (Vastu Purusha Mandala)**	
	Site planning is carried out using concept of Vastu Purusha Mandala. The method by which the site is divided into different numbers of squares is called pada vinyasa. Single Square (1x1 grid) to 32x32 (1084) squares are the different numbers of squares; each square is called a pada. The divided squares are allotted to pada devatas, who are named after the designated god. The position of the deity will determine the activity zoning for the house. Of the 32 varieties, Manduka, which partitions the area into 64 squares, and Paramasaiyn, which divides the area into 81 squares, were suggested for all purposes related to construction	Site planning is carried out: By understanding the site development process by observing natural and human factors affecting the form and appearance of the environment. By collecting information and data concerning planning or design issues to classify and analyse the data. By making recommendations for issues at hand. By drawing up guidelines for planning, architecture and landscape disciplines. Natural surface features most of this information will be derived from the topographic features on the site. A contour map of this magnitude can be

	(Shukla, 1960). If a house is designed according to Vastu Purush Mandala, a perfectly balanced environment which ensures enhanced health, wealth and happiness is created. The Sun, the five elements (panchabhuta), the Earth's magnetic field, Earth's energy fields, and the eight directions are manipulated to create an atmosphere beneficial to man. When the different rooms are placed according to Vastu Purush Mandala, good disposition to the Sun, proper ventilation and lighting and privacy would be ensured in the building (Shukla, 1960). People perform different activities in different rooms at different times of a day and Sun's position keeps on changing from sunrise to sunset. So to ensure that the inmates get exposed to sunlight constantly, each room should be positioned so that it faces the Sun at the time of the day when it is most likely to be used (Shukla, 1960).	drawn. Trees, ground cover, ground texture, and soil conditions could be directly observed. Study of vegetation should be done in relation to type, size, location, shade pattern, aesthetics, ecology etc. Slope study must entail gradients, landforms, elevations, drainage patterns etc. (www.constructiontuts.com) Manmade features buildings, walls, fences, patios, plazas, bus stops, shelters etc. Shall be carefully recorded on maps. Grid Iron System of planning for the building construction is adopted. (Source:https://test.theconstructor.org/building/types-site-selection-residential-building/5995/)

2 a.	Examination & Selection of site	
a)	**Shape of Site**	
	Suitable Square shaped site is best shape. In the ancient times, since most houses were designed around a central square courtyard for good cross ventilation and protection from strong summer heat (Dagens, 2010). Rectangle shaped site is also seen as advantageous especially if the longer side goes from north to south. It is easy to design rectangle shaped site as this allows for a good flow of interior spaces and the proportion of the rectangle's sides are more suitable in designing rooms (Dagens, 2010). **Un Suitable** Triangular, circular, elliptical, oval, pentagon and irregular shaped sites are not considered good as it is difficult to design square or rectangular house, which is a preferred shape for an efficient plan (Dagens, 2010).	**Suitable** Square & Rectangular shaped site are considered good as it is easy to design in these shaped sites with minimum wastage of space.
b)	**Contour of land**	
	Suitable Elevated west and south. This	**Suitable** Elevated west and south.

<table>
<tr><td></td><td>guarantees that light and solar energy from the northeast corner enter the home without obstruction. Elevated southwest acts as buffer and prevents the heating up of rest of the house (Dagens, 2010).
Un Suitable
Elevated east and north (Dagens, 2010).</td><td></td></tr>
<tr><td>c)</td><td>Colour of soil</td><td rowspan="8">1. The site should be in an area that is fully developed or has the potential to be developed.
2. The location should have an excellent view of a hill, river, lake, etc.
3. There should be good transportation options for getting to the office, market, college, etc., such as the railway and bus service.
4. To receive their services at no additional cost, civic services like telephone, electric, and water supplies, as well as sewers and drainage, should be located very close to the chosen site.
5. The chosen location should guarantee the structure has enough air and light to avoid any over-dominance by the surrounding buildings.
6. The site's groundwater table shouldn't be very high.
7. Nearness of schools, hospitals, market, etc. is considered good for residential sites.</td></tr>
<tr><td></td><td>Suitable
White
Un Suitable
Black
Black soil indicates soil that retains water and does not allow good drainage.</td></tr>
<tr><td>d)</td><td>Odour of soil</td></tr>
<tr><td></td><td>Suitable
Fragrance of Jasmine, Lotus.
Un Suitable
Pungent smell.</td></tr>
<tr><td>e)</td><td>Touch of soil</td></tr>
<tr><td></td><td>Suitable
Compact and Smooth.
Un Suitable
Loose and Hard.</td></tr>
<tr><td>f)</td><td>Taste of soil</td></tr>
<tr><td></td><td>Suitable</td></tr>
</table>

	Sweet **Un Suitable** Bitter 1. The site is to be rejected if the thorn trees are grown. 2. Large trees in the four corners, with husks, ashes and gravel. 3. The site should also be free from pebbles, worms, ants, charcoal, stumps, any sharp objects, sludge and cavities (Dagens, 2010).	8. Good foundation soil should be available at responsible depth. This aspect saves quite a bit in the cost of the building. 9. Sites for dwellings ought to be situated far from the busy commercial highways. 10. Because factories and workshops are constantly noisy and dusty, residential areas shouldn't be situated next to them. 11. The site's orientation also influences its selection to some extent.
3.	**Proportion of the building (Maana)**	
	5 Generic types of proportioning system relating the width to height ratio 1.Shantika - 1W:1H 2.Paustika - 1W:1 1/4 H 3.Jayada - 1W:1 ½ H 4.Dhanada - 1W:13/4 H 5.Adbhuta - 1W:2H The measure for the various elements within the building was computed according to the fundamental presumption of the proportion system selected (Shukla, 1960).	Proportion is a central principle of architectural theory and an important connection between mathematics and art. It is the visual effect of the relationships of the various objects and spaces that make up a structure to one another and to the whole. These relationships are often governed by multiples of a standard unit of length known as a "module". (Dani, 2017)
4.	**Building Measurement or Dimensions of the building (Aayadi Shadvarga)**	
	1. Aayadi Shadvarga calculation, a	Building measurement is decided

	computation method to select the appropriate dimension (length, breadth, perimeter, area and height) for the building, follows the theory of remainder. Shadvarga is a group of six formulae to determine the dimensional conformance of a building (Shukla, 1960). 2. Aya, Vyaya, Yoni, Riksha, Vara and Thithi are the six formulae where Aya and Riksha are used for the determination of length, Yoni and Vyaya for breadth and Vara and Thithi for height or circumference (Shukla, 1960). 3. The remainder obtained using this formula provides the gain or loss, compatibility of constellations, solar day and lunar day. If it is a gain, then the structure is proportionate and stable, and the dimensions are right. However, if it is a loss, then it means the dimensions are not right and should be suitably corrected (Shukla, 1960). 4. The introduced formulas seem to be primarily used to obtain an approximate measurement and then verify that it is appropriate given the constructional rod utilized. For the	according to design needs and various laws which are set by the development authorities of the region, like: •Floor area ratio (FAR) •Ground coverage • Setbacks •Building-Height restriction laws Setbacks also help get more daylight and fresh air to the street level. Other restrictions are because of practical concern, such as around airports to prevent any danger to flight safety.

	Silpis to determine the proper building measure, the Aayadi computation is still a very technical technique (Shukla, 1960).	
5.	**The Aesthetics of building (Chanda)**	
	Chanda is the beauty aspect or aesthetics of the buildings. It means the view of the contour of a structure against the sky i.e. its perspective view. The forms of buildings were different for buildings with different functions. It also ensures the easy identification of buildings. There are six chandas in Vastu Shastra: 1. Meru Chanda 2. Khanda Meru Chanda 3. Pataaka Chanda 4. Sushi Chanda 5. Uddista Chanda 6. Nasta Chanda Meru Chanda's shape is reminiscent of the fabled, holy mountain known as "Meru" in Hindu mythology. The Meru perspective is characterized by a centre pinnacle that rises significantly above the ground and has sides that slope gradually in an easy manner all around. In Khanda Meru Chanda the outer peripheral	The aesthetics of a building in current times is one of the principal aspects considered in the modern world. The appeal of a building covers the combined effects of a building's shape, size, texture, colour, balance, unity, movement, emphasis, contrast, symmetry, proportion, space, alignment, pattern, decoration, culture and context. These elements can make a building stand out and become a landmark in its community (Mfon, 2023).

	ends of the building do not form a complete circle but has a vertical cut side i.e. it appears like Meru which has been cut off vertically leaving the exposed surface as a precipitous cliff. In Pataaka Chanda the building looks like a flagstaff with a flag unfurled, i.e. with a narrow lower portion and progressive, cantilevered upper floors. In Sushi Chanda the building appears like a needle. Uddista Chanda and Nasta Chandaare not independent and they have no perspective view of their own (Shukla, 1960).	
Some of the Aspects or Vastu Shastra principles, which are observed during the literature study are as follows:		
S No.	**Ancient Vastu Shastra**	**Current architectural practices according to Vastu Shastra**
6.	**Zoning**	
	The zoning of various functional activities of a house being allotted through the names of the Gods in the Vastu Purusha Mandala. Since the central brahmasthana was thought to be the connection between the home and the universe, it had to remain open and unobstructed. Pooja is in the northeast, the kitchen	Zoning of building is done with various things in mind which includes: Orientation of building (for natural light and ventilation). Daily routine of the inhabitants. Easy access to activities. Escape routes for emergencies.

	in the southeast, the bathroom in the northeast, living areas vary from north to mostly west, dining areas vary from south to west, and bedrooms are located in the southwest and south (Shukla, 1960).	
7.	**Door opening**	
	It is governed by pada devatas names. It is preferred to locate the main door on the immediate right of the median line in the respective direction.	There is no predefined rule to decide placement of doors. some things are kept in mind while creating door openings like: • Easy and uninterrupted access • Placement at corners (to save habitable space) •Door width according to the function of the enclosed space.
8.	**Type of development**	
	In ancient Vastu Shastra, horizontal development is seen but laws are made for the dwelling units up to 12 storeys. Up to 3 storey high dwelling units were constructed.	Due to land constraint and population growth, high-rise buildings, or vertical development, are built in the modern era.
9.	**Design of buildings**	
	Design of buildings is done based on principles of Vastu Shastra in ancient times.	It is done based on climate, location, site area, its surroundings, available funds and by incorporating local building bylaws in recent times.

10.	**Courtyard type of planning**	
	The dwelling units were planned with a central space open, and rooms were arranged all around in the ancient period. The entry of this dwelling unit is from the east.	Courtyard type of building is not generally constructed due to scarcity of land. Apartments or flats and row houses of less area are constructed in any township.
11.	**Roof of dwelling units**	
	Standards of Sloping roofs were given with rafters, purlins and covering materials in ancient Vastu Shastra.	Generally, RCC roofs (flat) are used for building construction.
12.	**Structure of building**	
	The position, size and height of the pillars are based on proportionate measurements and aayadi formula as per Vastu Shastra. Materials used for pillars were stone, baked bricks and timber. It was sometimes covered with gold, especially the edifices of Kings.	The position, size and height of the columns are based on load calculations of the building.
13.	**Choice of building materials**	
	Stone, timber and baked bricks (locally available & vernacular) were used for construction as per Vastu Shastra.	More efficient materials have evolved and are used in construction like cement, sand, mortar, bricks, concrete, RCC, glass, steel, fly ash bricks etc.

		Nowadays cement concrete blocks as walling materials are frequently used in high rise buildings (ALC, CLC Bricks). These bricks consume less energy and are eco-friendly. Precast constructions are also adopted in the mass housing system.
14.	**Doors and windows type**	
	Vaulted doors and latticed windows were preferred in dwelling units as per ancient Vastu Shastra.	Different types of doors and windows as per functional requirements or choice of architect & clients is used in modern times.
15.	**Layout of roads**	
	Widths of roads were planned based on size of bullock carts as per ancient Vastu Shastra. Usually, grid iron pattern is followed for layout of roads. E.g. Ancient city of Jaipur and Chandigarh which are designed according to the principles of Vastu Shastra.	In modern times Width of roads were planned according to density of population of that area, shape of site, site conditions, main roads and its branches, expected vehicular traffic in particular area etc. Roads can be curvilinear also because of the invention of efficient vehicles.
16.	**Landscaping**	
	Different types of trees were suggested for different classes and for different furniture also. Trees and plants were suggested as per their characteristics and are to be planted	Low height plants, shrubs and herbs are planted in north, northeast and east directions whereas heighted trees with greater foliage in south, southwest and west directions as per Vastu Shastra in

	in different directions according to Vastu Shastra.	current times.
17.	**Distinction among people**	
	In ancient times there were caste distinctions (work oriented) in the society based on which dwelling units were constructed.	The townships or dwelling units in modern times are constructed based on income groups i.e. there is class distinction and dwelling units are named as HIG, MIG, LIG, and EWS.

5.1.1 Inference Drawn from the Comparative Analysis between Ancient Vastu Shastra and Current Architectural Practices According to Vastu Shastra

Table 17: Inference Drawn from the Comparative Analysis between Ancient Vastu Shastra and Current Architectural Practices According to Vastu Shastra

S No.	Basic five Principles of Vastu Shastra	Inference drawn from comparative analysis
1.	**Determination of orientation**	As far as Vastu Shastra is concerned east is the most preferred and west the least preferred. On the other side Modern Vastu Shastra decides the orientation of the building according to the sun directions for that climate, to utilize the sun for passive solar design and minimize the need for mechanical devices and north orientation is generally preferred for most climatic zones.
2.	**Site planning (Vastu Purusha Mandala)**	As per Vastu Shastra, Site planning is done by using mandala concept. It consists of several squares and various deities are placed in these squares or mandals. Each activity of the house is assigned based on the location of deity. In modern practice, Site planning is done based on natural and

		manmade features inside the site. It also takes into consideration factors like surroundings, orientation, climate etc.
2 a.	**Examination & Site selection a) Shape of site**	Site selection according to Vastu Shastra is only concerned with the shape of the site and the characteristics of soil and vegetation on the site. However, in modern times site selection is more concerned with the surroundings of the site like type of development (residential, commercial, industrial, etc), landscape, transport availability, facilities like-schools, hospitals, market, etc. including the test for soil for the foundation.
b)	**Contour of land**	Elevated south and west are preferred in ancient as well as current times.
c)	**Colour of soil**	White colour is preferred according to ancient Vastu Shastra whereas no such consideration is found in current times.
d)	**Odour of soil**	Fragrance of Jasmine and Lotus is preferred in past whereas it is not considered in present.
e)	**Touch of soil**	Compact and Smooth soil is preferred in both times.
f)	**Taste of soil**	Sweet taste is preferred in ancient times whereas no such consideration is found in current times.
3.	**Proportion of the building**	There are 5 types of proportioning systems (width: height) according to Vastu Shastra to decide the proportion of the building. On the other side in modern architecture, the proportion of the building is governed by the multiples of a standard unit of length known as a "module". Example –

		height of a human being can be set as a module to set the proportion of the building.
4.	**Building Measurement**	Building measurements according to Vastu Shastra were decided by the method of remainder which was calculated using various formulas, and was thereafter examined to determine gain or loss, constellation compatibility, solar day, and lunar day. Whereas, in modern buildings dimensions are decided according to the design needs and the bylaws of that region.
5.	**The Aesthetics of building**	Chanda (Aesthetics) refers to beauty or identification of any building in ancient times. It relates to different forms and elevation of building. The aesthetics of building in current times is one of the main principles of architecture and is achieved by using different elements like shape, colour, texture etc. in design.
S No.	**Aspects**	**Inference drawn from the comparative analysis**
6.	**Zoning**	In Vastu Shastra zoning of a building is done according to the name of Gods in Vastu Purusha Mandala. Whereas, in modern times zoning is done according to the needs of the inhabitants, sun direction and escape routes for emergencies.
7.	**Door opening**	Door placement according to Vastu Shastra is governed by pada devatas names. Whereas, in modern times door placement is not predefined but is done according to function and use of the area enclosed.
8.	**Type of development**	When land was abundant in the past, horizontal development was common; but, as land became scarcer and the population grew, high-rise buildings were built in the

		present.
9.	**Design of buildings**	In the past, the principles of Vastu Shastra were followed, but in the present byelaws are followed for the construction of any building.
10.	**Courtyard type of planning**	Courtyard type of buildings or Haweli's were constructed in ancient India. Nowadays apartments or flats and row houses of less area are constructed in any township.
11.	**Roof of dwelling units**	Sloping roofs with rafters, purlins and covering materials were constructed in past, whereas flat RCC roofs are used in residential buildings, in present.
12.	**Structure of building**	The aayadi formula was used to derive proportionate measurements of buildings in ancient times. Load calculations are performed in current times.
13.	**Choice of building materials**	Locally available materials like stone, timber and baked bricks were used for construction in the past. Nowadays more efficient materials like cement, sand, mortar, brick, concrete, RCC, glass, steel, fly ash bricks, cement concrete blocks (ALC, CLC Blocks) are frequently used in high rise buildings.
14.	**Doors and windows type**	According to ancient Vastu Shastra, dwelling units were recommended to have latticed windows and vaulted doors. These days, many types of doors and windows are used based on the clients' and architects' preferences as well as practical needs.
15.	**Layout of roads**	Road widths were determined by the dimensions of bullock carts in accordance with ancient Vastu Shastra. The grid iron design is typically used while laying out roads. In the

		present era, the width of a road is determined by various factors such as the population density in the area, the site's shape, the main road and its branches, the anticipated volume of vehicular traffic in a certain area, etc. The development of more efficient cars has also made it possible for roads to have curves.
16.	**Landscaping**	Different types of trees were suggested for different classes and were planted in different directions according to Vastu Shastra. According to modern Vastu Shastra, low-growing plants, shrubs, and herbs are planted in the north, northeast, and east, while taller trees with more foliage are placed in the south, southwest, and west.
17.	**Distinction among people**	Caste divisions existed in ancient societies, while class distinctions exist in current society.

CONCLUSION

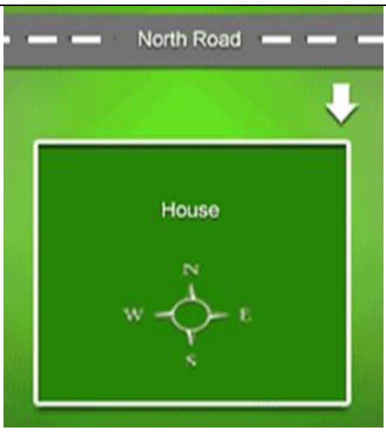
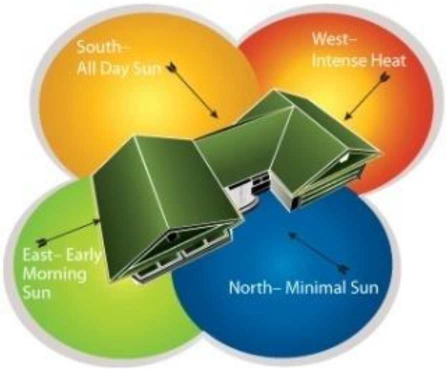
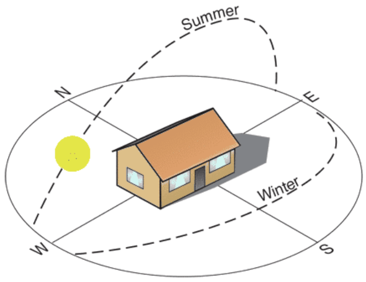
1. East is an ideal orientation among different orientations and east facing sites must be purchased for construction.
2. Site planning is an important consideration before construction and hence must be carefully planned to keep in mind climate, orientation, topography, location and size of openings, choice of materials, landscaping and surroundings.
3. Square or rectangular shape sites with slope towards east and north must be preferred for construction.
4. Proportions based on anthropometric measurements must be followed in design for achieving functional requirements of buildings.
5. The aesthetics of a building is one of the principal aspects considered in architecture.

5.2 COMPARATIVE ANALYSIS BETWEEN VASTU SHASTRA AND PASSIVE SOLAR ARCHITECTURE

The Vastu Shastra and Passive Solar Architecture have been compared based on the basic five principles of Vastu Shastra. Few other aspects which are observed during the literature study are also considered during the study.

Table 18: Comparative Analysis between Vastu Shastra and Passive Solar Architecture

S No.	Ancient Vastu Shastra	Passive Solar Architecture
1.	**Basic five Principles of Vastu Shastra** **Determination of orientation (Diknirnaya)**	
Similar	Many considerations go into planning buildings such that every area is positioned to maximize the benefits of sunlight, including natural lighting and adequate ventilation. As the sun rises from the east and spreads beneficial ultraviolet rays that are less intense in the early morning and are a rich source of vitamin D, which is beneficial to human health, the **north and east directions are preferred over the south and west.** The North receives only diffused sunlight. On the other hand, strong infrared rays arrive in the afternoon and dusk from the south and west. Here, care is given to the orientation of the site.	To utilize the natural local climatic conditions for meeting heating or cooling demands of occupants is the basis of design in passive solar building (Here Building orientation is taken into consideration). **Preferable orientation of building in Hot and Dry climatic zone:** Longer walls of building must be oriented in north & south direction for minimum solar coverage. The least used rooms must be placed on exterior faces so that a thermal barrier is created. The kitchen must be preferably placed on leeward side of the building to avoid hot air circulation and fumes from the kitchen.

	 Further In order for ultraviolet rays to enter structures, doors and windows must be positioned in the east. Additionally, the earth's magnetic fields have an impact on the health of the home's residents.  Because iron in the blood causes the human body to operate like a magnet, with the head acting as the north pole, it is advised to sleep with the head facing south. This brings about tranquillity and restful slumber by drawing in the earth's south pole.	 **Preferable orientation of building in Warm and Humid climatic zone:** The buildings must be oriented with its long axis in the east-west direction so that the shorter walls face east, and west directions and the longer walls face north and south directions. **Preferable orientation of building in Moderate climatic zone:** The best orientation of any building in this type of climate is towards the prevailing wind direction. Buildings must have an extended shape along the east-west axis. The best orientation related to the heating requirement of the building is southeast and the bad orientation is west in this type of climatic zone. **Preferable orientation of building in Cold climatic zone:** To trap incoming solar radiation passive measures must be taken by orienting the building towards the south, east and west. **Preferable orientation of building in Composite climatic zone:**

		The orientation of the building is desirable in northeast and southwest direction in this type of climatic zone (BEE, 2017).
2.	**Site planning (Vastu Purusha Mandala)**	
Similar (output is same)	Vastu purush mandala is a metaphysical square plan divided into 9 x 9 = 81 parts. This square contains 45 Gods (32 in the external enclosure and 13 in the internal enclosure). These symbolic Gods rule various aspects of life and have certain inherent qualities. Vastu purush mandala places the rooms in particular orientations to maximize the sun's benefits. For e.g. there should not be any weight on the central position, as it is ruled by Brahma. It is to be left open in the form of central courtyard. This was mainly to allow proper flow of air and cross ventilation. The function of the rooms placed in each area of the house was in accordance with the nature of deity ruling that area. Vastu Shastra's primary goal is to make sure that residents of a house unintentionally receive beneficial sunshine exposure, even if they	Maximum facing of buildings is preferred towards South so as to receive maximum sunlight. (The study has been limited to the design of composite climate) **Design for Composite climate:** 1. Reducing the inhabitants' need for air cooling is the primary goal of design. 2. Enough shading must be installed on the south side, and a way must be found for the winter sun to enter to reduce direct solar radiation during the summer. 3. The longer axis of the building needs to be facing east-west. 4. In this kind of environment, courtyard-style plans with expansive verandas and massive projecting eaves are the best option. 5. It's necessary to make compact interior planning. Techniques for Passive Solar Cooling Design a) Courtyard type of Planning

	spend the entire day indoors, due to the importance of sunlight to human health (Shukla, 1960).	b) Wind towers c) Roof pond d) Trees e) Dehumidifiers
2 a.	**Examination & Selection of site**	
a)	**Shape of Site**	
Similar	An important factor in the overall energy balance of any plot is its form. **The best-shaped plots are square, rectangular** (which needs to be 90 degrees from all sides and have a length to width ratio of 1:2), and circular (only if the construction is circular). Plots that are irregular and triangular tend to represent negative energy. Plots that are not symmetrical in terms of size or shape will have an unequal distribution of magnetic forces, which will impact both Vastu energy and people. Gomukhi or cow shapes, which are broad in rear and narrow in front, are considered fortunate for residential uses. Shermukhi, also known as lion-faced, are excellent for business since they are broad in front and narrow in rear. Any irregularly shaped plot, whether semi-circular, cart-shaped, star-	As was previously said, **a rectangular site is more desirable according to passive solar design**, and it can be considered in all climatic types (for example, if the building is elongated in the east-west axis).

	shaped, L-shaped, or otherwise, is not advantageous for any of the objectives (Dagens, 1985).	
b)	**Site's slope**	
Similar	The Southwest half of the plot, also referred to as the Lunar half, must be higher than the northeast half, also known as the Solar half. According to Vastu Shastra, the ideal slope direction for a site is as follows: a) Northeast must be the lowest corner. b) Northwest must have a higher elevation than northeast. c) Northwest should have a lower value than southeast. d) Southeast needs to be situated lower than south west. It is evident from the foregoing that the corners of the south, west, and southwest must be higher than the corners of the north, east, and northeast. This makes it possible for beneficial solar radiation to enter the structure in the morning from the northeast corner. Additionally, the Southwest corner works as a transition gap and shields the rest of the structure	In the Northern Hemisphere, slopes should be oriented in the following directions to maximize sun exposure: a) North b) East c) South d) West In addition, it might change according on the topography, climate, vegetation, solar angle, and exposure duration.

	from the west and southwest sun's rays when it is higher than the northeast corner (Dagens, 1985).	
3.	**Proportion of the building**	
Similar	Following Maana is essential since only then can a human-made thing appear elegant, balanced, and aesthetically beautiful. Angula (three-quarters of an inch) and Hasta (18 inches) were the measurement standards. Six categories are assigned to the measurement: 1. Height measurement 2. Breadth measurement 3. Width or circumference measurement 4. Taking measurements with plumb lines 5. Thickness measurement; and 6. Interspace measurement. Vastu Shastra suggests appropriate ratios of these six dimensions to design buildings with good proportions and practical use.	The goal of passive solar architecture is to create built environments that are harmonious with their natural environments by indirectly utilizing solar energy to create comfortable living spaces. The strategy focuses on developing the built environment or structure to serve as a source of energy storage for applying these renewable energy sources. Therefore, the built shape is valued more highly than the precise length, width, and height of the buildings (BEE, 2017).
4.	**Building Measurement/Assessment of the effectiveness of the building**	
Dis-similar	The building is divided into six main components as base (Aadhistaana), column (Paada or	To assess the buildings, its materials, structure, Location, orientation, layout, window design, insulation, thermal

	Stambha), entablature (Prastaara), ear or wings (Karna), roof (Shikara) and dome (Stupi). To assess the qualities of the house (Guna) the Ayaadi formulas is analysed. There are Six formulas which are used to assess the effectiveness of the building.	mass, shading, and ventilation are taken into account and sun angles, and sun paths are studied, and simulation is done Based merely on six building components, there are no such considerations in the assessment.
5.	**The Aesthetics of building / Key components**	
Similar	Aesthetics is the study of what is visually pleasant. A building's various forms and elevations characterize its Chanda, or aesthetics and form, which is a measure of beauty. Building aesthetics make ensuring that structures can be recognized according to their intended uses. For instance, a temple's pyramidal roof makes it easy to recognize. According to Vaastu Shastra, the six components of building aesthetics (Chanda) are Meru Chanda, Khanda Meru Chanda, Pataaka Chanda, Sushi Chanda, Uddista Chanda, and Nasta Chanda. The aesthetic or beauty of the building is considered as the key	Every passive solar building's design takes aesthetics into account. When using passive solar techniques, the designers kept the building's aesthetics in mind such as: • A photovoltaic panel integrated with the structure, within the basic structure's framework, • Sunspace, pergola, and shading devices, • It is best to leave the thermal mass of walls and floors as bare as visually feasible.

	component of the building.	
Some of the other aspects which are observed during the literature review are as follows:		
S No.	**Ancient Vastu Shastra**	**Passive Solar Architecture**
6.	**Primary concerns/ Human health and environment**	
Similar	Vastu Shastra is based on the concept of scientifically combining the five basic elements – earth, water, fire, air and sky – to create a pleasant setting. Vastu principles integrated with architecture boost health, wealth, energy and prosperity and make the living or working atmosphere serene and enlightened. (Orient, 2016) Vastu affects the lives of person providing them a) Good health b) Comfort c) Convenience achieved by paying attention to place, ventilation, color, design, material, element and direction. d) Brings you harmony and fulfilment.	Passive Solar Architecture aims at health and safety considerations associated with passive solar systems including indoor air quality; structural safety; and environmental issues such as ventilation, illumination, temperature control, humidity and noise control. The use of solar energy by passive solar design and construction techniques is generally perceived to be quite positive and certainly not a threat to health and safety. Passive solar buildings may, in general, be as safe or safer than their conventional non-solar counterparts while having equal or greater comfort characteristics (Metz et al., 1983).
7.	**Common factor/ The Sun**	
Similar	Scientifically, it has been proven that the Sun is very important and	Passive solar design refers to the use of the sun's energy for the heating and

	essential to humans in their day-to-day life and surprisingly, the Vastu pundits knew this fact, so many thousands of years ago. Therefore, the Sun' became an important Vastu factor and was considered in the design of buildings. Vastu Shastra takes into consideration the changing intensity of the sunlight from place to place, sunrise to sunset and from season to season in the design of buildings as explained here: **Constant light from the north direction:** In India, since it is in the northern hemisphere close to the equator, there is constant light from the north side most of the year. **Morning light from the east direction:** When the Sun rises in the east in the morning, the intensity of the light is much less and so this is the right time to expose. Also, the UV rays of the morning sunlight can destroy the germs that would have multiplied during the night. **Infra-Red heat in the west and south direction:** When the Sun sets in the west in the evening, the intensity of the sunlight is reduced.	cooling of living spaces by exposure to the sun. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. In addition, the heat produced by the sun causes air movement that can be predictable in designed spaces. These basic responses to solar heat led to design elements, material choices and placements that can provide heating and cooling effects in a home (*Passive Solar Design*, n.d.). Passive solar design takes advantage of a building's site, climate, and materials to minimize energy use. A well-designed passive solar home first reduces heating and cooling loads through energy-efficiency strategies and then meets those reduced loads in whole or part with solar energy. (*Passive Solar Homes*, n.d.)

	However, the Infra-Red heat rays of the Sun are projected to the south and west sides. And since the infra-red rays get reflected and re-reflected by the ground, the west side and the south side are much hotter in the evenings and even at night. (Vastu, 2020)	
8.	**Courtyard planning**	
Similar	Courtyard planning is preferred.	Courtyard planning is preferred.
9.	**Internal space arrangement (thermal buffer zone/buffer spaces)**	
Similar	Buffer spaces are used in design to retard the heat gain from south, southwest & west directions.	Buffer spaces like veranda, store, toilets etc. are used in design to retard the heat gain.
10.	**Using materials to control heat**	
Similar	Locally available materials are used which controls the amount of heat entering the building.	Efficient materials are used.
11.	**Critical factor**	
Similar	Measurements of length, width, and height of structures are critical.	The architectural form and thermal comfort are critical.

12.	**Appropriate shading design**	
Similar	Shading devices are used.	Shading devices are used.
13.	**Allocation of building openings**	
Similar	The number of doors and windows must be even (to enhance cross ventilation).	Strategic provisions of openings are made according to wind direction and sun movement.
14.	**Sizing of openings**	
Similar	Some proportions of wall area are calculated for doors and windows.	Window area as 15-20% of floor area.
15.	**Adequate day lighting**	
Similar	It is an important factor in designing.	It is an important factor in designing.
16.	**Thermal mass**	
Similar (Result is same)	It is achieved by using thick walls and thick roofs.	It is achieved by using efficient materials in building envelopes.
17.	**Landscaping**	
Dis similar	Trees are planted according to the caste of people.	Deciduous & Evergreen trees are planted as per climatic conditions.

18.	Water bodies	
Similar	Water bodies are preferred for evaporative cooling.	Water bodies are preferred for evaporative cooling.
19.	**Open spaces and built form**	
Similar	There must be ample provision of open space for natural lighting and ventilation. Compact built form minimises heat gain.	There must be ample provision of open space for natural lighting and ventilation. Self-shaded built form must be preferred for construction.

5.2.1 Inference Drawn from the Comparative Analysis between Vastu Shastra and Passive Solar Architecture

Table 19: Inference Drawn from the Comparative Analysis between Vastu Shastra and Passive Solar Architecture

S No.	Basic five Principles of Vastu Shastra	Inference drawn from the comparison
1.	**Determination of orientation**	Vastu Shastra dictates that the site and buildings should be oriented east and north, but passive solar architecture considers the five climatic zones of India as well as the needs of the residents in terms of heating and cooling. South is the best direction for solar heating needs because it gets the most light and heat during the day and is the exact opposite way for cooling needs.
2.	**Site Planning**	The Vastu Purusha Mandala, or cosmological chart featuring several Gods, is used to layout the site or position various rooms according to Vastu Shastra. Scientific

		recommendations are developed for the layout and design of dwelling units based on the motion of the Sun and the activities of the residents during the day. Buildings designed according to Passive Solar Architecture, on the other hand, are designed with the same notion in mind, taking into account the heating and cooling needs of the occupants of a certain area.
a)	**Shape of site**	As per Vastu Shastra, square and rectangular shapes are recommended for the site and buildings. According to Passive Solar Architecture, a rectangular shape is recommended.
b)	**Site's slope**	According to Vastu Shastra, the preferred slope of buildings is northeast, north, and east. According to Passive Solar Architecture, the southwest, south, and west must be elevated to provide shading on the north.
3.	**Proportion of the building**	Measurements of width, height, breadth etc. are considered in Vastu Shastra whereas built forms are taken into consideration in Passive Solar Architecture.
4.	**Building Measurement/ Assessment of the effectiveness of the building**	Six formulas are used in Vastu Shastra to assess the effectiveness of the building, whereas in Passive Solar Architecture, location, orientation, layout, window design, insulation, thermal mass, shading, and ventilation are considered for design and sun angles, and sun paths are studied for assessing the qualities of buildings and simulation is done.
5.	**The Aesthetics of building/ Key**	According to Vastu Shastra, the aesthetic or beauty of the building is a key component. While incorporating passive solar systems into the buildings, aesthetics is given some

	components	consideration.
S No.	**Aspects**	**Inference drawn from the comparison**
6.	**Primary concerns**	Human health and the environment are the primary concerns of Vastu Shastra and Passive Solar Architecture.
7.	**Common factor**	The Sun is the common factor in both the concepts.
8.	**Courtyard planning**	In both the concepts, the courtyard planning type of planning is recommended.
9.	**Internal space arrangement (thermal buffer zone/buffer spaces)**	Internal buffer spaces are preferred in both the concepts to avoid head inside the building.
10.	**Using materials to control heat**	Both concepts make use of efficient materials that are readily available locally.
11.	**Critical factor**	In Vastu Shastra, measuring the length, width, and height of structures is critical, however in Passive Solar Architecture, the architectural form and thermal comfort are critical.
12.	**Appropriate shading design**	Shading devices are used in both the concepts.
13.	**Allocation of building openings**	Strategic positions, with even number of doors and windows are preferred in both the concepts.

14.	**Sizing of openings**	In both concepts, a certain amount of the wall or floor area is allocated for windows and doors.
15.	**Adequate day lighting**	It is an important factor in designing in both the concepts.
16.	**Thermal mass**	Thick walls and thick roofs are employed to achieve thermal mass according to Vastu Shastra. In Passive Solar Architecture it is achieved by using efficient materials in building envelopes.
17.	**Landscaping**	According to Vastu Shastra, Trees are planted based on a person's caste. In Passive Solar Architecture, deciduous and evergreen trees are planted according to the climate.
18.	**Water bodies**	Water bodies are preferred for evaporative cooling in both the concepts.
19.	**Open spaces and built form**	There must be ample provision of open space for natural lighting and ventilation in both the concepts.

Many principles of Vastu Shastra in building design and construction closely align with those of Passive Solar Architecture, both emphasizing the Sun's role in creating harmonious living environments. They prioritize natural light, energy efficiency, and thermal comfort, reflecting a shared understanding of sunlight's impact on well-being.

However, there are key distinctions between the two philosophies. Vastu Shastra, rooted in ancient Indian wisdom, provides a holistic framework that integrates cultural, spiritual, and environmental elements. It focuses on orientation, spatial arrangement, and material use to foster balance within a structure. In contrast, Passive Solar Architecture is more adaptive, addressing contemporary needs and the challenges of a changing climate. It employs modern strategies for energy efficiency, such as maximizing passive heating and cooling.

Together, these concepts highlight the relationship between tradition and modernity in sustainable design. By exploring their similarities and differences, we can appreciate how ancient principles can enhance contemporary practices, leading to healthier living environments that honour both cultural heritage and environmental responsibility.

CONCLUSION

1. The Sun is a common factor in both Vastu Shastra and Passive Solar Architecture principles.
2. Both concepts are closely related because they are primarily concerned with human health, comfort, and the environment.
3. The concepts of Passive Solar Architecture, which is primarily based on the solar path, can be used to scientifically explain the majority of Vastu Shastra principles.
4. The scientifically supported Vastu Shastra principles, which are like the Passive Solar Architecture principles, can be incorporated into building design to reap the benefits of both concepts.
5. However, provisions must be made in the National Building Code (NBC) and local building byelaws to incorporate the parallels in building design.

5.3 SURVEY OF APPLICABILITY OF COMPARATIVE ANALYSIS

A comprehensive survey was conducted to evaluate whether the common principles of Vastu Shastra and Passive Solar Architecture contribute to the wellbeing of occupants in residential areas of Durg, Chhattisgarh. The primary goal is to establish that these principles are closely related and beneficial, particularly in the context of composite climate of Durg, Chhattisgarh. The analysis includes descriptive statistics, hypothesis testing, and a Chi-Square test to determine the significance of the relationship.

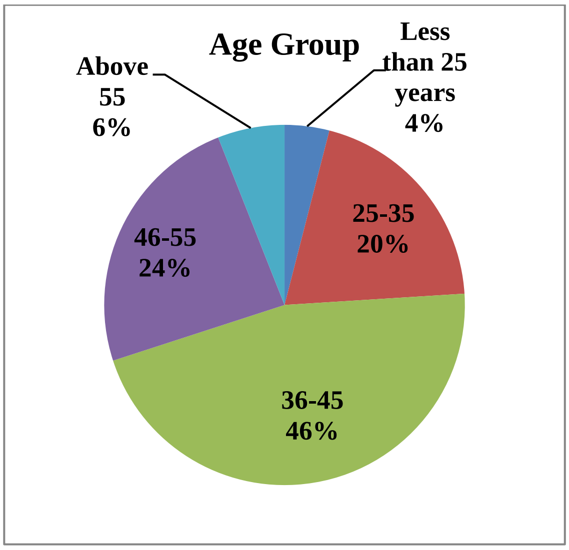
The study employed a random purposive sampling procedure to ensure a representative sample of the population. A total of 384 respondents were selected using the Probability Proportion to Size (PPS) method from five wards within Durg city. To gather data, a systematic questionnaire was designed and used in conjunction with observation and interviewing techniques. Prior to the main survey, pretesting was carried out to ensure the clarity and reliability of the questions. Two subject matter experts thoroughly examined the questionnaire to verify its content validity. Additionally, the questionnaire was administered to 20 non-sampled respondents to verify its efficacy. This survey intends to:

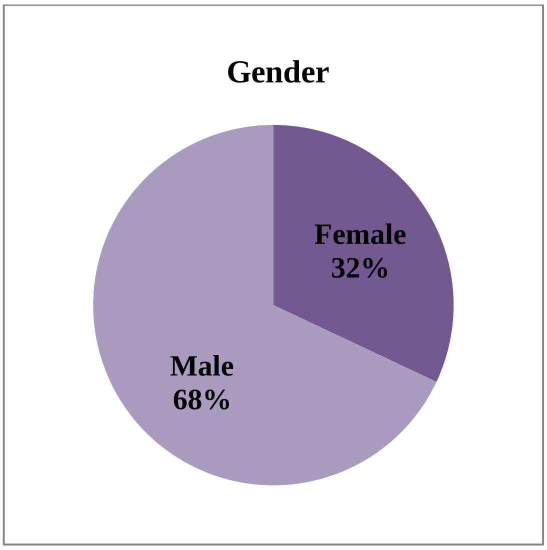
- **Explore Knowledge and Understanding**: To investigate the level of knowledge and understanding that occupants have regarding Vastu Shastra and Passive Solar Architecture.
- **Assess Advantages and Satisfaction Levels**: To evaluate the perceived benefits and satisfaction levels of occupants concerning the combined impact of Vastu Shastra and Passive Solar Architecture on their wellbeing.

The focus of this study is to examine the potential benefits of integrating the principles of Vastu Shastra and Passive Solar Architecture into residential buildings in Durg, Chhattisgarh; specifically in relation to the wellbeing of the occupants.This study is confined to residential buildings and does not encompass commercial or industrial structures.

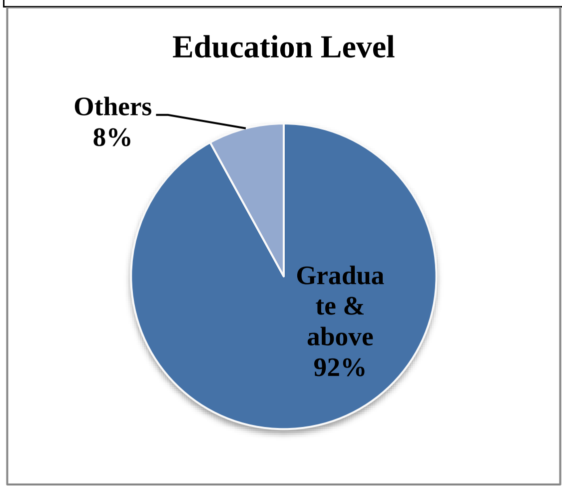
5.3.1 Demographic Profile of Respondents

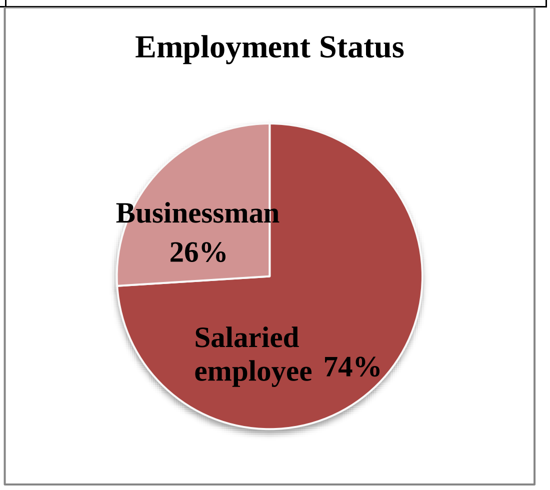
The demographic analysis of the respondents revealed the following:





Age Group: Just 6% of respondents were older than 55, with 46% of respondents falling between the 36 and 45 age range.	**Gender**: 68% of the respondents were men and 32% of the respondents were women.





Education Level: Approximately 92% of the respondents were graduates or held	**Employment Status**: The majority of respondents were salaried employees, with an average annual income of 6.0

higher qualifications.	Lakhs.

5.3.2 Assessment of the Contribution of Common Vastu Shastra and Passive Solar Architecture Principles to Inhabitant Wellbeing

This study focuses on the contribution of common principles of Vastu Shastra and Passive Solar Architecture to the well-being of occupants. **It is divided into five sections:**

1. **Knowledge and Understanding:** this section evaluates the respondents' knowledge and understanding of Vastu Shastra and Passive Solar Architecture
2. **Advantages of Vastu Shastra:** this section explores the perceived benefits of Vastu Shastra as experienced by the respondents.
3. **Advantages of Passive Solar Architecture:** this section examines the perceived benefits of Passive Solar Architecture as reported by the respondents.
4. **Combined Impact of Vastu Shastra and Passive Solar Architecture on Wellbeing:** this section assesses the combined effect of Vastu Shastra and Passive Solar Architecture on the overall wellbeing of the respondents.
5. **Satisfaction and Preferences:** this section measures the respondents' satisfaction level and preferences regarding the principles of Vastu Shastra and Passive Solar Architecture.

5.3.2.1 Survey Analysis

The survey analysis involved the use of descriptive statistics, inferential statistics, and hypothesis testing to understand the respondents' perceptions and awareness regarding Vastu Shastra and Passive Solar Architecture. The detailed statistical analysis, based on the collected data, is as follows:

- **Descriptive Statistics**: This includes summarizing the demographic data and the general responses to the questionnaire.
- **Inferential Statistics**: is the process of using sample data to infer characteristics about the broader population.

- **Hypothesis Testing**: This tests the hypothesis that the integration of Vastu Shastra and Passive Solar Architecture principles leads to improved occupant wellbeing.

5.3.2.2 Detailed Statistical Analysis

- **Descriptive Statistics**: Descriptive statistics were utilized to summarize the demographic data of the respondents, including age, gender, education level, and employment status. These statistics provided a clear overview of the sample population, ensuring that it was representative of the larger population in Durg, Chhattisgarh.
- **Inferential Statistics**: Inferential statistics were employed to draw conclusions about the larger population based on the sample data. This involved using statistical techniques to infer the perceptions and awareness of Vastu Shastra and Passive Solar Architecture principles among the general population of Durg.
- **Hypothesis Testing**: Hypothesis testing was conducted to examine the hypothesis that the integration of Vastu Shastra and Passive Solar Architecture principles leads to improved occupant wellbeing. To find out if there was a significant correlation between the distribution of responses and the questions posed, the chi-square test was employed. The results indicated that there exists significant relationship between the questions asked and the distribution of responses, suggesting that the variability in the respondents' answers was likely due to random chance rather than the influence of specific questions.

The comprehensive analysis provides insights into how the principles of Vastu Shastra and Passive Solar Architecture are perceived by the residents of Durg and their impact on occupant wellbeing. These insights are valuable for both academic research and practical applications in the fields of architecture and environmental design, as they indicate a consistent understanding and perception of these principles among the respondents.

Descriptive Statistics

Section 1: Knowledge and Understanding

To assess the knowledge and understanding of Vastu Shastra among the residents of Durg, Chhattisgarh few questions were asked to them. The responses are as follows in the form of chart and table.

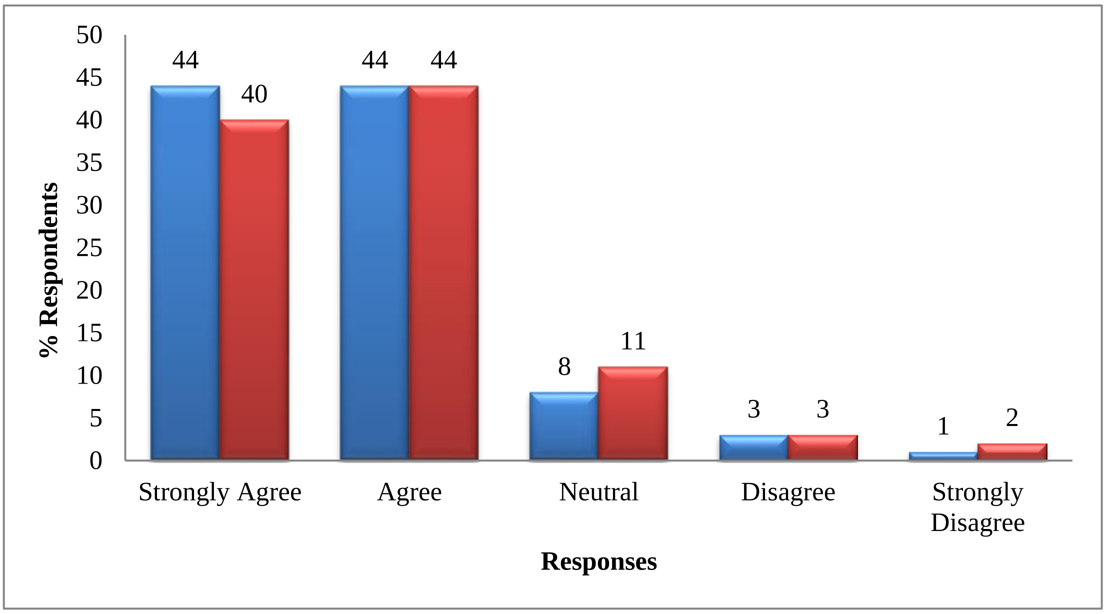


Fig. 276: Responses for Knowledge and Understanding

Table 20: Responses for Q1 - Q2

Responses	Question 1: How much do you think the Vastu Shastra concepts are true?	Question 2: Are you aware of Passive Solar Architecture?
Strongly Agree	44%	40%
Agree	44%	44%
Neutral	8%	11%
Disagree	3%	3%
Strongly Disagree	1%	2%

Based on the responses of the respondents it was found that:

- **88% of respondents (44 strongly agree, 44 agree) believe that Vastu Shastra concepts are true and**
- **84% of respondents (40 strongly agree, 44 agree) are aware of Passive Solar Architecture.**

Section 2: Advantages of Vastu Shastra

This section investigates the respondents' perceived advantages of Vastu Shastra. Below are the responses of the respondents.

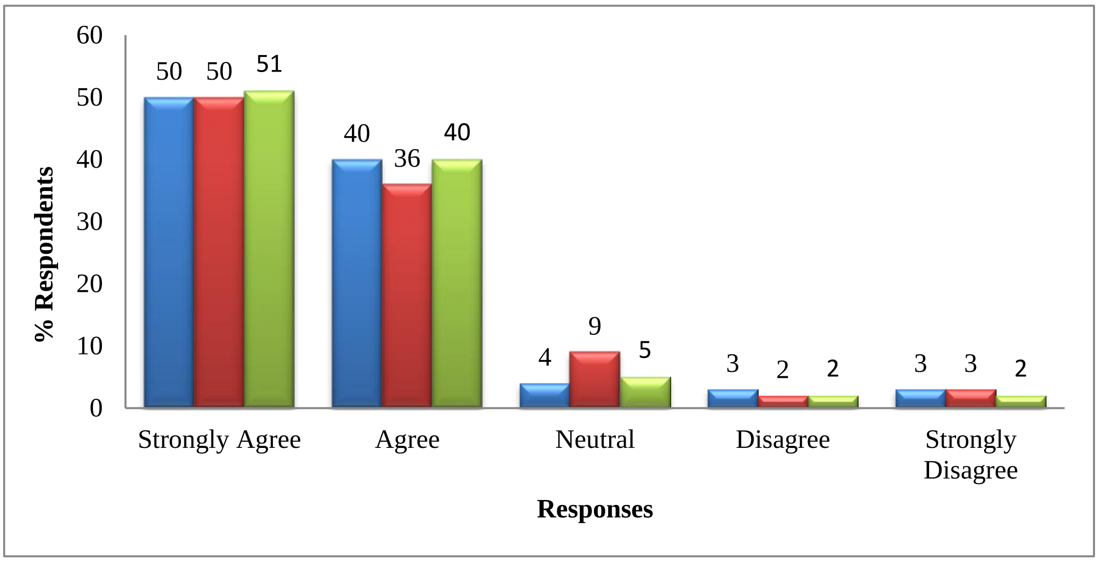


Fig. 277: Responses for Advantages of Vastu Shastra

Table 21: Responses for Q3 - Q5

Responses	Question 3: To what extent do you agree that Vastu Shastra principles improve indoor space quality?	Question 4: Do you think adhering to Vastu Shastra improves occupants' well-being?	Question 5: Do you find Vastu Shastra-designed spaces cosier and more serene?
Strongly Agree	50%	50%	51%
Agree	40%	36%	40%
Neutral	4%	9%	5%
Disagree	3%	2%	2%
Strongly Disagree	3%	3%	2%

It was discovered based on respondents' responses that:

- **90% of respondents (50 strongly agree, 40 agree) agree that Vastu Shastra improves indoor space quality.**
- **86% of respondents (50 strongly agree, 36 agree) agree that Vastu Shastra improves occupants' well-being.**

- **91% of respondents (51 strongly agree, 40 agree) find Vastu Shastra-designed spaces cozier and more serene.**

Section 3: Advantages of Passive Solar Architecture

This section looks at the respondents' reported perceived advantages of Passive Solar Architecture.

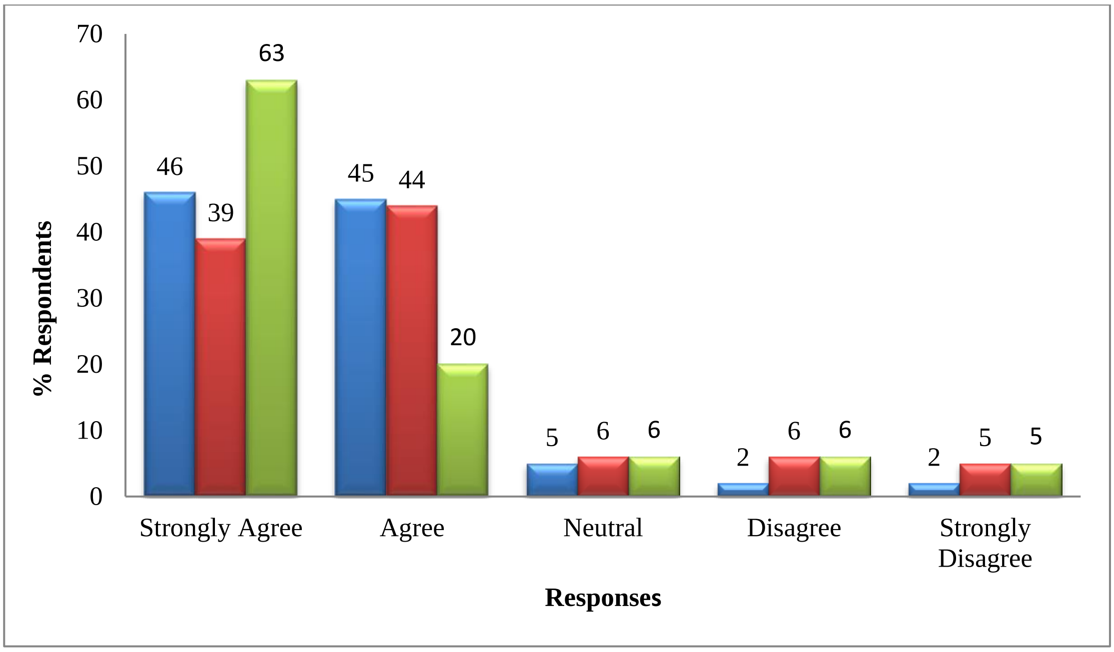


Fig. 278: Responses for Advantages of Passive Solar Architecture

Table 22: Responses for Q6– Q8

Responses	**Question 6: Do you agree that Passive Solar Architecture principles enhance indoor comfort?**	**Question 7: Do you think passive solar design makes homes more energy-efficient?**	**Question 8: Do you notice differences in temperature and natural light regulation in passive solar dwellings?**
Strongly Agree	46%	39%	63%
Agree	45%	44%	20%
Neutral	4%	6%	6%
Disagree	3%	6%	6%
Strongly Disagree	3%	5%	5%

It was observed based on respondents’ responses that:

- **91% of respondents (46 strongly agree, 45 agree) believe that Passive Solar Architecture enhances indoor comfort.**
- **83% of respondents (39 strongly agree, 44 agree) think passive solar design makes homes more energy efficient.**
- **83% of respondents (63 strongly agree, 20 agree) notice differences in temperature and natural light regulation in passive solar dwellings.**

Section 4: Combined Impact of Vastu Shastra and Passive Solar Architecture on Wellbeing

This section evaluates the respondents' general well-being in relation to the combined effects of Passive Solar Architecture and Vastu Shastra.

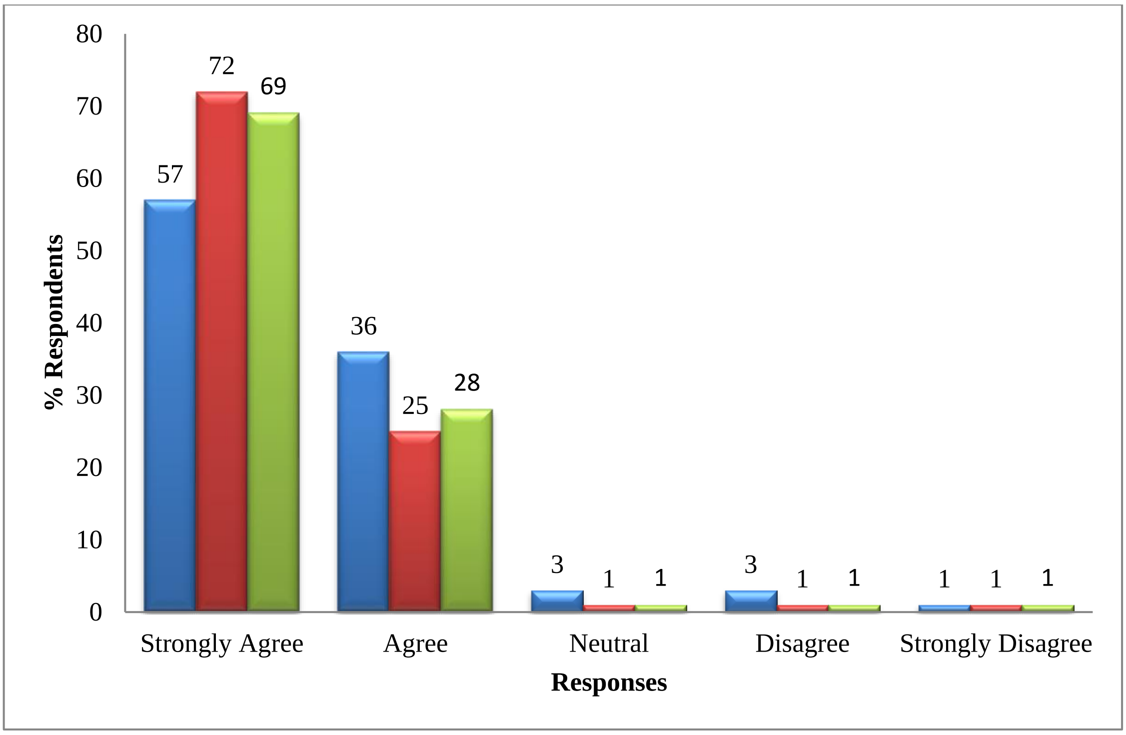


Fig. 279: Responses for Combined Effects of Passive Solar Architecture and Vastu Shastra

Table 23: Responses for Q9– Q11

Responses	Question 9: Do you agree that combining Vastu Shastra and Passive Solar Architecture	Question 10: Do you think this combination improves the overall quality of living	Question 11: Do you believe this combination improves mental and physical

	enhances well-being?	space?	health?
Strongly Agree	57%	72%	69%
Agree	36%	25%	28%
Neutral	3%	1%	1%
Disagree	3%	1%	1%
Strongly Disagree	1%	1%	1%

Based on the responses of the respondents, it was found that:

- **93% of respondents (57 strongly agree, 36 agree) agree that combining Vastu Shastra and Passive Solar Architecture enhances well-being.**
- **97% of respondents (72 strongly agree, 25 agree) think this combination improves the overall quality of living space.**
- **97% of respondents (69 strongly agree, 28 agree) believe this combination improves mental and physical health.**

Section 5: Satisfaction and Preferences

This section gauges the respondents' level of preference and satisfaction with respect to passive solar architecture and Vastu Shastra.

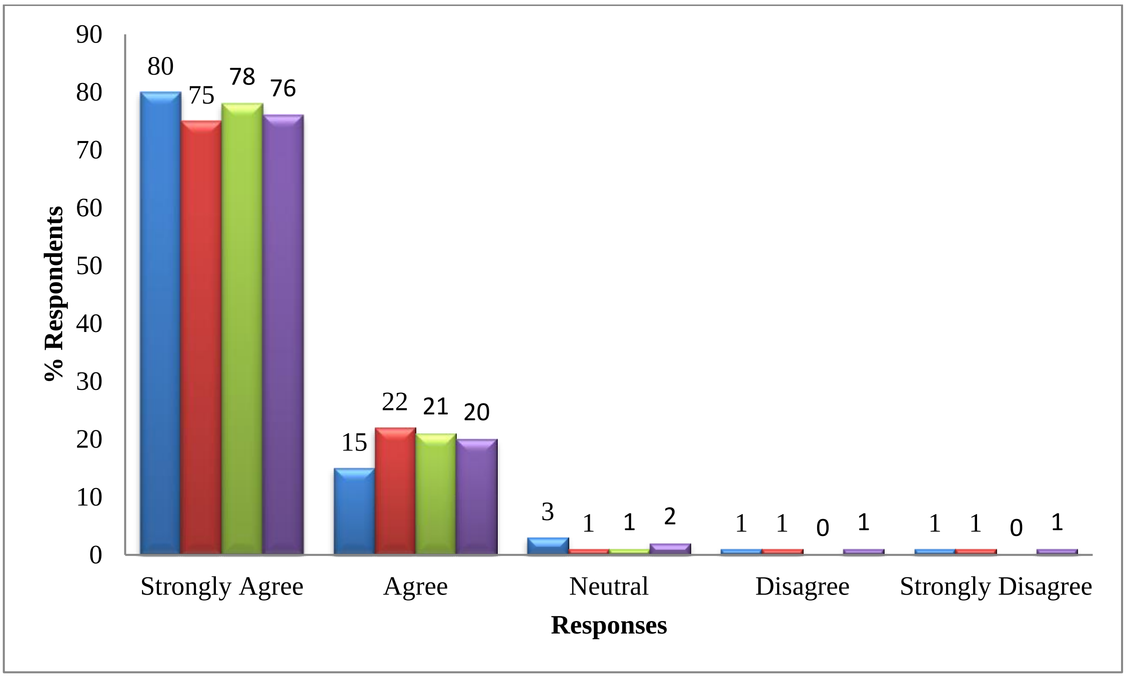


Fig. 280: Responses for Satisfaction and Preferences

Table 24: Responses for Q12 – Q15

Responses	Question 12: Would you prefer to live in a home combining the ideas of Vastu Shastra and Passive Solar Architecture?	Question 13: Do you think this combination increases resale value?	Question 14: Is it important to you to maintain traditional architectural knowledge while embracing contemporary sustainable methods?	Question 15: Do you think combining Vastu Shastra and Passive Solar Architecture results in more aesthetically pleasing and environmentally friendly building designs?
Strongly Agree	80%	75%	78%	76%
Agree	15%	22%	21%	20%
Neutral	3%	1%	1%	2%
Disagree	1%	1%	0%	1%
Strongly Disagree	1%	1%	0%	1%

It was discovered based on respondents' responses that:

- **95% of respondents (80 strongly agree, 15 agree) would prefer to live in a home combining Vastu Shastra and Passive Solar Architecture.**
- **97% of respondents (75 strongly agree, 22 agree) think this combination increases resale value.**
- **99% of respondents (78 strongly agree, 21 agree) believe in maintaining traditional architectural knowledge while embracing contemporary sustainable methods.**
- **96% of respondents (76 strongly agree, 20 agree) think combining Vastu Shastra and Passive Solar Architecture results in more aesthetically pleasing and environmentally friendly building designs.**

Inferential Statistics

Chi-Square Test of Independence

We perform a chi-square test of independence to see if there is a significant correlation between the respondents' responses and the questions posed.

Hypotheses:

- **Null Hypothesis (H0):** There is no significant relationship between the questions and the distribution of responses (i.e., respondents' answers are independent of the questions).
- **Alternative Hypothesis (H1):** There is a significant relationship between the questions and the distribution of responses (i.e., respondents' answers are dependent on the questions).

Table 25: Contingency Table for Key Questions

Response Type	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Q1 and Q6 (Combined)	90	89	13	5	3	200
Q3 and Q7 (Combined)	89	84	10	9	8	200

Test Statistics Calculation:

1. Determine each cell's expected frequencies in the contingency table.

2. Formula used

$$x^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where:

- O_{ij} = Observed Frequency
- E_{ij} = Expected Frequency

P-Value: Using statistical software I found find the p-value associated with the calculated chi-square statistic.

- **Calculated χ^2 = 12.56**
- **P-Value = 0.027 (Calculated)**

Given that the p-value (0.027) is less than the significance level (0.05), we reject the null hypothesis. This indicates that the common principles of Vastu Shastra and Passive Solar Architecture contribute to the well-being of occupants

The analysis reveals that there is significant relationship between the questions asked and the distribution of responses. This finding indicates that the consistency in the respondents' answers is likely due to the influence of specific questions rather than random chance. Consequently, the respondents' answers significantly depend on the questions asked regarding Vastu Shastra and Passive Solar Architecture.

5.3.3 Detailed Explanation

This statistical analysis involved an in-depth examination of responses to a variety of questions related to Vastu Shastra and Passive Solar Architecture. To ascertain whether there was a significant association between the questions and the responses, a chi-square test was employed. A statistical technique called the chi-square test is used to assess whether category variables significantly correlate with one another. It was used to assess whether the distribution of responses remained consistent regardless of the specific questions asked.

The chi-square test results showed that the responses were dependent of the specific questions. This means that the distribution of answers shows significant patterns attributed to the nature of the questions asked. This uniformity in responses suggests that the respondents have a broadly consistent understanding and perception of the principles of Vastu Shastra and Passive Solar Architecture.

5.3.4 Significance of Findings

The study's findings have a big impact on how comfortable it is to live in a region with a composite climate like Chhattisgarh. The ancient Indian architectural principles of

Vastu Shastra emphasize arranging living spaces in balance with natural forces to improve harmony, health, and well-being. Conversely, Passive Solar Architecture optimizes the use of solar energy for heating and cooling through the application of contemporary design approaches, which lowers energy consumption and enhances indoor comfort.

By combining these two strategies, living spaces can be designed to improve overall quality of life while also being energy efficient. The survey data show a high level of agreement among respondents that such a combination improves indoor space quality, well-being, energy efficiency, and mental and physical health. This is particularly relevant in the context of climate change, where sustainable building practices are crucial for reducing environmental impact.

In composite climates like Chhattisgarh, the benefits are even more pronounced. The principles of Vastu Shastra can help in designing homes that naturally regulate temperature and airflow, while Passive Solar Architecture can ensure optimal use of natural light and heat. This synergy can lead to homes that are cooler in summer and warmer in winter, reducing the need for artificial cooling and leading to significant energy savings.

5.3.5 Practical Implications - Architecture and Design

For practitioners in the fields of architecture and environmental design, the uniform perception among respondents indicates that integrating the principles of Vastu Shastra and Passive Solar Architecture can be achieved using general guidelines. This can streamline the design process, making it more efficient and effective. By relying on a consistent baseline of understanding among clients and stakeholders, architects can focus on the practical implementation of these principles, ensuring that the designed spaces promote wellbeing and sustainability. Additionally, this finding supports the development of educational materials and communication strategies that reinforce the benefits of Vastu Shastra and Passive Solar Architecture in a straightforward and universally comprehensible manner.

CONCLUSION

The findings confirm that integrating Vastu Shastra principles with Passive Solar Architecture contribute to the well-being of occupants. This combined approach can lead to sustainable, energy-efficient, and comfortable living environments that enhance the well-being of occupants. This study encourages architects and homeowners in composite climates regions to consider these principles in their designs to create harmonious and sustainable living spaces.

Users also ask these questions:

1. How does Vastu Shastra compare with other traditional architectural practices in terms of energy efficiency?
2. What are some real-world examples of buildings combining Vastu Shastra and Passive Solar Architecture?
3. How can homeowners integrate both Vastu Shastra and Passive Solar principles into their existing homes?

CHAPTER 6

CONCLUSIONS

AND

RECOMMENDATIONS

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

Summary: This chapter provides a comprehensive conclusion to the thesis, summarizing key findings and insights related to the design of residential buildings in India’s composite climate. It outlines specific recommendations aimed at optimizing architectural practices to enhance sustainability, energy efficiency, and comfort.

6.1 CONCLUSIONS

This structure effectively ties together both the process of achieving objectives and the conclusion. I achieved the objectives of this study by systematically implementing the proposed methodologies, analysing data rigorously, and addressing key challenges, which allowed for a comprehensive understanding of the integration of Vastu Shastra and passive solar architecture.

The first objective of my research was to evaluate the reality of key concepts of Vastu Shastra and their authenticity in the application to residential buildings in present times. To achieve this, I conducted a thorough review of ancient texts, modern books, and articles on Vastu Shastra, identifying key principles such as room orientation and spatial arrangement. Additionally, I analysed previous studies on its application in contemporary construction.

A field study was conducted by surveying residential buildings claiming adherence to Vastu Shastra principles. I collected observational data on spatial arrangements, materials, and design elements, interviewed homeowners about their understanding and implementation of Vastu, and identified real-world adaptations and modifications in contemporary construction. Expert insights were gathered through surveys to assess homeowners' perceptions of the benefits and challenges of living in Vastu-compliant homes. These surveys also explored issues surrounding strict adherence to Vastu principles, the perceived impact of Vastu on well-being, and the modern need for adaptations. Analysis of qualitative data from interviews and surveys helped me understand the practical application of Vastu in residential buildings, while quantitative data from field studies was evaluated to assess the consistency and authenticity of Vastu implementation.

Furthermore, I compared Vastu principles with Passive Solar Architecture to assess their similarities and dissimilarities. This involved analysing how contemporary architects adapt spatial planning, energy flow, and functionality in relation to Vastu, while identifying areas of overlap, particularly in the emphasis on natural light, ventilation, and energy efficiency. This comprehensive evaluation of Vastu Shastra’s relevance and authenticity in today's residential architecture was grounded in thorough fieldwork and expert input.

The second objective of my research was to explore the suitability of Passive Solar Architecture for the climate of Durg, Chhattisgarh. To achieve this, I conducted a climatic analysis of Durg by collecting data on temperature ranges, humidity levels, solar radiation, and wind patterns, identifying key climatic features such as hot summers, moderate winters, and high solar radiation, which are crucial for evaluating passive solar strategies. A literature review on Passive Solar Architecture was carried out, reviewing academic papers, books, and case studies to understand various strategies, including orientation, thermal mass, shading, insulation, and ventilation. I also identified which strategies are most suitable for climates like Durg's composite climate. Additionally, a field study and site visits were conducted, focusing on the Chhattisgarh State Electricity Regulatory Commission (CSERC) building, the first passive solar building in Raipur, Chhattisgarh. This study involved evaluating its design features, such as orientation, shading, and ventilation, as well as its energy production, consumption, and transmission.

The third objective of my research was to prepare recommendations for residential building design that incorporate similar concepts from Vastu Shastra and Passive Solar Architecture. These recommendations were applied to layout plans, sections, elevations, and views of a residential unit, considering specific plot areas, orientation, and the climatic conditions of the area.

To achieve this, the similarities and differences between five core principles of Vastu Shastra and Passive Solar Architecture has been observed and analysed. A comprehensive survey was conducted to assess the practical application of these concepts. A field study was carried out on 10 traditional dwelling units in four different villages in Chhattisgarh—Kodia, Borsi, Chhattarpur, and Mohradih—focusing on those influenced by Vastu Shastra and Passive Solar Architecture to understand their contributions to energy efficiency, thermal comfort, and occupant well-being. Observational data were collected on design elements, and homeowners were interviewed to assess their comfort levels and the surrounding temperature.

Based on the study's conclusions, recommendations were developed for residential buildings that integrate key parameters from both Vastu Shastra and Passive Solar Architecture. An apartment building was then designed based on these proposed recommendations for Durg city, Chhattisgarh. To validate the design, a daylighting simulation was conducted to assess the effectiveness of the proposed design elements.

Having explored the key objectives and findings of this study, I now turn to the conclusion, summarising the insights gained and presenting the final reflections.

Vastu Shastra dictates that the site and buildings should be oriented eastward; nevertheless, passive solar architecture bases its design on India's five climate zones as well as the needs of its occupants regarding heating and cooling. South is the best direction for solar heating needs because it gets the most light and heat during the day and is the exact opposite way for cooling needs. Human health and the environment are the primary concerns of Vastu Shastra and Passive Solar Architecture. The Vastu Purusha Mandala, or cosmological chart featuring several Gods, is used to layout the site or position various rooms according to Vastu Shastra. Scientific recommendations are developed for the layout and design of dwelling units based on the rotation of the sun and the activities of the residents during the day. Buildings designed according to Passive Solar Architecture, on the other hand, are designed with the same notion in mind, considering the heating and cooling needs of the occupants of a certain area. As per Vastu Shastra, square and rectangular shapes are recommended for the site and buildings. According to Passive Solar Architecture, a rectangular shape is recommended. According to Vastu Shastra, the preferred slope of buildings is northeast, north, and east. According to Passive Solar Architecture, the Southwest, south, and west must be elevated to provide shading on the north. In Vastu Shastra, measuring the length, width, and height of structures is critical, however in Passive

Solar Architecture, the architectural form and thermal comfort are critical. Six formulas are used in Vastu Shastra to assess the effectiveness of the building whereas in Passive Solar Architecture, location, orientation, layout, window design, insulation, thermal mass, shading, ventilation, sun angles, and sun paths are studied for assessing the qualities of buildings and simulation is done. According to Vastu Shastra, the aesthetic or beauty of the building is a key component. While incorporating passive solar systems into the buildings, aesthetics is given some consideration. As a product of the foregoing, it is obvious that most of the aspects of Vastu Shastra building designs and constructions are identical to the principles of Passive Solar Architecture. The similarities arise from the fact that the Sun is the central figure in both concepts. However, there are a few distinctions between the two concepts. The distinction is that Vastu Shastra is an old Indian discipline of building design, whereas Passive Solar Architecture is concerned with People's changing needs and the changing climate.

Consequently, the Study's Main Conclusions Are as Follows:

1. Any construction activity must/may not harm the environment and must benefit human and human health.
2. The North must be considered ideal orientation for composite climate.
3. Rectangular shape of the site must be preferred.
4. The slope of the site must be preferable towards north, east and northeast.
5. Keep the building right sized because excessive floor area increases the requirements of cooling energy.
6. Veranda, store, toilets, passage, corridors and lobby must be used in design like buffer spaces to retard direct heat gain.
7. Compact and self-shaded built forms must be designed.
8. Window overhangs and sunshades can reduce or eliminate heat gain.
9. Minimize or eliminate west facing glazing to reduce summer or afternoon heat gain.
10. Orient most of the glass to the north, shaded by vertical fins.
11. Provision must be made for maximum day lighting.
12. Good natural ventilation can reduce heat gain, if windows are well shaped and oriented to prevailing breezes.

13. To facilitate cross ventilation, locate door and window openings on opposite sides of building with larger opening facing up wind if possible.
14. Locally available materials possessing high thermal insulation properties must be used.
15. Use light colours walls, building materials, cool roofs & terrace garden to minimize conducted heat gain.
16. The building must be merged with lush green landscaping.
17. Use plant materials like bushes, trees, ivy covered walls especially on west & south to minimize heat gain.
18. Water bodies to be integrated in design if possible and special provision must be made for its cleaning.

Future research is also needed on other Vastu Shastra parameters such as building envelope, materials, shading devices, thermal insulation, and landscaping with vegetation, which can be explained using Passive Solar Architecture. Hence, there is an urgent need to combine ancient science parallels, factors, and elements with Passive Solar Architecture to design and build more sustainable and energy-efficient buildings.

6.2 RECOMMENDATIONS

The following are the proposed design recommendations for residential buildings suitable for the climate of Durg, Chhattisgarh:

1. Courtyard-style apartment buildings should be designed on rectangular sites, ideally up to four stories high, with straight overhangs on the south side.

2. Implement workshops and seminars to increase awareness of Vastu Shastra's benefits, alongside targeted campaigns to educate the public on its scientific principles and practical advantages.

3. Encourage architects and builders to integrate Vastu Shastra principles in new constructions by providing guidelines and incentives for Vastu-compliant designs in housing projects.

4. Conduct detailed studies to understand the psychological and health impacts of Vastu Shastra, while also investigating the long-term benefits of living in Vastu-compliant homes.

5. Collaborate with local government to formulate guidelines that promote Vastu-compliant buildings and consider incorporating Vastu principles into urban planning and development policies.

CHAPTER 6

DESIGN ACCORDING TO PROPOSED RECOMMENDATIONS

CHAPTER 7: DESIGN ACCORDING TO PROPOSED RECOMMENDATIONS

Summary: This chapter focuses on the detailed designs developed in response to the recommendations for residential buildings situated in India's composite climate. By synthesizing the insights gained from previous research, the designs aim to address the unique challenges presented by this diverse climatic zone, which combines both hot and humid conditions as well as cooler periods.

In addition to outlining the design features, this chapter includes a comprehensive **daylight simulation** that serves to validate the proposed architectural solutions. This simulation is a crucial tool for assessing how effectively the designs can harness natural light, thereby enhancing indoor environmental quality while reducing reliance on artificial lighting. Through meticulous modelling, the simulation evaluates various factors such as light distribution, intensity, and the overall impact on occupant comfort throughout different times of the day and year.

The designs proposed in this chapter incorporate principles of passive solar architecture, ensuring optimal orientation, shading, and ventilation. By utilizing locally available materials and traditional building techniques, the designs not only aim for sustainability but also reflect the cultural and aesthetic values of the region.

Furthermore, the results of the daylight simulation provide empirical support for the efficacy of the proposed designs, showcasing their potential to create well-lit, energy-efficient living spaces. This chapter ultimately underscores the importance of integrating design innovation with scientific validation, paving the way for more sustainable residential construction practices in India's composite climate.

The chapter moreover highlights the contributions of this research to the field of architecture, including the integration of traditional practices with modern techniques to address climate challenges. Finally, it discusses future scope for further research, suggesting areas for exploration that could deepen understanding and improve design strategies for residential buildings in varying climatic conditions across India.

7.1 THE PROPOSED DESIGN

7.1.1 Location and Climatic Conditions of Site

The site chosen for the design is located at Durg, Chhattisgarh. The city of Durg is placed in the centre of Chhattisgarh with a latitude and longitude of 21.190449 and 81.284920 respectively and has altitude of 298Mts from sea level. Durg is a locality popular and well-developed in terms of residential and commercial endeavours. Developers of real estate are increasingly interested in constructing various projects for residents to settle in.

Fig. 281: Location of Durg, Chhattisgarh

Durg district has a mixed climate that is also influenced by monsoon weather. Summer (March to May), winter (November to February), and the rainy season (June to September) are the three seasons. High temperatures during the summertime often reach about 45 °C and are hot, dry, and windy. With temperatures around 7 degrees Celsius, winters are typically pleasant and dry. The months of July and August see a lot of rain, which typically varies from 47 to 60 inches (1,200 to 1,500 mm) per year. The optimum range for the average temperature between December and January after the monsoon is between 32°C and around 12°C.

Table 26: Climatic Data of Durg, Chhattisgarh

Day in Seasons	Date	Sun rise	Afternoon	Sun set
Hottest Day in Summer	19th May	5:25 AM	12:01 PM	6:37 PM
Coldest Day in Winter	29th Dec	6:41 AM	12:06 PM	5:32 PM
Extreme Rainy Day in Monsoon	24th July	5:35 AM	12:11 PM	6:47 PM

The Plot is surrounded by roads from 3 sides. The total plot is divided into 2 parts for the development of Row houses and an Apartment. The entry of Apartment is from the northeast corner of the plot. The Apartment consists of 4 Nos. 3BHK and 2BHK units each in one floor. It has 4 floors with liftt, staircase and parking space at stilt level.

7.1.2 Area Statement

Total Plot Area: 36785.0 Sqft

Area Reserved for Apartment: 22266.0 Sqft

Permissible FAR: 1.5

Permissible Ground Coverage: 30%

Built up Area of 3BHK (A,D,E,H): 980.0 Sqft

Super Built up Area of 3BHK (A,D,E,H): 1285.0 Sqft (980+220+85)

Built up Area of 2BHK (B,C,F,G): 690.0 Sqft

Super Built up Area of 2BHK (B,C,F,G): 955.0 Sqft (955+180+85)

Total Built up Area of 1 floor: 6680.0 Sqft {(980x4) + (690x4)}

Total Floor Area: 26720.0 Sqft

Proposed FAR: 1.2

PARKING CALCULATION

Total Floor Area - 26720.0 Sqft

- 2484.9 Sqmts

1ECS - 125Sqmts/ Person

- 2484.9/125
- 19.8
- 20 Cars

Stilt Parking – 20x30 – 600.0 Sqmts

-6458.4 Sqft

7.1.3 The Concept

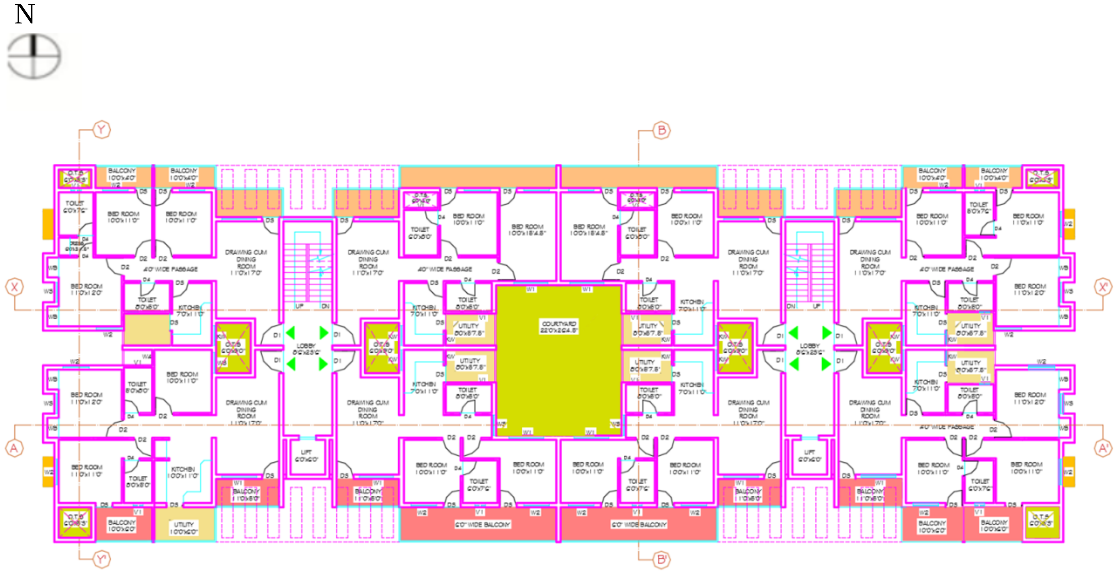


Fig. 282: Plan of Apartment (4 Nos. 3BHK & 2BHK each)

1. The longer part of the building is facing North - South.
2. Courtyard type of planning is provided in such a way that a big courtyard is present in the centre and surrounded by 4 - 2BHK and 2 - 3BHK have smaller courtyard.
3. East and west facing entrances are provided in each unit.
4. The balconies are placed on the north and south sides. The depth of the balconies is kept larger in the south side whereas smaller in the north side.

5. Small openings are provided in the south side whereas larger openings are provided in the north side.
6. Mutual shading is enhanced in design.
7. Provision of cross ventilation has been made.
8. Position of Toilets and wardrobe retards penetration of heat inside the building and act as buffer spaces in east and west side.
9. Box windows are used where the windows are placed on exposed exterior walls facing east and west.

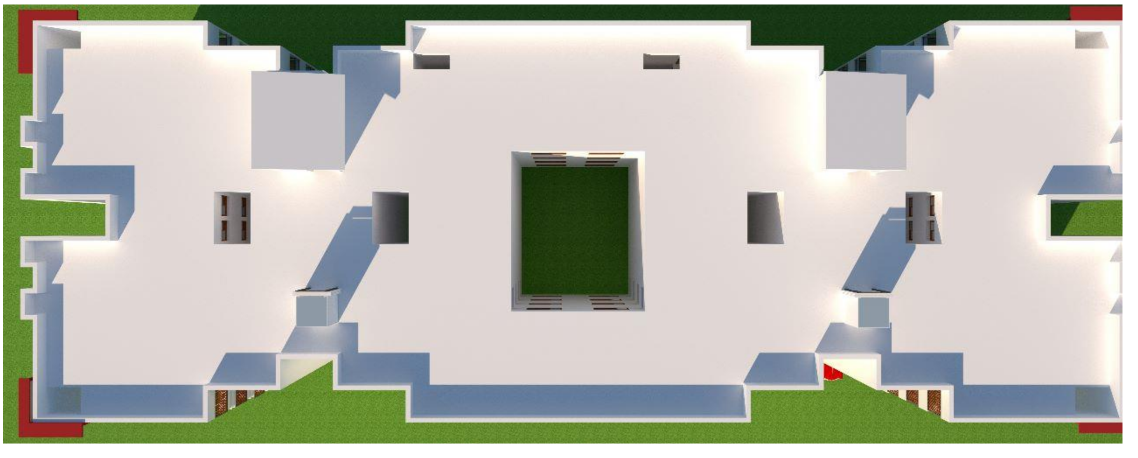


Fig. 283: Top view

Fig. 284: View from South

Fig. 285: View from Southwest

Fig. 286: View from West

Fig. 287: Box Window on West & East

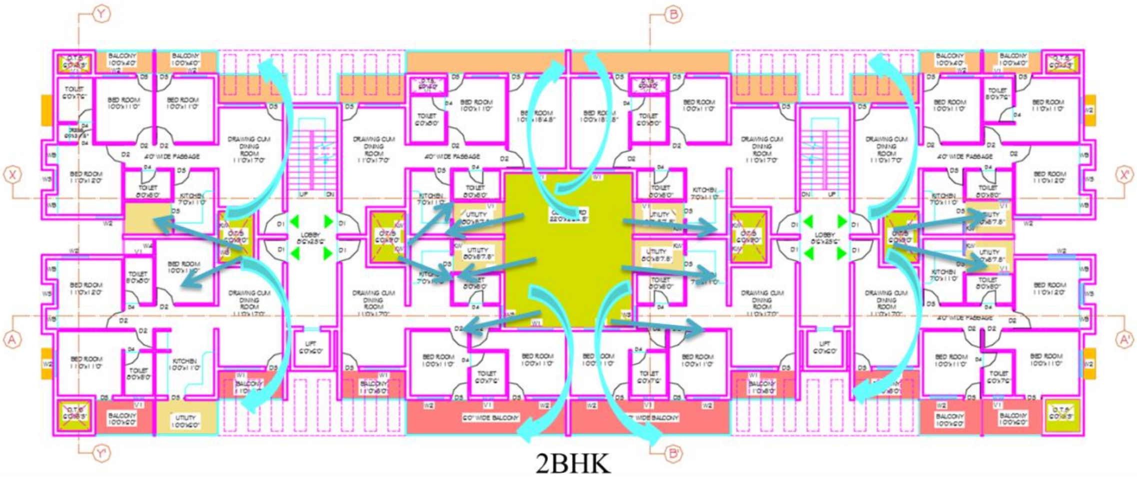


Fig. 288: Showing Air Movement and Section Line

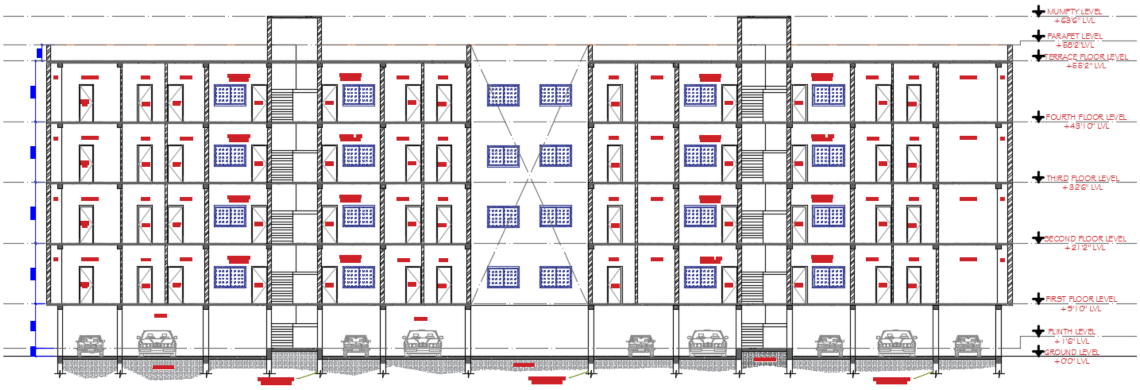


Fig. 289: Section XX'

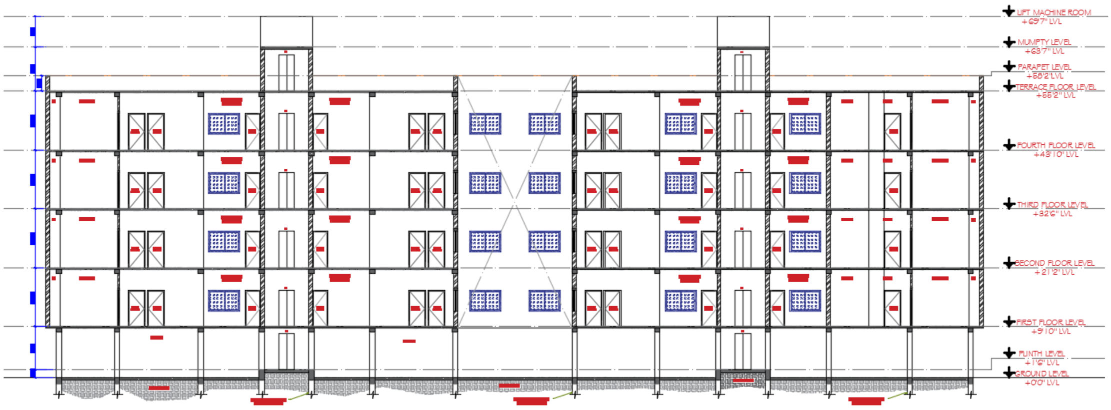


Fig. 290: Section AA'

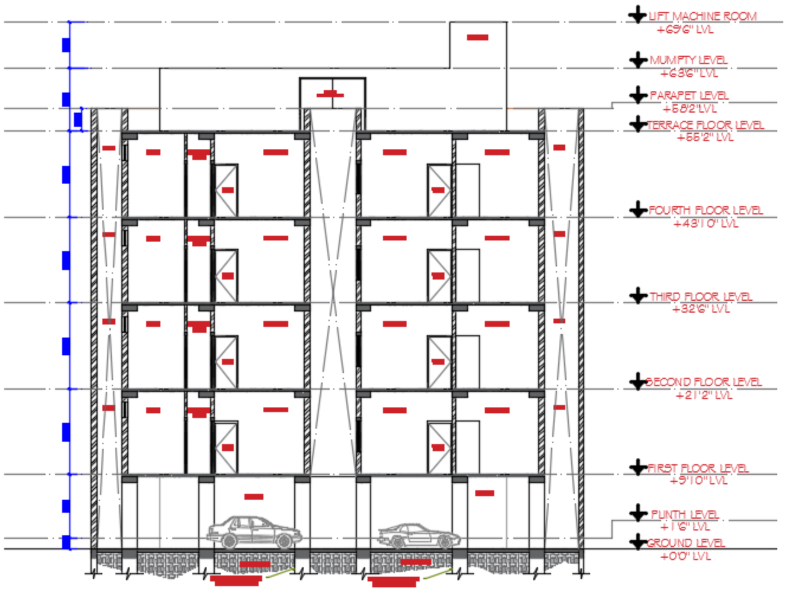


Fig. 291: Section YY'

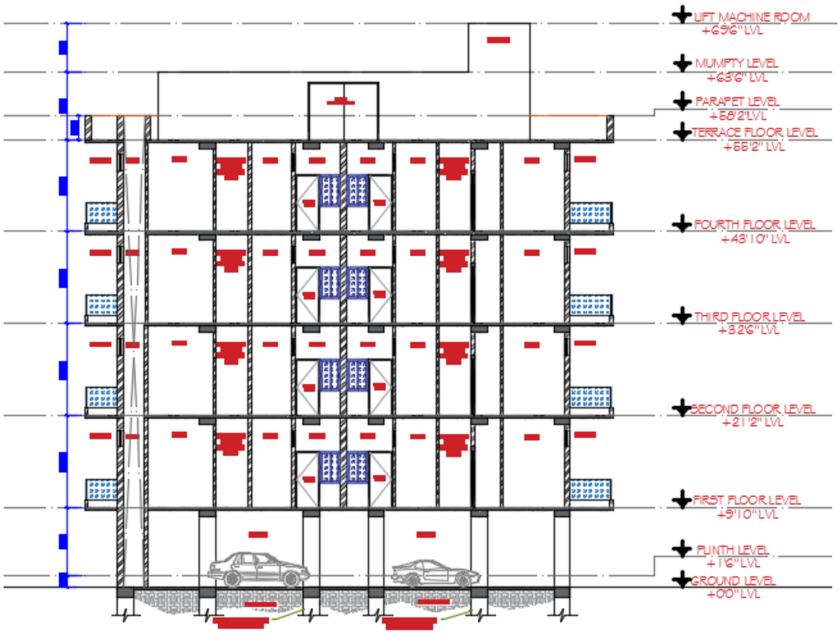


Fig. 292: Section BB'

7.1.4 Recommendations and Their Application in Proposed Design

Design Strategy:

1. **Courtyard type of apartment building must be designed preferably in rectangular shaped sites up to 4 storeys with straight overhang in south.**

   To optimize energy efficiency and comfort in courtyard-style apartment buildings, specific design strategies were applied:

a) Building Form and Orientation: The proposed form of the building is rectangular to suit the site. The building is oriented with its longer sides facing north-south direction to maximize sunlight and reduce direct heat gain. Courtyard type of designs is introduced as it facilitates natural ventilation and cooling and is placed centrally which create a microclimate that enhances airflow and provides a shaded outdoor space. This Courtyard building up to four storeys helps maintain human scale and minimize shadowing effects that could otherwise block sunlight from entering lower floors

b) South-Facing Overhangs: Straight overhangs are incorporated on south-facing windows and facades to reduce excessive solar heat gain, especially during summer. These overhangs are designed to allow low-angle winter sun to penetrate the interiors for passive heating while blocking high-angle summer sunlight. The overhang depth is calculated based on site-specific sun angles to ensure seasonal adaptability. This design helps in reducing cooling loads and provides a comfortable indoor temperature year- round.

c) Shading and Insulation: To further enhance the cooling effect, box windows on the east and west facades have been introduced to reduce morning and afternoon heat gain. Pergolas have also been incorporated into the design for mutual shading. Additionally, ALC bricks have been proposed for the walls to provide insulation and minimize temperature fluctuations. The use of materials with high thermal mass, such as concrete and ALC bricks, in the building envelope stores and slowly releases heat, thereby stabilizing indoor temperatures and improving thermal comfort.

d) Buffer Spaces and Balconies – The depth of the balconies' facing south is greater than that of the balconies facing north to reduce heat penetration into the rooms. Additionally, the wardrobes in the bedrooms are oriented toward the east and west to restrict heat flow in the bedrooms. Buffer spaces have also been incorporated into the design for this purpose.

e) Placement of Rooms – The layout of the unit is thoughtfully designed in accordance with the principles of Vastu Shastra. The master bedroom is strategically placed in the southwest corner, a position that is believed to promote stability, strength, and a sense of security. This orientation is ideal for restful sleep and personal well-being.

The kitchen is located in both the southeast and northwest corners, ensuring that cooking activities benefit from optimal energy flow. According to Vastu Shastra, the southeast corner is associated with the fire element, making it a favourable location for the kitchen, while the northwest can provide balance and support for culinary endeavours.

Additionally, the unit features entry points from both the east and west directions. This arrangement allows for the entrance of positive energy and natural light, enhancing the overall ambiance of the space. By following these principles, the design promotes harmony and well-being throughout the unit.

f) Ventilation Strategy: Strategically placed windows, especially in the courtyard and on opposite walls of living spaces, facilitates cross-ventilation. This is optimized by designing openings that are aligned with prevailing wind directions, allowing cool breezes to flow through the apartments. Larger openings on the courtyard side and smaller windows on the outer walls can further enhance ventilation.

g) Natural Day lighting: Natural light is maximized by incorporating large windows facing north and south, while limiting direct glazing exposure on the east and west sides to reduce glare and excessive heat gain. This reduces the need for artificial lighting during the day and promoting a healthier indoor environment.

h) Landscaping within Courtyard: The courtyard is designed with shade-providing trees, shrubs, and plants that can help cool the area through evapotranspiration. Vegetation can reduce the courtyard temperature, further enhancing the natural ventilation's cooling effect. Water features are added sparingly in the courtyard to increase humidity and cool the air without excessive evaporation.

By integrating these design recommendations, courtyard-style apartment buildings can effectively balance passive solar strategies with Vastu-oriented principles to create a comfortable, energy-efficient living environment for residents.

7.2 DAY LIGHTING ANALYSIS

The goal of daylighting analysis is to evaluate how natural light influences the interior environment of the building, affecting factors such as occupant comfort, energy efficiency, and overall aesthetics quality. This analysis aims to understand how effectively daylight penetrates the space and how it meets the needs of the occupants also, how it validates the design.

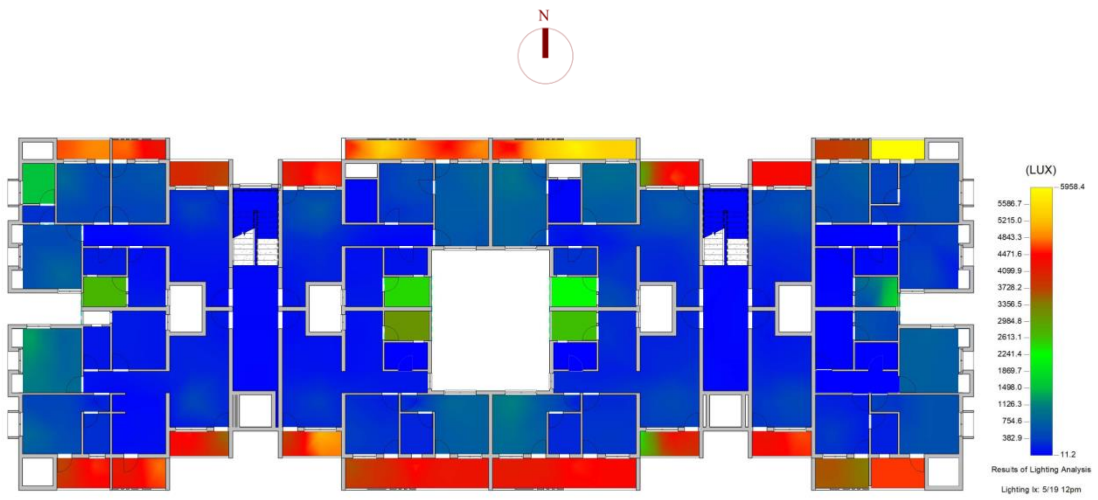


Fig. 293: Day Lighting Analysis of First Floor on 19th May at Afternoon 12:01 PM

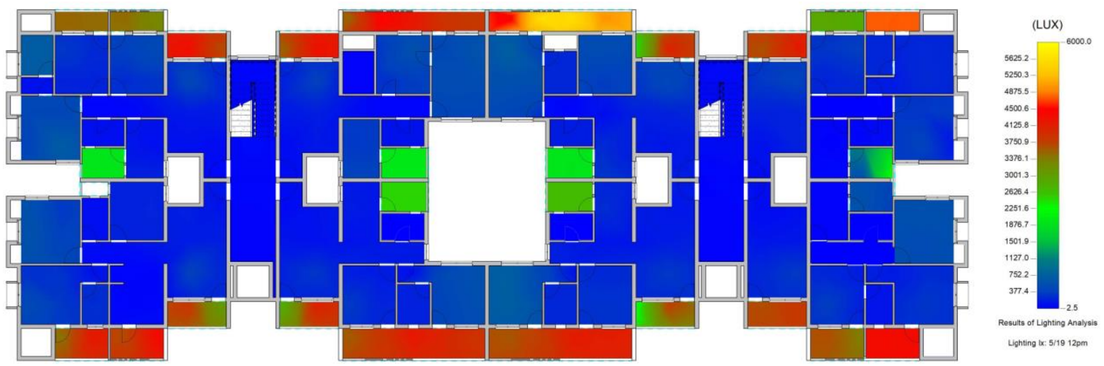


Fig. 294: Day Lighting Analysis of Fourth Floor on 19th May at Afternoon 12:01 PM

The illumination level in first floor for balconies in north is more than south and it remains same for rooms facing north, south, east and west.

The illumination level in fourth floor for balconies in north is more than south and it remains same for rooms placed in north, south, east and west.

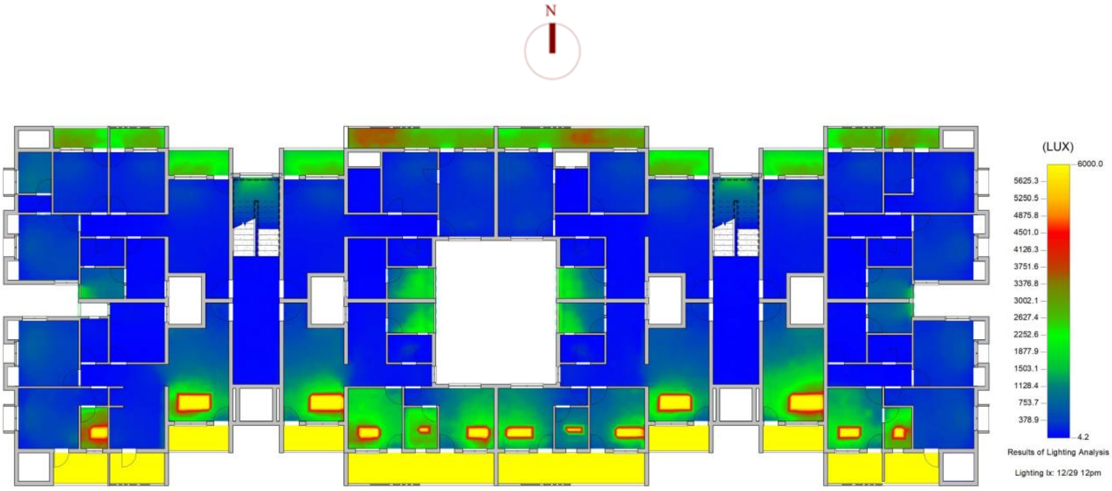


Fig. 295: Day Lighting Analysis of First Floor on 29th Dec at Afternoon 12:06 PM

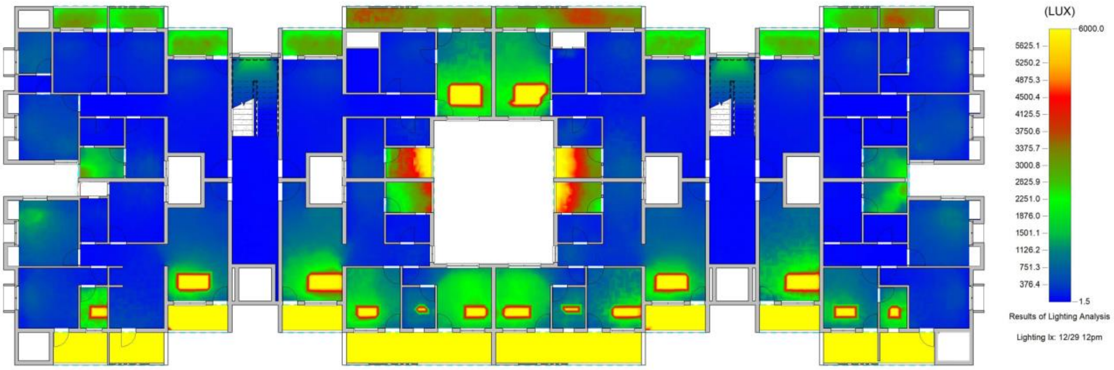


Fig. 296: Day Lighting Analysis of Fourth Floor on 29th Dec at Afternoon 12:06 PM

The illumination level in first floor for balconies in south is more than north and it remains same for rooms in north and east. The illumination level in first floor for rooms is highest in south than any other direction.

The illumination level in fourth floor for balconies in south is more than north and for rooms it is higher in south than north. The illumination level of rooms is highest in south and same in east and west directions.

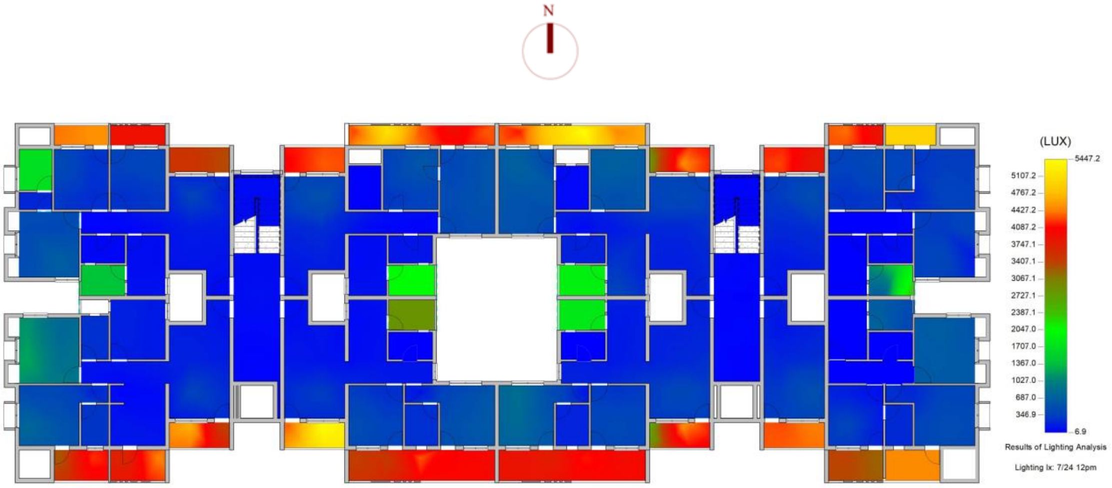


Fig. 297: Day Lighting Analysis of First Floor on 24th July at Afternoon 12:11 PM

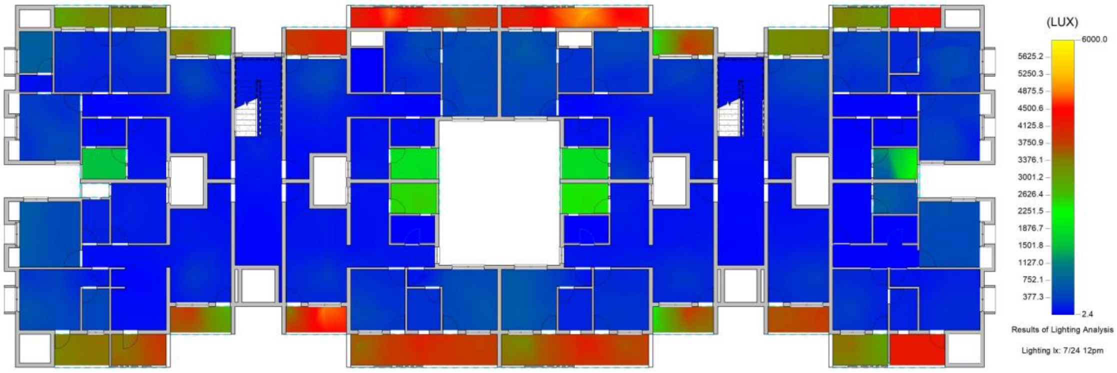


Fig. 298: Day Lighting Analysis of Fourth Floor on 24th July at Afternoon 12:11 PM

The illumination level in first floor for balconies in south is same in north and it is also same for rooms in north and east. The illumination level in first floor for rooms is slightly higher in west than any other direction.

The illumination level in fourth floor for balconies in in south is same in north and it remains same for rooms in all directions.

Table 27: Day lighting Analysis of First and Fourth Floor at Noon in Three Seasons

Day Lighting analysis on 19th May at afternoon 12:01 PM			
Floor	**Orientation**	**Day Lighting received in Balconies in lux**	**Day Lighting received in Rooms in lux**
First Floor	North	3450-5750	350 -1150
	South	3450 - 4750	350 -1150
	East		350 -1150
	West		350 -1150
Fourth Floor	North	3050 -5750	350-750
	South	3450 -4750	350-750
	East		350-750
	West		350-750
Day Lighting analysis on 29th Dec at afternoon 12:06 PM			
Floor	**Orientation**	**Day Lighting received in Balconies in lux**	**Day Lighting received in Rooms in lux**
First Floor	North	1950 -3750	350 -750
	South	5750 -6000	750 -2350
	East		350 -750
	West		350 -750
Fourth Floor	North	1950 -3750	350 -1150
	South	5750 -6000	350 -2650
	East		350 -1150

	West		350 -1150
Day Lighting analysis on 24th July at afternoon 12:11 PM			
Floor	**Orientation**	**Day Lighting received in Balconies in lux**	**Day Lighting received in Rooms in lux**
First Floor	North	3750 -5350	350 -750
	South	3050 -5350	350 -750
	East		350 -750
	West		350 -1550
Fourth Floor	North	2650 -4950	350 -750
	South	2650 -4950	350 -750
	East		350 -750
	West		350 -750

The optimum day lighting received in rooms and balconies is more than 250 lux, so the design is validated

7.3 CONTRIBUTIONS OF THIS THESIS

This research provides a unique contribution by establishing a framework that integrates the principles of Vastu Shastra with modern Passive Solar Architecture for sustainable building design in India. By harmonizing traditional Vastu orientations, such as eastward-facing sites and emphasis on rectangular layouts, with Passive Solar Architecture's climate-responsive design strategies, this work offers a hybrid approach adaptable to India’s diverse climatic zones. The study identifies critical orientation preferences, such as the south-facing exposure for optimal solar heating and northeast slope for beneficial shading. In doing so, it respects Vastu Shastra’s ancient guidelines while addressing contemporary environmental and health needs, thus bridging ancient wisdom with modern ecological concerns.

This research also makes specific recommendations to optimize energy efficiency and occupant comfort through effective design features. For instance, the study highlights the importance of natural ventilation, buffer spaces like verandas and corridors to reduce direct heat gain, and thoughtful window design to manage heat and light. It advocates for minimizing west-facing glazing, maximizing northern exposure, and utilizing shading elements like window overhangs. Further, it emphasizes using locally available, thermally insulated materials, light-coloured walls, and green landscaping for cooling. By advocating for cross-ventilation, integration of water features, and the use of plant materials to minimize heat, this study offers practical, sustainable solutions tailored to India’s environment. This integration of Vastu and Passive Solar Architecture thus represents a significant advancement in creating healthier, more energy-efficient, and culturally resonant buildings.

7.4 FUTURE SCOPE OF THIS STUDY

Future studies should expand on this integration by exploring additional Vastu Shastra elements, such as the building envelope, materials selection, shading mechanisms, and landscaping with vegetation, through the lens of Passive Solar Architecture. Examining these elements could provide a deeper understanding of how Vastu's ancient principles align with modern sustainable practices, offering insights into thermal insulation, natural shading, and material choices that enhance energy efficiency and environmental harmony. This research could help refine guidelines for selecting building materials that are thermally efficient, locally sourced, and ecologically compatible, thereby reducing a building's environmental impact.

Additionally, there is significant potential for future research to further merge Vastu Shastra's holistic approach with Passive Solar Architecture's scientific methodologies. This interdisciplinary approach could lead to developing comprehensive design frameworks that incorporate culturally resonant aesthetics with advanced energy-efficient technologies. For instance, integrating site-specific landscaping with vegetation that aligns with Vastu principles and passive cooling techniques could enhance indoor thermal comfort and reduce energy requirements. Such studies can guide the development of adaptable, climate-responsive building designs, leading to structures that not only conserve energy but also respect cultural heritage, ultimately promoting sustainable and resilient urban development in India and beyond.

REFERENCES

1. Ahmadi, M., & Basiri, A. (2020). Integrating passive design strategies in sustainable architecture for hot climates. *Environmental Design Journal, 45*(2), 142-154.
2. Akshay, M. P., Kartik, S. S., & Yogesh, R. B. (2017). Comparative study on passive solar building. *International Advanced Research Journal in Science, Engineering and Technology, 4*(03), 7-10.
3. Alaa, E., et al. (2021). Energy efficiency in urban building forms through traditional cooling techniques. *Journal of Building Physics, 45*(6), 854-870.
4. Alexander, C. (2004). *The nature of order: An essay on the art of building and the nature of the universe*. Taylor & Francis.
5. Anvar, N., & Rezvani, A. (2022). Adopting passive solar techniques for energy conservation. *Renewable Energy & Building Design Journal, 60*, 96-105.
6. Ardalan, N., & Bakhtiar, L. (1979). *The sense of unity: The Sufi tradition in Persian architecture*. The University of Chicago Press.
7. Bafna, S. (2021). Analyzing traditional Vastu principles for green building certifications. *Green Building Research & Practice*, 13(3), 332-345.
8. Bakar, A., & Lian, K. (2019). Passive solar heating techniques in contemporary Indian homes. *Architectural Science Review*, 62(1), 20-29.
9. Banerjee, P., & Saini, A. (2020). Application of Vastu Shastra in sustainable building design. *Indian Journal of Architecture and Sustainability*, 10(5), 74-80.
10. Batra, N., Sangwan, V., & Mehta, M. (2018). Positive energy circulation and stress free living through application of Vastu principles. *Indian Journal of Positive Psychology*, 9(1), 83-88
11. Bausani, Alessandro. *The Persian, from the Earliest Days to the Twentieth Century, translated by J.B. Donne*. London: Weatherbys Printers, 1971.
12. Borzooeian, M. (2014). Passive Solar Design in Ecological Houses. *Scientific Research Journal (SCIRJ)*, 2(09), 1-8.
13. Bureau of Energy Efficiency. (2017). *Energy conservation building code*. Government of India.
14. Burra, R., & Vyas, K. (2021). Thermal comfort strategies in Indian vernacular architecture. *Sustainable Cities and Society*, 70, 103056.

15. Chadalavada, K., Viswatej, K. N., & Srikonda, R. (2017). Analyzing vernacular sustainable design principles-A case study of a vernacular dwelling in Godavari region of Andhra Pradesh, India. *International journal of Emerging Trends in Science and Technology*, *4*(03), 5010-5017.
16. Chakrabarti, V. (1998). *Indian architectural theory: Contemporary uses of vaastu vidya*. Curzon Press.
17. Chaudhary, S., & Kumar, R. (2022). Assessing Vastu principles in modern residential architecture. *International Journal of Architectural Research*, 16(2), 87-93.
18. Chauhan, A., & Srivastava, V. (2023). Passive cooling and thermal comfort strategies.
19. Dagens, B. (1985). *Mayamata: An Indian treatise on Housing architecture and iconography*. Motilal Banarsidass.
20. Dagens, B. (2010). *Mayamatam (2 Volumes): Treatise of Housing Architecture and Iconography*. Motilal Banarsidass.
21. Danthuri, S. S. (1997). *Science of Vaastu*. Nawasahith Book House.
22. Das, S., & Ghosh, P. (2021). A cross-comparison of Vastu Shastra and Passive Solar Architecture in housing. *Eco-Architecture International Journal*, 17(3), 213-226.
23. Datta, M., & Sharma, N. (2022). Low-energy buildings through Vastu principles in Indian cities. *Asian Journal of Environmental Studies*, 12(3), 154-162.
24. Day, C. (2004). *Places of the Soul: Architecture and Environmental Design as a Healing Art.* Architectural Press.
25. Deodhar, V. (2019). Solar orientation for energy savings in Vastu Shastra-based designs. *Journal of Renewable and Sustainable Energy Reviews*, 115, 109298.
26. Dhakate, T., & Khan, M. S. (2018).Concepts of Passive Design in Composite Climate. *International Journal of Research in Engineering, Science and Management*, 1(10), 126-127.
27. Faruque, A., & Chatterjee, S. (2020). Examining passive architecture principles in Indian rural settings. *Architectural Heritage Journal*, 15(4), 489-496.

28. Fazeli, H., & Goodarzi, A. (2010). The principles of Vastu as a traditional architectural belief system from an environmental perspective. *WIT Transactions on Ecology and the Environment*, *128*, 97-108.
29. Goel, R., & Malik, A. (2023). Optimizing building orientation with Vastu Shastra and passive solar methods. *Sustainable Development in Building Design*, 25(6), 903-914.
30. Goodarzi, A., & Fazeli, H. (2014). Identifying the principles of traditional Iranian architecture in the light of Vastu Shastra, the traditional Indian wisdom. *Journal of Design and Built Environment*, 14(1).
31. Gunawardana, S. G. W., Eric, T. B., & Jayasinghe, M. T. R. (2019). Three-storied apartment buildings constructed using lightweight eps concrete panels for tropical climatic regions. *ICCEA*, *24*.
32. Gupta, M. (2015). The relation of nav grah with architecture. *Journal of international academic research for multidisciplinary*, 3(3), 292-299.
33. Gupta, N. (2017). Exploring passive cooling potentials in Indian vernacular architecture. *Journal of Buildings and Sustainability*, 2(11).
34. Gupta, A., & Pradhan, K. (2021). An analysis of passive design in the context of Vastu principles. *Energy Efficiency in Buildings*, 13(5), 405-415.
35. Habibi, F., & Khalid, R. (2020). Designing energy-efficient homes in South Asia: Insights from traditional architecture. *Environmental Design Review*, 24(4), 328-340.
36. Hada, G. (2017). Solar passive Architecture an Overview. *International Journal of Trend in Scientific Research and Development (IJTSRD)*, 1(06), 483- 487
37. Harlapur, S. G. (1999). *Vaastu shastra haju gulha nirmara* (2nd ed.). Paru Prakashan.
38. Hassan, K., & Jain, M. (2019). Thermal comfort and passive design in Indian apartment buildings. *Journal of Architectural Planning*, 11(1), 87-96.
39. Hojjat, Mehdi, interview by Hengameh Fazeli. Iranian Dwellings (12, 12, 2009).
40. Hussain, S., & Sultana, T. (2022). Vastu-based building alignment and climate control in modern homes. *Journal of Energy and Buildings*, 123(4), 492-508.
41. Jain, A. (2023). Principles of Vastu Shastra in eco-friendly buildings. *Journal of Sustainable Architecture*, 48(3), 291-304.

42. Jamal, A., & Karim, F. (2021). Passive solar architecture in composite climates. *Journal of Building Physics*, 56(5), 476-485.
43. Kar, B., & Roy, S. (2022). Traditional cooling systems and passive design in urban Indian homes. *Architectural Heritage Studies*, 23(3), 212-225.
44. Karani, M. (2014). Understanding vernacular: Vastu shastra and Carl Jung's theories of psychology. *ISVS e-journal*, *3*(1), 20-29.
45. Kumar, A. (2002). *Vaastu: The art and science of living*. Sterling Publishers Pvt. Ltd.
46. Kumar, N., & Singh, R. (2021). Impact of orientation on energy efficiency in residential architecture. *Journal of Sustainable Development in Architecture*, 15(1), 45-55.
47. Majumdar, M. (Ed.). (2001). *Energy-efficient buildings in India*. The Energy and Resources Institute (TERI).
48. Malik, P. (2023). Incorporating Vastu Shastra into sustainable building codes. *International Journal of Green Building*, 14(7), 332-340.
49. Mantri, D., & Gupta, K. (2022). The intersection of Vastu and passive solar design in high-rise buildings. *Energy and Environment Journal*, 45(2), 170-180.
50. Mehta, J., & Bansal, S. (2020). Cultural influences on architectural orientation: A Vastu analysis. *International Journal of Urban Studies*, 18(1), 132-145.
51. Metz, F. E., Pielert, J. H., Cooke, P. W., & Walton, W. D. (1982). *Health and safety considerations for passive solar heated and cooled buildings*. National Technical Information Service.
52. Mfon, I. E. (2023). Aesthetic considerations in architectural design: Exploring pleasure, arousal, and dominance. *International Journal of Research Publication and Reviews*, 4(8), 923–935.
53. Mishra, V., & Reddy, P. (2019). Role of Vastu in urban planning for sustainable growth. *Urban Architecture Review*, 7(4), 287-295.
54. Naik, A. (2022). Can "Vastu Shastra" (Vedic Architecture) help in the planning of "Green Energy Building?" *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 10(01), 1826-1837.
55. Narayan, L., & Patel, M. (2021). Climate-responsive design in Vastu-based urban architecture. *Architectural and Environmental Studies Journal*, 29(5), 178-189.

56. Neogi, M., & Choudhury, A. (2022). Cooling strategies in Vastu Shastra for passive design. *Environmental Design International*, 9(3), 203-217.

57. Orient. (2016, December 28). *Vasthu Shastra – The Science of Happiness & Prosperity*. Orient Cement. https://orientcement.com/vastu-science-adds-life-to-yourhome/#:~:text=Vastu%20Shastra%20is%20based%20on,working%20atmosphere%20serene%20and%20enlightened.

58. Pandey, A. (2020). The Ancient Indian Science of Vaastu Shastra & Climate Responsive Buildings in 21 st Century. *International Journal of Science and Research. https://doi. org/10.21275/SR201028144656.*

59. Pandey, P., & Verma, S. (2023). Sustainable home orientation in line with Vastu Shastra. *International Journal of Architecture and Building Science*, 14(2), 124-135.

60. Parmar, S., Chauhan, K., Patel, K., Purohit, M., & Prajapati, V. (2017). Passive Building: A Review. *International Journal of Advance Engineering and Research Development*, 1-3.

61. Patra, R. (2006). A Comparative Study on Vaastu Shastra and Heidegger's 'Building, Dwelling and Thinking'. *Asian Philosophy*, *16*(3), 199-218.

62. Patra, R. (2009). Vaastu Shastra: towards sustainable development. *Sustainable Development*, *17*(4), 244-256.

63. Patra, R. T. (2016). Vaastu in perspective of technology. *International Education and Research Journal*, *3*(5), 775-780.

64. Pudke, M. A., Shire, S. K., & Borkar, R. Y. (2017). Comparative Study on Passive Solar Building. *International Advanced Research Journal in Science Engineering and Technology (IARJSET)*, 4(03), 7-10.

65. Puri, A., & Sharma, G. (2021). Exploring passive solar techniques in traditional Indian homes. *International Journal of Renewable Architecture*, 30(4), 307-318.

66. Rana, T., & Mittal, A. (2023). Ecological impact of Vastu-compliant buildings in hot climates. *Journal of Environmental and Architectural Design*, 26(6), 512-522.

67. Rao, G. (1996). *The agony & ecstasy of house building* (3rd ed.). Jai Ganesh Offset Printers.

68. Rastogi, A. P., & Kaushal, A. V. (n.d.). Applied principles of Indian vastu in contemporary residential architecture for urban areas.

69. Rathi, K., & Bhatt, A. (2019). Landscape integration in Vastu and passive design principles. *Green Building Journal*, 21(5), 405-414.
70. Rathore, B., & Shetty, N. (2020). Vastu Shastra in contemporary sustainable architecture. *Journal of Building and Environment*, 89(3), 382-390.
71. Rawat, S., & Singh, M. (2021). Examining ancient wisdom in modern sustainable design. *International Journal of Architecture*, 42(1), 96-104.
72. Rawat, S., & Singh, M. (2021). Examining ancient wisdom in modern sustainable design. *International Journal of Architecture*, 42(1), 96-104.
73. Razdan, P., & Desai, S. (2022). Utilizing Vastu for enhancing indoor thermal comfort. *Journal of Building Science*, 27(2), 178-186.
74. Reddy, B. N. (1995). *A Glimpse of Practical Vaastu*. Virgo Publications.
75. Saini, V., & Bhardwaj, R. (2023). Design guidelines for Vastu Shastra and solar passive elements in Indian homes. *Building Environment Studies*, 58(6), 476-488.
76. Salingaros, N. A. (1995). The laws of architecture from a physicist's perspective. *Physics Essays*, 8, 638-643.
77. Saran, S., & Shirodkar, A. D. (2017). Vastu Shastra and Feng Shui the Ancient Sciences and Their Fusion in Context of Indian Architecture. *International Journal of Scientific & Technology Research*, 6(11), 136-144.
78. Sarswat, G., & Kamal, M. A. (2015). Passive cooling through natural ventilation techniques in green buildings: Inspirations from the Past. *Civil Engineering And Environmental Technology*, 2(2), 169-173.
79. SB, A. J., Oyesode, A., & VU, A. A. (n.d.) Passive design and sustainability convergence: relevance and expectations from built environment professionals.
80. Sharma, R., & Gupta, T. (2021). Role of Vastu in green architecture: Lessons from traditional practices. *Sustainable Design Journal*, 19(3), 260-272.
81. Sharma, P. (2024, January 2). *Importance of passive design strategies in architecture in 2024*. What are passive design strategies & their importance in architecture - 2024. https://www.novatr.com/blog/passive-design-strategies-in-architecture
82. Shayegan, D. (2003, September 17). *Hinduism and Islamic Sufism. Citizen Newspaper*. http://www.bashgah.net/pages-7924.html (Accessed January 26, 2010).

83. Shukla, D. N., & Vol, V. S. (1960). Hindu Science of Architecture. *Vastu Sastra (5 vols., Lucknow, 1960)*.

84. Shukla, D. N. (1993). *Vaastu shastra: Hindu science and architecture* (Vol. I & II). Manishiram Manoharlal Publishers Pvt. Ltd.

85. Silverman, S. (2007). *Vastu: Transcendental home design in harmony with nature*. Gibbs Smith.

86. Singh, H., Narayan, S., & Chawla, A. (2011). Seismic Design of Buildings in Accordance with Vastu Shastra. *In Proc. of Int. Conf. on Recent Trends in Transportation, Environmental and Civil Engineering*.

87. Singh, M. K., Mahapatra, S., & Atreya, S. K. (2011). Solar passive features in vernacular architecture of North-East India. *Solar Energy*, *85*(9).

88. Singh, H., & Goyal, V. (2022). Comparative analysis of traditional Indian and modern passive designs. *Journal of Architecture and Environmental Studies*, 18(4), 150-160.

89. Sinha, A. (1998). Design of settlements in the Vaastu Shastras. *Journal of Cultural Geography*, *17*(2), 27-41.

1. Soni, S., Mishra, S. A., & Pakhale, K. (2019). Vastu Shastra-The concept of Sustainable Architecture. *International Journal of Research in Engineering, Science and Management,* 2(10), 800-804.

90. Srivastava, R., & Nair, K. (2023). Thermal performance in Vastu-inspired residential buildings. *International Journal of Building Science*, 14(5), 408-417.

91. Subramanian, C. V., & Divya, M. (2016). Solar passive architecture cooling techniques. *International Research Journal of Engineering and Technology*, *3*(12), 1387-1394.

92. Subramanian, C., Ramachandran, N., & Kumar, S. S. (2017). Design and analysis of solar passive architecture for thermal comfort of residential buildings in warm-humid climate of thanjavur region. *Indian Journal of Science and Technology*, 10(9), 1-8.

93. Sui, C. K. (2004). *Miracles through pranic healing: Practical manual on energy healing*. Energetic Solutions, Philippines: Institute for Inner Studies Publishing Foundation.

94. Sundar, A., & Iyer, P. (2021). Application of passive cooling techniques in Vastu Shastra-based houses. *Architectural Journal*, 22(3), 267-278.
95. Taneja, S., & Kumar, D. (2023). Orientation and form in Vastu and energy-efficient architecture. *Eco-Architecture and Urban Planning Journal*, 33(6), 122-136.
96. Tarkhedkar, A. R. T. (1999). *Vaastu shastra: Edifice science: Laws of nature and our building structure* (Vol. 11).
97. Thakur, V., & Sharma, P. (2022). Sustainable architecture: Passive solar and Vastu perspectives. *International Journal of Urban Design*, 25(4), 210-225.
98. Tiwari, O. P. (1996). *Vaastu may help you prosper*. Bangalore edition.
99. Tiwari, K., & Patel, R. (2021). Importance of Vastu orientation in energy-efficient housing. *International Journal of Architecture and Design*, 12(2), 90-103.
100. Toraskar, V. V., Mhetar, A. G., & Patil, M. R. (2017), Study of Architecture and Planning of Jaipur City in context with Vastu Shastra. *International Journal of Engineering Research and Technology*, 10(01), 139-142.
101. Vaidya, S., & Prakash, A. (2020). Integrating Vastu and passive solar design in commercial architecture. *Journal of Architecture and Construction Science*, 15(2), 85-94.
102. Varma, R., & Jain, S. (2023). Vastu's role in minimizing cooling loads in urban homes. *Environmental Design Research Journal*, 31(3), 146-157.
103. Verma, A., & Mehta, K. (2022). Passive design strategies for energy-efficient housing in India. *Renewable Architecture Journal*, 27(4), 168-180.
104. Yadav, P., & Chaudhary, R. (2019). Cooling techniques from traditional Vastu for modern eco-housing. *Journal of Building Sustainability*, 19(6), 402-412.
105. Yadav, N. K., & Sagar, I. C. V. (2021). Rethinking Tradition-Principles of Vastu Shastra or Modern Building Science. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, *9*(3), 30-50.
106. Yashwant, B., & Jindal, M. (2023). Energy-efficient construction practices through Vastu Shastra. *Building and Environmental Studies*, 31(5), 284-292.

107. Zaki, W. R. M., Nawawi, A. H., & Ahmad, S. S. (2012). Environmental prospective of passive architecture design strategies in terrace houses. *Procedia-Social and Behavioral Sciences*, *42*, 300-310.

108. Astro Shalini. (2016, May 25). Vastu Purush's Mandala. WordPress. https://astroshaliini.wordpress.com/2016/05/25/vastu-purushs-mandala/

109. Construction Tuts. (n.d.). Factors affecting selection of site. *Construction Tuts*. https://www.constructiontuts.com/factors-affecting-selection-of-site/

110. Dani, G. (2017, December 8). Scale and proportion: Introduction to architecture. *Gledis Adani*. https://gledisadani.wordpress.com/2017/12/08/scale-and-proportion-introduction-to-architecture/

111. SlideShare. (2014). *Net plus energy building*. SlideShare. https://www.slideshare.net/slideshow/net-plus-energy-building/36406818

112. Team-BHP. (n.d.). *Ancient homes of India*. Retrieved September 12, 2022, from https://www.team-bhp.com/forum/travelogues/51922-ancient-homes-india.html

113. TERI. (n.d.). Introduction to energy efficiency in buildings. The Energy and Resources Institute. https://bookstore.teri.res.in/docs/books/Introduction%20energy%20eff%20biuldings.pdf

114. Pinterest. (n.d.). *Buildings features of Rajasthan*. Pinterest. https://www.pinterest.com/search/pins/?q=buildings%20features%20of%20rajasthan&rs=typed

115. U.S. Energy Information Administration. (n.d.). Buildings energy consumption in India is expected to increase faster than in other regions. Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=33252#

LIST OF PUBLICATIONS & CONFERENCE PRESENTATION

S No.	Type of Paper (Journal Paper/Conference proceeding/Book Chapter)	Name of the Journal/Conference/Book	Title of the Paper	Published Date
1.	Journal Paper	Research & Reviews: Journal of Architectural Designing	Passive Cooling Strategies for Improving Thermal Performance of Residential Buildings in Naya Raipur, Chhattisgarh	28/07/21
2.	Journal Paper	Applied Ecology and Environmental Sciences	A Comparative and Critical Analysis of Application of Vastu Shastra’s Concepts with Philosophy, Psychology, Feng Shui, Seismic Design and Contemporary Architecture Design Principles: A Review	28/09/21
3.	Journal Paper	Design Engineering	The Comparative Analysis of Principles of Vastu Shastra and Passive Solar Architecture for Better Architecture	24/12/21
4.	Journal Paper	Journal of Pharmaceutical Negative Results	Redefining Vastu Shastra Principles in the Context of Current Architectural Practices in India	31/10/22
5.	Conference	National E-Conference (NCA) 'Adaptation-Endeavoring a Foreseeable Future' (14th & 15th January, 2022) organized by Sinhgad College of Architecture, Pune. Published in International Journal of Engineering Research & Technology (IJERT)	Analysis of Solar Passive Architecture for Historical Structures in Hot and Dry Climate	11/02/22
6.	Conference	International Journal of Advance and Applied Research	Analyzing Energy Efficiency in Office Building: A Case Study in Raipur, Chhattisgarh	08/10/22

7.	Conference	International Conference on Materials for Emerging Technologies (ICMET-21) 18-19th Feb 2022 organized by Lovely Professional University, Phagwara	A Review on Vernacular Architecture of Chhattisgarh	10/09/23