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Passive Solar Building

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ABSTRACT

We used the course assignment "Analysis and design of a G+2 Residential Building" to satisfy our curricular requirements. The ETABS software has been used for the structural study and design of a multi-story skyscraper. For the purposes of Civil Engineering, a "building" is any form of structure that includes a base, walls, columns, floors, roof, doors, windows, ventilators, and a variety of surface treatments, among other things. A structure that can withstand all loads for its entire expected lifetime is the result of careful structural study and design. It is essential to conduct geotechnical investigations to gather data on the supporting soil before analysing and designing any structure. The goal of doing a geotechnical site investigation is to gather data and assess the site's conditions in order to plan and build the foundation of a building. Engineers specialising in structural design must ensure that a building can carry out its intended purpose for the duration of its expected lifespan, as well as provide the most cost-effective and efficient design possible. X-Steel, micro Station, STAAD PRO, ETABS, SAP 2000, STRAP, NISA, X-Studs, and other programs are used for building analysis and design. As of right now, this project is being handled by ETABS Software.

Keywords: Solar Building, direct gain, over-heating.

I.INTRODUCTION

Rising energy consumption is a direct outcome of both the exponential rise of the global population and the exponential acceleration of technological advancements in recent decades. Concerns about sustainability arise from this excessive consumption. Both energy efficiency and environmental protection are negatively affected by this.

For this reason, the term "passive solar building design idea" describes a novel approach to constructing that makes use of preexisting energy rather than relying on external mechanical or electrical sources. These structures make the most of the environment in which they are built. The building's performance might be evaluated with the help of a thorough site investigation.

New construction follows the principles of passive solar design. Existing structures, however, may be modified to exhibit passive behaviour. Since no mechanical or electrical components are used to implement the principle, the structure is referred to as a passive solar building.

Modern civilisation relies on electrical energy to make their lives more comfortable. Primarily, this electrical power comes from the combustion of fossil fuels. These fuels are depleting supplies at an alarming pace, which is adding to environmental degradation. A passive solar design for a house may harness solar energy and use it to power less electrical appliances and electronics. An environmentally friendly approach, passive solar architecture seeks to make the most of the sun's heat to keep inside temperatures comfortable. During the day and year, when the sun is at its highest and lowest points, therefore decreasing the need for power-hungry HVAC systems. Homes are built to absorb solar heat in the winter and reflect it in the summer via strategically placed windows, walls, and flooring. An rise in energy consumption is a direct result of population expansion, fast urbanisation, and technical and industrial advancements.

This is a crucial problem because of the negative influence of energy on the environment. My theme is Passive Solar Building, and I'm implying that we need to make a rapid change regarding the energy utilisation in buildings. When a structure is designed with passive solar principles in mind, its windows, walls, and floors are engineered to absorb, store, and transfer heat from the sun during the winter months, while simultaneously reflecting it during the summer months. Because no mechanical or electrical components are used in passive solar design, it differs from active solar heating systems. An proper site study is essential for passive solar construction design in order to make the most of the local climate. Factors to think about include shading, thermal mass, thermal insulation, window location and size, and glazing type. While new construction is the best candidate for passive solar design approaches, older structures may be modified or "retrofitted" to include these systems. Environmental science, thermodynamics (specifically heat transfer: conduction, convection, and electromagnetic radiation), fluid mechanics/natural convection, and human thermal comfort (based on heat index), psychometrics, and enthalpy control for buildings that can be inhabited by humans or animals, as well as for greenhouses that can be used to grow plants—form the scientific basis for passive solar building.

1.1 Concept of Passive Solar Buildings

The fundamental idea behind passive solar buildings is to make the building materials—the windows, walls, and floors—able to absorb and store solar energy. Both in the winter for heating and in the summer for cooling purposes, this energy is put to good use.

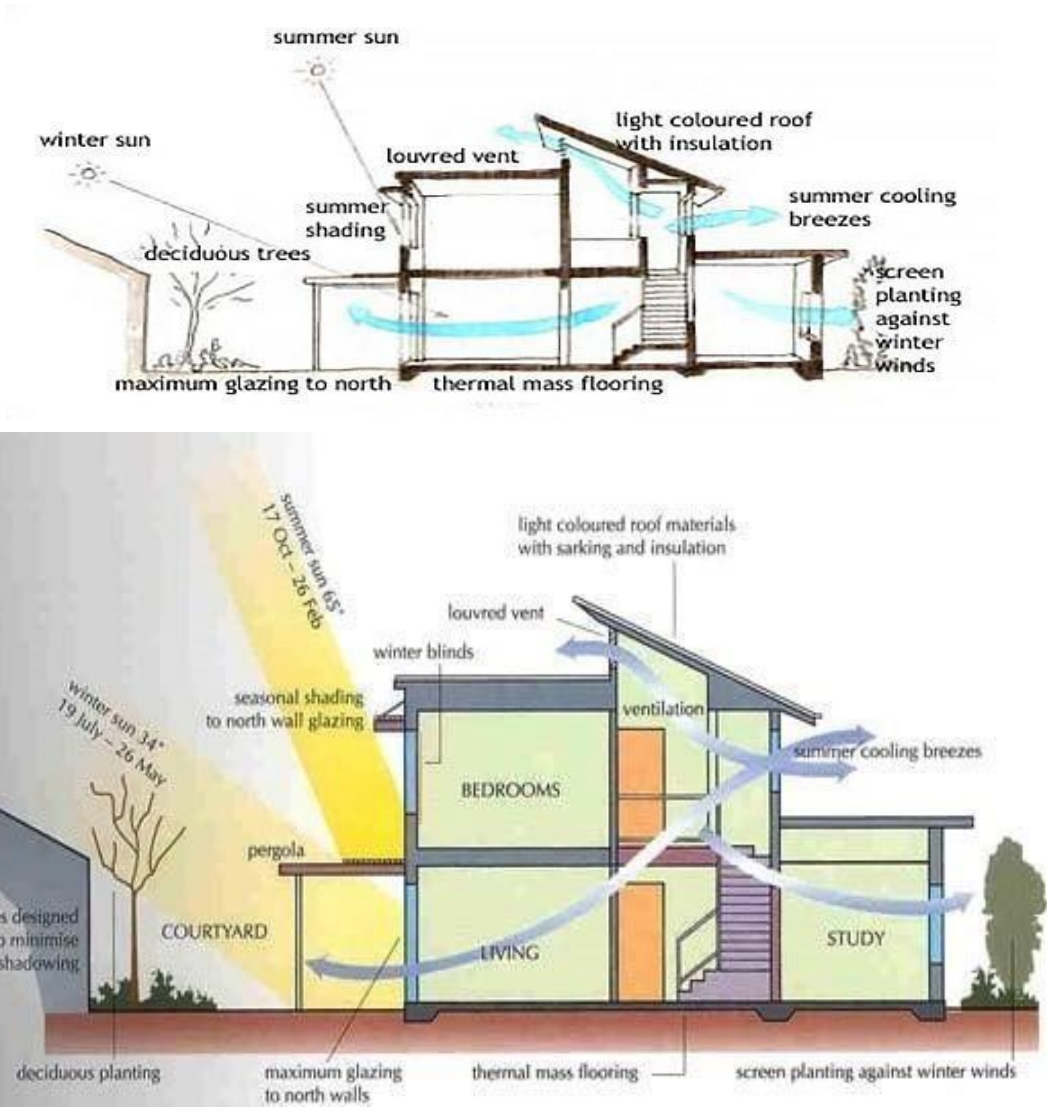

Fig 1: Concept of Passive Solar Buildings

There is no additional mechanical system needed by the structures to transform the solar energy into usable power. The term "passive solar" refers to energy harvesting methods that do not include any mechanical devices; in contrast, "active solar" makes use of thermal collectors. With little input from external energy sources, these technologies transform solar radiation into useful heat (in the forms of water, air, and thermal mass), generate airflow for ventilation purposes, or store heat for later use. Solariums located on buildings facing the equator are a frequent example. To lessen the burden on air conditioners throughout the summer, passive cooling makes use of comparable design ideas. To improve solar energy collecting, storage, and utilisation while decreasing unwanted heat transfer, certain passive systems use a little quantity of conventional energy to regulate dampers, shutters, and night insulation, among other devices. Some examples of passive solar technologies are thermosiphon-based solar water heating systems, solar cookers, the solar chimney, earth sheltering, and direct and indirect solar gain for space heating. Other examples include using thermal mass and phase-change materials to reduce indoor air temperature swings and solar water heating systems.

Among the most popular solar technologies is the solar furnace. However, this kind of device usually needs additional energy to position its focussing mirrors or receivers, and it has never been feasible or cost-effective to utilise it on a large scale. Over time, it has been discovered that passive solar energy is best used for "low-grade" energy demands, such heating water and spaces.

1.2 LIFE CYCLE ASSESSMENT

Designing passive solar buildings scientifically while optimising products for quantitative cost-benefit analysis is Rigorous for a beginner. Because of the intricacy, there is a lot of terrible architecture that keeps popping up, as well as a lot of unscientific building projects that rely on intuition and end up disappointing the designers and wasting a lot of money. Science, technology, engineering, and mathematics all have strong financial incentives. Applying it more aggressively to new building construction starting in 1980 (based on lessons learnt in the 1970s) may have saved about $250,000,000 per year on costly energy and pollution-related costs for the United States today. Educational institutions, governments, and energy research organisations have been using Passive Solar Building Design since 1979 to help them reach their goal of zero energy use. This includes the United States Department of Energy and the energy research experts they have funded for decades. Cultural absorption into the building-owner decision-making process, construction trades, and the cost-effective proof of concept has been very sluggish and difficult to modify, despite its establishment decades ago.

Passive Solar Design

Buildings that employ passive solar architecture do not rely on mechanical or electrical systems, but instead harness the energy of the sun to provide heating, cooling, and lighting. Including certain materials and the positioning of windows or skylights in the building's design often accomplishes this.

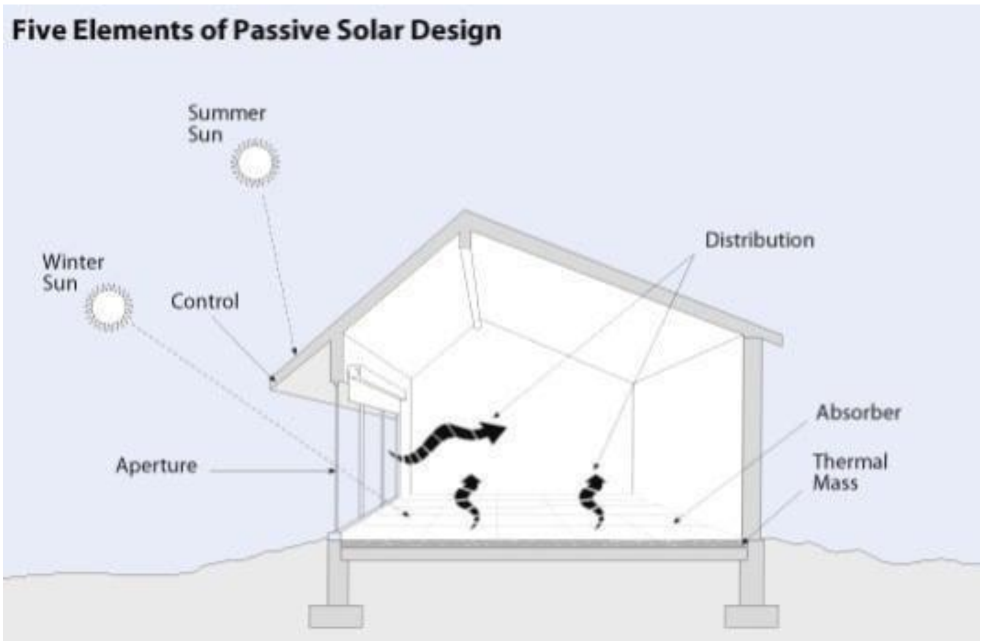

Fig 2 : Elements of passive solar design

a. Rules Of Passive Solar Systems

1. On an east-west axis, the structure need to be extended.
2. Ideally, during the heating season, sunlight should reach the south face of the building between 9:00 A.M. and 3:00 P.M.
3. The south side of the structure should be the one that receives the greatest natural light and has the lowest heating and cooling needs.
4. Spaces that aren't often utilised should be on the northern side.

b. The Advantages of Passive Solar Design

1. Reduced energy expenses year-round due to high energy efficiency.
2. Investment: keeps saving money even after initial cost is recovered, and it is not affected by future increases in fuel prices.
3. Benefits: great resale value, happy owners.
4. Beautiful home with plenty of natural light, spacious rooms, and windows that face the outside.
5. Minimal Upkeep: long-lasting, little need for operation and maintenance.
6. Dependable ease: silent (no working noise), regulated temperature (warm in winter, cool in summer) (even in the event of a power outage)
7. The following are some of the goals of passive solar design, which is based on the local environment and makes use of renewable energy sources like the sun and wind:
8. Keep the building at a pleasant temperature all year round; minimise energy waste; promote sustainability by reducing carbon dioxide emissions and keeping the built environment in good repair;
9. Making it easier to include active solar energy systems as required.

1.3 Characteristics of Building Design Issues

- It is advised to take advantage of solar transmission and absorption during winter to prevent overheating and reduce or eliminate heating energy demand.
- To cover your short-term heating demands, employ solar energy; for longer-term storage, invest in embedded thermal mass or a dedicated system.
- Use insulating materials and windows that allow the maximum amount of solar heat to enter the building.
- Shade management systems or the judicious planting of deciduous trees may help mitigate the increased cooling demand caused by summer solar gains.
- You may utilise natural ventilation to transfer heat from warm to cold places in the winter and from hot to cold places in the summer. Additional heat transfer methods include evaporative cooling, ground-source heating and cooling, and others.
- Invest in photovoltaic shingles for the roof or solar panels for window shading to save money and energy. These materials can create electricity and block heat gain, so they're a win-win.
- To avoid creating a glaring shadow, day-lighting aims to guide the sun's rays into rooms or onto surfaces for work.

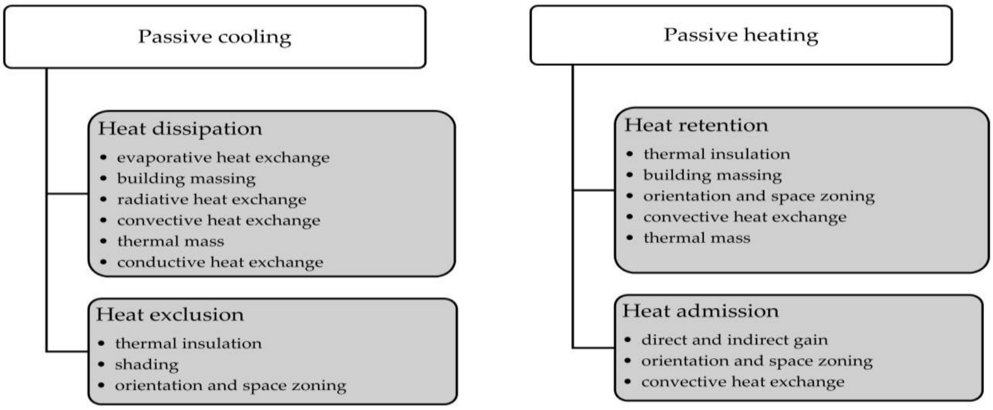

Fig 3 : Characteristics of Building Design

Passive Solar Systems

Systems that collect, store, and transfer solar radiation without using energy-intensive mechanical components are known as passive solar. Put simply, passive solar energy does not include any panels, batteries, or input into the larger power system. You might utilise a passive system to heat or cool your home. By maximising the utilisation of natural energy fluxes via air and materials—radiation, conduction, absorption, and natural convection—passive solar buildings minimise energy usage for heating and, potentially, cooling (Robertson and Atheneites, 2010). Direct heat gain systems, which use windows as collectors and building materials as heat storage medium, may benefit from this. Solar heaters for water or air that rely on thermosiphoning to store heat instead of pumps or fans may also employ this approach. As stated by Hibshman (1983), an ideal passive solar architecture would look like this:

- According to Hibshman (1983), the three most prevalent solar passive systems are as follows: the direct gain system, which lets sunlight into an inhabited area via windows and is absorbed by the floor and walls;...
- A structure's walls or another heat storage medium in one area might act as a heat sink, absorbing and storing heat that can subsequently be transmitted to other areas of the building by radiation, convection, or conduction in an indirect gain system.
- A system that uses ducts to transfer solar energy from an isolated location (like a greenhouse or solarium) to a residential environment is known as an isolated gain system.

II. LITERATURE REVIEW

According to Serkanet.al (2003), this particular residential structure may reduce its yearly energy consumption by 18% with the use of energy-efficiency design methods that include passive solar components. These tactics add around 9% to the entire construction cost. There will be a 31% drop in cooling energy use and a 40% decrease in lighting energy use, both of which are necessary for visual comfort and space conditioning. The largest reduction in heating energy usage is 61%. On the other hand, a 34% increase is required for cooling.

According to Andreas Athienitiset al. (2008), homeowners can expect to build cost-effective homes with low or near-zero energy use in about 5 years if they use a heat pump system for heating and recover and efficiently use heat from their PV system.

According to Tanbiruj et.al. (2010), a direct gain passive solar system doesn't need any additional equipment to harness the sun's rays for heating purposes; all that's needed is for the structure to be in direct sunshine. Using materials that face south in the Northern Hemisphere and wide windows facing the sun are two ways to implement passive solar heating. With proper insulation, a structure using this material may harness the sun's energy and cut heating costs by half. In order to automate the computations required to hand out the four spreadsheets, the U.S. Department of Energy has created a builder-friendly computer application called BuUderGWd.e. The user inputs building data into the application, which then calculates them, much like a spreadsheet. I include all table lookups and print out the results. Even while it's quicker, more convenient, and less prone to mathematical mistake than filling out the spreadsheets by hand, the outcomes are same. It is possible to rapidly assess a wide range of design alternatives.

Direct gain, indirect gain, isolated gain, and other approaches were studied by JavadSadeghsaberi et.al. (2013) in the context of passive solar energy construction.

According to research by NajmehNajafiet.al (2013) on Shiraz's traditional architecture, eco-friendly and long-lasting structures are within reach.

This article summarises the various passive solutions and design approaches that can be implemented in buildings, particularly in tropical countries, and draws conclusions about the concept of solar energy distribution through the use of a sun path diagram and its various applications in energy efficiency and the evolution of passive solutions in buildings (Anil Kumar, 2013).

Research by AbdolvahidKahoorzadeh et.al. (2014) demonstrates shading devices and other passive solar components. The addition of these components would allow for a more consistent and pleasant temperature throughout the building. It is also possible to regulate the relative humidity inside a room. Let fresh air in and reduce the building's internal heat by opening the windows at night. Keep the heat out by closing the structures throughout the day. Consequently, regardless of the weather, residents are more at ease with a conventional passive solar system. There are monetary advantages as well. Buildings really only need modest heating and cooling systems.

III. METHODOLOGY

3.1 RESEARCH SAMPLE & DATA COLLECTION

Even while green construction isn't exactly new to the average person, it might be difficult for those without firsthand experience with passive solar structures to grasp the idea and appreciate its merits. Even for those who have lived in passive solar houses before, it's hard to tell whether the interior is healthy and pleasant for the residents based on their attitudes and the green construction practices used.

3.2 QUESTIONNAIRE DESIGN

The inhabitants and the industry each have their own set of surveys. There are four main parts to the surveys. The surveys use basic English language and consist of both closed and open-ended questions.

Here are 3 parts:

1. Concept of passive solar building
2. Attitude towards the green features
3. Suggestions for improvement

3.3 BASIC PRINCIPLE OF DESIGNING QUESTIONS

In the survey, you'll find both closed and open-ended questions. When time is of the essence and quantitative responses are required for statistical analysis, the survey will make use of closed questions. Consequently, data is gathered from three of the four parts of the questionnaire. Respondents may pick and choose what to fill out with ease. In the last portion of the questionnaire, in addition to the closed questions, the open question is used to gather any unprompted replies. It states that researchers utilise open-ended questions when they do not aim to steer the responder in any one direction. In most cases, the goal of asking such questions is to get insight into the views and actions of the responders.

IV. DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

Among the many methods that make up passive solar design is passive solar heating. These solutions, when implemented correctly, may help with the HVAC, lighting, and ventilation of almost any structure. Passive solar heating is useful for a wide variety of structures, from small repair shops to massive bar racks. Passive solar heating usually entails:

- Sunlight harvesting by means of south-facing windows that are positioned correctly.
- Putting this energy into what is known as "thermal mass," which consists of things like concrete, brick, or tile that have a high heat capacity.
- The gradual return of the solar energy stores to the indoor environment via natural convection and radiation as needed.
- Technical details for windows that provide a greater solar heat uptake coefficient while facing south.

These are some of the advantages of passive solar design for buildings::

- Light floods the inside of the structure, making it a pleasant place to be. The transfer of visible light waves is responsible for this. Glare and overlighting management were considered throughout the system's design.
- Because direct exposure to UV rays is dangerous, this feature blocks this kind of radiation. The benefit of a passive solar construction system is that it blocks almost all UV light, around 99.9 percent. The interior textiles and décor would be preserved and made to last longer if this were to be avoided.
- It keeps the inside cool throughout the summer, making it more bearable. Clearly, this would lower the energy costs associated with cooling.
- ➢ The result would be a low SHGC, or solar gain coefficient.
    - Warmer winter weather

- Room kinds, interior doors, walls, and furniture in buildings are the primary aspects that are taken into account.
- The building's orientation was with the Equator facing down.
- A building's elongation in the east-west plane
- Sliding windows that let in enough light in the winter and provide welcome shade in the summer.
- Do not open windows facing west.
- Thermal mass, such as floors or walls, is used.

4.2 Types and Costs of Technology

For structures that are mostly skin-load dominated, four passive solar heating methods are available:

(1) sun-tempered,
(2) direct gain,
(3) indirect gain, and
(4) isolated gain.

1. Minimal augmentations to south-facing windows accomplish sun-tempering. A typical home from a tract builder will have a quarter of its windows on each face, and the amount of south glass will be about 3% of the total floor area. A sun-tempered home or barracks might raise this amount to 5% to 7%, depending on the environment. Since the "free mass" of the gypsum wallboard and furniture is enough to absorb the extra solar heat, no thermal mass additions to the fundamental design are required in this instance.

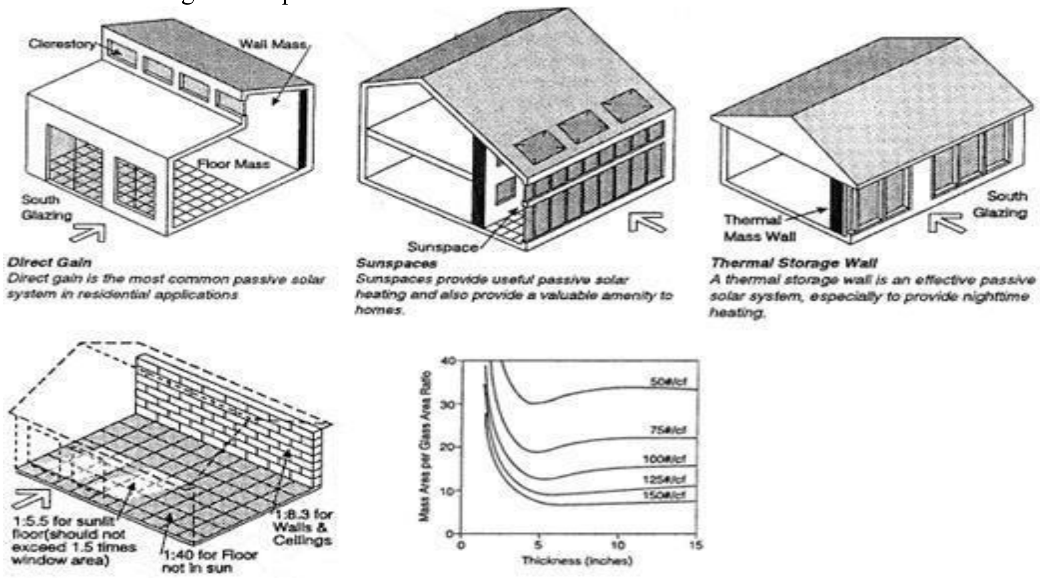

Fig 4 : Solar heating methods

The simplest kind of passive solar heating is direct gain. A thermal mass embedded in the floor or inner walls absorbs sunlight that enters the area via south-facing glass (in the Northern Hemisphere). No more than twelve percent of a home's floor space should have direct gain glass, but this number might vary by climate. It becomes more difficult to supply adequate thermal mass for year-round comfort beyond that, and issues with glare or fabric fading are likely to emerge.

Design Considerations

When using passive solar heating, it is recommended to follow these basic guidelines.

- When developing an energy-efficient building envelope, be sure to pay close attention to detail.
- Take orientation into account while designing the site. Limit the amount of glass facing east and west and seal up any gaps that might be vulnerable to the winter winds.
- When working on external walls, be sure to create an airtight seal around openings such as windows, doors, and electrical outlets. To maximise energy efficiency, use entrance vestibules and make sure all ducting is contained inside the building's insulated shell. To prove airtightness and reduce duct losses, it could be necessary to test model dwellings with blower doors.

- Windows and glazing should have low U values (thermal transmittance) and high SHGC (solar heat gain coefficient) so that they let in enough solar radiation. If you are looking for proven performance figures, you might check resources like the Certified Products Directory put out by the National Fenestration Rating Council. Building type and weather conditions determine the quantity of glazing.
- In a passive solar structure, check that the south window doesn't add to the need for additional summer cooling. Summer shade is as important as winter solar gain in many regions. To determine the optimal overhang design, refer to the overhang figure below and utilise the summer (B) and winter (A) solar angles.

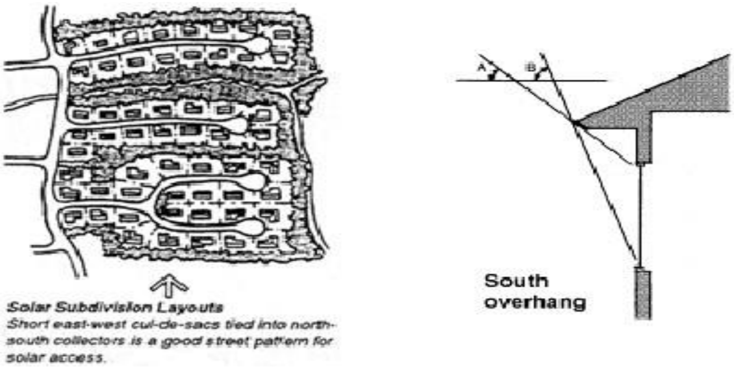

Fig 5 : Solar Subdivision Layouts and South Overhang Angles

- ➢ During the warmer months, the moveable windows are strategically placed to allow air to circulate freely. Additional air movement may be achieved with the help of ceiling fans or heat recovery ventilators. If you live in a climate where the temperature changes a lot from day to night, you may naturally lower the inside temperature by opening the windows at night and shutting them during the day.

All rooms should be illuminated by natural light. Direct and indirect gain are both used by some of the most beautiful passive solar heated buildings. Depending on the purpose of each room, this may offer light of an appropriate quality.

- If at all feasible, arrange the building's length along the east-west axis to make the most of the available south-facing elevation and windows.
- Layout the building such that the more utilised parts, like living or working areas, are on the south side and the less used parts, like storage or restrooms, are on the north side. For windows facing south, be sure they are no more than 20 degrees off from true south.
- Use high-performance, low-e glazing or nocturnal, movable insulation to decrease heat loss from glass at night to improve building efficiency.
- In order to maximise solar gain in winter, make sure that south windows are not blocked by vegetation or fences. This will allow them to have full exposure to the sun from 9 a.m. to 3 p.m.
- For summer shade, use overhangs or other structures like trellises or deciduous trees.
- Make sure the walls, roof, and flooring are adequately insulated to prevent air from leaking in. A good place to start when trying to figure out how much insulation you need is with the minimal requirements laid forth in the Model Energy Code by the Council of American Building Officials.
- If you want to maximise the passive solar heating impact, you need install an auxiliary heating, ventilation, and air conditioning system. Never use "rules of thumb" to make the system too big.
- Verify that there is sufficient thermal mass. It could be challenging to provide sufficient amounts of effective thermal mass in passive solar heated structures with large solar contributions.
- Styled to block the sun's glare. In order to keep electronic devices like computers and TVs from being blinded by the sun, careful planning of room and furniture arrangements is required.

4.3 Physical Characteristics of Windows

A house's ability to passively reduce its energy consumption is heavily dependent on the placement and size of its windows, as these two factors work hand in hand to 1) let in the maximum amount of natural light and 2) enhance thermal comfort via the use of natural ventilation. The use of appropriate shade devices may also help regulate the temperature within a building. The following elements are bolstered by the profound impact that day lighting has on home design:

- Reducing energy costs and increasing energy savings;
- Improving the inhabitants' physiological and psychological well-being via use of aesthetic considerations;
- Enhancing the quality of healthy living in relation to our surroundings.

During the winter, the south-facing windows let in warm natural light, and during the summer, they let in plenty of natural light thanks to the varying angles of the sun's rays. Figure 3 shows that a pitched roof with an appropriate overhang and a high ceiling may help with thermal comfort in the summer by reducing the amount of sunlight reaching the south façade, but it can still let some light in during the winter. Living rooms, dining rooms, and bedrooms are some of the places that might benefit from direct sunlight for heating and lighting, and they are positioned on the south façade. The early morning light streaming in through the windows on the eastern façade improves the internal air quality. The north and west façades are equipped with windows to facilitate the cross ventilation that is essential in hot and humid climates. Furthermore, in order to reduce glare, the opening's area should be minimised. Certain areas, such as stair boxes, shopfronts, and garages, which face north, need less illumination and heating than others.

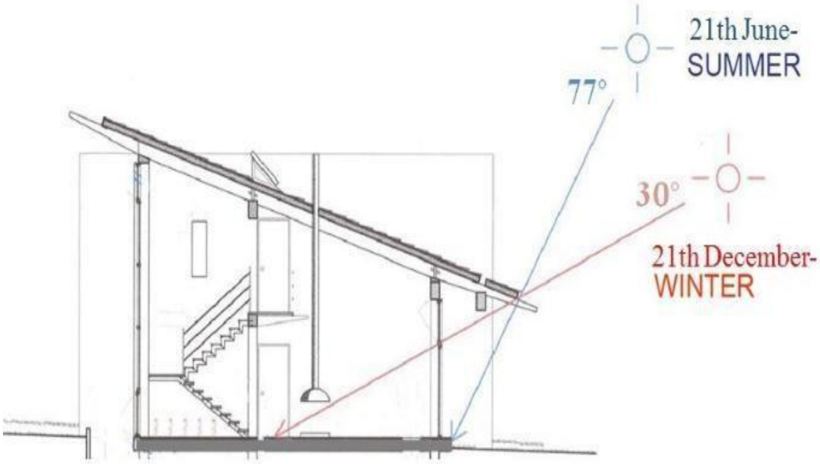

Fig 6: The Role of Roof Eave in South Direction in Sun Control for Summer

Furthermore, plants and trees may offer evaporative cooling and even create shadow areas, which helps keep inside temperatures bearable [17]. Instead of using shade devices, it is more acceptable to use trees to regulate the sun's rays on the west and north façades. As green walls, they are built within buildings to improve the air quality and health of the interior areas. But the city's inadequate water supply is a major issue. Because of their low water requirements, deciduous trees are ideal for landscaping projects. Furthermore, as trees shed their leaves in the winter, they allow solar radiation to warm buildings [18]. In addition, as can be shown in Figure 4, deciduous trees provide sufficient summer shade, and vegetation may decrease energy use for cooling and heating by 25% [19].

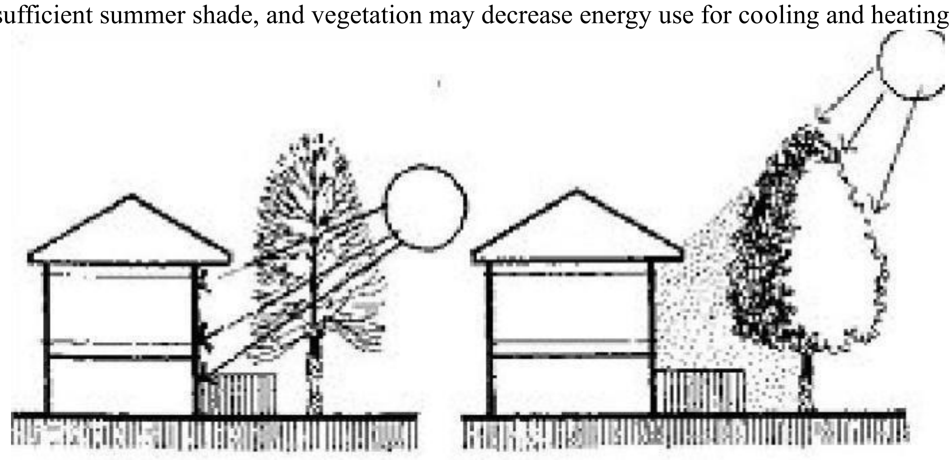

Fig 7: Suitable Examples of Landscape to Decrease Over-Heating

4.5 Evaluation of Existing Buildings

Depending on the structure's nature and the amount of information available about its current condition, there are three available methods for evaluation: structural analysis based on known material properties, dimensions, and loading; analysis and structural modelling; and analysis and physical load testing.

When there is enough data available but load testing would be too risky or impracticable owing to the complexity of the testing and loading setup, evaluation by analysis is utilised. If you anticipate a quick and fragile failure, you should avoid doing a load test. Analysing the collected data, the safe load-carrying capability of the structure or part of the structure is determined.

When analytical methods alone are not practical or provide enough certainty for a structure's evaluation due to factors such as its complexity, the difficulty in determining loading and material properties, structural distress that introduces uncertainties into analytical evaluation input parameters, difficulty in determining the severity of defects, or uncertainty regarding the structure's adequacy under future loading exceeding the original design criteria, physical load testing becomes the preferred method of evaluation.

In order to prepare the load test and identify its position and amount, preliminary and approximate analytical assessment is conducted before to the test.

A full-scale load test isn't always necessary; sometimes, building and testing structural models can suffice. When other methods have failed to provide a unique solution, when the design is complex, when there are constraints such as sudden failure, impractical load testing, significant shrinkage creep, temperature, differential settlement, etc., or when the part in question cannot be tested at full scale with other parts of the structure, this method is employed. If it is possible to model the structure, loads, constraints, and material strengths, and then use the principles of modelling to interpret the findings, then the results will be trustworthy.

V. CONCLUSION

Passive solar energy building adoption and its associated benefits and drawbacks in our environment were the subjects of this research. To better understand the ideas and causes that impede environmentally friendly construction, as well as to identify potential avenues for raising public awareness of the importance of eco-friendly building practices and their positive effects on the environment, is the overarching goal of this research.
This was accomplished by gathering different perspectives from persons in the business or consumer sectors on their needs and perceptions of passive solar energy buildings, and then making recommendations based on these findings. In addition, the adoption of passive solar energy building was examined by capturing employee views, experiences, likes, and dislikes, which allowed for a closer investigation of this phenomena.
We can learn more about the possibilities and challenges of green building efficiency improvements in our area from this research. Being one of the few studies that include a questionnaire component into the research of 'passive solar energy' structures, especially within the Indian setting, makes this study significant.By explaining the unexpected nature of the questionnaire responses and recording other crucial details, this enabled for a more thorough explanation of the findings and contributed to our understanding of the dynamics at work in passive solar architecture.
Although opinions vary on what constitutes a viable approach to incorporating passive solar energy into building design, this study concludes that the construction industry as a whole is optimistic about the future of passive solar energy.

REFERENCES

1. Randell JE. Ambient energy and building design. New York: Construction Press Limited; 1978.
2. Nayak JK. Solar energy and energy conservation. New Delhi: Wiley Eastern Limited; 1992.
3. R.V. Ralegaonkar, R. Gupta / Renewable and Sustainable Energy Reviews 14 (2010) 2238– 2242 2241
4. Mani A, Chacko O. Solar radiation climate of India. Solar Energy 1973;14:139– 56.
5. Modi V, Sukhatme SP. Estimation of daily total and diffuse insolation in India from weather data. Solar Energy 1979;22:407–11.
6. Chandel SS, Aggarwal RK, Pandey AN. A new approach to estimate global solar radiation on horizontal surfaces from temperature data. Journal of the Solar Energy Society of India 2002;12(2):109–14.
7. Gopinathan KK. A general formula computing the coefficients of the correlation connecting global solar radiation to sunshine duration. Solar Energy 1998;41(6):499–502.
8. Reddy J. An empirical method for the estimation of total solar radiation. Solar Energy 1971;13:289–97.

9. Aguiar R, Pereira M. TAG: a time-dependent, autoregressive, Gaussian model for generating synthetic hourly radiation. Solar Energy 1992;49(3):167–74.
10. IS: 7662. Indian standard orientation of buildings (part I)—non industrial buildings. New Delhi: Bureau of Indian Standards; 1974.
11. Manual on solar passive architecture. Mumbai: Energy System Engineering IIT, Bombay and New Delhi: Solar Energy Center Ministry of Non-conventional Energy Sources Government of India; 1992.
12. Gupta R, Ralegaonkar RV. Estimation of beam radiation for optimal orientation and shape decision of buildings in India. Architectural Journal of Institution of Engineers India 2004;85:27–32.
13. Priyanka Kulkarni, & Dr. Swaroopa Shastri. (2024). Rice Leaf Diseases Detection Using Machine Learning. Journal of Scientific Research and Technology, 2(1), 17–22. https://doi.org/10.61808/jsrt81
14. Shilpa Patil. (2023). Security for Electronic Health Record Based on Attribute using Block-Chain Technology. Journal of Scientific Research and Technology, 1(6), 145–155. https://doi.org/10.5281/zenodo.8330325
15. Mohammed Maaz, Md Akif Ahmed, Md Maqsood, & Dr Shridevi Soma. (2023). Development Of Service Deployment Models In Private Cloud. Journal of Scientific Research and Technology, 1(9), 1–12. https://doi.org/10.61808/jsrt74
16. Antariksh Sharma, Prof. Vibhakar Mansotra, & Kuljeet Singh. (2023). Detection of Mirai Botnet Attacks on IoT devices Using Deep Learning. Journal of Scientific Research and Technology, 1(6), 174–187.
17. Dr. Megha Rani Raigonda, & Shweta. (2024). Signature Verification System Using SSIM In Image Processing. Journal of Scientific Research and Technology, 2(1), 5–11. https://doi.org/10.61808/jsrt79
18. Shri Udayshankar B, Veeraj R Singh, Sampras P, & Aryan Dhage. (2023). Fake Job Post Prediction Using Data Mining. Journal of Scientific Research and Technology, 1(2), 39–47.
19. Gaurav Prajapati, Avinash, Lav Kumar, & Smt. Rekha S Patil. (2023). Road Accident Prediction Using Machine Learning. Journal of Scientific Research and Technology, 1(2), 48–59.
20. Dr. Rekha Patil, Vidya Kumar Katrabad, Mahantappa, & Sunil Kumar. (2023). Image Classification Using CNN Model Based on Deep Learning. Journal of Scientific Research and Technology, 1(2), 60–71.
21. Ambresh Bhadrashetty, & Surekha Patil. (2024). Movie Success and Rating Prediction Using Data Mining. Journal of Scientific Research and Technology, 2(1), 1–4. https://doi.org/10.61808/jsrt78
22. Dr. Megha Rani Raigonda, & Shweta. (2024). Signature Verification System Using SSIM In Image Processing. Journal of Scientific Research and Technology, 2(1), 5–11. https://doi.org/10.61808/jsrt79