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Thermal Comfort in Traditional and Modern Passive Buildings in Warm Humid region

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Abstract : Traditional buildings all throughout the world employ solar passive architectural concepts and principles. Thermal performance of such old structures is considerably within the acceptable range specified by thermal comfort standards. However, most modern building's internal environmental conditions and thermal comfort are inadequate due to poor design. The survey's findings also indicated that traditional dwellings are more pleasant than contemporary houses.

The goal of the project is to design and build a contemporary residential building using accessible modern building materials in Jamshedpur's warm and humid environment using solar passive architecture ideas that can make the building thermally pleasant like traditional structures.

For a period of 12 months, the thermal performance of the built house is evaluated. Statistical analysis is performed using statistical tools, and a linear regression equation suited for Jamshedpur is developed as a result of the research. According to the findings of a research on built solar passive houses, solar passive approaches can reduce interior temperatures sufficiently to provide inhabitants with a comfortable indoor environment. In compared to comparable modern structures, the temperature of the planned solar passive building is 50C to 100C lower in the summer. According to the findings of the study, building design has a significant influence in energy conservation, which will have an impact on the national and global economies.

***Kyewords* – Thermal comfort, Passive building, Jharkhand, Humidity**

I. INTRODUCTION

In traditional structures globally, solar passive design ideas are applied. For numerous years, these old principles were applied for passive air-cooling in warm humid locations. Solar passive design may be referred to as a technique to design buildings to create a comfortable atmosphere that reduces energy utilisation and mechanical system dependency. Modern structures are currently created without considering their shape, orientation and other elements properly. This led to a significant rise in energy use. Extensive study has been carried out, emphasising on the relevance for thermal comfort in residential structures of solar passive architecture and passive cooling architecture interventions. A full analysis of numerous ways for passive cooling in various traditional buildings is provided in this chapter, while comparing traditional and modern structures for thermal conveniences. The study shows that the approaches employed in ancient structures may be integrated in modern structures in a passive manner for future structures to attain thermal comfort.

Abdul Manah Dauda (2016) analysed the Ghana architecture traditionally and modernly. In usual interior environments, the recorded temperature varied between 28-35 0C and 31-37 0C. In the older buildings the maximum mean radiant temperature (MRT) was 4-5 0C less and 3 0C higher than the appropriate interior air temperatures in the contemporary structure. The roof is built of a stalk and guarantees adequately ventilated membrane with pores in the intermediate. This provides excellent isolation and makes it possible for hot air to escape, In ancient or traditional Building. Modern housing is equipped with corrugated metal sheets, which permit heating and increase air temperatures. A thermal comfort is better than a contemporary building with effective passive and natural control system in the old building.

In the new Egyptian Assist home, AMR Sayed et al. (2013) analysed thermal comfort and interior settings. The ASHRAE Standard 55 and the Adaptive Comfort Standard (ACS) psychometric diagrams were employed in warm summer for studies. In the course of the research, the maximum outside temperature was 430C with 4% humidity, while indoor temperatures were about 270C 40%, with lower humidity and a minimum exterior temperature. Results have shown a high internal temperature in various natural ventilation systems ranging from 31 to 400C. The data measured in the summer season is determined to be well within natural ventilation and evaporative cooling with the use of bioclimatic chart.

Tinker JA et al. (2004) found that much of Sarawak, eastern Malaysia's new low-income housing is completely inconceivable in a warm, wet environment and the dwellings are thermally unpleasant for most of the day. However, traditional Malaysian homes have been created to meet climate requirements so that the inside conditions are comfortable. The characteristics of thermal comfort in traditional homes as well as in typical contemporary residences with low incomes in East Malaysia have been measured. The CFD code is utilised to analyse information and a method for assessing comfortable levels is employed for the Corrected Effective Temperature (CET) index.The investigation proved that the traditional Malaysian home offered a great deal of thermal convenience, whereas the contemporary dwellings did not. It was observed that when doors and windows are partially open or closed, thermal comfort cannot be attained. Although thermal comfort is achieved when, despite the high inside temperature, doors and windows are fully open, the danger of safety does not allow this. According to the findings of the study, grills for permanent air flow and comfort provide adequate safe ventilation.

Nishita Baderia (2014) investigated the function of thermal mass in a humid subtropical environment in Ningbo on China's eastern coast.The walls were 300 mm thick with high thermal mass concrete and the slab was 400 mm thick with high thermal mass concrete.The Parametric study was carried out using Thermal Analysis Simulation (TAS) software. Out of the four examples tested, the results showed that buildings with high thermal mass and night ventilation provided the most comfort and efficiency.

Madhumathi et al. (2014) have been conducting study on selecting appropriate ceilings in warm humid climate conditions in India for natural ventilated residential structures. Six residential building case studies were selected in Madurai, Tamilnadu, India.50% of the building's heat charge is of the roof. Different roof treatments for the comparison of their efficient passive cooling have been explored. The average interior air tempers in the RCC roof slab were at 33.57 °C, which did not decrease to the ASHRAE norms inside the indoor comfort zone. The Madras Terrace roof had a high thermal capability among the researched traditional roofs as it held the heat absorbed for a longer duration. The historic building with Madras terrace rooftop had average internal temperature ranging from 30.55 °C in July. The thermal comfort level in accordance with the ASHRAE rules is almost comparable. The study concludes that multi-layered roof materials with diverse thermal physical qualities are preferable It has been concluded.

Instead of the typical weathering course, Vijaykumar et al. (2006) established a new laying idea for Hollow Clay Tiles (HCT) on the RCC roof (WC). It has been shown that this technology makes it possible to obtain 38-63 percent energy savings over conventional toilet roofs. Heat radiated across the uncovered roofs of single or two-story residential structures at a rate of 50 to 70%.Hollow clay tiles have shown a reduction in the transfer of heat, and, moreover, air movement via the hollow passageways takes care of all changes in the environment and thermal radiation.

In 2014, Hanan M.Taleb simulated building performance with eight solar passive cooling solutions in the United Arab Emirates using IES software. Applied in a case study villa, the eight main passive cooling policies involve louvre shades, double vitrification, wind and cross ventilation, green roofs, isolation, evaporative cooling through a fountain, indirect radiant cooling and high-depth colouration coatings. The possibility of reducing the cooling load of these passive cooling solutions by 9% has been disclosed in detail in the research. There were observations of energy savings of 23.6%. Thomas et al. (2006) reported the combined findings of an analytical, computational, and experimental assessment of the factors for selecting economical materials and designing thermal comfort in solar passive structures. To reduce costs, it is necessary to minimise the quantity of the construction material, which becomes the value index for costs. Three guest house rooms were selected for thermal research in Egypt for the Inshas Science City project near Cairo. There was a high domed ceiling in one chamber, a ceiling in the second, and a low dome in the third. All windows and doors are kept closed during studies in all three rooms.All of the rooms' air and wall temperatures were measured, both inside and out. The investigation's findings indicated that the maximum temperature obtained in each room is affected by its direction. The highest temperatures in the north, north-west, and southern rooms were 31 degrees Celsius, 32 degrees Celsius, and 33 degrees Celsius, respectively. Material selection was discovered to have an effect on thermal comfort. The time lag and decrement factors are solely determined by the thickness of the wall and the thermal diffusivity.

II. RESEARCH METHODOLOGY

A questionnaire study was used to assess respondents' thermal sensations about thermal comfort criteria, among building occupants of both traditional and contemporary houses in the Jamshedpur region within a 60-kilometer radius. In order to make a meaningful comparison, it was important to ensure that the number of answers in each categories was large enough and almost equal. The research included 120 people from traditional homes and 124 people from contemporary homes. All 244 residences chosen were livable and had individuals living in them. Occupants between the ages of 20 and 60, with an equal representation of male and female, were chosen and submitted to a questionnaire survey throughout the severe summer season to measure their subjective reaction to thermal comfort. Before completing the survey, all 244 participants were given enough input, including a brief explanation to the survey and the techniques for responding.

Questionnaire Development

The questionnaire was separated into three sections: basic personal information, comfort answers on thermal sense parameters, and methods used in controlling activities with building characteristics. Subjective reactions include temperature, humidity, air circulation, general comfort, methods to maintain thermal comfort, and building features. Appendix A contains the questionnaire survey forms for both traditional and modern structures.

The subjective scale of freezing (-3), cool (-2), light cool (-1), neutral (0), slightly warm (+1), warm (+2), and hot (+3) was used to measure indoor temperature.

The subjective scale of extremely dry (-3), moderately dry (-2), slightly dry (-1), neutral (0), slightly humid (+1), moderately humid (+2), and very humid (+3) was used to measure humidity. The subjective scale of extremely still (-3), moderately still (-2), somewhat still (-1), Acceptable (0), slightly draughty (1), moderately draughty (2), and very draughty (3) was used to measure air flow inside the structure (3). The subjective scale for assessing total thermal comfort is as follows: extremely unpleasant, uncomfortable, somewhat uncomfortable, comfortable, and very comfortable.

The study was conducted during the peak summer months of April and May, with the condition that no mechanical aids such as fans, air coolers, or air conditioners were used to increase or change the thermal comfort of the indoor environment. The questionnaire was created after a thorough review of the literature on thermal comfort.

III. RESULTS AND DISCUSSION

The survey findings are assessed based on the subjective votes received from various building tenants. The basic criterion for any structure or interior space to be pleasant is that 80 percent of the residents are pleased with the current thermal conditions. However, according to ASHRAE standard 55, thermal acceptability is defined as a situation in which 80 percent of occupants vote for the middle three categories of slightly chilly (-1), neutral (0), and slightly warm (1).

Thermal sense is frequently regarded as one of the most essential human responses to thermal settings, aiding in the definition of ideal circumstances and acceptable ranges. Figure 3.1 depicts the pattern of subjective responses to air temperature during the summer season. A comparison of thermal sensation votes reveals that, whereas 88 percent of comfort votes recorded by respondents varied from the middle three categories (-1, 0, +1) for traditional structures, only 54 percent voted for the same in modern buildings. In historic structures, 38 percent of voters prefer somewhat chilly, 28 percent prefer neutral, and 22 percent prefer slightly warm. In modern structures, the distribution of votes is 8% for somewhat cold, 17% for neutral, and 29% for slightly warm. In both ancient and contemporary structures, none of the residents chose cold. In the modern category, 17% of residents chose hot, whereas none chose the same in the traditional category. Traditional building inhabitants voted 4 percent for cool and 8 percent for warm, whereas contemporary building occupants voted 2 percent and 27 percent, respectively. Figure 3.1 demonstrates that the votes of people who live in traditional structures are balanced around the neutral condition, but the votes of those who live in modern buildings are skewed toward the warm condition. Most people in traditional houses believe their homes are cool, whereas most people in modern houses believe their homes are slightly warm in the summer, because the thermal characteristics of traditional envelopes play an important role in controlling temperature, which is not properly designed in modern buildings.

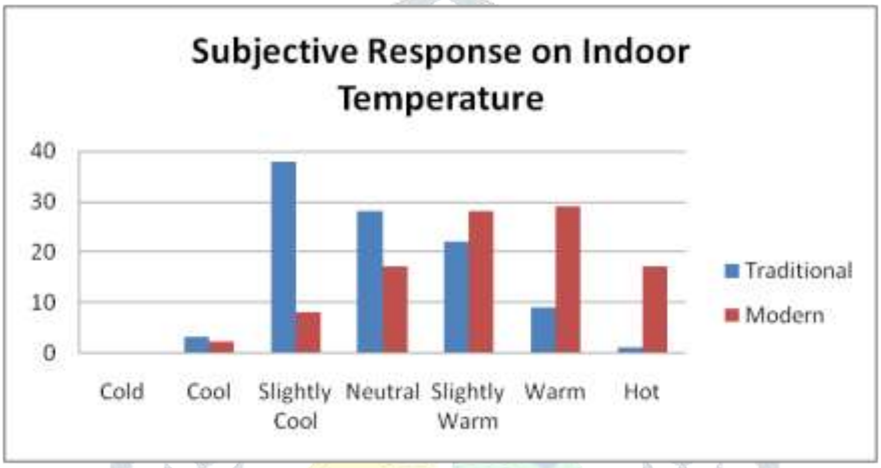

Figure 3.1 Distribution of Subjective response on Indoor temperature

Figure 3.2 depicts the subjective reaction to humidity in the summer. According to the data, 84 percent of respondents in traditional construction and 74 percent of respondents in contemporary construction think that their homes are comfortable in terms of humidity. The distribution of votes in traditional structures is 9 percent for somewhat dry, 37 percent for neutral, and 38 percent for slightly humid. In modern structures, 19% chose for somewhat dry, 27% for neutral, and 28% for slightly humid. While around 7% of inhabitants in older buildings opted for fairly dry, 10% of people in contemporary structures voted for the same. 8% of the occupants voted for moderately humid, 1% of the occupants voted for very dry and none of them voted for very humid in traditional buildings. 11% of the occupants voted for moderately humid, 3% voted for very dry and 2% for the very humid category in modern buildings.

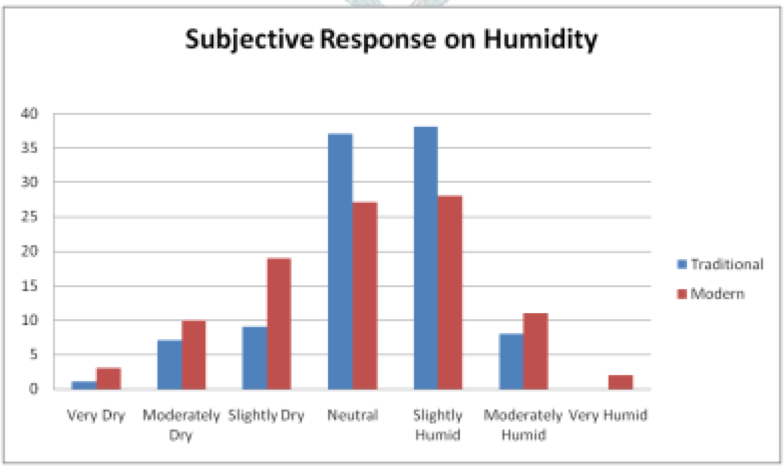

Figure 3.2 Distribution of Subjective responses on Humidity

In a warm, humid atmosphere, air circulation is critical. The major cause of summer heat discomfort is an increase in relative humidity. The only method to produce a comfortable interior atmosphere is to have control over the air temperature, which should be supported by continuous air movement to ensure the appropriate rate of evaporation from the occupants' bodies. Figure 3.3 depicts the distribution of subjective reactions to air movement. In traditional structures, 84 percent of residents opted for the core three groups. Similarly, 72 percent of respondents chose the same in newer constructions. In classic structures, 14 percent voted for somewhat still, 54 percent voted for acceptable, and 16 percent voted for slightly draughty, whereas 15 percent voted for slightly still, 36 percent voted for acceptable, and 21 percent voted for slightly draughty. In contemporary structures, none of the inhabitants chose extremely still and very draughty, whereas 1% of occupants chose both categories in ancient buildings. In traditional structures, 6 percent of inhabitants opted for moderately still and 8 percent voted for moderately draughty, whereas 19 percent and 10% of residents voted in contemporary buildings, respectively. According to the responses, the traditional building envelope allows for continuous air flow and maintains the inhabitants more comfortable even in the summer than the residents of modern buildings.

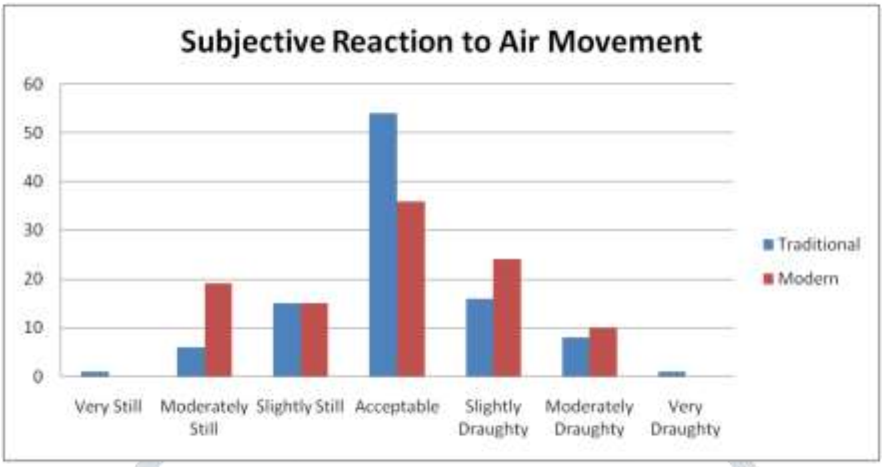

Figure 3.3: Subjective Response Distribution to Air Movement

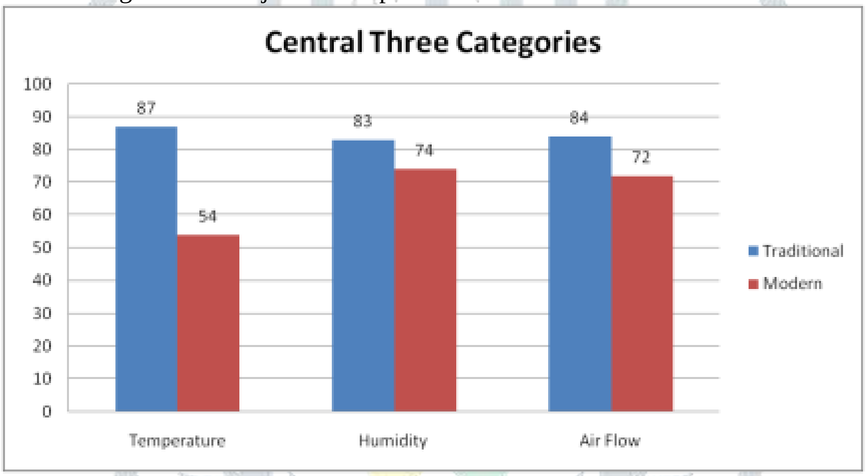

Figure 3.4: Subjective response distribution on the central three categories

Figure 3.4 depicts the distribution of subjective answers on the centre three categories of a 7-point scale survey for temperature, humidity, and air flow in traditional and modern structures. According to the three characteristics, respondents in historic buildings are more comfortable than occupants in contemporary buildings, and also in accordance with ASHRAE pleasant requirements, with a clear majority of 80 percent or above. This was mostly owing to the solar passive elements incorporated in the traditional structure.

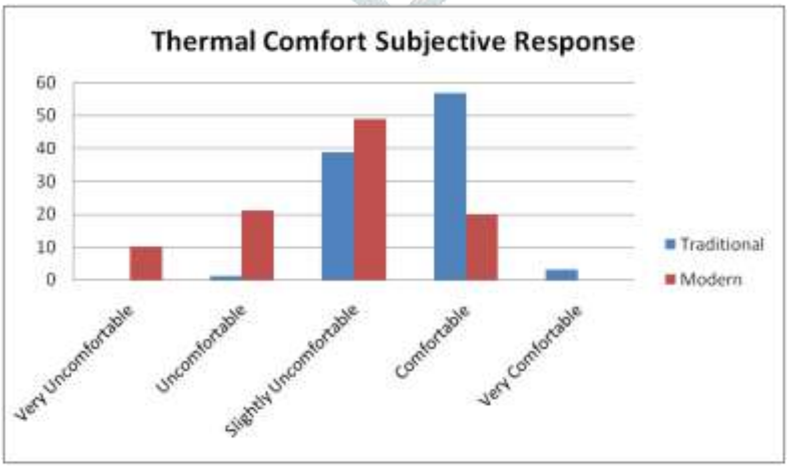

Figure 3.5: Subjective Response Distribution on Thermal Comfort

Figures 3.5 and 3.6 depict the distribution of subjective responses to thermal comfort and total thermal comfort. Residents of typical houses replied 60 percent (57 percent comfortable and 3 percent extremely comfortable) for the comfortable group, whereas 40 percent (39 percent somewhat uncomfortable and 1 percent uncomfortable) for the uncomfortable category. Eighty percent of inhabitants in a contemporary house were uneasy (49 percent slightly uncomfortable, 21 percent uncomfortable and 10 percent very uncomfortable). Only 20% of them felt at ease in the contemporary houses. The subjective response distribution on thermal comfort observed for factors (temperature, humidity, and air movement) individually is in good agreement with their voting for overall thermal comfort. This implies that those who took part in the survey replied appropriately and appropriately for the situation.

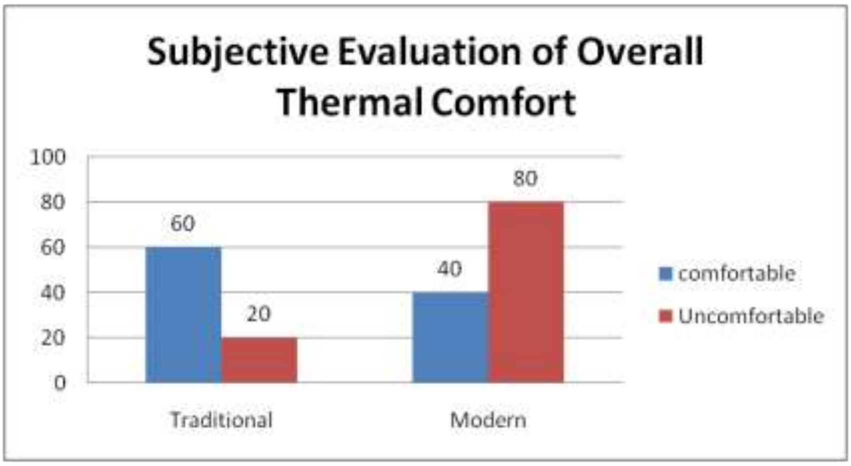

Figure 3.6: Subjective response distribution on total thermal comfort

Figure 3.7 depicts the distribution of mechanical devices used to alleviate heat discomfort in ancient and modern structures. During the unpleasant time, around 64% of inhabitants of both old and contemporary buildings utilised fans and air conditioners to maintain thermal comfort. During the uncomfortable summer months, 60 percent of inhabitants in contemporary buildings use air conditioners (AC), whereas just 16 percent of residents in older structures use AC.

Figure 3.8 depicts the distribution of various components found in traditional and modern structures. According to the figure, survey, and analysis, architectural characteristics such as courtyards, tiled roofs, thick walls, and natural ventilation contribute significantly to thermal comfort in traditional structures.

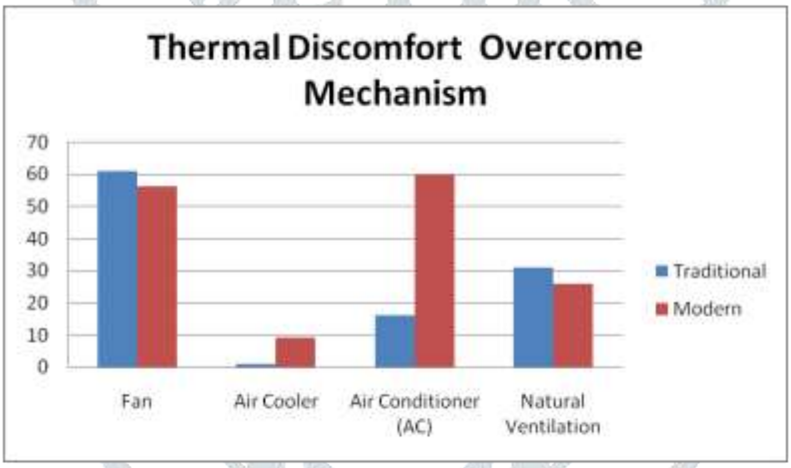

Figure 3.7: Distribution of mechanical devices used to alleviate temperature discomfort in ancient and modern structures.

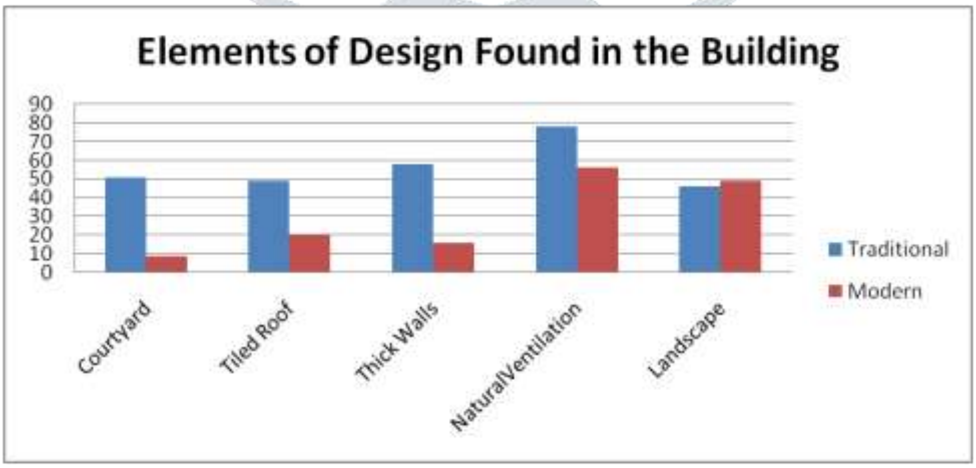

Figure 3.8 Illustration of the distribution of key architectural features seen in traditional and modern structures

Conclusion

For different criteria of thermal comfort, grading scale of total thermal comfort, methods to retain thermal comfort, and characteristic aspects of the building, a questionnaire survey on subjective answers was conducted for traditional and contemporary dwellings in the Jamshedpur region. Subjective reactions give important indicators on appropriate solar passive architecture design for achieving thermal comfort over environmental factors such as temperature, humidity, and air movement. The survey's findings and analyses reveal that traditional residential structures in the Jamshedpur region are more successful than contemporary ones at creating a suitable thermal interior environment. This is mostly owing to the existence of solar passive features in historic structures against the absence of similar designs in modern ones.

As a result, it is argued that a suitable living environment may be achieved in modern structures using little or no energy if they are constructed using conventional architecture expertise.

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