www.ijiarec.com

ISSN:2348-2079

Volume-8 Issue-3

International Journal of Intellectual Advancements and Research in Engineering Computations

Thermal comfort of traditional and modern building in Palakkad based on questionnaire survey among occupants

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ABSTRACT

In traditional buildings, solar passive techniques are adopted to attain thermal comfort. But most of the current day contemporary buildings forget and ignore the architectural traditions. Contemporary design depends on mechanically controlled built environments so as to attain thermal comfort. This also increases the energy demand. Study of traditional buildings is administrated worldwide to arrive out sustainable solutions for the look of recent buildings. so as to match the results of the scientific analysis with the user responses from the residents of traditional furthermore as modern residential buildings, a questionnaire survey was conducted in Palakkad district during various seasons like winter, summer and monsoon. A questionnaire was prepared intimately to grasp the effect of things which affect thermal comfort like temperature humidity and air flow within the evaluation of thermal comfort. This paper is predicated on the compilation of responses from the conducted survey.

Index terms: Traditional Buildings, Modern Buildings, Thermal comfort, Questionnaire survey

INTRODUCTION

Thermal comfort is that the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55) The figure will be viewed as an engine where food is that the input energy. The material body will generate excess heat into the environment; therefore the body can still operate. the warmth transfer is proportional to temperature difference. In cold environments, the body loses more heat to the environment and in hot environments the body doesn't exert enough heat. Both the recent and cold scenarios result in discomfort. Maintaining this standard of thermal comfort for occupants of buildings or other enclosures is one in all the important goals of HVAC (heating, ventilation, and air conditioning) design engineers. The general public will feel comfortable at temperature, colloquially a variety of temperatures around 20 to 22 °C (68 to 72 °F), but this might vary greatly between individuals and reckoning on factors like activity level, clothing, and humidity.

Thermal neutrality is maintained when the warmth generated by human metabolism is allowed to dissipate, thus maintaining equilibrium with the environment. The most factors that influence thermal comfort are those who determine heat gain and loss, namely rate, clothing insulation, air temperature, mean radiant temperature, air speed and ratio. Psychological parameters, like individual expectations, also affect thermal comfort.

Kerala, a state in India located within the southwest coast, falls within the warm-humid zone in line with Bureau of Indian Standards. The

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presence of high amount of moisture within the atmosphere, thanks to its geographical setting, for major a part of the year causes thermal discomfort as there's less evaporation, leading to sweating. This becomes more acute in summer when the air temperature and ratio become higher. Studies on passive methods of achieving thermal comfort in buildings are under progress within the kind of extracting methods and techniques from traditional buildings in various countries. In India, such studies are reported recently from the North-east part where the climate is composite in nature. The authors have conducted an investigation of traditional architecture within the context of Kerala, where the climate is warm-humid, to grasp the passive environment system.

Palakkad district is one among the 14 districts of the Indian state of Kerala. Also, it's the biggest district in Kerala from 2006, also referred to as the Granary of Kerala. Palakkad may be a city and municipality within the state of Kerala in India, cover a locality of 26. 60km2.The climate of Palakkad district is tropical the summer months of March to May are scorching hot. During the monsoon months (June to September), the Palakkad district and its surrounding areas receive heavy rainfall. During winter season temperatures ranges from minimum of 220C and may get up to a maximum of 370C. The temperature is lowest within the month of December

OBJECTIVE OF THE STUDY

The questionnaire was prepared well to grasp the effect of things which affect thermal comfort like temperature, humidity and air flow within the evaluation of thermal comfort. Respondents from age groups starting from 20 to 70 years, with more or less equal representation from either sex were selected for the survey. A Summary of Experimental Investigations Already Reported on Kerala Traditional Residential Buildings is included during this paper

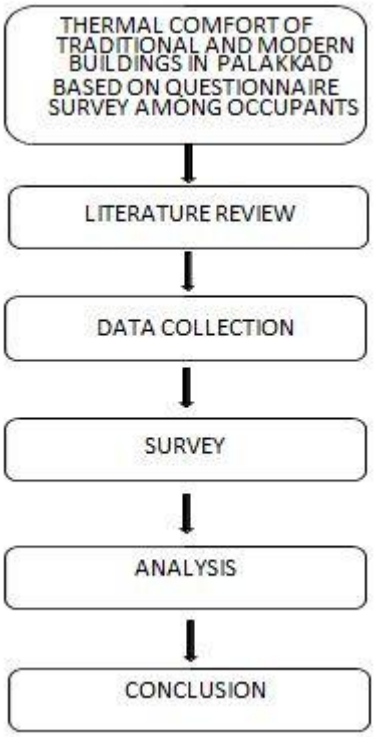
SCOPE

A questionnaire based survey on the residents of the standard and modern residential buildings was required to check with the results obtained from the quantitative analyses. Thus a questionnaire survey was conducted among the residents of traditional and modern buildings through various seasons to assess the subjective response of thermal comfort. The study was conducted during various seasons like winter, summer and rainy period of monsoon season.

METHODOLOGY

The survey was conducted with the assistance of the many interested people during this field. They were educated very well about the relevance and objectives of the survey by the authors. the various components of the questionnaire, its meaning and also the gradation were also explained ahead. The survey was conducted within the peak of every season simultaneously in several locations

FLOW CHART



DATA COLLECTION

Selection of individuals

The survey was conducted among the chosen people from selected families of both traditional and modern buildings of Palakkad district Kerala. Fifty families each living in traditional and modern building were selected for the survey. A complete number of 200 people each from traditional and modern houses were selected for the study with a mean of 4 members from each family.

Features of Traditional Building

The traditional houses of about 200–300 years old, built in step with the traditional principles were selected for the survey. The essential module of traditional residential building of Kerala is understood as nalukettu with four blocks built around an open courtyard. they're generally rectangular or square in plan with blocks topped with a sloping roof on all four sides while the courtyard is left hospitable the sky for letting air and light-weight inside. There's an interior veranda round the courtyard for defence from rain and sun.

The roofs have steep slopes up to almost 45 degrees and are topped with clay tiles on wooden framework with gaps provided in between tiles to boost ventilation and to permit the nice and cozy air to flee. Further, ventilators are provided for the ventilation of attic spaces that are formed by the wooden false ceiling (tattu) provided for the area spaces. This roof encloses an outsized insulated air space keeping the lower areas cooler. a close description on the standard residential buildings of Kerala and its typical layout are given elsewhere.

Features of Modern Building

Modern buildings of but 20 years old were selected for the survey. Modern buildings of Kerala don't have any common design principles nor do they follow a typical type of architecture. Most of the buildings are constructed with brick masonry walls plastered with cement mortar and topped with RCC roof. The roofs are either flat or sloping at different angles. Window openings are

provided all round the buildings and that they are extensively covered with glass panelled shutters.

The buildings, both traditional and modern, were selected from various parts of Palakkad district no matter the micro level variations in climate and topography. People with sensible mind and keen observation skill on thermal comfort were selected for the survey. They were briefed about the scope of the survey, and got sufficient input before the conduct of the survey on the way to answer the questionnaire

QUESTIONNAIRE PREPARATION

The questionnaire consists of three parts: Basic personal data, Comfort responses on thermal sensation parameters and therefore the methods adopted up to speed actions with building characteristic elements. Enquires of subjective responses include temperature, humidity, air movement, overall comfort, measures to retain thermal comfort and characteristics elements of the building.

Indoor temperature assessment was applied using the subjective scale of cold, cool, light cool, neutral, slightly warm, warm and hot. Humidity assessment was done using the subjective scale of very dry, moderately dry, slightly dry, neutral, slightly humid, moderately humid and extremely humid. Air movement inside the building was assessed using the subjective scale of very still, moderately still, slightly still, Acceptable, slightly draughty, moderately draughty and really draughty. The subjective scale used for assessment of overall thermal comfort is extremely uncomfortable, uncomfortable, slightly uncomfortable, comfortable and extremely comfortable. The survey was applied during the height summer within the months of April and will. The condition during the assessment is when the inhabitants don't seem to be using any of the mechanical aids like fan, air cooler or cooling to enhance or modify the thermal comfort of the indoor environment. The questionnaire was prepared supported the detailed analysis of literature associated with the thermal comfort

The questionnaires prepared got in two different colours - blue colour for traditional buildings and yellow colour for contemporary buildings. The questionnaire was given in English and Malayalam (regional language - Kerala) and was made available for reference during the conduct of the survey.

RESULTS AND ANALYSIS

The subjective responses, on various thermal comfort parameters which on the thermal comfort, obtained from the questionnaire survey conducted during various seasons are illustrated below. The analysis and interpretation of the results obtained from the survey is provided at the top of this section. a mean vote for overall thermal comfort in an annual basis is additionally illustrated.

Winter season

Fig. 1 shows the distribution of subjective response on temperature in winter season. While about 40% of the residents of traditional buildings voted for neutral temperature, only 30% of the residents of contemporary buildings voted for the identical. Also, while25%of the residents of traditional buildings voted for slightly extreme temperature, 42% of the residents of recent buildings voted for the identical. 19% of the residents of contemporary buildings believe that their buildings are warm in winter while 8% believe that it's hot. When 37% of the residents of the standard buildings believe that their buildings are slightly cool, only 13% of the fashionable building residents believe the identical. It’s evident from the Fig. 1 that, while the votes from people of traditional buildings are balanced round the neutral condition, the identical of recent buildings shows a bent towards warm condition.

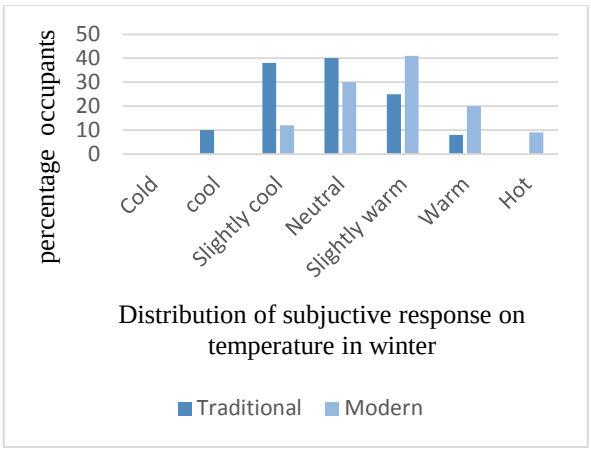


Fig. 1. Distribution of subjective response on temperature in winter

The distribution of subjective response on humidity in winter season is shown in Fig.2.From this figure, it's clear that, around 50% of the people within the traditional and modern buildings believe that their dwellings are neutral in terms of humidity in winter season. While about 35% of the residents of traditional buildings voted for slightly dry, 38% of the residents of contemporary buildings voted for the identical. but 10% of individuals in both the buildings believe that their buildings are humid in winter season. Also, but 10% of individuals in both the buildings believe that their buildings are moderately dry in winter and nobody voted for "very dry".

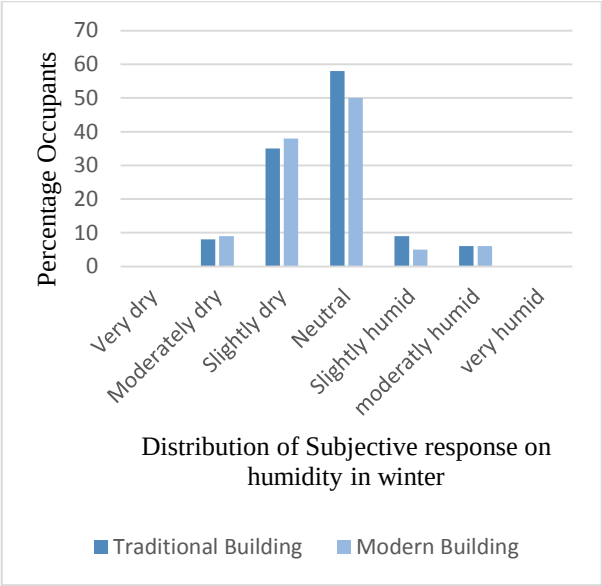


Fig.2. Distribution of subjective response on humidity in winter

Fig. 3 shows the distribution of subjective response on air movement in winter season. over 70% of the occupants of the normal houses voted for acceptable air movement. The remaining people of the normal houses voted towards still air as shown in figure. Almost 80% of the occupants of the fashionable buildings have difference in opinion about air movement starting from slightly still to moderately draughty. the intense characteristics, very still and extremely draughty are selected by but 10% of the occupants of recent houses.

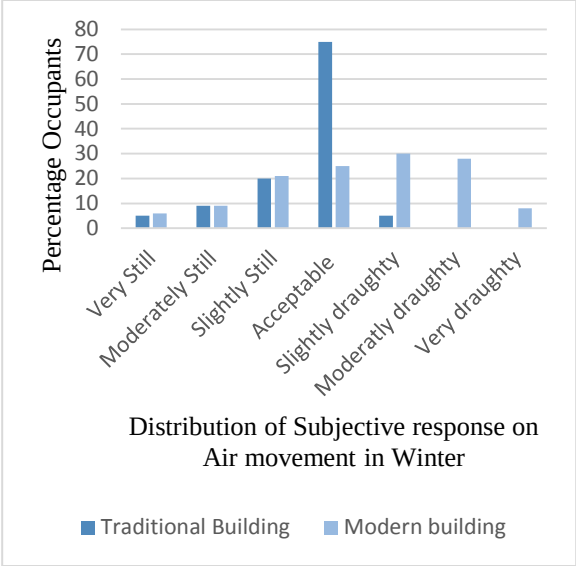


Fig. 3. Distribution of Subjective response on Air movement in winter

The distribution of subjective response on overall thermal comfort in winter season is shown in Fig. 4. 75% of the occupants of the normal buildings voted that their dwellings are very comfortable in winter. The remaining 27% voted for comfortable and slightly uncomfortable with a distribution of 25 try to 5% respectively. Only 10% of the occupants of the trendy buildings voted that their dwellings are very comfortable in winter. 63% from the fashionable buildings voted for comfortable and slightly uncomfortable with a distribution of 30% and 35% respectively. The remaining 29% of the fashionable buildings voted for uncomfortable and extremely uncomfortable with a distribution of 15% and 12%respectively as shown in Fig.

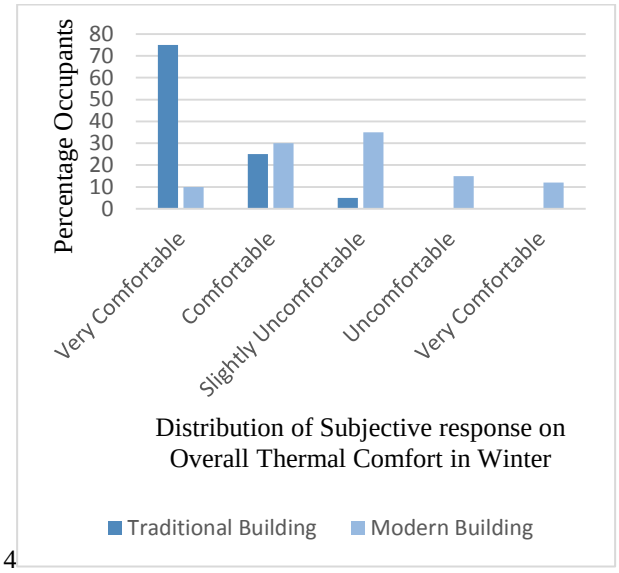


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Fig. 4. Distribution of Subjective response on overall thermal comfort in winter

SUMMER SEASON

Fig. 5 shows the distribution of subjective response on temperature in summer season. While about 50% of the residents of traditional buildings voted for neutral temperature, only 10% of the residents of recent buildings voted for the

identical. Also, while about 9% of the residents of traditional buildings voted for slightly heat, 12% of the residents of recent buildings voted for the identical. it's evident from this figure that nobody within the modern buildings feels their dwellings are slightly cool, cool or cold. 81% of the residents of the trendy buildings voted for warm and hot with a distribution of 48% and 35%respectively.

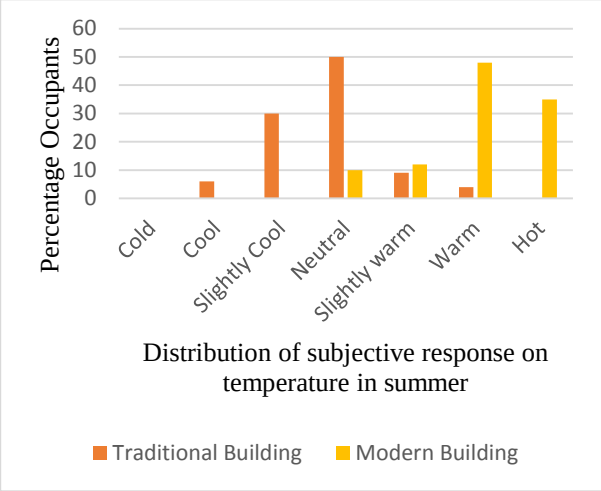


Fig. 5. Distribution of subjective response on temperature in summer

The distribution of subjective response on humidity in summer season is shown in Fig.6. From this figure, it's clear that, 65% of the people within the traditional buildings believe that their dwellings are neutral in terms of humidity in summer season. Only 12% of the residents in modern buildings believe that the condition is neutral. While 10% of the residents of traditional buildings voted for slightly dry, 7% of the residents of contemporary buildings voted for the identical. 76% of the residents of the trendy buildings voted for slightly humid, moderately humid and really humid with a distribution of 25%, 38% and 18% respectively. Out of 24% of the residents of the standard buildings, only 6% believes that their dwellings are moderately humid. The remaining voted for slightly humid. While nobody voted for very dry, 18% of the fashionable residents voted that their dwellings are very humid.

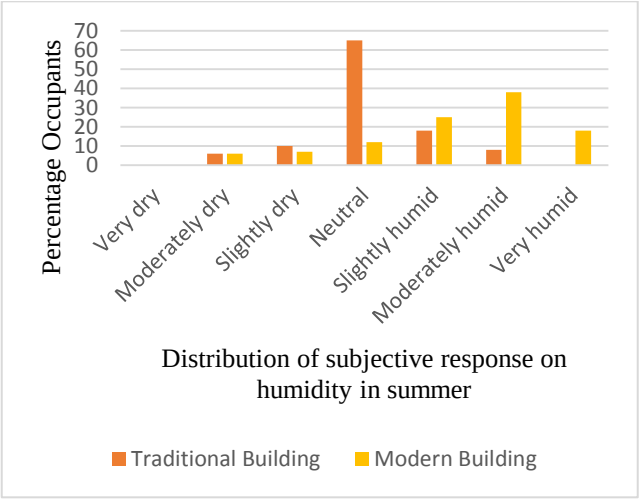


Fig.6. Distribution of subjective response on humidity in summer

Fig. 7 shows the distribution of subjective response on air movement in summer season. Over 80% of the occupants of the normal houses voted for acceptable air movement. Most of the remaining people of the normal houses voted towards still air as shown in figure. About 80% of the occupants of the trendy buildings have difference in opinion about air movement almost equally starting from slightly still to moderately draughty. The intense characteristics, very still and extremely draughty also are reported by but 10% of the occupants of contemporary houses.

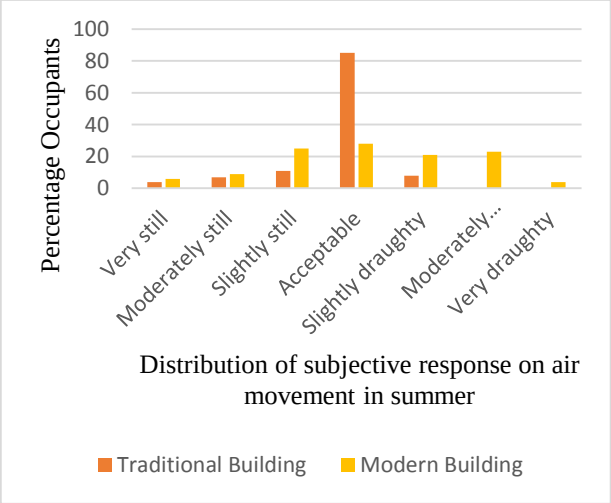


Fig.7. Distribution of subjective response on air movement in summer

The distribution of subjective response on overall thermal comfort in summer season is shown in Fig. 8. Over 70% of the occupants of the normal buildings voted that their dwellings are very comfortable in summer. The remaining 30% voted for comfortable and slightly uncomfortable with a distribution of 30% and 6% respectively. Nobody among the occupants of the fashionable buildings voted that their dwellings are very comfortable in summer except for 78% of the occupants feel that, their dwellings are very uncomfortable. The remaining 29% of the fashionable buildings voted for slightly uncomfortable and uncomfortable with a distribution of 12% and 25% respectively.

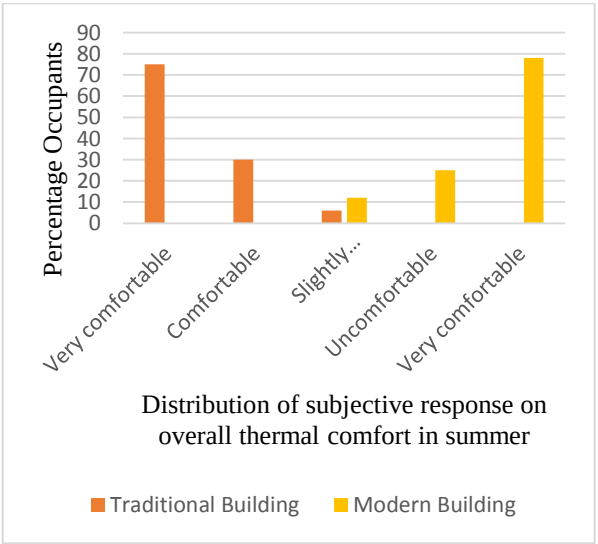


Fig.8. Distribution of subjective response on overall thermal comfort in summer

Rainy season

Fig. 9 shows the distribution of subjective response on temperature in time of year. While about 33% of the residents of traditional buildings voted for neutral condition, 38% of the residents of contemporary buildings voted for the identical. Also, while 55% of the residents of traditional buildings voted for slightly extreme temperature, only 12% of the residents of contemporary buildings voted for the identical. Only 4% of the residents of contemporary buildings believe that their buildings are warm in season. While 9% of the residents of the standard buildings believe that their buildings are slightly cool, only 5% believe that the temperature is cool in time of year. it's evident from this figure that, nobody within the traditional buildings likewise as modern buildings feels that their dwellings are cold or hot during season.

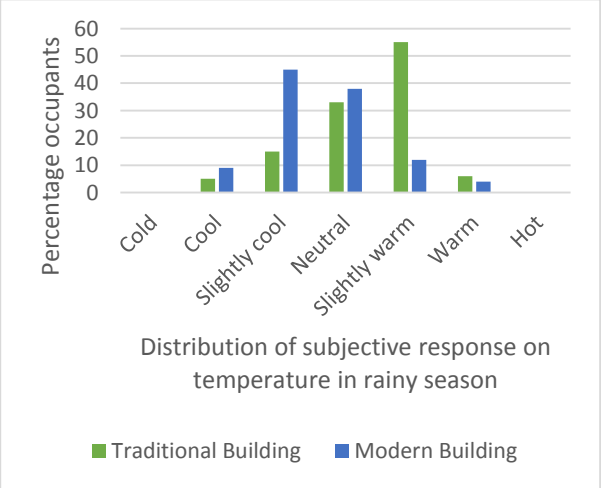


Fig.9. Distribution of subjective response on temperature in rainy season

The distribution of subjective response on humidity in time of year is shown in Fig. 10. From this figure, it's clear that, around 55% of the people within the traditional and modern buildings feel that their dwellings are neutrally humid in time of year. While about 3% of the residents of traditional buildings voted for slightly dry, 8% of the residents of recent buildings voted for the identical. Around 10% of individuals in both the buildings believe that their buildings are moderately humid in winter season. it's evident from this figure that; nobody resides within the traditional buildings furthermore as modern buildings feels that their dwellings are very dry, moderately dry and extremely humid during time of year.

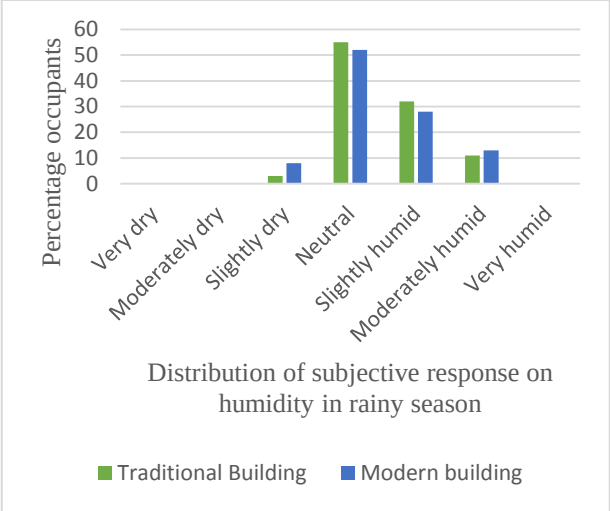


Fig.10. Distribution of subjective response on humidity in rainy season

Fig. 11 shows the distribution of subjective response on air movement in season. 72% of the occupants of the normal houses voted for acceptable air movement. Most of the remaining people of the standard houses voted towards still air as shown in figure. 60% of the occupants of the fashionable buildings voted for slightly draughty, moderately draughty and extremely draughty with a distribution of 30%, 19% and 12% respectively. 9% of the occupants of the normal buildings voted for very still and moderately still air movement with a distribution of 6%, 2% respectively.

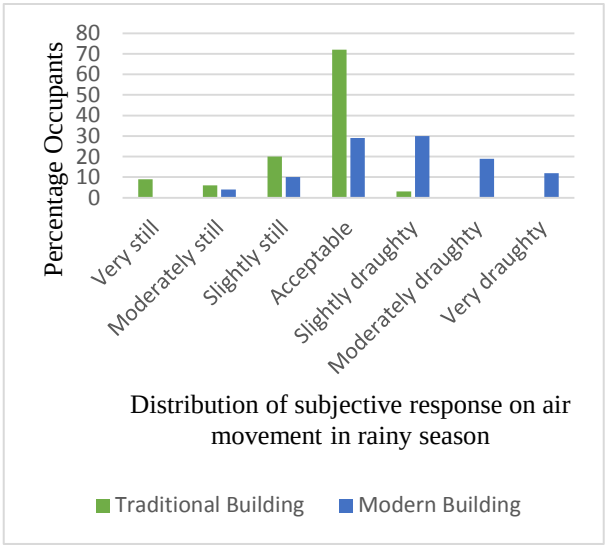


Fig. 11. Distribution of subjective response on air movement in season

The distribution of subjective response on overall thermal comfort in season is shown in Fig. 12. 68% of the occupants of the normal buildings voted that their dwellings are very comfortable in time of year. The remaining 34% voted for comfortable and slightly uncomfortable with a distribution of 30% and 6% respectively. Only 20% of the occupants of the fashionable buildings voted that their dwellings are very comfortable in time of year. 59% of the trendy buildings voted for comfortable and slightly uncomfortable with a distribution of 32% and 28% respectively. The remaining 22% of the fashionable buildings voted for uncomfortable and really uncomfortable with a distribution of 13% and 11% respectively as shown in Fig. 12.

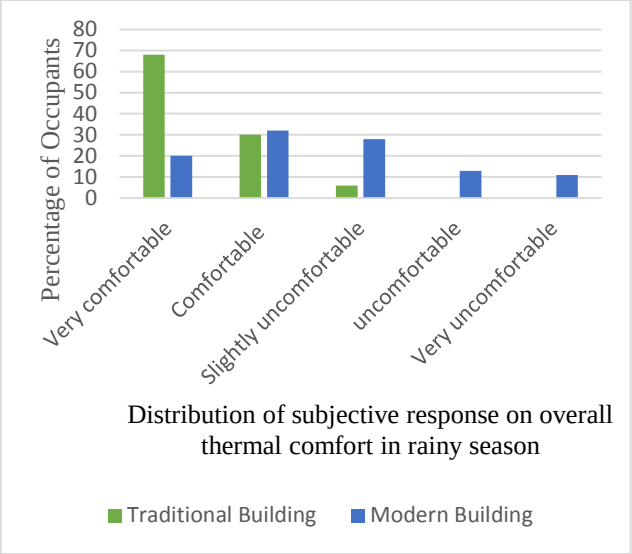


Fig.12. Distribution of subjective response on overall thermal comfort in rainy season

Comparison, Analysis

In this section, the results of the questionnaire survey illustrated above are compared between various seasons for analysis and better understanding. Comparing Figures 1,5 and 9, it is often seen that while over 50% of the residents of the normal buildings voted for neutral condition in terms of temperature in summer,30–35% people voted for the identical in other two seasons. Most of the people in traditional houses feel that their dwellings are cooler in winter and summer, and are warmer in season. The thermal characteristics of the Kerala traditional building envelope are playing an important role in controlling the temperature. It can even be learned from the Figures 1, 5 and 9 that, the fashionable buildings are warmer in winter and rainy seasons and are hotter in summer.

In summer most of the residents of the trendy buildings feel that their dwellings are humid as evident from Figure 6. While the residents of both traditional and modern buildings voted almost similar manner about humidity in winter and season, they differ in their opinion in summer season. From Figures 2, 6 and 10, it will be seen that over 50% of the residents of the standard buildings voted for neutral condition for humidity altogether seasons. The combined effect of temperature and humidity in traditional buildings in various seasons is explained below to substantiate this time.

It may be seen from Figures 3, 7 and 11 that residents of traditional houses voted for air flow almost in a very similar manner all told seasons. Nobody among the residents of traditional houses voted for moderately draughty and extremely draughty air flow and 70–80% of the identical people voted for a suitable air flow all told seasons. On the opposite hand, from the identical figures, it is seen that, the residents of the trendy houses have a mixed opinion on the air flow starting from very still to very draughty.

On judging the general comfort, comparing Figures 4, 8 and 12, it is seen that around 70% of the occupants of the standard houses voted for very comfortable condition altogether seasons; while nobody feels that they're uncomfortable or very uncomfortable. At the identical time, it may be seen that but 20% of the occupants of the fashionable houses voted for very comfortable condition in winter and rainy seasons; while nobody feels that they're very comfortable in summer season.

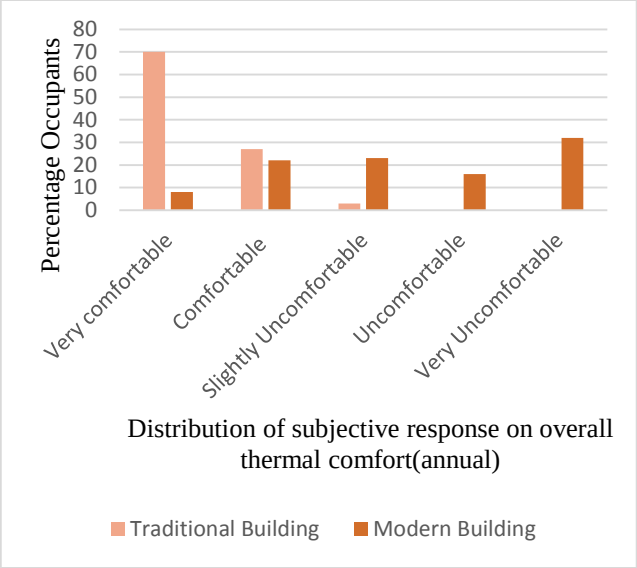


Fig. 13. Distribution of subjective response on overall thermal comfort

Fig. 13 shows the distribution of subjective response on overall thermal comfort in an annual basis. A median of 70% of the occupants of the normal buildings feels that their dwellings are very comfortable in a very year. The remaining 30% may be averaged as comfortable and slightly uncomfortable with a distribution of 27% and three respectively. Only 9% of the occupants of the fashionable buildings are found that very comfortable all told seasons. 43% of the fashionable buildings may be averaged annually as comfortable and slightly uncomfortable with a distribution of 21% and 22% respectively. The remaining 48% of the fashionable buildings are found to be uncomfortable and extremely uncomfortable with a distribution of 17% and 31% respectively as shown in Fig. 13. Majority of the people participated during this survey seems to own responded sensibly and their vote represents thermal comfort conditions of the homes they board. The voting for the parameters affecting thermal comfort – temperature, humidity and air movement – are considerably in agreement with their voting for the thermal comfort. It indicates that the choice of individuals for the survey is suitable for the context. The extent of participation of the people involved within the survey reflects the perfection of the results. The result of the questionnaire survey and its analysis clearly indicate that the normal houses of Kerala are very comfortable to measure in around the year regardless of the seasons.

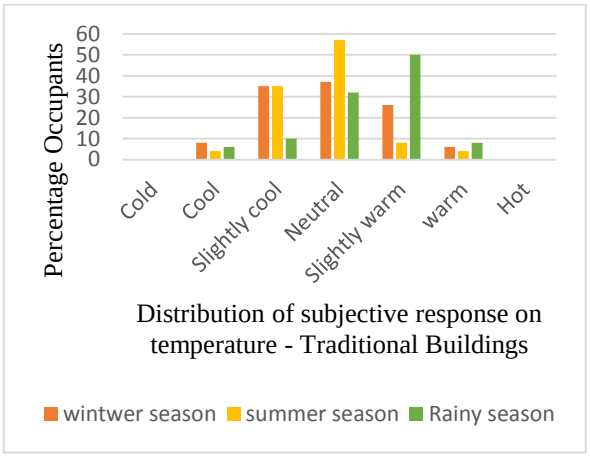
DISCUSSION

There is an increasing concern over the standard of indoor environment because the standard of living improves in society. The most purpose of buildings is to produce a cushty and healthy indoor environment to its dwellers in various seasons, that's essential to perform their works effectively. The atmospheric parameters – air temperature, ratio and air movement have a vital role in providing thermally comfortable indoor environment. Researches on the aspect of thermal comfort and energy efficiency of buildings are underway throughout the planet.

The simplest solution to form an energy efficient, healthy and cozy indoor environment is to produce a passive system of ventilation in buildings. The adoption of techniques from traditional buildings is very important to attain thermal comfort indoors in an exceedingly passive manner. The results of the survey at a look reflect that the residents of the standard houses of Kerala value more highly to stay there because they're very comfortable to measure in no matter the seasons.

It is found that, the most reason for thermal discomfort in Kerala is that the increase in air

temperature together with the presence of excess moisture within the atmosphere. In such a climatic condition, the thermal comfort is often achieved by providing a highly insulative building envelope while maintaining a controlled and continuous airflow through the building. The standard buildings of Kerala have these characteristics so as to realize the specified thermal comfort condition [26]. This will be substantiated by the results obtained from the survey given in Fig. 14.



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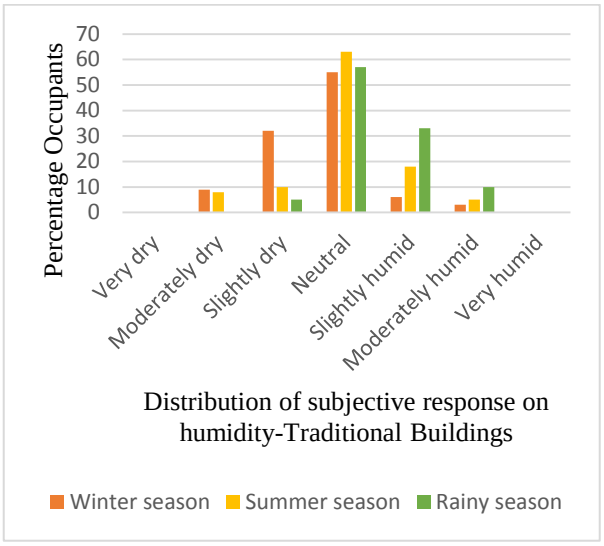

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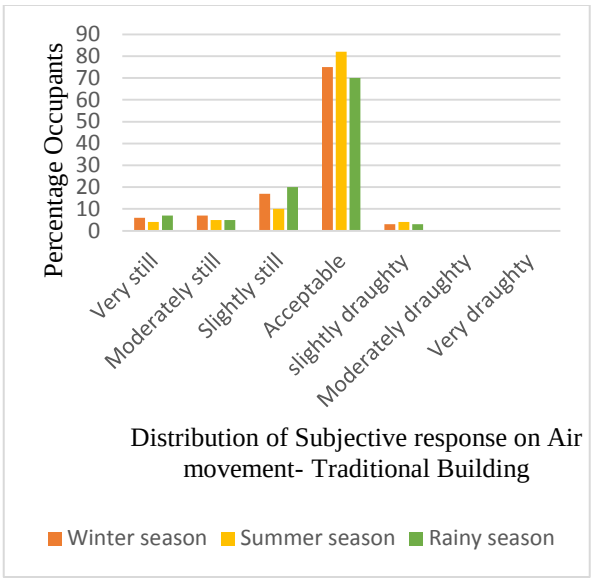

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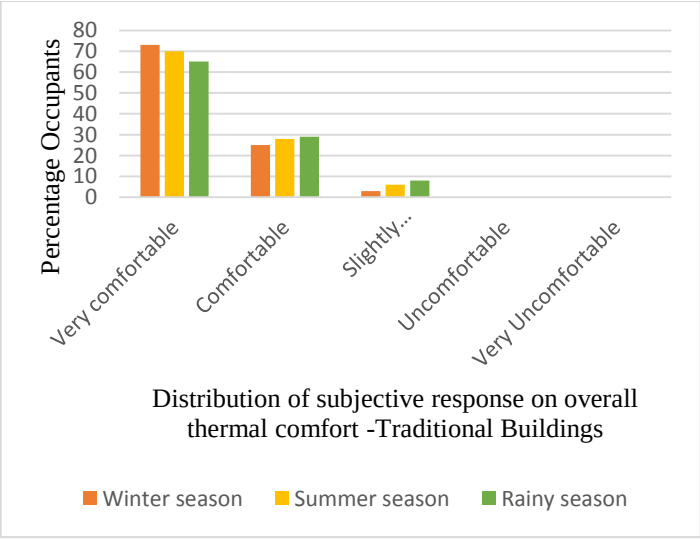


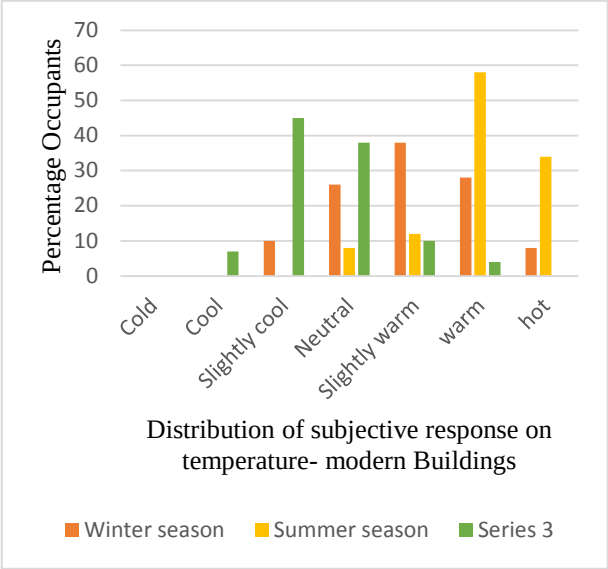
(d)

Fig. 14. Distribution of subjective response on various comfort parameters in traditional buildings during various seasons. (a) Subjective response on temperature, (b) subjective response on humidity, (c) subjective response on air movement, (d) subjective response on thermal comfort.

The distribution of subjective response on various comfort parameters in traditional buildings during various seasons is given in Fig. 14. Fig. 14a shows that quite 50% of the occupants of the standard buildings voted that their dwellings are slightly warm or warm. Also, nobody feels that they're hot. This result's purely in agreement with the high insulative property of the building envelope.

Around 75% of the people of traditional buildings feel that they get a suitable air movement in their residences altogether seasons. The share voted for slightly draughty air movement is a smaller amount than 5% and no one voted formoderatelyorverydraughty air movement in any season (Fig. 14c). From Fig. 14b, it is often seen that, about 55% of the people feel that their houses are neutral in humidity altogether seasons. Also, nobody voted for very humid. These results substantiate that the standard buildings are perfect

in maintaining a controlled and continuous airflow to produce a cushty indoor environment by control the warmth from outside and wash out the moisture inside the building.



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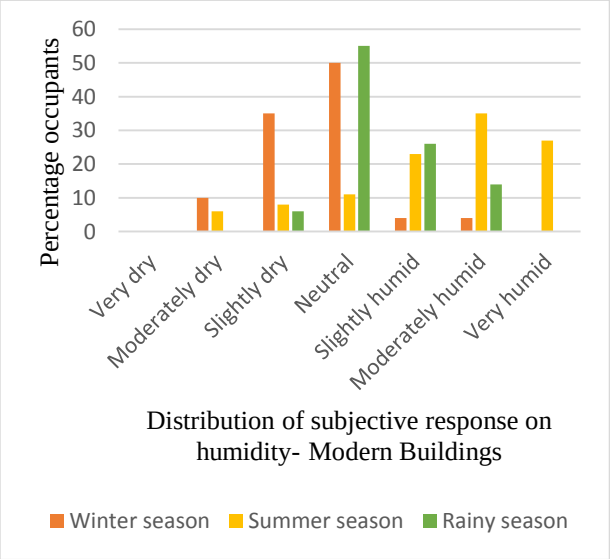

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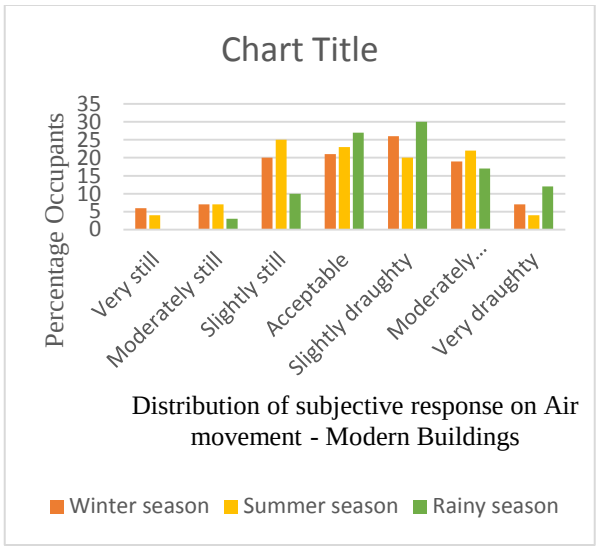

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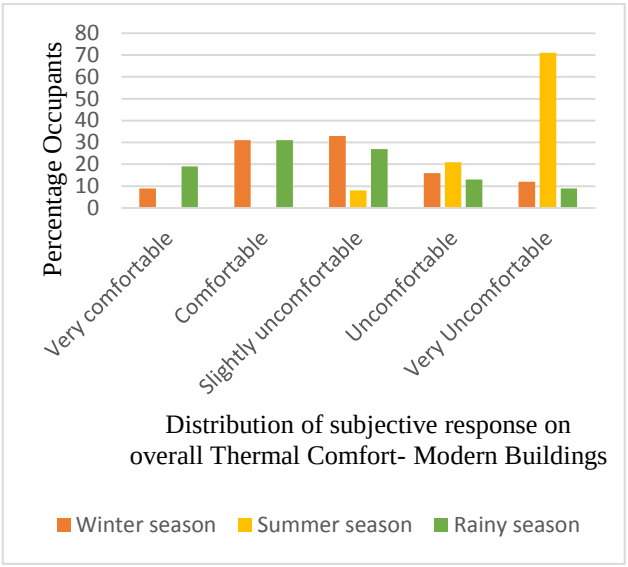

(d)

Fig. 15. Distribution of subjective response on various comfort parameters in modern buildings during various seasons. (a) Subjective response on temperature, (b) subjective response on humidity, (c) subjective response on air movement, (d) subjective response on thermal comfort.

Fig. 15 shows the distribution of subjective response on various comfort parameters in modern buildings during winter, summer and rainy seasons. it's clear from this figure that the fashionable buildings of Kerala are very uncomfortable for living in summer. A mixed opinion is obtained from the people in other two seasons within the case of contemporary buildings. From Fig. 15c, it may be seen that the people in modern building significantly differ in their opinion about air movement. Only about 20% of the people feel that they get an appropriate air movement in modern buildings. It clearly shows that, the controlled and continuous air flow, that's essential for better thermal comfort within the warm-humid climate of Kerala, is almost absent in modern buildings.

It is clear from this study that energy intensive solutions are required in modern buildings to realize thermal comfort conditions in terms of cooling, and ventilation. All of the occupants of the trendy houses depend upon fans to survive within the

uncomfortable conditions. About 20% of them within the upper middle and high income groups use air-con systems to induce thermal comfort. this can cause severe depletion of non-renewable energy resources and environmental degradation. However, traditional buildings of Kerala are very effective in providing thermal comfort by passive methods altogether seasons.

CONCLUSION

Thermal comfort features a great influence on the productivity and satisfaction of indoor building occupants. Thermal comfort is incredibly difficult to define. This is often because we'd like to require into consideration a variety of environmental and private factors when picking the temperatures and ventilation which will make feel comfortable. The most effective that we will realistically hope to realize may be a thermal environment which satisfies the bulk of individuals within the workplace, or put more simply, 'reasonable comfort. The aim of this study is to match the thermal comfort of traditional and modern buildings in Palakkad district. during this study, an in depth questionnaire survey on the subjective responses on parameters of thermal comfort together with a rating of overall thermal comfort was conducted in traditional and modern buildings. The analysis of the survey results confirms that Kerala traditional residential buildings are very effective in providing comfortable indoor environment no matter the seasons. The modern practice in architecture lacks conscious effort in using passive methods of controlling the indoor environment. Traditional residential buildings of Kerala, by virtue of their design, and materials and special methods used for construction, provide a snug indoor environment. It can therefore be concluded that Kerala traditional residential buildings maintains a balanced condition of temperature and humidity together with an appropriate airflow to supply the desired thermal comfort through all seasons.

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