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Thermal Comfort in Indoor Transition Spaces

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CHAPTER-1 THERMAL COMFORT IN INDOORTRANSITIONSPACES

1.1 INTRODUCTION $ AIM:

Thermal comfort is important to architecture ,since it not only lays the foundation forthe building design, but also affects the field of **sustainable design** .feeling comfortable in an interior space directly impacts peoples mood

Taking account of six parameters:

- **Air Temperature,**
- **Mean Radiant Temperature,**
- **Relative Humidity,**
- **Air Velocity,**
- **Clothing Level, And Metabolic Rate**

Transitional spaces——those areas that ***are influenced by outdoor climate***, yet are architecturally bounded by a building. In this work, we focused on transitional space as a space in between outdoor and indoor.

The aim of this research is to understand the relationships between thermal conditions, thermal comfort and people's use of indoor transitional space with a view to determining if indoor transitional space can help the**building save energy**.

1.2 OBJECTIVES:

- Importance Of **Studying Thermal Comfort** And Research On Thermal Comfort In Transitional Spaces
- To Investigate **The Occupants' Thermal Comfort Perceptions In Indoor Transitional Spaces.**
- To **Calculate And Compare Temperature**, Preferred Temperatures And Comfort Temperature Range Of TheDifferent Indoor Transitional Spaces, Using The Mean Thermal Sensation Vote Responses
- **Comparing Room Temperature Of Transition Space, Indoor Space And Outdoor Space**
- **Comparing The Styles Of Transition Spaces**
- **Live case study**.

1.3RESEARCH METHODOLOGY:

1. **Field study approach**: Field study and surveys were conducted to investigate the thermal performance of indoortransitional spaces in commercial buildings and variations of subjective responses.

2. **Study Of transitional spaces** is designed with appropriate energy saving strategies such as passive design, hybrid ventilation and flexible HVAC controls.

3. **Human behavior monitoring.**

1.4 STUDYING RESEARCH PAPER ON:

A. *Thermal Comfort In **Transition Spaces***
B. *Thermal Comfort **Residential Unit Case Studies***
C. *Thermal Comfort Conditions In **Airport Terminals: Indoor Or Transition Spaces***
D. *Transition Spaces And Thermal Comfort – **Opportunities For Optimizing Energy Use***

4. Literature Case Study
5. Live Case Study **Case Study Buildings:**

Vijaya forum mall,vadapalani

1.5RESEARCH QUESTIONS:

- How relevant is the adaptive thermal comfort model to indoor transitional spaces?
- How do thermal conditions influence people's use of indoor transitional space?
- Whether people will accept lower temperature (requiring less energy) in indoor transitional space than in other types of spaces.

1.6ANAYLSIS

CHAPTER NO. 2 LITERATURE CASE STUDY

2.1 LITERATURE CASE STUDY

ARTICLE NAME: Thermal Comfort in Transition Space

AUTHOR: Adrian Pitts

ABSTRACT:

This paper deals with transition spaces (entrance foyers, circulation zones, lift lobbies, stairways and atria) and thermal comfort experiences. It both reviews existing reported research into comfort in such spaces, and introduces new information from a range of studies completed in recent years. It assesses the usefulness and applicability of design standards which exist, but whichare primarily concerned with more permanently (rather than transitorily) occupied spaces within buildings.

METHODOLOGY

Predicted Percentage Dissatisfied (PPD) compared to Predicted Mean Vote (PMV)showing the impact of extending the comfort standard range

- Thermal sensation votes
- Thermal preference votes
- Thermal responses
- Preference vote Expectation voteSensation vote

TOOLS:

FIELD STUDY APPROACH

CONCLUSION:

This paper has addressed the important sub-set of building spaces identified as transition zones. Three categories or types of transition zone have been suggested, each of which is distinguished by differences in residence time, in likely activity, and also potentially by differences in clothing level of their occupants. It has been demonstrated that occupants both react differently intransition zones and have different thermal expectations of them. As a result the application of strict design standards for comfort can result in unnecessary use of building space conditioning systems

CHAPTER NO.1.2 LITERATURE CASE STUDY

2 Thermal comforts in Lebanese residential unit case studies: a coastal region in Lebanon

AUTHOR: O. Omar & Y. Sabsaby

ABSTRACT:

Thermal comfort is considered as one of the most important parameters in designing the building to improve thequality of living conditions. This paper searches for the most appropriate strategies in developing comfort in Lebanese coastal housing.

METHODOLOGY:

- THERMAL COMFORT AND STANDARDS :
- Metabolic activity, measured in Met, as in (UNI EN ISO 8996 [6]);
- Clothing, measured in Clo, as in (UNI EN SO 9920 [7]);
- PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied), as in (UNI EN ISO 7730 [8]).

ASHRAE STANDARD:

- ✓ Indoor parameters that should be controlled and measured are:
- ✓ Air temperature (dry bulb temperature);
- ✓ Mean radiant temperature;
- ✓ Relative humidity;
- ✓ Air velocity.

LEBANESE THERMAL STANDARD:

The Thermal Standard for Buildings (TSB) sets the minimum requirements for the thermal performance of building envelopes. It provides methods for determining compliance with these requirements (ADEME [14]).

- ✓ **Thermal transmittance "U";**
- ✓ **Solar heat gain coefficient "SHGC".**
- ✓

TOOLS:

Logger from HOBO Company and a Carbon Dioxide and Temperature Monitor fromTelaire 7001

CHAPTER NO.1.3 LITERATURE CASE STUDY

3 THERMAL COMFORT CONDITIONS IN AIRPORT TERMINALS: INDOOR OR TRANSITION SPACES

ABSTRACT:

This paper reports on the investigation of the thermal comfort conditions in three airport terminals in the UK. In the courseof seasonal field surveys, the indoor environmental conditions were monitored in different terminal areas and questionnaire-guided interviews were conducted with 3087 terminal users. The paper focuses on the thermal perception,preference and comfort requirements of passengers and terminal staff.

METHODOLOGY

The methodology included extensive on-site surveys in three airport terminals, London City Airport (LCY), Manchester Terminal 1 (MAN T1) and Manchester Terminal 2 (MAN T2). During the week-long surveys, the indoor environmental conditions were monitored across the different terminal spaces and questionnaire guided interviews were simultaneouslyconducted with terminal users. Each terminal was surveyed in summer and winter in 2012 and 2013 to allow for the seasonal variations, daily from 5am to 9pm to obtain the peak and off-peak occupancy profiles

- **Terminal buildings surveyed**
- **Environmental monitoring**

TOOLS:

FIELD STUDY APPROACH

CONCLUSIONS

This work investigated the nature of thermal comfort conditions in three airport terminal buildings of different size and typology.

The indoor environmental conditions were extensively monitored in different terminal areas along with questionnaire-guided interviews with people across different seasons.

Thermal sensation was predominantly determined by the combination of temperature, clothing insulation and activity levels.

Ultimately, understanding the differing comfort requirements of the key population groups in airport terminals is important to improve thermal comfort conditions and identify appropriate strategies for reducing energy consumption.

Such knowledge can influence the design and potential refurbishment of this energy intensive sector to maintain occupants' well-being.

CHAPTER NO.1.4 LITERATURE CASE STUDY

4 .Transition Spaces and Thermal Comfort – Opportunities for Optimizing Energy Use

ABSTRACT:

This paper reports on research that examines the role of transition spaces in buildings and the energy use therein, with particular reference to occupant thermal comfort. Transition **spaces include: entrance foyers, corridors, buffer zones, lobbies and other transitory areas** used within buildings but not permanently occupied. Such spaces have a different impact on people passing through than either outdoor or fully indoor areas.

TOOLS FOR REVIEWING COMFORT ISSUE:

Predicted mean vote (PMV) is commonly used as a measure of the average response from a large group of people voting on scale as shown in the left-hand column of table 1.

The Predicted Proportion Dissatisfied (PPD) calculation used in Fanger's comfort equation combines air temperature, mean radiant temperature, relative humidity, and air speed together with estimates of activity and clothing levels.

METHODOLGY:

Initially, four different types of notional buildings, described as Models A, B, C and D of 1000m2 each, have been investigated. These simplified buildings are single storey but of differing forms and layouts; they have been evaluated taking into account variations in orientation and fenestration, principally to assess heat gains and losses.

Some, but not all of the options are reported in this paper. Identical floor areas for different plan variations were picked as examples as they show variations often developed at the design stage that are based on a building's cost budget

CONCLUSION:

This study has investigated energy saving potential if more flexible approaches to defining comfort in transition spaces can be accommodated in building design. This has been tested for four basic building layouts.

The results clearly show substantial opportunity for energy saving which can be quantified (for winter) in the region of 6% if set point control temperatures are allowed to vary by ±3ºC and 10% if a ±5ºC variation is permitted. Further detailed analyses are required for a more holistic picture for the energy consumption of common non-domestic building configurations, which will be investigated as the current project progresses.

It is recognised at this stage that many simplifications have had to be made with the methodology; however the task was to assess indicative values of potential heating energy savings in order to determine the future strategy for the subsequent elements of the research project.

CHAPTER-4 NETCASE STUDY

CASE STUDY-1

INVESTIGATION OF THERMAL COMFORT IN TRANSITIONAL SPACES

AN INSTITUTIONAL BUILDING OF JAIPUR THROUGH COMPUTER SIMULATION

PROFILE OF STUDY AREA

Jaipur has been chosen as an example of hot and dry city of Indian subcontinent. It is situated at 26.9124°N and 75.7873°E, referring to geographic co-ordinates. Jaipur has a monsoon influenced hot semi- arid climate (Köppen climate classification) with long, extremely hot summers and short, mild to warm winters.

The temperature during the summer months varies between 32°C to 45°C and 22°C to 8°C during the winter months with a mean relative humidity of 30% to 50%.

The current study is limited to the transitional spaces of institutional buildings at Jaipur. To test the case, Aayojan school of Architecture is chosen. The institute is located in the outskirts of Jaipur. The transitional spaces selected are corridor, courtyard, entrance canopy and stairwell.

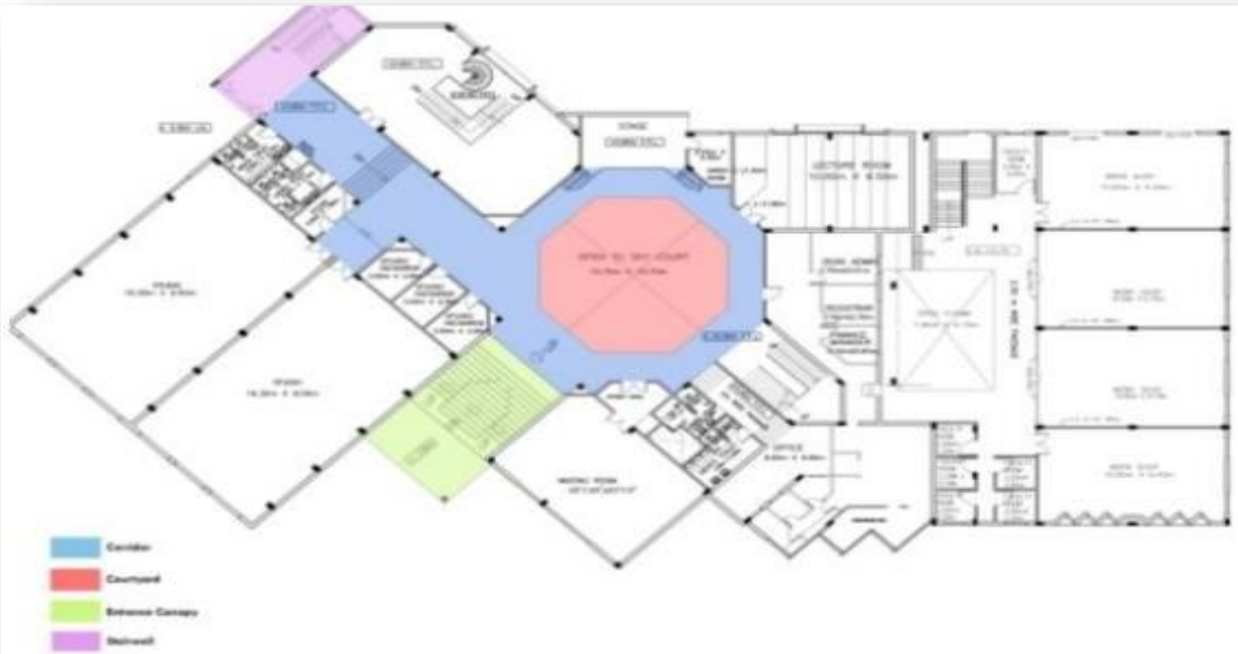


Figure 1: Ground floor plan of Aayojan School of Architecture

DATA &SOFTWARE USED FOR MODELLING:

- Air temperature (Tai),
- Air speed (ASi),
- Relative Humidity (RHi),
- Metabolic Rate (Mi)
- Clothing Insulation (Icli)

- Mean Radiant Temperature (Tri),

Are used to calculate Thermal Comfort (TCi).

- The Study Was Performed In The Month Of October 2019. Due To Limited Time, The Study Could Not Be Extended For Other Months.
- The Parameters Of The Indoor Environment I.E. Air Temperature, Air Speed And Relative Humidity Were Monitored Using Testo 480vacinstrument (Range: -20-70°C For Air Temperature, 0-100% For Relative Humidity And 0-5m/S For Air Speed).
- The Parameters Were Measured At The Entrance Canopy, Corridor, Courtyard And Stairwell Of Aayojan School Of Architecture At 1.1m Above The Floor Level
- Based On ASHRAE Standard 55. Air Temperature Is Measured In °C, Air Speed Is Measured In M/Sec And Relative Humidity Is Measured In Percentage.

Table 1: Key characteristics of the building

Name of the space	Corridor	Courtyard	Entrance canopy	Stairwell
Location in the block	not applicable (internal)	north-west	north-west	east
Length	33.3 M	10.6 M	10.0 M	8.8 M
Width	4 M	10.6 M	6.4 M	3.2 M
Height	3 M	Not applicable (o.t.s)	3 M	3 M
Material- outer wall	exposed brickwork	not applicable	exposed brickwork	exposed brickwork
Material- inner wall	cement plastered	cement plastered	cement plastered	cement plastered
Material- flooring	marble	stone	marble	marble
Material- roofing	reinforced concrete	not applicable (o.t.s)	reinforced concrete	reinforced concrete
Color wall	white	not applicable (o.t.s)	white	white
Color floor	white	grey	white	white
Average no. of occupants	14	6	12	10

Source: Primary data survey

METHODOLOGY:

The above-mentioned data are used for the block to develop the following factors: **air temperature, air velocity, relative humidity, metabolic rate, clothing insulation and mean radiant temperature**.

- **Air temperature:** The temperature of the air surrounding the occupant. It is Expressed in degree Celsius

- **Air speed :** An average of the instantaneous air velocity over an interval of time

- **Relative Humidity :** The ratio of the partial pressure (or density) of the water vapour in the air to the saturation pressure (or density) of water vapour at the same temperature and the same total pressure

- **Metabolic rate:** It is the rate of transformation of chemical energy into heat and mechanical work by metabolic activities of an individual, per unit of skin surface area (expressed in units of met) equal to 58 W/sq.m which is the energy produced per unit skin surface area of an average person seated at rest.

- **Clothing insulation** : It is the resistance to sensible heat transfer provided by a clothing ensemble, expressed in units of clo where1 clo is equal to 0.155 sq.m °C/W5 [6].

- **Mean radiant temperature** (Tri) ASHRAE defines mean radiant temperature (MRT) as "the temperature of a uniform, black enclosure that exchanges the same amount of heat by radiation with the occupant as the actual surroundings"

- **Energy simulation** using ECOTECT 2011 to find Mean Radiant Temperature Mean Radiant Temperature for the above-mentioned spaces is calculated using Energy simulation software-ECOTECT 2011.

RESULT FROM SIMULATION:

The mean internal temperature (Ta) obtained from the field measurement is 28.1°C.
The Mean Radiant Temperature obtained from the simulation method is 32.02°C. Hence the obtained value is put into the equation 7 and an operative temperature also known as comfort temperature is derived.

The derived operative temperature is 30.06°C.

This is also known as comfort temperature.

Result from Empirical data:

The mean internal temperature (Ta) obtained from the field measurement is 28.1°C.
The value of mean thermal sensation vote known as comfort vote (Cm) was established by calculating the total average sensation scale, and identified as 3.

The value of the intercept (a) from the linear multiple regression analysis is 0.435. Hence all the obtained values are put into the equation 9.

The derived comfort temperature (Tc) is 30.39°C.

It is found that the comfort temperature derived from the simulation method and empirical methods are very similar and close to each other.

According **to the simulation method, the people are comfortable at 30.06°C**. The empirical method also proved this. Therefore, people are comfortable truly at 30.06-30.39°C. This is an exception to psychometrics chart. Thus the null hypothesis is rejected.
Thermal comfort in transitional spaces does not follow the psychometrics chart in hot and dry climate of Indian subcontinent.
The comfort zone defined in the psychometrics chart is between 20-26°C.

CHAPTER-4 NETCASE STUDY

CASE STUDY-2

ATRIUM OF GLAMORGAN UNIVERSITY (AGU) ,UNIVERSITY OF SOUTH WALES

- Atrium is in a campus of University of Glamorgan, Cardiff, and Wales. It is CCI (the Cardiff School of Creative & Cultural Industries), the home to one of the University's five faculties.

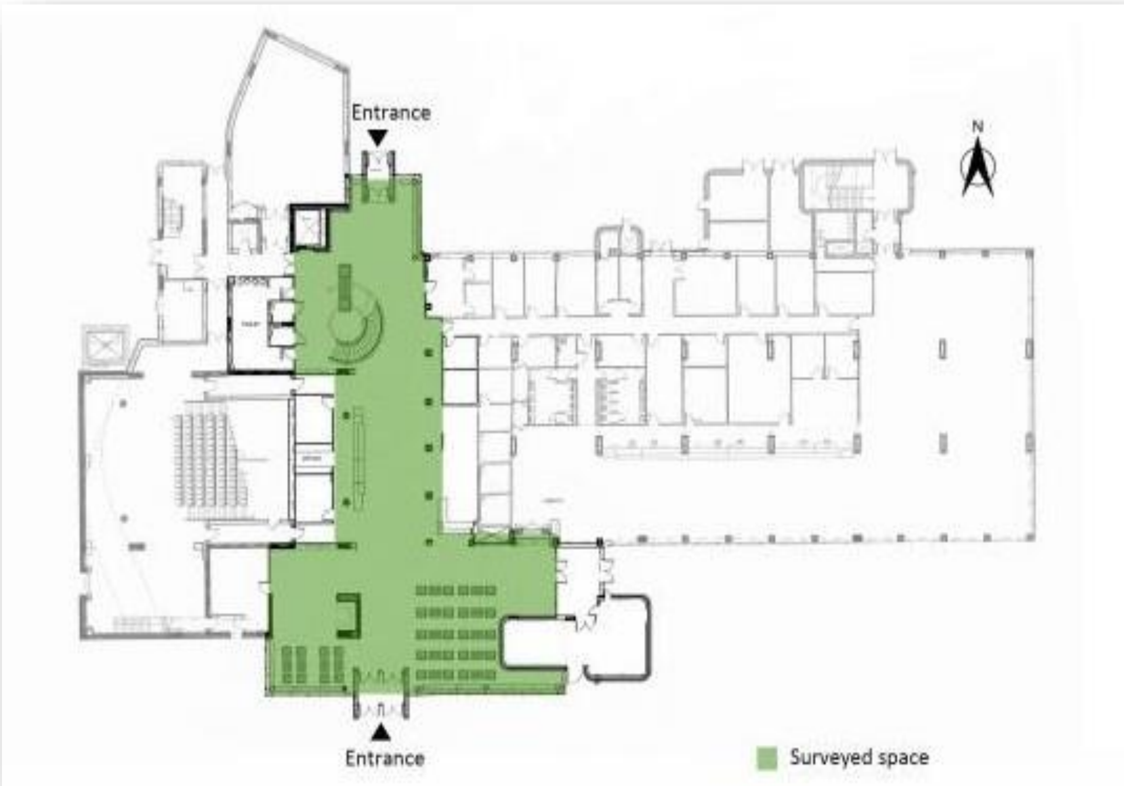
- This building is located on Adam Street, near Cardiff Queen Street railway station. The building includes a television studio, two tiered theatre, auditoriums, sound studios, learning resource centre and gallery etc.

- It comprises a refurbished former BT office block and a newly-built extension, linked by a glass atrium.

- The transitional space of this building includes four parts: corridor split the office block, a café, rest area connect to the library and a small rest area close to north door.

Figure 4.2 The case study building (ATU) and transitional space of ATU.

Methodology Two principal methodologies used in this study are questionnaires and physical measurements.



DEMOGRAPHIC STUDY OF ATRIUM OF GLAMORGAN UNIVERSITY (AGU):

1 To evaluating the thermal environment of each field study case in both seasons;

2. **To investigating occupants' thermal perception in each studied indoor transitional space case;**

3. **To evaluating the relationship of thermal environment and actual thermal sensation in indoor transitional spaces.**

Elements	Category	AGU Winter (%)	AGU Summer (%)
Gender	Female	54	42
	Male	46	58
Age	16-24	80	35
	25-34	14	25
	35-44	2	17
	45-54	2	16
	55-64	2	6
	65-74	0	1
	74over	0	0
Occupantion	Student	84	51
	Skilled without degree	8	40
	Skilled with degree	8	9
Frequency of visit	Almost everyday	18	22
	Several times per week	57	19
	A few times per month	9	12
	Rarely	11	26
	None	5	21
Dwell time	Less than 20 minutes	1	7
	More than 20 minutes	99	93

THE KEY CHARACTERISTICS AND SURVEY TIME OF CASE STUDY BUILDING.

Name of Case study Building		Atrium of Glamorgan University (AGU)
Date of building		2007
Business type		Academic
Building area		2490 m²
Transitional Space area		810 m²
External façade orientation		North
Type of windows		Double glazing
Open windows		No
Type of building service	Winter	Electrical under floor heater
	Summer	Air cooling mechanism
Number of inward opens		7
Number of and outward opens		3
Surveyed period	Winter	09:00-17:00
	Summer	09:00-17:30
Number of questionnaires	Winter	123
	Summer	122
Dates of studies	Winter	24,25,27,28,29,30, 31 January 2013
	Summer	29,30,31 July, 01,02,05,06,07 August

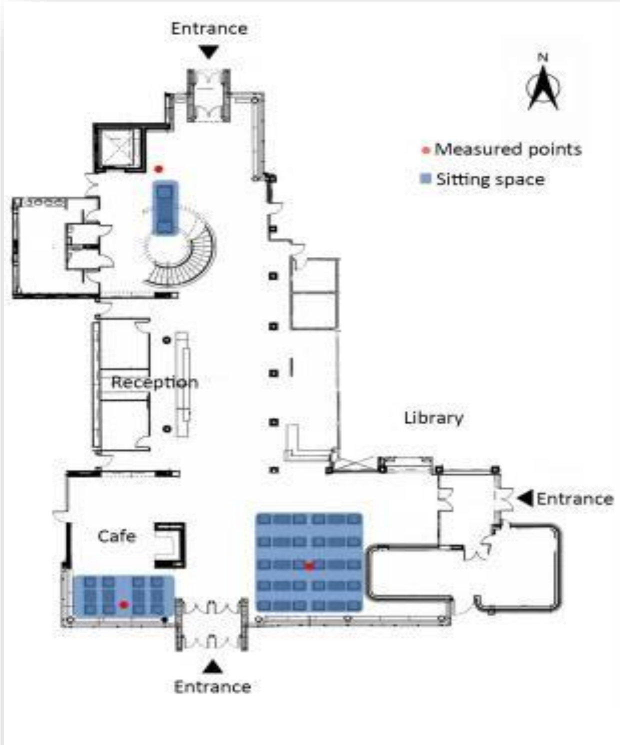


Figure 5.1 Plan of surveyed AGU transitional space.

THE OUTDOOR CLIMATIC PROFILE DURING AGU SURVEY

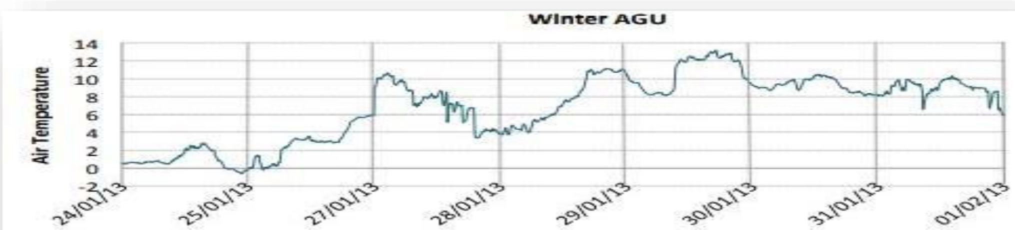


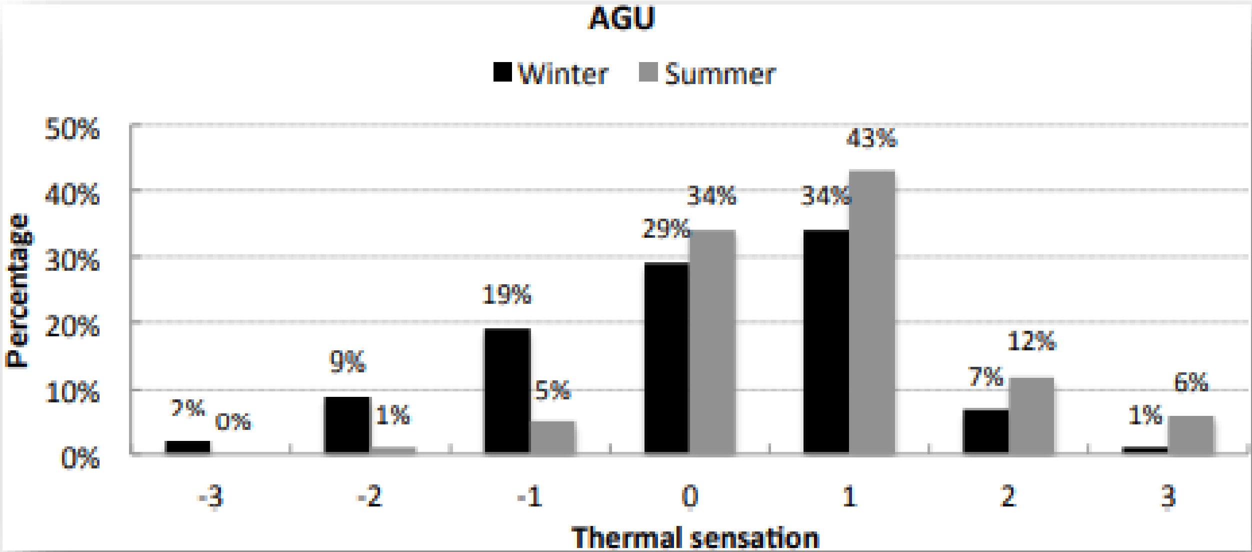
Figure 5.12 External air temperatures in winter during the field study of AGU.

External air temperature in summer during the field study of AGU

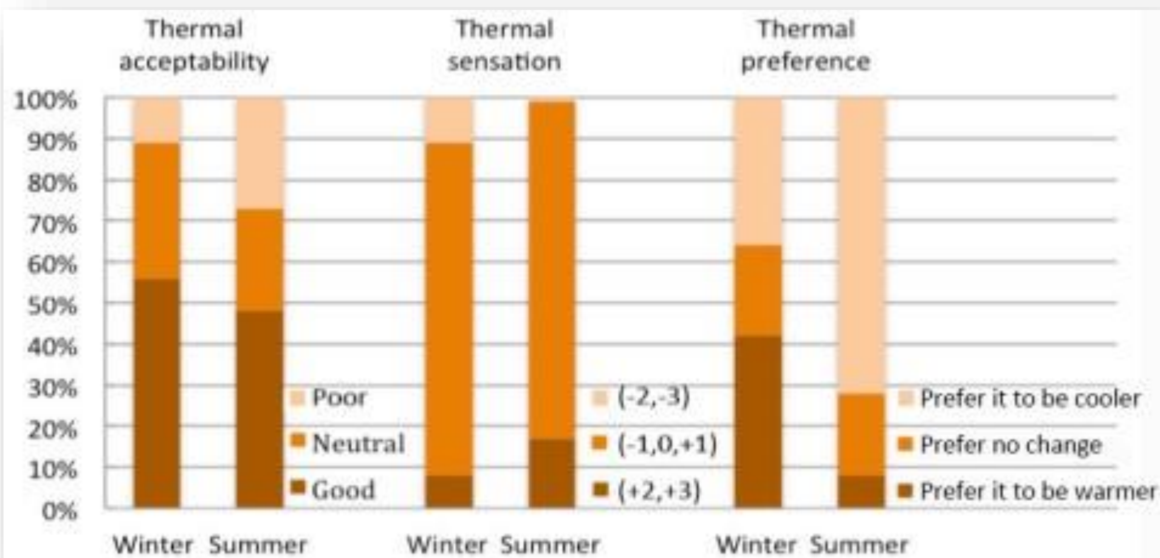
		Winter	Summer
		AGU	AGU
Air temperature (°C)	Mean	7.4	21.5
	Max	13.2	31.0
	Min	0.5	16.2
	SD	0.7	1.3
Humidity (%)	Mean	70.7	56.4
	Max	87.7	83.7
	Min	53.2	33.0
	SD	4.3	6.3
Air speed (m/s)	Mean	4.39	2.38
	Max	8.82	6.31
	Min	0.13	0.15
	SD	0.98	0.73

ANALYSIS OF PARTICIPANTS' THERMAL RESPONSE

- The PPD thermal comfort index is based on the assumption that people voting in the middle three categories (i.e. "slightly cool" -1, "neutral" 0, and "slightly warm" +1) of the 7-point thermal sensation scale are satisfied with their thermal environment.
- Extending the assumption to the AMV in this survey, 82% of the participants in winter and summer were satisfied
- With their transitional space thermal conditions.
- By logical extension, votes on +2 (warm), +3(hot), -2(cool), -3(cold) can be regarded as an expression of thermal dissatisfaction, which in this survey amounted 18% both in winter and summer.
- This indicates that the AGU transitional space, in which the survey was conducted, successfully met the industry- accepted minimum standard of 80% acceptability, as recommended in regulatory documents such as ASHRAE Standard 55



DISTRIBUTION OF THERMAL SENSATION IN AGU TRANSITION SPACE



COMPARISONS OF VARIOUS SUBJECTIVE RESPONSES IN AGU WINTER AND SUMMER

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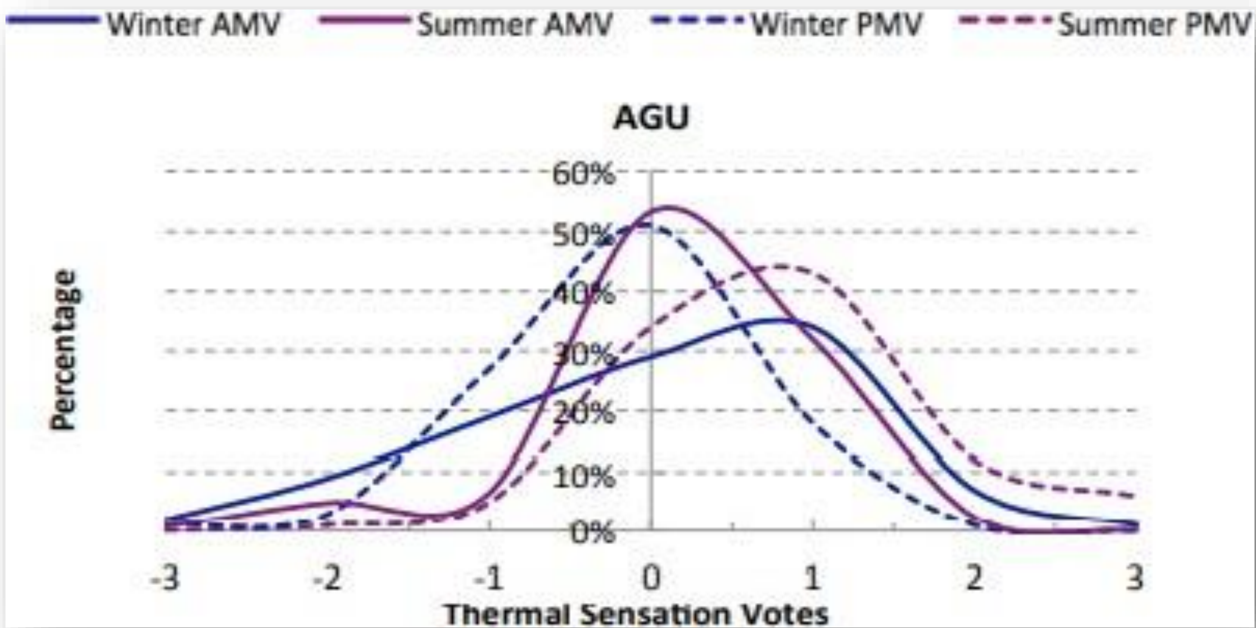
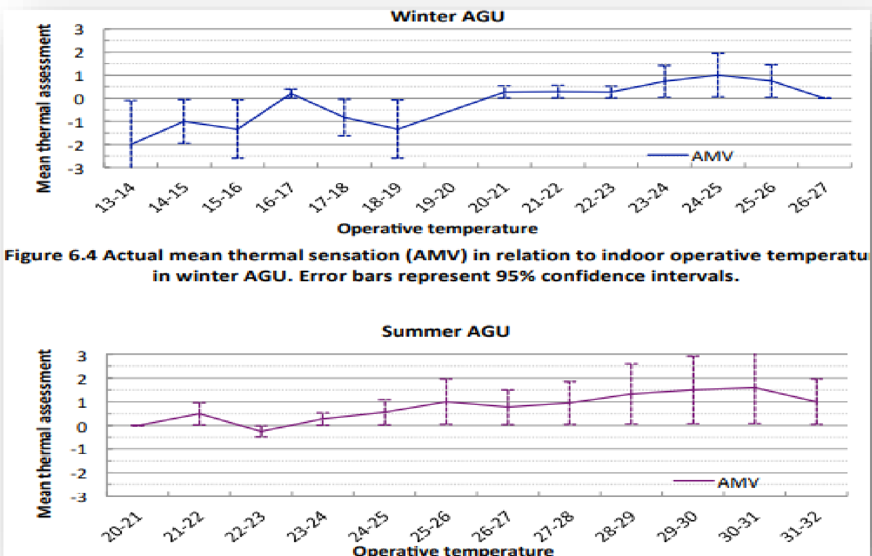
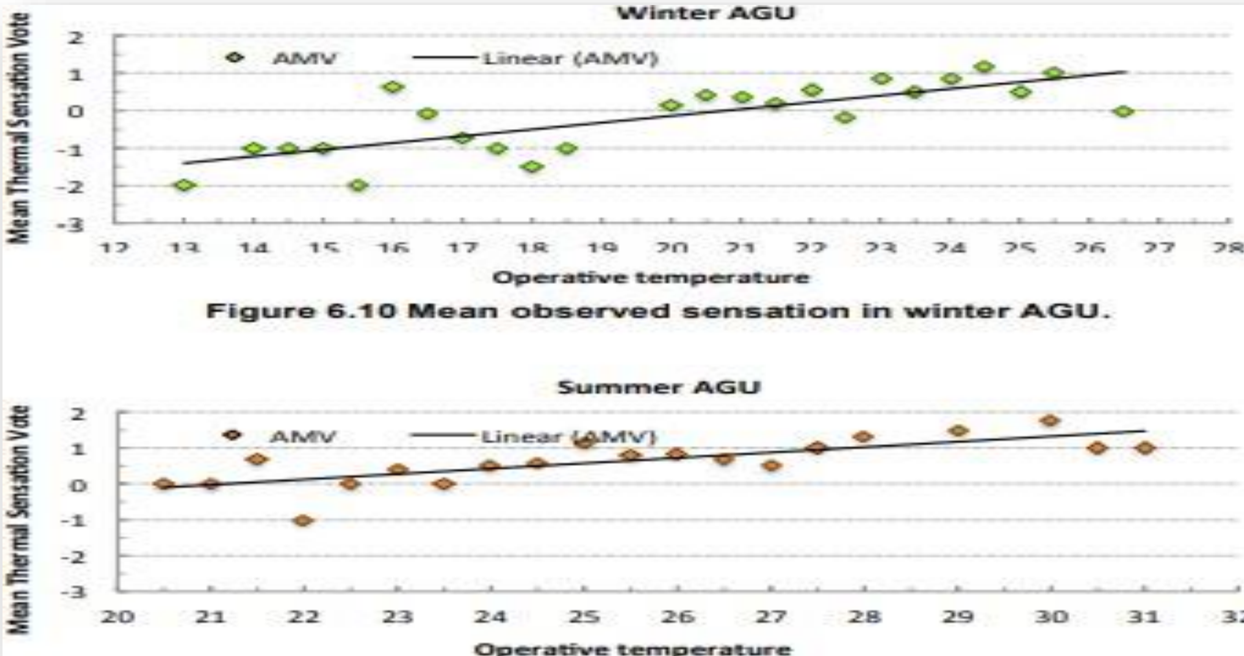




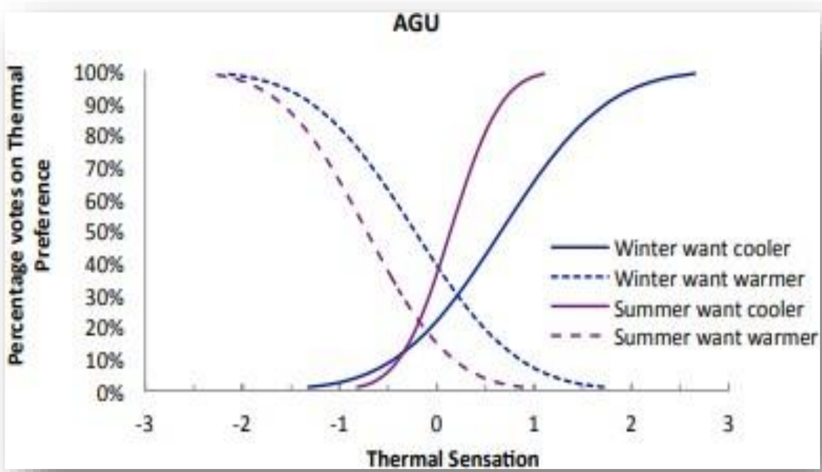
Actual mean thermal sensation (AMV) in relation to indoor operative

Temperature in summer AGU

MEAN OBSERVED SENSATOIN IN SUMMER AGU

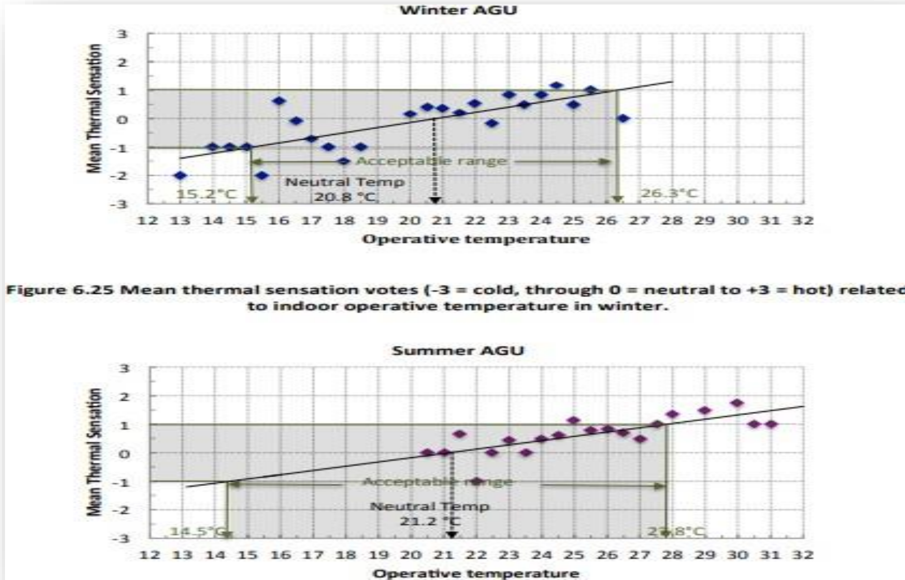


Preferred Sensation and Temperature in AGU

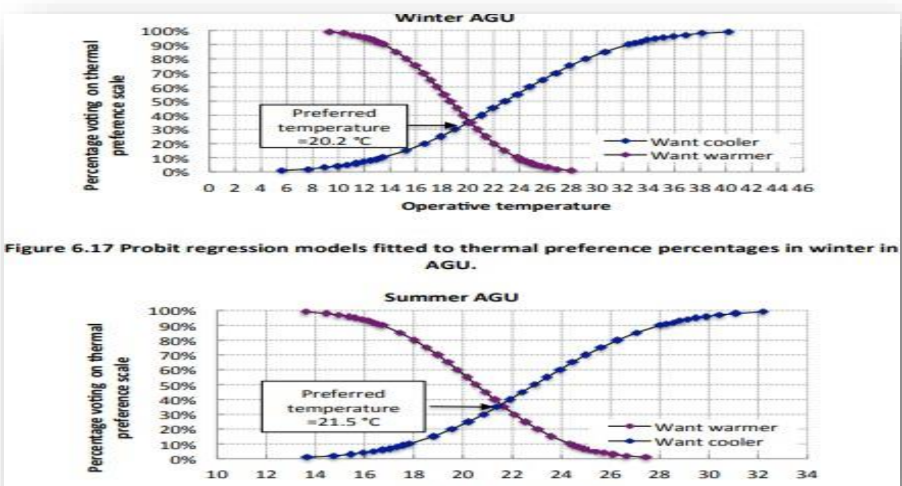


Preferred Sensation and Temperature in AGU

Thermal comfort range



Mean thermal sensation vote (-3=cold, 0 is neutral, +3 is hot related to indoor operation temperature in summer



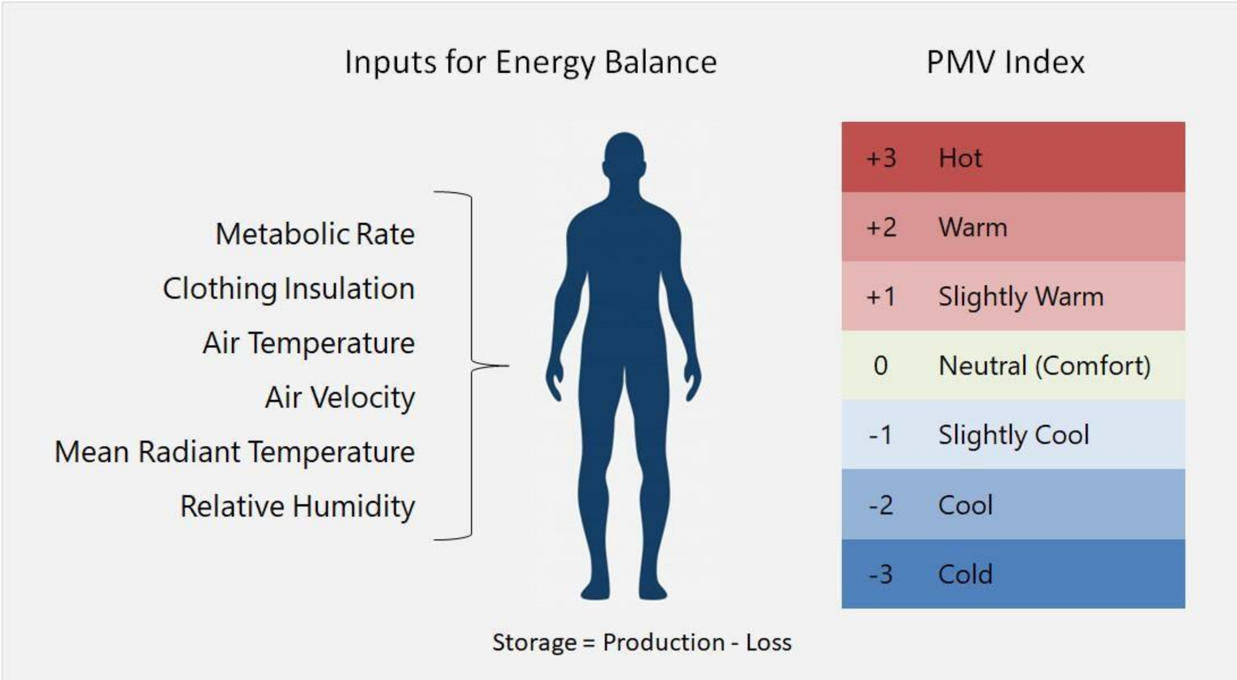
NETCASE STUDY 2:

Addressing research questions and objectives there are three questions this study attempts to answer as already mentioned in the introduction of this thesis:

- How relevant is the adaptive thermal comfort model to indoor transitional spaces? 204
- How do thermal conditions influence people's use of indoor transitional space?
- Whether people will accept lower temperature (requiring less energy) in indoor transitional Space than in other types of spaces?

Therefore, the following set of objectives was developed

1. to investigate the occupants' comfort perceptions in indoor transitional spaces;
2. to measure and compare neutral temperature, preferred temperatures and comfort temperature range of the occupants in different indoor transitional spaces, using the mean thermal sensation vote responses;
3. to investigate the relationship between the environment parameters and the actual sensation vote in different indoor transitional spaces;
4. to examine the influence of thermal condition on the use of indoor transitional space;
5. to examine physical and psychological factors that affect thermal adaptation between different transitional spaces by studying behaviour of people; and
6. To decide whether occupants have lower comfort expectations for transitional spaces that could lead to savings in energy consumption.



CHAPTER-3 LIVE CASE STUDY AND ANALYSIS

VIJAYA FORUM MALL

TRANSISTION SPACE IN FORUM MALL

Forum Vijaya Mall is a shopping mall located in Vadapalani, Chennai, Tamil

Nadu, India, developed by Prestige Group. This mall has approx 650,000 square feet of retail space. More than 100 shops occupy its four floors.

This mall distinguishes itself by being local by housing Chennai-based brands in the mall such as Spar Hypermarket, RmKV, Lifestyle, Max, Marks & Spencer, Westside, Fab India and Via South.

- Three broad types of transition space can be identified: entrance areas and other spaces with strong connections to the exterior; interior circulation spaces with greater compartmentalization separation from the exterior; and semi-occupied spaces with secondary uses in which it can be assumed occupants will gather for a longer period of time.

- Atrium spaces are included (range of between 10% and 45%)

ADDRESSING RESEARCH QUESTIONS AND OBJECTIVES

There are three questions this study attempts to answer:

- How relevant is the adaptive thermal Comfort model to indoor transitional spaces?
- How do thermal conditions influence

- People’s use of indoor transitional space?
- Whether people will accept lower temperature (requiring less energy) in indoor transitional space than in other types of spaces?

FUNCTION OF TRANSITIONAL SPACE

Transitional spaces can increase the available range of thermal zones so that people can select the micro climates most suited to their thermal needs. In this context, transitional spaces have become an important architectural form in citizen’s life.

Transitional spaces are used widely in the city depend on the function as follows:

Shelter from rain and sunshine:

The original role of public building transitional space was to keep out the rain, and in hot summer, block out

Sunshine and reduce the solar radiation using devices such as a canopy.

Traffic guidance space:

Public building transition spaces not just acts as a traffic hub between external and internal spaces, it also played as transport guidance

Enrich building facade and space level:

Public building transition space is a subsidiary part of the main building, with very flexible form and can enrich the effect of facade of the building .

Transfer of visual, auditory, tactile:

When people move through interior, transitional and exterior spaces, these three different Environments cause the changes in physical sensations

Psychological aspects of experiencing transition spaces:

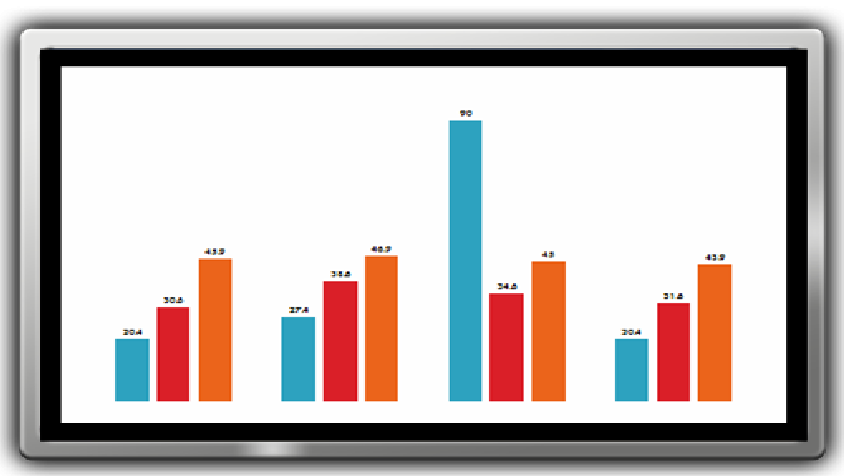
Public building transition spaces work on human psychological functions mainly for suggesting that people behave transformation and transition space can give people a sense of security, so as to give people a sense of feeling pleasure

Provide space for social communicating:

Transitional space within and outside public buildings, both connected to indoor environment and can easily observe the various outdoor activities.

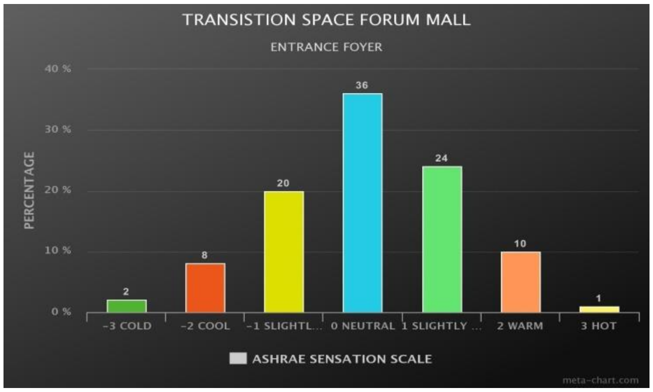
CHAPTER 4. Predicted Mean Vote (PMV)

- The predicted mean vote (PMV) is a well-known benchmark for evaluating thermal comfort in a building.
- We used the PMV to estimate the amount of thermal environments, and the characteristics of the participants in our study could be fitted to a particular climate zone.

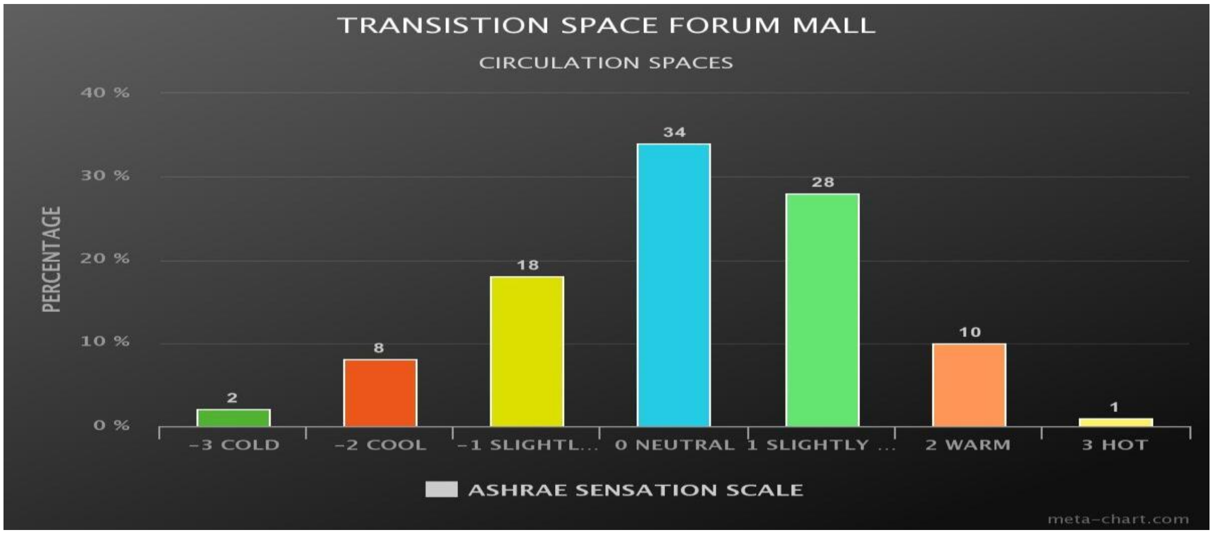


THE ENTRANCE ZONES

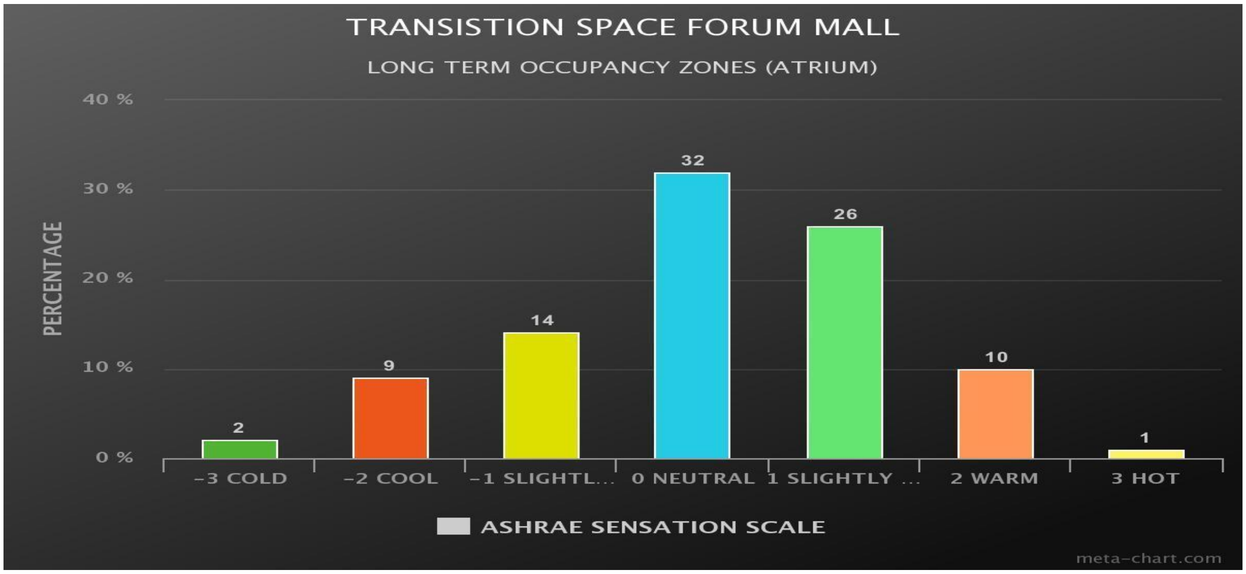
- PMV is calculated as per ashrae sensation scale where markings like -3,-2, - 1,0,1,2,3.
- Provided in which - 3 is cold -2 is cool -1is slightly cool 0 is neutral 1 slightly warm 2 is warm 3 is hot .
-



THE CIRCULATION ZONE



LONGER-TERM OCCUPANCY ZONES (SUCH AS ATRIUM):



THERMAL DISCOMFORT SENSATION IN TRANSITION SPACES

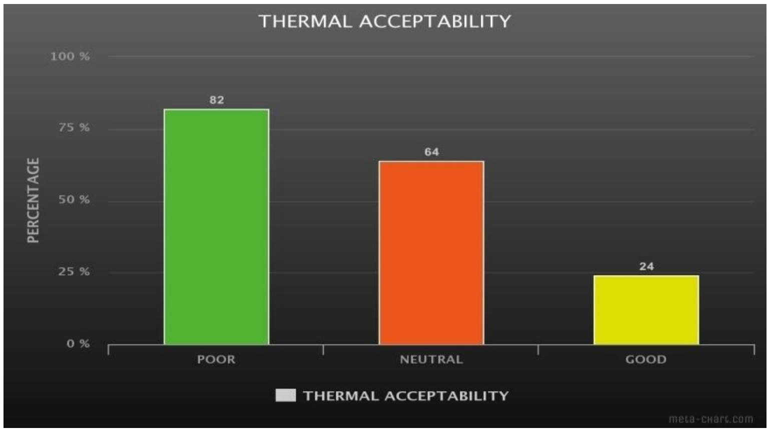
Thermal discomfort is not just a lack of satisfaction with the ambient temperature but. Reflects a situation where there is a potential threat to health.

The parameters were too hot

, too cold, too little sunshine, too much sunshine.

THERMAL ACCEPTABILITY

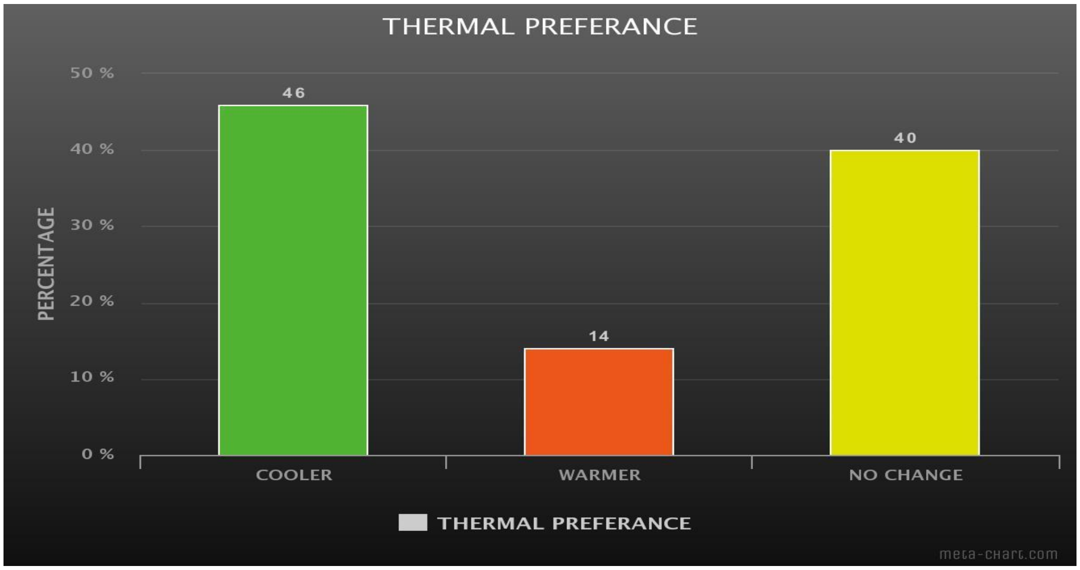
Thermal acceptability determines whether the current thermal conditions are considered to be acceptable The parameters where (poor, neutral and good)



THERMAL PREFERANCE

Thermal preference is intended to determine if and how a subject would prefer the thermal conditions to change.

The parameters were cooler, warmer, no change



CHAPTER-5 ANALYSIS

Factors influencing thermal sensation

A. Changing place

Since very little can be done to modulate temperature environment, in addition to clothing adjustments, moving from uncomforted area to comfort area is another way by which participants adapt to mitigate their thermal conditions.

Moving from direct sunlight to shade or from draft area to no draft area is the common form of adaptation seen during the observations.

B. Experience and expectations

Comparing the neutral and the preferred temperatures and the time spent by participants in the transitional space is employed as the way to evaluate the effects of expectations and experience on thermal sensation. The small difference between the neutral and preferred temperatures illustrates all indoor

Transitional spaces created similar expectations of thermal environment conditions

C. Attendance and Activity

The analysis of thermal preference depends on the stay reason in case shows that the participants 'thermal perception has a close relationship with participants'

The stay reasons in the indoor transitional spaces. People stay in the space care more and more sensitivity to the thermal environment than people just passing through the space.

D. Visiting frequency

People use this space not frequently feeling more uncomfortable than these people who visit it frequently and get used to the environment they stay in.

This evident the exits of thermal adaptation while the results of other two spaces indicate people who visit the space daily are more familiar with its thermal environment and less tolerant of thermal discomfort, it also explains the possibility that people visit these space rarely care less about the thermal environment there.

E. Visit duration

The results of evaluate relationship of thermal comfort and time of stay in indoor transitional space indicates that people stay in a space for a short time have a lower thermal preference rate than people stay in a space for a longer time.

F. Clothing:

Clothing adjustments is an important and natural behaviour to improve thermal comfort. It plays an important influence on people's thermal adaptation in indoor transitional spaces.

The influence of clothing insulation level on participants' thermal perception is quite apparently in this study, for example, the lowest preference temperature has the correlated highest clothing insulation level.

SUMMARY OF STUDY FINDINGS

- The subjective thermal sensations, represented by actual thermal sensation vote were compared with the PMV as a heat balance model

- Therefore, this finding expands the existing knowledge and provides evidence that indoor transitional spaces' thermal comfort merely depends on physiological approach for evaluating.

- Other factors as behavioural and psychological adaptation explain the different between the actual thermal sensation and the calculated thermal sensation bases on steadystate models such as PMV.

- Field study and surveys were conducted to investigate the thermal performance of indoor transitional spaces in commercial buildings and variations of subjective responses.
- It was found that an opened area is easily influenced by variable weather conditions as it is close to natural environment while an enclosed one is totally separated from the exterior environment and commonly air conditioned.
- This may lead to different subjective thermal responses in these types of spaces. It was also discovered that people can accept wider thermal environment in transitional spaces and their thermal response varies with dressing, activity level, past thermal experience and prior thermal preference.
- It is believed that the current comfort standards and criteria are not designed for transitional spaces.
- The proposed thermal comfort ranges for transitional spaces were examined using PMV
- If the transitional spaces are designed with appropriate energy saving strategies such as passive
- Design, hybrid ventilation and flexible HVAC controls, it can help achieve more energy efficient and healthy buildings in the future.