International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 6, Issue 2, pp: (149-160), Month: October 2018 - March 2019, Available at: www.researchpublish.com

Thermal Comfort Report for Student Residential Building

Usman Abudllahi Zakari[1], Halil Alibaba[2]

[1]Faculty of Architecture, Department of Architecture, Eastern Mediterranean University, Mersin 10, Turkey

Abstract: **Building Structures devour 40% of aggregate vitality and around 48% of which is devoured by Warming Ventilation and Cooling (air conditioning). This features the significance of creating vigorous and dynamic Building Monitoring Systems (BMS) that are fit for giving the ideal task of central air frameworks regarding expanding warm solace of building inhabitants while limiting vitality utilizations. Various experimental investigations have shown that tenant conduct is a key calculate hidden vitality utilization existing structures. In any case, barely any dependable informational indexes exist recording exact human exercises and their related inhabitant comfort levels inside buildings. Besides, little on the off chance that anything is thought about how this data straightforwardly identifies with building vitality execution. This research documents ongoing development of software prototype tools for modeling thermal comfort in buildings based on real-time occupant and building systems data.. The results help building proprietors to distinguish territories that require enhancements concerning warm solace with more extensive effects that enhance tenant profitability, solace, and prosperity. The essential specialized commitment is to display human solace on the building level dependent on genuine tenant utilization, with the end goal to recognize and target vitality effectiveness estimates that advance vitality use as per comfort as opposed to most extreme vitality reserve funds alone. Future research will blend building inhabitant and sensor information to help relapse examination that may recognize the relationship of the detailed warm solace, exercises of building tenants, and building conditions. Such information may likewise be utilized to create calculations for controlling inside lighting, deplete fans, ventilation, and central air temperature set focuses that streamline comfort while limiting vitality requests. In order to understand the current conditions of the thermal sensation and the environment control actions in different climate zones of the student residential building, a questionnaire survey was given in the building during extreme weather in winter.**

Keywords: **Indoor thermal Environment, Building Occupants, Questionnaire, Energy Performance, Environment control strategy.**

1. INTRODUCTION

Building area represents 40% of essential vitality utilization in the Assembled States while operational vitality utilization inside building is the biggest contributing variable. Various experimental examinations have shown that inhabitant conduct is a key consider basic vitality utilization existing building. In any case, scarcely any solid datasets exist reporting exact human exercises and their related inhabitant comfort levels inside buildings. Moreover, little is thought about how this data specifically identifies with building vitality execution. A few examinations have been produced to comprehend inhabitant conduct and warm solace and additionally their effect on building vitality utilization. These incorporate assessing the effect of tenant conduct on vitality utilization of private workplaces utilizing building recreation.[1], assessing the exactness of inhabitance displaying utilizing different surrounding sensor factors and distinguishing the commitment of every sensor variable on the demonstrating results.[2], understanding inhabitant conduct in a place of business by detecting every day exercises and their communication with building vitality gadgets which distinguished 38% potential vitality reserve funds because of killing machines when not being used.[3], exhibiting the effect of inhabitant conduct vulnerabilities on building vitality utilization utilizing parametric recreation of business and private structures which demonstrated noteworthy effect on yearly vitality use.[4], building up a structure to comprehend comfort profiles of building tenants in the central air control circle and control air conditioning framework dependent on

inhabitants' customized solace profiles which demonstrated a relative controller calculation that is fit for keeping the warm zones' temperatures in the scopes of favored temperatures.[5], what's more, building up an operator based way to deal with record for the jumpers and dynamic vitality utilization designs among inhabitants in business structures which indicated 25% variety in the anticipated vitality utilization of a place of business.[6].

Besides, a few models and devices have been created to assess and enhance warm solace of building tenants, including a warm solace device by community for the constructed condition that is fit for assessing solace of building inhabitants as indicated by ASHRAE standard-55 which prompts low-vitality plans.[7]; Multi-Specialist Solace and Vitality Reproduction (MACES) to display elective administration and control of building frameworks and tenants to decrease building vitality utilization while keeping up tenant solace.[8]; multi-operator based savvy control framework for accomplishing compelling vitality and solace administration in building condition which is equipped for encouraging the cooperation among building and tenants.[9]; furthermore, inhabitance checking framework that is equipped for distinguishing indoor temperature, stickiness, CO2 focus, light, entryway status, sound and movement in an exertion of supporting interest driven air conditioning activities.[10].

In spite of the noteworthy commitment of the current investigations and models of understanding and enhancing warm solace of building tenants while limiting vitality request, there is constrained or no exploration that concentrated on assessing the general warm solace execution of structures in a scalar grid dependent on tenant input and building frameworks information. This paper talks about the on-going improvement of a warm solace report card and programming model devices for displaying warm solace in structures dependent on constant tenant criticism and building frameworks information. A portable application is being created for ware cell phones to naturally accumulate information on tenant conduct at the action level, their apparel, and also seen warm solace. While acknowledgment of exercises will be done naturally, the building tenants will utilize the created cell phone application to report their garments and dimension of warm solace in each room over some undefined time frame. The aftereffects of warm solace investigation is conveyed in a building "warm solace report card," which will exhibit room-by-room comfort levels through time and a building warm execution yearly normal, in view of real utilization designs. All the while, indoor ecological conditions is gathered using different building sensors over some stretch of time. The coordinated information from building tenants and sensors is being utilized to build up a measurement for assessing warm solace of building inhabitants. Later on, this measurement will be approved utilizing gathered criticism information identified with apparent solace.

2. ASSESSING THERMAL COMFORT OF BUILDING OCCUPANTS

Most buildings presently depend on the business guidelines, and expect that warm solace in building is being met as indicated by American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standard uses Anticipated Mean Vote (PMV) as a warm solace record that surveys and guarantees tasteful natural conditions amid building inhabitance. The PMV is intended to measure the normal building inhabitant comfort recognition dependent on two suppositions apparel levels, and metabolic rates, combined with four other indoor conditions including air temperature, dampness, brilliant air temperature, and velocity to anticipate warm solace in structures. By and large, these six parameters are changed in accordance with guarantee that an explicit least dimension of Predicted Percentage Dissatisfied (PPD) is accomplished in the plan of structures.

In spite of the progressions in Building Management Systems (BMS) and the ongoing exploration in versatile building control frameworks, the PMV file and air-quality levels are the most widely recognized strategies to keep up tenant solace in structures without thinking about the genuine inhabitant inclinations and their solace levels. Another warm solace report card is proposed in this exploration to assess the warm solace of building inhabitants which will introduce room-by-room comfort levels through time and a building warm execution yearly normal, in view of real use designs. This framework sets the solace levels of building inhabitants dependent on the six parameters distinguished by the ASHRAE Standard 55 out of 2010 [20]. As of now, in any case, ASHRAE Standard 55 assesses a space in a double design, as either meeting warm solace necessities (falling inside the endorsed locale on the psychometric diagram) or not [10]. The new warm solace report card requires a scalar measurement. In this way, comfort level limits are distinguished in the temperature-relative mugginess diagram dependent on these six parameters, which are isolated into 11 zones of various solace levels. These 11 zones are spoken to with a score that ranges from 0.0 to 10.0, as appeared in Table 1. The most elevated score (10) speaks to the most safe place that is recognized by the ASHRAE Standard 55 (2010) with a zero PMV esteem which brought about 5% PPD [20]. The solace score diminishes as the mix of dry globule temperature and relative dampness go amiss from the recognized line of zero PMV. The most minimal score (0.0) is spoken to with PMV

estimations of (≥2.50) and (≤-2.50) that outcomes in PPD higher than 93.5%. For instance, the safe place of ASHRAE Standard 55 for indoor states of air speed 0.1 m/s, garments 0.5 clo, and metabolic rate 1.1 met is featured with light green zone which compares to PMV estimations of (0.5) and (- 0.5) as appeared in Figure 1. When these four variables are set (deciding the edge of the safe place as indicated by different measurements), the 11 zones of warm solace can be distinguished for these natural conditions by recognizing the dry knob temperature dependent on different relative moistness esteems (0– 100%) that outcome in PMV values as appeared in Table 1. It ought to be noticed that, the safe place that is recognized by the ASHRAE Standard 55 [10,20] is spoken to in this model with score that ranges from 8.0 to 10.0, as appeared in Figure 1. In light of the distinguished 11 zones, a solace score can be recognized for a predetermined indoor states of the dry knob temperature and relative moistness, once more, accepting recommended values for the other four elements. For instance, a dry knob temperature of 26°C with 55% relative moistness, as appeared in Figure 1 for point A, compares to a solace score of 9.0.

Table 1: Thermal Comfort score and their accociated PMV and PPD

Score	PMV (+)	PMV (-)	PPD (%)
10	0	0	5
9	0.25	-0.25	6.3
8	0.50	-0.50	10.0
7	0.75	-0.75	16.9
6	1.00	-1.00	26.3
5	1.25	-1.25	37.9
4	1-50	-1-50	51.1
3	1.76	-1.76	64.6
2	2.00	-2.00	76.9
1	2.25	-2.25	86.8
0	>2.50	<-2.50	>93.5

The new report card is being created for buildings utilizing this scalar measure to speak to warm solace of building inhabitants. Thusly, it is fit for introducing room-by-room comfort levels through time and a building warm execution yearly normal. In particular, this report card utilizes the previously mentioned scoring strategy to distinguish the solace score (instead of the double "agreeable" "uneasy" appraisal) for every inhabitant in the building. A room score is then determined dependent on the normal solace score of every inhabitant in the room.

This room score will represent the accounts of the building information and ecological conditions to figure the solace score occasionally. A normal solace score is determined for every inhabitant in the room which speak to the solace dimension of the building tenant over some stretch of time. The general Building Thermal Comfort Score (BTCS) is determined dependent on the room territory (artificial intelligence), building region (An), and warm solace room score (RSi), as appeared in Condition (1). This general solace score speak to the solace dimension of the building dependent on the solace score in each room/space that is determined over some stretch of time and the span of the room when contrasted with the building surface zone. For instance, a warm solace report card can be created and envisioned for an office, as appeared in Figure 2. This report card demonstrates the rooms/spaces that have the most elevated solace levels, for example, the hall room, and the rooms/spaces that have the least solace levels, for example, office # 1 which is in earnest need of enhancing its solace levels. The general solace score of the building is determined as 6.5 out of 10 which can be increment at first by enhancing solace levels in office # 1. This can be performed by investigated the assembled information of the building and the natural conditions and deliver the building needs to enhance the warm solace in territories of poor solace scores. The suggestions of the warm solace report card to enhance the general warm solace score of the building can be sent to the building tenants utilizing the cell phone application.

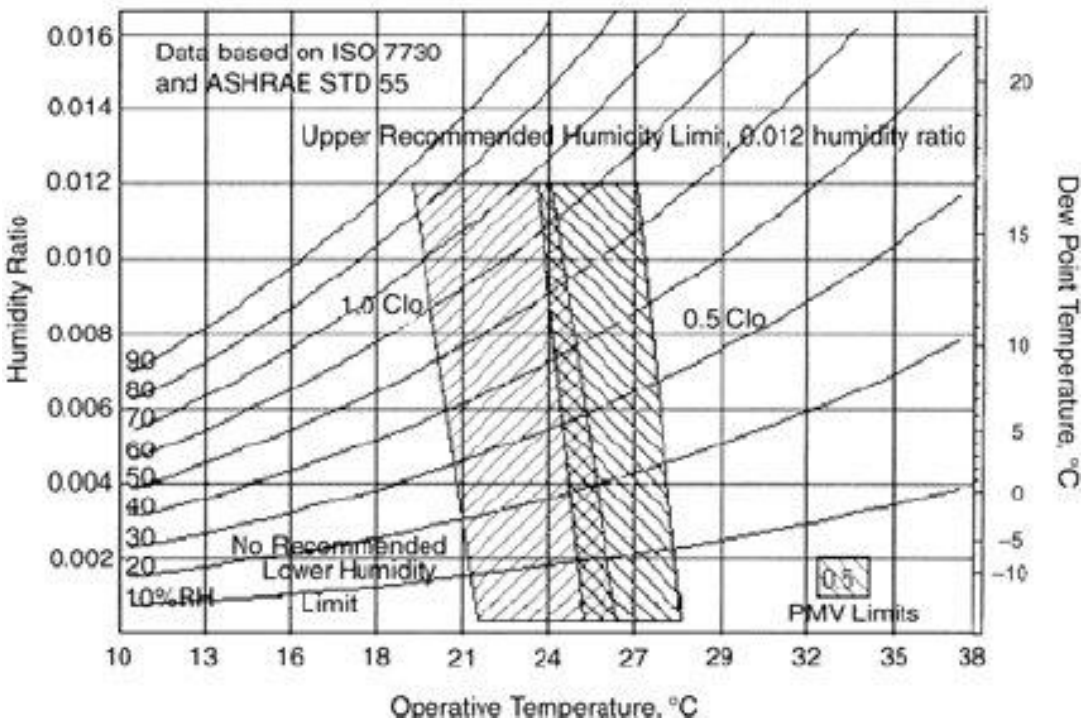

Figure 1.

Thermal comfort scores of building occupants as assessed according to the frame set by addition four ASHRAE Standard 55 factors

Where n is number of rooms/spaces in the building, A_i is surface area of room/space $_{i,\ A}$ is building surface area RS_i, is thermal comfort room score of room/space $_i$.

A is building area excluding unoccupied spaces such as vestibule entrances and corridors.

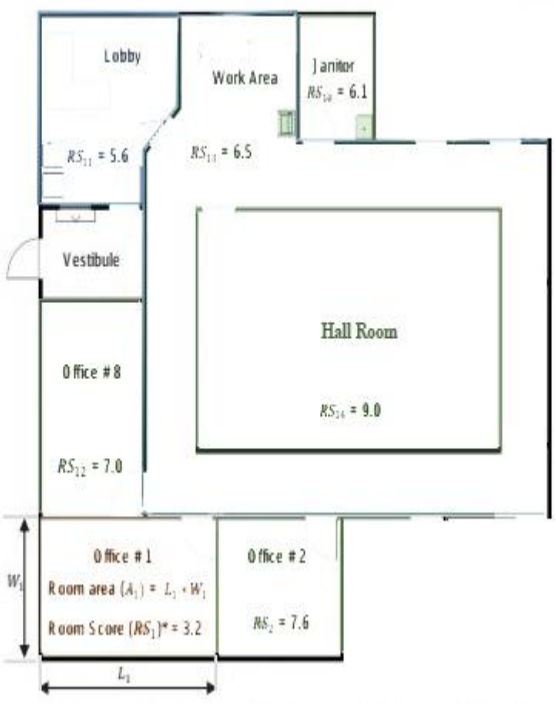

Figure 2: Example thermal comfort report card visualization

3. MEASURING THERMAL COMFORT

Warm solace report card scores and assesses the solace execution of structures dependent on the six parameters that are distinguished by the ASHRAE Standard 55 out of 2010 [20]. The information of these parameters will be gathered dependent on BMS, sensors, and cell phone applications. The drybulb temperature and stickiness will be gathered utilizing temperature and moistness sensors that are introduced in each room of the building and are associated with the BMS. The temperature and moistness in each room will be measures and recorded occasionally (e.g. each 1 hr.) in a framework database. The brilliant temperature will be measures and recorded utilizing brilliant temperature sensors that are introduced close to building inhabitants. Wind stream meters will be utilized to quantify velocity in each room of the building. The estimations of metabolic rates and apparel are recognized dependent on the ASHRAE Guidelines. The metabolic rates can be recognized dependent on the action level that are classified in the ASHRAE Guidelines, including resting, strolling, office exercises, driving/flying, incidental word related exercises, and different relaxation exercises. These exercises results in metabolic rate that ranges from 0.7 met units for resting to 8.7 met units for wrestling [20]. The building inhabitant will report their metabolic rate by choosing their kind of actives utilizing the cell phone application. The garments parameter of warm solace can be recognized dependent on the garments protection esteems for run of the mill groups in the ASHRAE Guidelines. The attire protection is separated into six areas with various protection esteems, including pants, skirts/dresses, shorts, overalls/coveralls, athletic, and sleepwear which ranges from o.57 clo for pants with short-sleeve shirt to 1.3 clo for suite coat, long clothing bottoms, long sleeve sweater, shirt, pants, and long-sleeve shirt [20]. Building tenants will report their garments protection esteems by choosing articles of clothing utilizing the cell phone application. The gathered information utilizing BMS and sensors will be incorporated with the cell phone information to figure the solace score for each room in the building and agreeing the BTCS. Besides, building tenants will report their solace level utilizing the cell phone application dependent on score that ranges from 0 to 10 where 0 speak to the most noticeably awful dimension of warm solace and 10 speak to the largest amount of warm solace. The detailed input from building inhabitants will be utilized to approve the created warm solace metric and enhance its precision and execution.

4. METHODOLOGY

4.1. Case Study and Questionnaire design.

QUESTIONNAIRE DESIGN; The overview of the survey aimed to record the occupants' perception of thermal comfort and environmental control strategies in a minute detail, and the questionnaire content mostly include common information of tenant, indoor thermal comfort and environmental control strategies, as shown in **Figure 6**. The common information section involves age, gender, current residence, which can conform random distribution of respondents and remove unnecessary data. The indoor thermal conditions were checked by voting the thermal sensation, humidity sensation and draught sensation using the assessment scale listed in **Figure 5**. The environment control approach includes individual behavior and also usage of the cooling devices. Individual adaptive behaviors includes 4 mainly behaviors: less clothing, hand fan, shower, and cold drink. An 'other' option which can be filled in by other adaptive behavior. Usage of cooling devices involves usage of air-conditioner and electric fan. Temperature setting is associate with the item 'whether turn on the air-conditioner'. Void data can also be eliminated if setting temperature is over 30℃ (Upper limit of temperature with cooling mode). Before filling out the questionnaire, the respondents were informed of objectives of the survey and the meaning of terminology in detail.

4.2. Result and Discussions.

A. Respondents

In total, 37 questionnaires were given out, in Uzun 14 apartment located in raif hassan sk. Magusa, Were the tenants all have different climate settings in there apartment. Respondents' age ranges from 15 to above 30 years old. The distribution of respondents' location were scattered floor by floor. Fig. 4 showed the age, gender, and weight of the respondents.

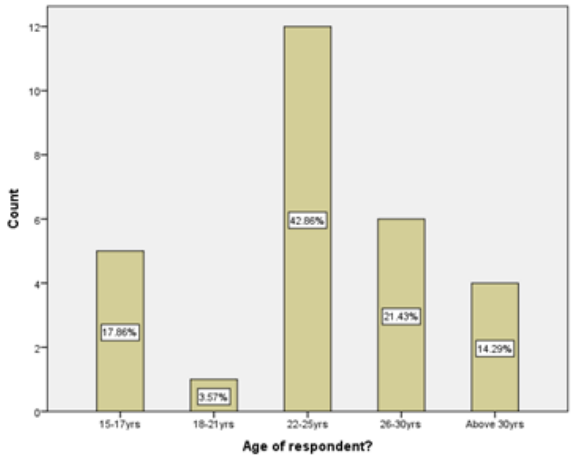

Fig. 4 (a)

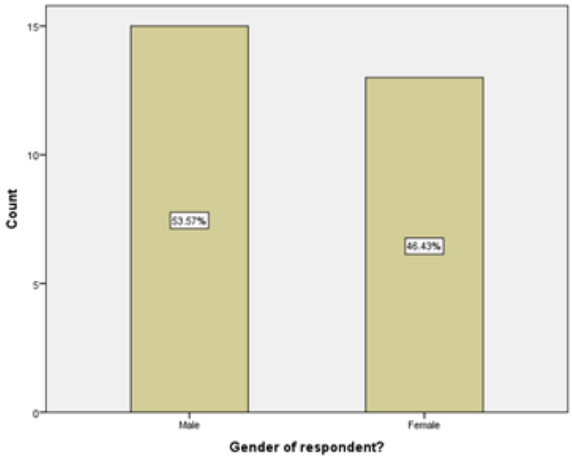

Fig. 4 (b)

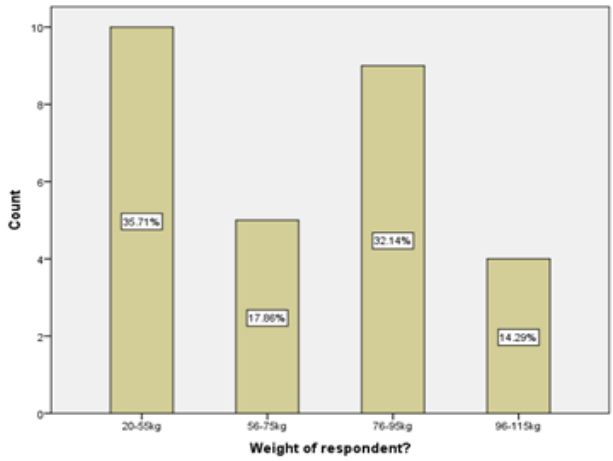

Fig. 4 (c)

According to the respondent result, 17.86% are 15-17, 3.57% are 18-21, 42.86% are 22-25, 21.43% are 26-30, and 14.29% are above 30 years old. While for the gender 53.57% are males and 46.43% are females in the apartment building of Uzun14. For the weight percentage of the tenant is as follows, 35.71% are 20-55kg, 17.86% are 56-75kg, 32.14% are 76-95kg, 14.29% are 96-115kg in weight.

B. Humidity Sensation

Fig. 5 show the distribution of questions in other to determine the indoor thermal environment of their apartment individually.

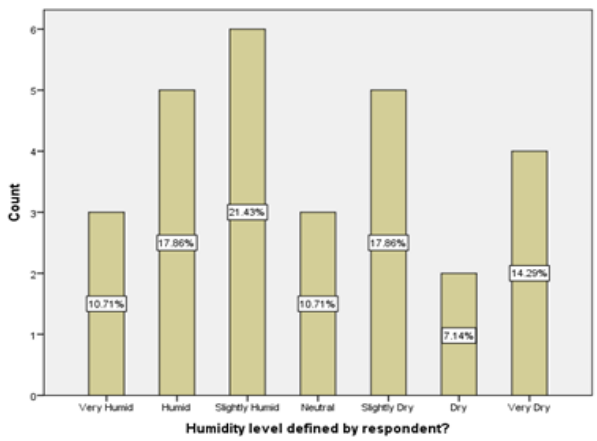

Fig. 5 (a)

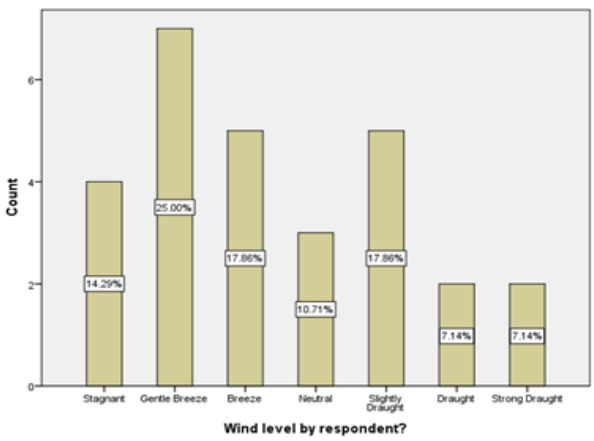

Fig. 5 (b)

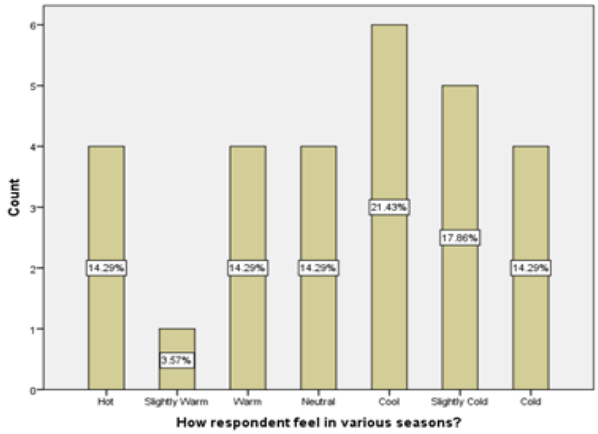

Fig. 5 (c)

From these fig. 5 it is clear that 10.71% voted for very humid, 17.86% voted for humid, 21.43% vote for slightly humid, 10.71% vote for neutral, 17.86% vote for slightly dry, 7.4% voted for dry, and 14.21% vote for very dry. In various seasons of summer, spring, winter, and fall seasons. While for the wind level it is clear that 14.29% voted for stagnant, 25.00% vote for gentle breeze, 17.86% voted for breeze, 10.71% vote for neutral, 17.86% voted for slightly draught, 7.14% vote for draught, and lastly 7.14% voted for strong draught in various seasons of the year.

C. Personal Adaptive behaviors

Fig. 6 shows the distribution of questions about adaptation behaviors it is mainly focus on behaviors of occupant's daily habits and activities round the clock.

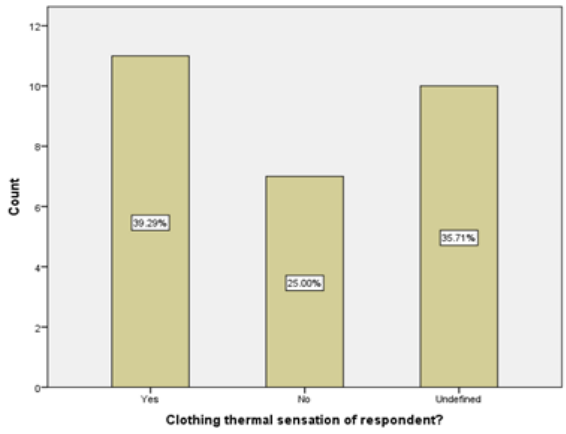

Fig. 6 (a)

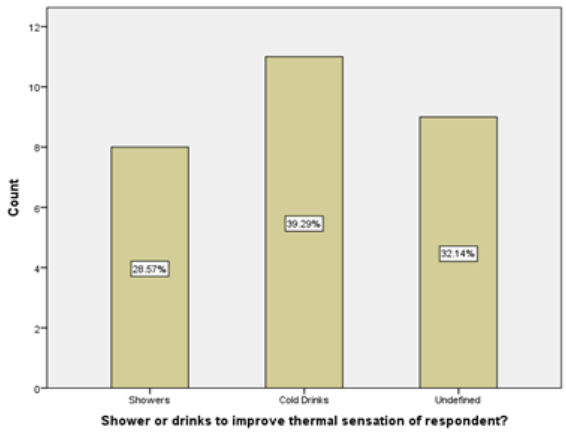

Fig. 6 (b)

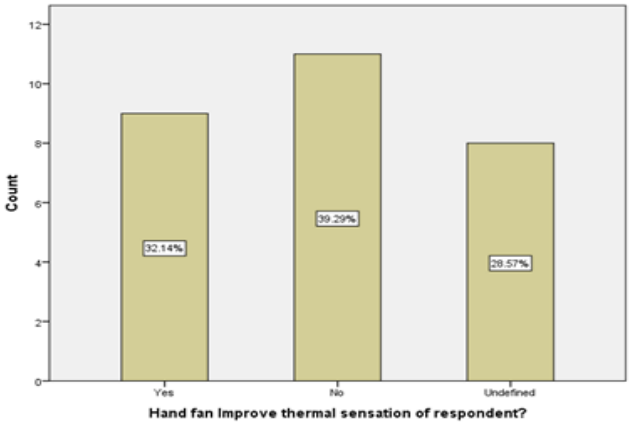

Fig. 6 (c)

As it is shown in fig. 6 (a) 39.29% of occupant in the building use less or more cloth to improve thermal sensation, 25.00% don't use that method for thermal sensation improvement, and 35.71% use other methods. 28.75% take showers for comfort, 39.29% take cold drinks, and 32.14% use other options to improve their thermal comfort in the building. 32.14% use fans to improve thermal, and 39.29% don't, while 28.57% tends to go for other options.

D. Usage of cooling devices

Fig. 7 shows the rate of air-conditioner use in the apartment individually, where the respondents were staying.

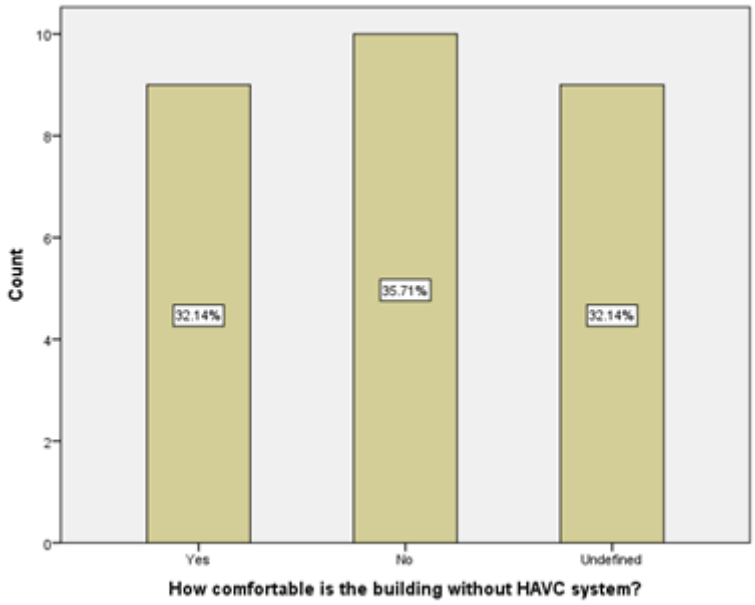

Fig.7

The result shows the level of air-conditioner users is a little lower at 32.14% compare to the rate of non-users which is at 35.71%, while 32.14% of the occupant says it don't really matter to them.

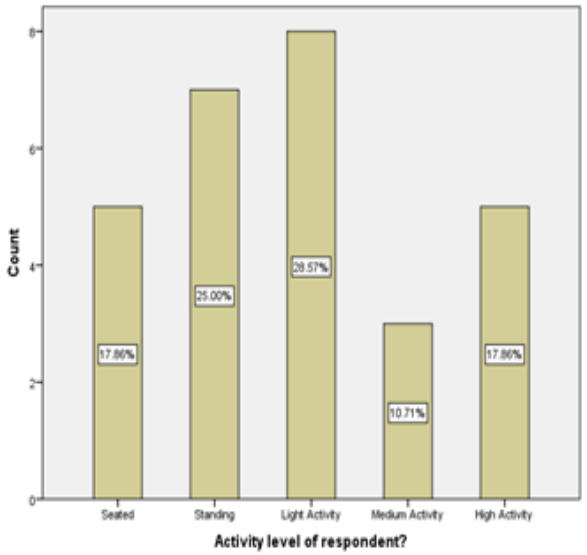

Fig. 8 (a)

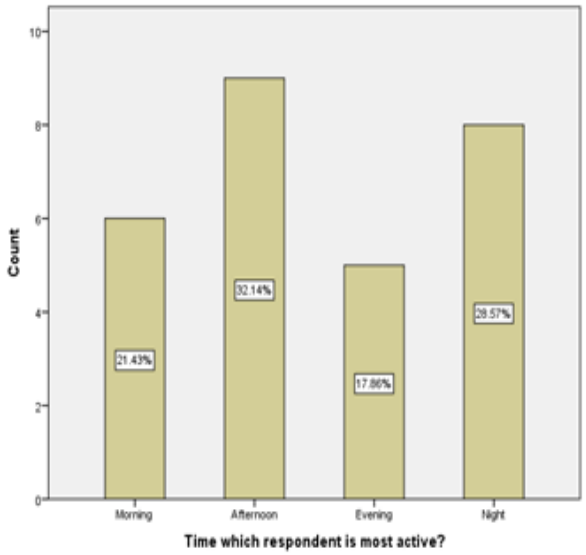

Fig. 8 (b)

Fig. 8 show the activity level of the occupants in the building, with 17.86% seated, 25.00% standing, 28.57% light activity, 10.71% medium activity, and 17.86% with high activity, and for the time of the day they are most active with 21.43% in the morning, 32.14% in the afternoon, 17.86% in the evening, and 28.57% in the night.

E. Satisfactory level of the thermal capability of the building

Fig. 9 show the rating and level at which the occupants of the building are satisfied with the, air quality, and temperature of the apartment building uzun14.

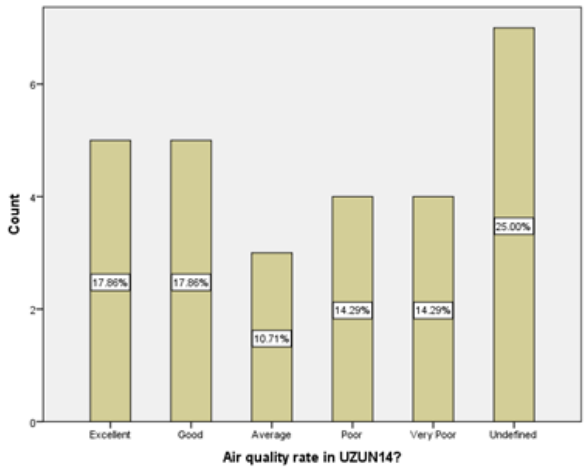

Fig. 9 (a)

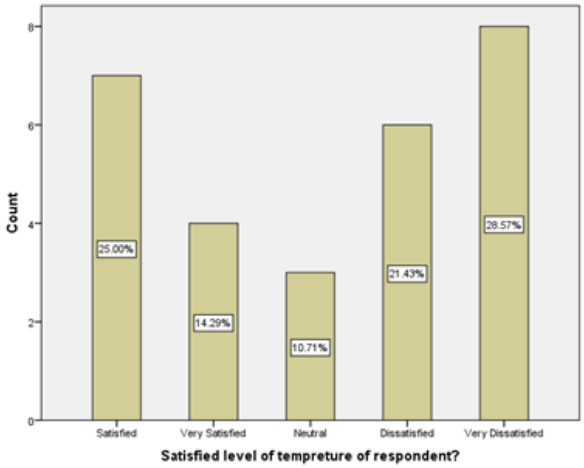

Fig. 9 (b)

The result shows, 17.86% of the tenants rate the building at excellent, 17.86% at good, 10.71% at average, 14.29% at poor, 14.29% at very poor, and mostly 25.00% rate the air quality of the building at undefined.

For the satisfactory level of the temperature of the building the tenant rate at, 25.00% satisfied, 14.29% at very satisfied, 10.71% for neutral, 21.43% at dissatisfied, and slightly more for very dissatisfied at 28.57%.

5. SUMMARY AND CONCLUSIONS

During the time spent on this study, a far reaching poll review on the individual reactions of warm recognition alongside versatile exercises was directed in three atmosphere state of the building. The investigation and overview of the paper results is:

- In general, the utilization recurrence of climate control system in 3+1 is somewhat higher than that in the other two. In any case, it is discovered that the reliance on climate control system in 3+1 and 2+1 is more vigorously than that of the 1+1in the north if going further into the examination of the connection between warm sensation and forced air system running.

- Reducing clothing protection is the most widely recognized adjustment conduct to enhance warm solace. Concerning the sexual orientation distinction, females are increasingly touchy to wind stream, in this way, contrasted and male respondents, progressively male respondents might want to utilize hand fans to enhance their warm solace.

This survey was mostly to understand the current indoor conditions of the thermal environment in hot summer days and cold winter times, and current position in other climate is understood as reference. The questionnaire survey in winter times and field study of indoor thermal environment in hot summer days and cold winter times will be conducted in following step. Meanwhile, merging with study of energy consumption, the whole study aims to regulate energy consumption under the premise of thermal comfort.

The paper also shows another way to deal with assessing human solace inside building. The created warm solace report card assesses by and large and discrete warm solace for building tenants dependent on room-by-room comfort levels through time and a building warm execution yearly normal. The proposed framework recognizes the warm solace of building inhabitants dependent on the six parameters distinguished by the ASHRAE Standard 55 including dry knob temperature, relative stickiness, brilliant mean temperature, air speed, metabolic rate, and attire level. These parameters are measures in structures utilizing BMS and sensors alongside cell phone application. The announced information of these parameters are utilized to distinguish 11 zones of solace levels which are spoken to with a score that ranges from 0.0 to 10.0 where 0.0 speak to the most exceedingly bad warm solace score and 10.0 hates the best warm solace score. A room comfort score is determined dependent on the normal solace score of all tenants in the room. The general warm

solace score of a building is then determined dependent on the room comfort score, room surface zones, and building surface territory. The execution of the created measurement for distinguishing warm solace of building tenants will be assessed, broke down, and enhanced by enabling building inhabitants to report their real warm solace levels with a comparable score that ranges from 0.0 to 10.0. The revealed criticism from building inhabitants will approve the created warm solace metric and enhance its execution. Besides, the examination of the revealed warm solace scores alongside the created measurements will give input on the real execution of ASHRAE Standard 55 dependent on inhabitant criticism and inclinations.

Fig. 10 showing the elevation view of the north

Fig. 11 showing the west entrance and the south façade

Fig. 12 showing the lower level of the building

Fig. 13 showing the west entrance

Fig. 14a showing the openings on the south facade

Fig. 14b

ACKNOWLEDGEMENT

This Study was supported by Halil Alibaba

REFERENCES

[1] T. Hong, H.-W. Lin, Occupant Behavior: Impact on Energy Use of Private Offices, in: 1st Asia Conference of International Building Performance Simulation Association, 2013.

[2] Z. Yang, N. Li, B. Becerik-Gerber, M. Orosz, A systematic approach to occupancy modeling in ambient sensor-rich buildings, SIMULATION. 90 (2013) 960–977. doi:10.1177/0037549713489918.

[3] G. Kavulya, B. Becerik-Gerber, Understanding the Influence of Occupant Behavior on Energy Consumption Patterns in Commercial Buildings, in: International Conference on Computing in Civil Engineering, American Society of Civil Engineers, Clearwater Beach, (G. Kavulya, 2012) Florida, United States, 2012. http://ascelibrary.org/doi/abs/10.1061/9780784412343.0072 (accessed October 20, 2014).

[4] C.M. Clevenger, J.R. Haymaker, M. Jalili, Demonstrating the Impact of the Occupant on Building Performance, Journal of Computing in Civil Engineering. 28 (2014) 99–102. doi:10.1061/(ASCE)CP.1943-5487.0000323.

[5] C. Clevenger, J. Haymaker, the impact of the building occupant on energy modeling simulations, in: Joint International Conference on Computing and Decision Making in Civil and Bu ilding Engineering, Montreal, Canada, 2006.

[6] F. Jazizadeh, A. Ghahramani, B. Becerik-Gerber, T. Kichkaylo, M. Orosz, Human-Building Interaction Framework for Personalized Thermal Comfort-Driven Systems in Office Buildings, Journal of Computing in Civil Engineering. 28 (2014) 2–16. doi:10.1061/(ASCE)CP.1943-5487.0000300.

[7] F. Jazizadeh, A. Ghahramani, B. Becerik-Gerber, T. Kichkaylo, M. Orosz, User-led decentralized thermal comfort driven HVAC operations for improved efficiency in office buildings, Energy and Buildings. 70 (2014) 398–410. doi:10.1016/j.enbuild.2013.11.066.

[8] E. Azar, C.C. Menassa, Agent-Based Modeling of Occupants and Their Impact on Energy Use in Commercial Buildings, Journal of Computing in Civil Engineering. 26 (2012) 506–518. doi:10.1061/(ASCE)CP.1943-5487.0000158.

[9] E. Azar, C.C. Menassa, Sensitivity of Energy Simulation Models to Occupancy Related Parameters in Commercial Buildings, in: Construction Research Congress, American Society of Civil Engineers, Purdue, IN, 2012: pp. 1381–1390. http://rebar.ecn.purdue.edu/crc2012/papers/pdfs/-108.pdf.

[10] S. Schiavon, T. Hoyt, A. Piccioli, Web application for thermal comfort visualization and calculation according to ASHRAE Standard 55, UC Berkeley: Center for the Built Environment. (2013). http://www.escholarship.org/uc/item/4db4q37h (accessed October 20, 2014).

[11] L. Klein, G. Kavulya, FarrokhJazizadeh, J. Kwak, B. Becerik-Gerber, P. Varakantham, et al., Towards Optimization Of Building Energy And Occupant Comfort Using Multi-Agent Simulation, in: Proceedings of the 28th ISARC, IAARC, Seoul, Korea, 2011: pp. 251–256. http://www.iaarc.org/publications/proceedings_of_the_28th_isarc/towards_optimization_of_building_energy_and_occupant_comfort_using_multiagent_simulation.html (accessed October 19, 2014).

[12] R. Yang, L. Wang, Development of multi-agent system for building energy and comfort management based on occupant behaviors, Energy and Buildings. 56 (2013) 1–7. doi:10.1016/j.enbuild.2012.10.025.

[13] Z. Yang, N. Li, B. Becerik-Gerber, M. Orosz, A Non-Intrusive Occupancy Monitoring System for Demand Driven HVAC Operations, in: Construction Research Congress 2012, ASCE, 2012. http://cedb.asce.org/cgi/WWWdisplay.cgi?289937

[14] Z. Yang, N. Li, B. Becerik-Gerber, M. Orosz, A multi-sensor based occupancy estimation model for supporting demand driven HVAC operations, in: Proceedings of the 2012 Symposium on Simulation for Architecture and Urban Design, Society for Computer Simulation International, 2012: p. 2. http://dl.acm.org/citation.cfm?id=2339453.2339455

[15] F. Calvino, M. La Gennusa, G. Rizzo, G. Scaccianoce, The control of indoor thermal comfort conditions: introducing a fuzzy adaptive controller, Energy and Buildings. 36 (2004) 97–102. doi:10.1016/j.enbuild. 2003.10.004. 682 Moatassem Abdallah et al. / Procedia (F. Calvino, 2004)

[16] P. Duan, H. Li, A novel data-based control strategy of dynamic thermal comfort for inhabited environment, in: 2010 8th World Congress on Intelligent Control and Automation, IEEE, 2010: pp. 4865–4869. doi:10.1109/WCICA. 2010.5554901.

[17] M.M. Gouda, Fuzzy ventilation control for zone temperature and relative humidity, in: Proceedings of the 2005, American Control Conference, 2005., IEEE, 2005: pp. 507–512. doi:10.1109/ACC.2005.1469986.

[18] A.E. Ben-Nakhi, M.A. Mahmoud, Cooling load prediction for buildings using general regression neural networks, Energy Conversion and Management. 45 (2004) 2127–2141. doi:10.1016/j.enconman.2003.10.009.

[19] M. Nowak, A. Urbaniak, Utilization of intelligent control algorithms for thermal comfort optimization and energy saving, in: 2011 12th International Carpathian Control Conference (ICCC), IEEE, 2011: pp. 270– 274. doi:10.1109/ CarpathianCC.2011.5945862.

[20] ANSI/ASHRAE, Thermal environmental conditions for human occupancy, American Society of Heating, Refrigerating and Air- Conditioning Engineers, Standard 55, 2010. https://www.ashrae.org/resources -- publications/ bookstore/standard-55.

[21] Halil Alibaba, Sustainability, Determination of Optimum Window to External Wall Ratio for Offices in a Hot and Humid Climate, 7, January, 2016, Academic Editor: Adrian Pitts, https://www.mdpi.com/2071-1050/8/2/187