Investigating the Thermal Comfort and Well-being of Differently Abled War Veteran's Housing in Sri Lanka

KSKNJ Kudasinghe[1#], KDHJ Premarathne[1] and NMRAT Nawaratne[2]

[1]*Department of Architecture, Faculty of Built Environment and Spatial Sciences, General Sir John Kotelawala Defence University, Sri Lanka*
[2]*Sri Lanka Army*

[#] ksknjkudasinghe@kdu.ac.lk

Abstract*: Wellbeing inindoor built environment has become a crucial research topic in relation to thermal comfort which help to improve sustainable builtenvironments. Thus, thermal comfort requirements for humans is a main consideration in building designing.It's important to consider comfort and wellbeing of people with physical disabilities. Thus, this research was conducted to investigate the indoor environment quality of spaces in relation to the thermal comfort in physically disabled war veterans' housingin Sri Lankan context.Onfield investigation was carried out to obtain physical measurements of microclimatic parameters of interiors including indoor temperature, relative humidity and air velocity. Secondary data were collected through semi structured interviews.*

Results explicitly prove through onfield investigations that the mean value of the operative temperature is 32.2°C, which is above the ASHARE 55-2013 standard for comfortable thermal conditions.Mean wind velocity is 0.25m/s, is low, as there is a high operative temperature adequate interior ventilation needs to be provided. The Humphries comfort equation states the required comfort temperature is 28.92°C, the obtained mean operative temperature is more than this comfort temperature, proving the interiors are overheated. Most common adaptive behaviour of the veterans are switching fans on and moving towards open spaces. Results also indicate that there is a psychological link with thermal adaptive behaviour as these veterans opt to remain in free outdoor spaces rather than confined spaces as their battlefields. Thus, this research paper highlights on the thermal conditions needed for interior spaces for disabled war veterans and in the long-run contributing to regulations to add developments to the National Policy on Disability in Sri Lanka.

Keywords: *Thermal comfort, physically disable people, indoor built environment*

1. Introduction

Thirty years of civil war in Sri Lanka resulted in massive human and social costs as many soldiers from tri-forces suffered from traumatic experiences which caused immense physical, emotional, and psychological distress. Thus, rehabilitation of differently abled war veterans is a prime national obligation.

The vision of facilitating a comprehensive rehabilitation process was fulfilled by originating the Ranaviru Sevana Rehabilitation Center in the year 1990. This need was further expanded by establishing seven long term caregiving homes for war veterans in varying locations of the country.

These shelters for war heroes are for residential patients with spinal cord/head injuries and amputees with one or more limb losses mainly under knee and the rehabilitation process prioritizes life-long health care with physical, mental, social and spiritual well-being. Although the built

environment supports to accommodate essential functions of these centers with a focus on physical well-being the major challenge of these centers is on mental health treatment as many of the residents suffer from Post-Traumatic Stress Disorder (PTSD). Thus, informs the importance of investigating the spatial and microclimatic ambience of these centers in facilitating the psychosocial rehabilitation process which contributes to life-long health and well-being of the differently abled war veterans of Sri Lanka. Thus, the primary objective of the research is to experimentally investigate indoor environmental quality of occupied spaces in relation to thermal comfort and secondary objective is to understand the user perception on spatial ambience of the built environment.

2. Background and Literature Review

The consequences of war-related trauma cause enormous suffering and problems adjusting to post-war life in many parts of the world (Odenwaldet al.2007). War has a catastrophic effect on the health and well-being of nations (Murthy & Lakshminarayana, 2006). The World Health Organization (WHO) defines mental health as a state of well-being in which the individual realizes his or her own abilities can cope with the normal stresses of life, and can work productively to make a contribution to his/her community. War trauma negatively affects the mental health parameters. The civil war with the LTTE in Sri Lanka was brought to a halt in 2009 by the tri-forces of Sri Lanka. However, this victory came with a massive human and social cost. Following the thirty year armed conflict in Sri Lanka many combatants underwent traumatic experiences that caused immense physical, emotional, and psychological distress. These experiences were events outside the range of usual human experience.

The number of persons with physical disability among defence personnel is estimated as 20,000(Asia Development Bank, 2005). These were the numbers by the year 2005, the war ended in 2009, thus the projected number of disable veterans is higher. Rehabilitation is an ecological approach that aims at the long term recovery and maximum self-sufficiency. The World Health Organization in 1996 developed a consensus statement on psychosocial rehabilitation. The WHO defined psychosocial rehabilitation as a process that facilitates individuals who are impaired, disabled or handicapped by a mental disorder to reach an optimal level of independent functioning in the community. In order to achieve optimum level of independent functioning, the long term caregiving homes for these disabled war veterans need to promote optimum living interior conditions. Built environment has an effect on physical and psychological wellbeing of occupants (Hashemi S, 2019) Thus, it is of paramount importance to prioritize the built environment and the environmental health factors on both the physical and mental health of these disabled war veterans.

Many researchers have found that human well-being depend on social interaction, genetics as well as physical environment (Hashemi S, 2019). According to the model of built environment and well-being which introduced by Clements-Croome and Wang (2016), thermal comfort is one of main influenctial factor coming under indoor built environment.

The needs of standards on thermal comfort for people with disability (also the aged) had been identified bytheInternational Standards Organisation (ISO) through their system of international voting. Parsons. K, (2005) has emphasized that, requirements of thermal comfort are similar for the people with disability and without disability. “There were no significant differences found in the Thermal Comfort requirements of people with physical disabilities and people without physical disabilities” (Webb L.H, 2000).

Thermal comfort has been defined as "the condition of mind that expresses satisfaction with the thermal environment" (ISO 7730, 1994). It is satisfactory perception of thermal environment which assessed subjectively.Variables of thermal comfort can be categorized into environmental and physical variables. The environmental variables vary from: air temperature, air relative humidity, air velocity and mean radiant and two human variables: clothing insulation and human activity.

There is a limitation in research with regard to the preffered thermal environments of the disabled in Sri Lanka. No comfort range standards are established for this group of individuals. Thus, this paper explore the thermal environment requiremnts for the differently abled people which special reference to the war veterans as there is an added psychological component which contribute aspects regarding thermal environments. This paper can serve as a stepping stone for contributing standards in the policy developoments to the National Policy on Disability in Sri Lanka.

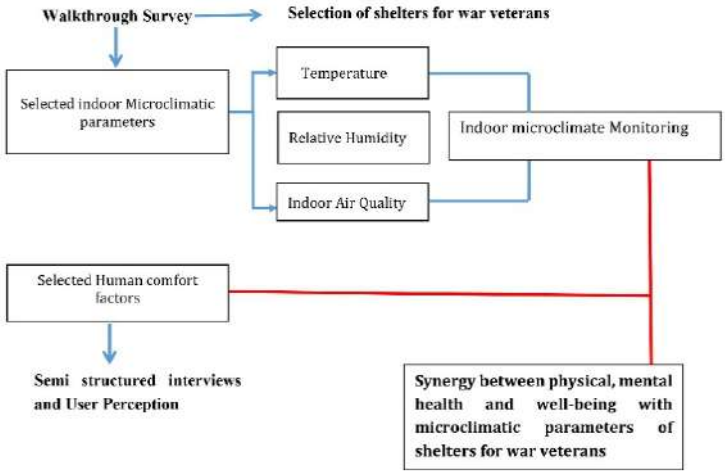

Figure 01:Graphical Representation of the Research Design*Source: By Author*

3. Methodology

Research design is composed major steps as follows;

a) Literature survey
b) Walkthrough survey: Filtering process of case study shelter for war heroes- Abimansala Anuradhapura
c) Onsite experimental investigation
d) Semi structured interviews

The selected case study is Abimasala in Anuradhapura. The population sample size is 53. The research was conducted in two parts- an on field investigation was carried out to obtain physical measurements of the microclimatic parameters of the interiors, Table 01 illustrates the equipment used to obtain these measurements.All the measurements are taken in the month of August 2019. Semi structured interviews were carried out to explore the perception of the veterans in these veteran care homes.

Table 01:Equipment Used to Obtained the Measurements Source: By Author

	Parameter measured	Equipment used	Place of measurement
01	Indoor temperature	HOBO Temp/ Temperature data logger	In two locations inside the veteran home (bed rooms)
02	Relative Humidity	HOBO humidity/ Humidity data loger	In one place immediately inside the building.
03	Wind Velocity	Anemometer	In the same place where the HOBOs were placed indoor.

The seated individuals were subjected to the measurements under the standards of ANSI / ASHRAE 55-2013 and ISO-7730 while the indoor thermal microclimatic parameters were obtained within 1m from an individual and of a height of 0.6m from the floor. The time period for the measurements were every 10 seconds(ISO, 2001). The operative temperature and mean radiant temperature were calculated using standardised formulas.

For the second part of the research, semi structured interviews were carried out figure out the adaptive measures these veterans undertook for maintaining thermally stable environments.

4. Results and Discussion

A. *Metabolic rate and clothing insulation*

During the process of the field investigations the commonly worn clothing type is sarong with a sleeveless or a t-shirt with a short sleeve which are typical clothing types in Sri Lanka. Their foot-ware is rubber slippers, whilst most of the veterans were barefoot. The clo values used for identifying the levels of clothing insulation (*Iclo*) were based on the evaluation values set by ISO 9920-2004, ASHARE standards 55-2004 and 2013. For obtaining the clo values, the war veterans were subjected to a seating position. The obtained clo values were as follows with regard to the clothing levels.

Table 02:Clo Values related to the clothing levels Source: By Author

Maximum	Minimum	Average	Most common Clothing items
0.38	0.15	0.33	Sarong and shirt

According to the ASHARE 55 2013 specify standards, there are no specific standards for disabled people. The provided mean clothing summer standard is an average of 0.5clo, while the veterans in Sri Lanka reflect an average value of 0.33clo which is lower than the ASHARE 55 2013 standards. Along with the clo values, the metabolic rate is also a determinant of thermal comfort as a personal factor. The metabolic rate is defined as the energy which the body produces due to various activities. It is important to note that the metabolic rate reduces with disability factors **(**Gomas A.S, Vigario P et.al, 2014). This is aided with the fact that the physical measurements of the veterams were obtained whilst they were seated. Thus, due to the aspect of the majority of veterans not being able to move, the metabolism rate was 1.0 which indicates seated, writing or reading. Thus, we can consider 1.0 as the metabolic rate for the veterans. The obtained metabolic rate and the clothing insulation value (Iclo) can be used to identify the Predicted mean vote(PMV), this aspect is not investigated in this paper.

B. *Thermal comfort parameters- indoor microclimate*

In spaces where there is a significant mass within the interiors the air temperatures can vary with the mean radiant temperatures. This aspect can be very useful to assess the thermal comfort of the occupants within the interior spaces. Thus, the operative temperature (Top) is calculated as it is a vital measure of human comfort which is obtained from the values of air temperature (Ta), mean radiant temperature (MRT) and the wind velocity. The formula which is used to calculate the operative temperature is as follows.

$$Top = \frac{Ta\sqrt{10v} + MRT}{1 + \sqrt{10v}}$$

The variation of the interior operative temperature and wind velocities in all the interior spaces of the veteran care homes were investigated. The mean value of the operative temperature is 32.2°C and the temperatures range from 29°C to 36°C, which a majority of temperature within the range 30°C to 33°C. These are aided by low velocity, as a majority of the frequency of the range of the wind velocity is between 0.06 to 0.3m/s. The mean wind velocity is 0.25m/s. As the wind velocities are very low, the operative temperature tends to increase and this proves that the level of ventilation received into the interiors is not adequate and
the design measures need to be undertaken to improve this aspect.

Mentioned previously are the existing temperatures of the interiors of the veteran care homes. However, these need to be compared against the standard thermal comfortable temperature ranges. The ASHARE 55-2013 standard for comfortable thermal conditions, the temperature within the range of 19- 28°C at 80% humidity levels. There are established thermal comfort ranges in some tropical countries such as in Thailand (Busch et al, 1992) the comfort temperature range is between 25.6°C-31.5°C.

Studies have proved that there is a correlation between this comfort temperature and the outdoor temperature (Humphreys, 1992 and Nicol, 2004). According to Humphreys (1992) there is a relationship between the comfort temperature and mean outdoor temperature for naturally ventilated building. The equation is-
Tc = 0.534Ta + 12.9.
The mean outdoor temperatures for Anuradhapura is 30.1°C. Thus according to the abover equation, the comfort temperature for these places include 28.92°C. The above mentioned comfort equation proves that in the higher outdoor conditions will have higher levels of comfort temperatures. Although the required comfort temperature is 28.92°C for these places, the obtained mean operative temperature through measurements indoors is 32.2°C. This proves that the interior spaces are overheated and there is a need to lower the temperature of the indoor spaces with the proper provision of natural ventilation.

For the next part of the research, actions of the war veterans were explored to understand the measures they undertake for maintaining their comfort levels in the interiors. These adaptive behaviours were investigated through semi-structured interviews. There is a theory defined as the adaptive comfort theory which explains the adaptive behaviors people undertake in order to adjust to existing micro-climatic conditions (Humphries and Nicol, 1998).

The results obtained with regard to these adaptive measures are two-fold as most veterans preferred the usage of a mechanical ventilated system such as switching on fans, whilst the other common option included the opening of windows and moving slowly into open spaces. The movement of these veterans are limited due to their disability,

thus they prefer open spaces within close proximity. Another reason attributed with

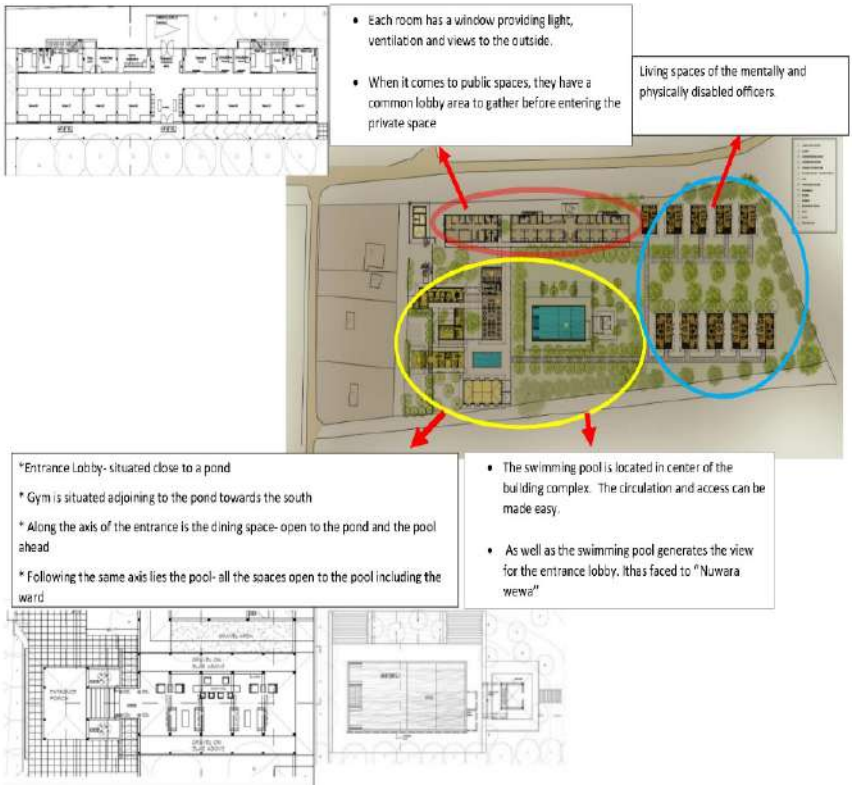

Figure 02: Connection ofIndoor and Outdoor Spaces in Abimansala, Anuradhapura Source: By Author

the preference of these open spaces is the psychological situation of these veterans. The veterans explain that they don't prefer to stay for prolonged hours in close enclosed spaces as they feel traumatised by feelings of enclosure with related to their traumatic experiences of being held captive during the war times. Although their movement is limited, they prefer to walk, and move in wheelchairs in outdoor and semi-outdoor green spaces has mentally they feel free opposed to the confined battlefield experiences. Results indicate a link of adaptive to thermal conditions with psychological conditions with these veterans. These aspects can be justified as (Thorosson et al, 2004 and Spangnolo et al, 2003) state that thermal preference is also dependent on psychological factors such as perception and culture. Futhermore, (Rajapakse, 2019) proved that elderly population in Sri Lanka opted to open windows for better thermal comfort conditions as opening of windows is a cultural habit of Sri Lankans. The Abimansala in Anuradhapura does have several outdoor and indoor connecting spaces, as illustrated in the Figure 02, however, several more interventions need to be implemented in order to achieve prescribed thermal comfort standards.

There is a limitation in the design of the inclusion of open spaces and semi-outdoor spaces in architecture for the disabled (differently abled) in Sri Lanka. Thus, more needs to be implemented in this area of research for the differently abled population in Sri Lanka. As the physical aspects and psychological components indicate a close relation, more effort needs to put to identify developments for the differently abled community of Sri Lanka. This will aid in the policy development process for adding comfort ranges for the disabled with regard

to the National Policy Development in Sri Lanka.

5. Conclusion

This research explored the thermal comfort aspects of war veterans in Sri Lanka. Several conclusions can be made from this research paper, these include,

- The mean value of the operative temperature is 32.2°C, which is above the ASHARE 55-2013 standard for comfortable thermal conditions, the temperature within the range of 19- 28°C.

- The mean wind velocity is 0.25m/s, which is low and as the operative temperature is high, the level of ventilation received into the interiors is not adequate and the design measures need to be undertaken to improve this aspect.

- According to (Humphries, 1992) comfort equation the required comfort temperature is 28.92°C for these places, the obtained mean operative temperature through measurements indoors is 32.2°C.

- This proves that the interior spaces are overheated and there is a need to lower the temperature of the indoor spaces with the proper provision of natural ventilation.

- According to the results of the adaptive behaviors of veterans, a majority preffered for the usage of fans and means of having access to open spaces. This reason attributed with the preference of these open spaces is the psychological situation of these veterans.

- There is a link of adaptive behaviours to thermal conditions with psychological conditions with these veterans.

References

ANSI/SHRAE Standard 55, (2013). Thermal environmental conditions for human occupancy, ASHRAE, Atlanta.

Busch, JF. (1992). A tale of two populations: Thermal comfort in Air-conditioned and naturally ventilated offices in Thailand. Energy and Buildings, 18(3-4), pp 235-49.

Fukasaku, K., Kawai, M., Plummer, M.G. and Trzeciak-Duval, A., 2005. Policy coherence towards East Asia: Development challenges for OECD countries.

Gomas A.S, Vigario P et.al (2014) Basal and resting metabolic rates of physically disabled adult subjects: a systematic review of controlled cross-sectional studies. National Library of Medicine.

Hashemi S. (2019) Do intelligent Buildings (Ibs) Promote WellBeing? Identify the Key Influential Factors andShortcomings. Science Arena Publications. Specialty Journal of Architecture and Construction.ISSN: 2412-740X. Vol, 5 (4): 40-45

Humphrey, M.A.(1992) Thermal comfort requirements, climate and energy. In Proceedings of 2nd WREC Conference, Reading, UK, 13–18 September 1992.

Horowitz, M. (1986). Stress Response Syndromes. Northvale, N.J.: Aronson.

ISO 7730 (1994) Moderate Thermal Environments - Determination of the PMV and PPD Indices and Specification of the Conditions for Thermal Comfort, 2nd edn. International Standards Organisation, Geneva, ref no ISO 7730:1 994(E)

ISO 7726 (International Organization for Standardization), (2001). Ergonomics of the thermal environment: Instruments for measuring physical quantities (BS EN ISO 7726: 2001) BSI, London, UK.

Jayatunge, R.M. (2010) The Similarities and Differences between the Vietnam War and the Eelam War

Licklider,R. (1995).”The, Consequences of Negotiated Settlements in Civil Wars, 1945-1993″,American Political Science Review

Murthy, R,S, Lakshminarayana R (2006) Mental health consequences of war: a brief review of research findings. World Psychiatry.

Nicol, J.F. (2004) Adaptive thermal comfort standards in the hot-humid tropics. Energy Build. 36, 628–637.

Odenwald, M., Lingenfelder, B., Schauer, M., Neuner, F., Rockstroh, B., Hinkel, H. and Elbert, T., 2007. Screening for posttraumatic stress disorder among Somali ex-combatants: a validation study. *Conflict and health*, *1*(1), pp.1-9.

Parson K. (2005) An Adaptive Thermal Comfort Method For People With Physical Disabilities.Department of Human Sciences, Loughborough University , UK.

Rajapakse, I (2019), Adaptive Behaviours of elderly for cooling in Tropics: Field studies in naturally ventilated aged care homes. In Proceedings of Climate at the Extremes 2019 conference

Spagnolo, J., de Dear, R., 2003. A field study of thermal comfort in outdoor and semi outdoor environments in subtropical Sydeny, Australia. Building and Environment, 38 (5)

Thorssoon, S., Lindqvist, M., Lindqvist, S., 2004. Thermal bioclimatic conditions and patterns of behaviour in an urban park in Goteborg, Sweden. International Journal of Biometeorology, 48(3)

Webb L, Parsons K, (2000) Thermal comfort requirements for people with physical disabilities. vol. 44, pp. 114–121

World Health Organization. (1996). Psychosocial rehabilitation: a consensus statement. Geneva: World Health Organization.