IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 16, Issue 11 Ser. I (November 2022), PP 23-27
www.iosrjournals.org

An Assessment of Energy Efficient Indicators of Outdoor and Indoor Conditions for Comfort in Residential Buildings of MUBI

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Abstract
Comfortable conditions are essential for the proper functioning of residential buildings long hours are spent in living rooms, bedrooms, kitchen, conveniences and other support rooms. Rooms should be liveable and inviting, but unfortunately many residential buildings lack such disposition, often mechanical devices as fans, chillers and air conditioners have to be employed to improveconditions within. These devices are energy driven and dependent, from time to time these devices and electric generators that run them need repairs, thereby piling costs of maintenance. With energy efficient/sustainable building design, these devices may not be necessary, or if used, it is minimal. This is the background in which the study is conceived and is set to find out how residential buildings in Mubi fare, In comparison to what an ideal energy efficient design should be. Four areas are selected from northwest, northeast, southwest and south east of Mubi were involved in the study, an inventory of outdoor and indoor design indicators in 75 buildings are studied. The results showed that in 82.7% of the developments, more than 1/3 of the site was built-up, contrary to planning laws, 77.3% of the compounds had concrete walls and surfacing that are hard, these may have contributed to why in 66.7% of compounds occupants responded that walls and surfaces get hot due to thermal radiation, for the interior spaces 81.3% of the buildings did not have cross ventilation,and 60.0% of the buildings occupants stay outside overnight in certain seasons to avoid thermal discomfort, the results showed in 54.7% of buildings fenestration had wrong orientation by facing west or east. The scenario is one that portends much solar radiation, heating up and results in thermal discomfort in rooms. Mubi is a known town for its fairness in weather. Houses are expected to have a comfortable outdoors and indoors, but it was found out in the study that external spaces and building interiors may not be comfortable, due to sharp practices by building owners. The acceptance of the situation by the needy occupants and tenants does not stir any urgency to solve the problem. To reverse these trends in existing buildings and new developments, inspection, energy efficient design and natural means of creating comfort in buildings and environment should be adopted. Mere discomfort as in the described situations can be source of thermal discomfort, lingering odours, insomnia, nervous palpitation, headache and disinclination to work at first. More serious diseases can set in, due to airborne bacteria and virus growth in spaces described, leading to meningitis, tuberculosis or of recent covid-19, it is recommended that building owners and tenants be educated about comfortable housing and its gains.

- ✓ *Health authorities shouldbe involved in inspections and plan approval.*
- ✓ *All arms of government should work toward provision of habitable housing or means of doing so.*
- ✓ *Mubi town is due for new layouts and expansion, the town has held its size, inspite of growing population.*

Keywords :- *Energy efficiency, Indicators, Conditions, Comfort.*

Date of Submission: 01-11-2022 Date of Acceptance: 12-11-2022

I. Introduction

A residential building will usually comprise of living rooms, bedrooms, kitchen, conveniences and other rooms as required. Conditions within a building are expected to have a liveable/comfortable microclimate. Comfort within a building was described by Gyoh (2018) as a combination of the right air velocity, relative humidity, solar radiation, air temperature. Often interiors of rooms have conditions that are at par with what is comfortable, or obtainable outside. Occupants find it necessary sometimes to employ mechanical devices for ventilating and cooling, such as electric fans of all types and air conditioners, these devices require electricity to function. Power from national grid, fossil fuel generators, solar or other sources of energy, in many cases buildings could have been designed to have integration of internal spaces of building with conditions outside, in doing so conditions in interior of buildings will breathe, less stuffy, cooler, fresher and comfortable with natural conditions, close to outdoor disposition. Buildings designed as such will require less or no energy for comfort of its occupants. As summarised by Olotuah(2013) there is need to enhance efficiency and moderation in the use of energy.

Comfort can be a broad term as described by the Encarta dictionary (2009). It could be physical, psychological or spiritual, the study is however limited to thermal/physical comfort of occupants in the microclimate of their homes, according to Tyler (1980) a temperature of 26^0c – 33^0c, humidity of 40% - 65% and air velocity of 2.8m/s can be considered a comfortable range. Thermal comfort contributes to well – being and health.

Parts of site are utilised for external works, landscaping or as called outdoors, can be treated in many ways. Soft and hard surface are common. Concrete, gravel stone aggregates or combinations can have different thermal effects on conditions of a site. Soft surfacing like lawn and grasses creates a cooler environment, the use of trees, shrubs, hedges and flowers provide beauty, shade and a naturally comfortable habitat.

The building has been described as an environmental envelope, its function of providing shelter and succour from rain, dust and solar radiation. However a building design should provide for adequate fenestration, which Uji (2008) noted provides daylight and sunlight, views to outdoors and ventilation, windows can be controlled. Size of opening can be regulated by reducing openingor completely closing the window, if conditions outdoor are hostile/uncomfortable. In the design of fenestration, there is need to provide adequately, to increase the interface of outdoor and indoor interaction, and create comfort in the room space naturally. It is notable that dark coloured surfaces are goodabsorbers, so are dark coloured roofs and finishes, on the otherhand, bright coloured materials reflect off heat and absorb less.

AIM

The aim of this study is to compare features of buildings in the study area, with standard practices for efficient energy design and sustainability.

OBJECTIVES

- ✓ Check how compliant the houses/building are to the standard of 1/3 only build-up requirement.
- ✓ To find out if any plants exist in the outdoors of buildings.
- ✓ To find out which aspect of the buildings studied defaulted energy efficiency and sustainability requirements.
- ✓ Find what was correct and commendable about the studied buildings.
- ✓ Promote environmental/climate consciousness among citizens.

II. Methodology

The study is conducted in areas of Mubi town, known for its fair weather, but effects of emission, deforestation and general development is taking its toll. 4 parts of Mubi are selected for the study. The modified, Cochran (1977) rules for proportionate allocation was applied to apportion number of houses in 4 areas of Mubi. They includeArhankunu on the North West with 15 respondents, Wurogude to North East 18, Kabang in South West 27 and tsamiya in South East 15 respondents, a total of 75 buildings were studied.

The instrument used for collecting data was through a structured form, with statements on outdoor and indoor conditions of the buildings. Statements on the outdoors were on effects of wind, sun, plants and materials of construction, while statements on interior of buildings enquired on fenestration, roof cover materials, walling material and orientation of fenestration. Issues relating to security, privacy and filth are also put forward to respondents. The statements are administered to the occupants/respondents and data collected on the buildings is collated, cumulated and analysed.

	Outdoor design indicators	Effects
1.	Type of fencing.	High solid walls can restrict air flow
2.	Concrete interlock or bare ground.	High absorption of solar radiation.
3.	Grasses, flowers, hedges, shrubs and trees.	Plants give shade and cooling to surroundings.
4.	Materials of surfaces.	Hard surfaces absorb heat at higher level.
5.	Type of fencing materials.	High heat absorption if solid.

Table 1: 0utdoor indicators

Source: Author

	Indoor design indicators	Effects
6.	Cross ventilation.	Gives comfort, freshness and health to occupants.
7.	Orientation of fenestration.	Facing directly East or West, results glare and harsh solar radiation.
8.	Window sizes.	Should total up to 15 – 25% of floor area of rooms.
9.	Number of windows.	At least 2, crossing centre of the room.
10.	Outdoor and indoor condition difference.	Air change in a space brings indoor condition closer to outdoor
11.	Safe, secure and good views out of windows.	Allows opening.
12.	Materials for walls of rooms.	High specific heat capacity will result, high heat release.
13.	Black or dark roof cover material.	Result high absorption of solar radiation in roof space.
14.	Sound/Noise in rooms.	High levels may not be comfortable.

Table 2: Indoor factors

Source:Author

RESULTS

The results of the study are presented in table 3 and 4.table 3 is on outdoor conditions of the building site. The responses on what occurs, external to the building but within site are shown on the table 3 below.

S/N	STATEMENT	POSITIVE	NEGATIVE	POSITIVE%	NEGATIVE%
1.	There is free movement of air only 1/3 of site or less is built – up.	13	62	17.3	82.7
2.	Solar radiation overheats surfaces.	50	25	66.7	33.3
3.	There are plants in the premises.	15	60	20.0	80.0
4.	Surfaces are concrete or hard material.	58	17	77.3	22.7
5.	Fencing is built of sandcrete blocks.	39	36	52.0	48.0

Table 3: comfort factors outside buildings.

Source: Author.

The result shows that free movement of air in outdoors had responses of 82.7% in the negative. Solar radiation had 66.7% and if hard materials are used had 77.3% in the positive. There are plants in the premises and use of Sandcreteblocks recorded 20% and 52% responded in the positive respectively. The results on indoor conditions inside rooms and other related factors are reported in table 4 below.

S/N	STATEMENT	POSITIVE	NEGATIVE	POSITIVE%	NEGATIVE%
6.	There is cross ventilation in rooms.	14	61	18.7	81.7
7.	Windows face East or West.	41	34	54.7	45.3
8.	Sizes of windows are adequate.	34	41	45.5	54.7
9.	Number of windows adequate.	38	37	50.7	49.3
10.	In some seasons we sleep outside.	45	30	60.0	40.0
11.	Windows not opened because of mess, odour and security.	26	49	34.7	65.3
12.	Walls of rooms built of sandcrete blocks.	41	34	54.7	45.3
13.	Roof cover of building is dark in colour.	24	51	32.0	68.0
14.	Rooms are quite/low sound or noise.	40	35	53.3	46.7

Table 4: comfort factors inside buildings.

Source: Author.

Cross ventilation and orientation of windows recorded 18.7% and 54.7% in the positive respectively. While staying overnight outdoors and quiet or low noise in the rooms posted responses of 60.0% and 53.3% respectively in the positive. Unused windows, use of sandcrete blocks for building, dark roof colour and noise/acoustic comfort responses in the positive are 34. 7%. 54.7% 32.0% and 53.3% respectively.

III. FINDINGS

The results in table 3 show responses on outdoor comfort factors, 82.7% of the houses in the study do not have free flow of air this may be associated with the high built – up area and fence the homes, while the planning standard stipulate building up to 1/3 or 33.3% of site some homes have up to 80 – 85% of site built – up. The result report 77. 3% of the houses had no soft surface within and surfaces are mostly hard and bare, 66.7% of respondents agreed that solar radiation heated up the surroundings of the buildings. On if there were plants within sites of buildings and use of sandcrete blocks, scored 20.0% and 52.0% respectively in positive responses.

The results on the indoor factor of comfort showed that ventilation and related responses were as presented in table 4. Responses on window size recorded 45.3% window number 50.7% and 34.7% are not usually opened to avoid filth, messy odours and for security, 54.7% of the windows had wrong orientation, by facing east or west directly. The combination of situations described does not portend a comfortable microclimate, these may have contributed to the response of 81.3% respondents disagreeing they had cross ventilation in their rooms. The result shows that 60.0% of the occupants of the houses slept/stayed outdoors overnight, in some seasons because of thermal discomfort in the rooms.

The types and nature of materials of construction show that 54.7%, building walls are of sandcrete blocks, which has high U – value and high specific heat capacity. Only 32.0% of roof are dark coloured, less thermal effect is expected as black/dark bodies are better absorbers of heat. The scenario shows that, the wall will retain larger amount of heat and heat capacity is high, warming the spaces within. The mostly bright roof 68.0% of the study number will not absorb as much as dark roof do and therefore there is a reduced heat intake in the buildings due to absorption through roof.

IV. Conclusion

The residential building is a home for living, sleeping and an anchor where the family stays, when the microclimate of external space and interior of the built – up part of site becomes uncomfortable, mostly due to thermal discomfort, occupants worry, which if not resolved is capable of what according to Victor (1998) affecting health and energy. In some seasons, occupants stay outdoors overnight as their rooms are unbearably hot. During the day time people the most time stay outdoor under tree shades fondly called ‘chambers’. The study is set out to find why the houses are uncomfortable and how the problem can be mitigated in existing and new buildings.

The comfortable microclimate for humans comprises a temperature of 26 – 36^0c, relative humidity of 40% - 65% and air velocity of 0.28m/s with clean air, on many occasions while the conditions in outdoor or out in the street was rather fair, it is often not so with what was attainable in rooms. There is inadequate synergy in flow of air and lack of integration of indoor and outdoor spaces. Sometimes there is restriction of air movement between outdoors of a site and the neighbourhoods as well, these could lead to harsh conditions particularly that, as found out in the study, 81.3% of the houses lacked cross ventilation and 77.3% of surfaces are hard usually concrete, coupled with little or no space within site. The result is unpleasant and condition of work and living which as pointed out by Musa (2021) are matters of concern.

A design that incorporates the attributes of nature and needs less or no mechanical conditioning of spaces, can be seen as moving towards sustainability, energy efficiency and bioclimatic compliance. In such a development only1/3 of the site should be developed, surfaces of soft materials are created in the landscaping, inclusion of grasses, flowers, hedges, shrubs and trees will produce shade, and reduced absorption of heat, a comfortable building interior and environment is the objective.

V. Recommendation

1. The benefits of comfort, health and energy for well – being in homes and progress of citizens should be propagated.
2. A form for health authority approval should be attached to submissions for plan approval at the urban/rural development authority.
3. Inspection of premises from time to time and reports should help improve conditions.
4. The shortage of housing make tenants accept what is available, the federal government has responsibility to provide more housing to its citizens.
5. Mubi has much land on its outskirts, but it is in many parts congested. New layouts should be created for a greater, larger and more comfortable Mubi.

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MUSA , Lazarus, et. al. "An Assessment of Energy Efficient Indicators of Outdoor and Indoor Conditions for Comfort in Residential Buildings of MUBI."*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 16(11), (2022): pp 23-27.