www.revistageintec.net
ISSN: 2237-0722
revista GEINTEC
Gestão, Inovação e Tecnologias

Validation of Awareness of Thermal Performance of Earth and its Sustainable Benefit Assessment Scale

Sanusi Sani Maimagani[1*]; Roshida Binti Abdul Majid[2]; Leng Pau Chung[3]

[1*]Waziri Umaru Federal Polytechnic, College of Environmental Studies, Dept. Arch. Tech. Birnin Kebbi, Kebbi State, Nigeria.

[1*]maimaganee@gmail.com

[2]Faculty of Built Environment and Surveying, Architecture Program, Universiti Teknologi Malaysia (UTM), Malaysia.

[3]Faculty of Built Environment and Surveying, Architecture Program, Universiti Teknologi Malaysia (UTM), Malaysia.

Abstract

This objective of the study is to assess the validity of the Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale (ATESBAS). A cross-sectional survey design was adopted with a 50 selected samples from the northwestern part of Nigeria. The instruments contained 20 items spread among the 2 constructs of Benefits of Compressed Earth Brick and Application of compressed earth brick. The data collected were entered into Microsoft Excel 2019, and SPSS 25 was used for the analysis. The scale was evaluated through content validity with experts and Reliability with Cronbach's Alpha technique. The results indicated that the scale has substantial content validity and acceptable reliability values of 0.80 (Benefits of Compressed Earth Brick) and 0.84 (Application of compressed Earth Brick). However, one item overall failed to satisfy the condition to be certified as valid and thus, entirely removed from the scale (Application of Compressed Earth Brick). Accordingly, with the satisfaction of measurement requirements by 63 items, it concluded that the developed ATESBAS validated in this study can be used to investigate the awareness of the thermal performance of earth as a wall material and sustainable benefit, among professional architects in North-western Nigeria.

Key-words: Compressed Earth Brick, Thermal Performance, Validity of Awareness.

1. Introduction

The thermal performance of buildings envelop explains the transfer of solar heat gains between the buildings and their surrounding environments [1]. The thermal performance of a building gives more attention on how to diminish the negative impact consequence of the external environment onto the indoor space of the building, which will enhance the indoor living condition of the building occupant, especially in tropical regions, all the measures to be considered to avert solar heat permeation into the building enclosed spaces such as proper configuration indoor spaces, construction techniques, and suitable building materials selection [2, 3, 4].

Countries situated within the tropical regions their weather conditions are characterized with extremely high temperature, which led their building enclosures became exposed to solar heat gain due to that factors, the building occupant is faced with uncomfortable thermal indoor spaces which have an unfavorable health consequence such as insomnia, fatigue, boredom, headache and asthma [5, 6, 7]. Geographical regions where high-temperature extremes, less humidity, and rainfall are experienced, such areas are characterized as hot-dry climate regions [8].

However, School buildings in those areas, need proper consideration through the appropriate selection of sustainable building materials with excellent thermal resistance, which aids in deterring the solar heat transfer into the building interiors. In other building typology, the materials should also be economically affordable and environmentally friendly to ensure optimum indoor thermal comfort and well-being of the building user.

Whenever there is a difference in temperature in two spaces between indoor and outdoor spaces, where the temperature is higher, it always tends to flow to where the temperature is lower as nature continues to hate the imbalance since it occurs naturally daily, sunrises and air temperatures increase, and heat is transferred directly or indirectly through the components building [9]. Building thermal performance and indoor thermal comfort rely on the utilization of the energy-efficient building materials. With the effective use of abundant natural resources as a building material, some of these materials are inexhaustible, such as soil, rock, timber, etc. These products are also reusable, recyclable, ready to use, and Affordable, but are not [5] Thermal performance in building envelopes incorporates energy optimization through the proper selection of energy-efficient building materials that cut down the building's lifecycle costs and, in turn, increases the energy savings. Moreover, other design measures improved the building's energy-efficient including; window glazing thickness types, wall sizes, and other building components [10, 11]

Utilizing sustainable building materials has a manifold advantage it is energy-efficient building materials due to its better thermophysical properties it's cut down the cost of utility bills, it is cost-effective, require less maintenance, inexpensive, locally sourced inexhaustible materials which generate income and employment to the locals, the material does not emit any harmful toxic to the environment, during its extraction, production and its assembly, and the also has other advantages of been reusable, recyclable.

2. Objective

This study aims at evaluating the quality of validation of Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale.

3. Methodology

3.1. The Research Instrument/Scale

The instrument for this study is a constructed and validated questionnaire. The instruments titled 'Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale (ATESBAS)' were divided into four (3) sections; A-C. Section A contains items to assess respondents' demographic information, including gender, years of experience, and educational Qualifications, e.tc. Section B. contained items to measure: Benefits of Compressed Earth Brick; section C have items to measure the Application of compressed earth brick. All the items generated were developed using established procedures in the literature and the stakeholders' perspectives, who are specialists in this study.

3.2. Measure of Benefits of Compressed Earth Brick

This section of the instruments contains items to measure respondent awareness of the Benefits of Compressed Earth Brick. The developed instrument was structured to suit the current research on closed-ended responses with a Likert-Type scale in different categories. The section contained eight (8) items carefully selected items rated on a 5-point Likert scale (Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). With a few modifications, the instrument was subjected to content validity, construct validity, and reliability. The report of reliability is presented in this report.

3.3. Measure of Application of Compressed Earth Brick

This section of the instruments contains items to measure the respondents' awareness of the Application of compressed earth brick. The developed instrument was structured to suit the current research on a closed-ended and Likert-Type scale. This section consists of 12 carefully selected items rated on a 5-point Likert scale (Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree

(SD). With a few modifications, the instrument was subjected to content validity, construct validity, and reliability. The report of the instrument's reliability is presented in this report.

3.4. Participants

In order to achieve the construct validity and the questionnaire's reliability, a pilot test was conducted. A sample of fifty (50) respondents participated in the pilot testing. The sample size comprises male and female in a selected northwestern state of Nigeria. According to Baker (1994) [12], a sample size of 10–20% of the study's actual sample size is considered a reasonable number to participate in a pilot study.

The respondents in the pilot testing were professionals in building with all related professions in the field. The demographic information of the Pilot study respondents is presented in table 1 below;

Table 1- Demographic Information of the Participants

SN	Variable	Level	Frequency	%
1	Gender			
		Male	41	82.0
		Female	9	18.0
2	Qualification			
		ND/NCE	4	8.0
		HND/B.Sc/B.Tech	8	16.0
		M.Sc/M.Tech	21	42.0
		PhD	17	34.0
3	Experience			
		1-5Years	10	20.0
		6-10Years	22	44.0
		11 - Above	18	36.0

4. Content Validity of the Scale

An instrument is said to be valid if it essentially measures what it is intended to measure. The content validity of the scale (Awareness of Thermal Performance of Earth and Its Sustainable Benefit Assessment Scale) was content validated by 3 professional researchers in building technology and environmental sciences and one other expert in related behavioral research (measurement and evaluation) for proper scrutiny. The experts validated the instruments in terms of clarity of language, the statement's ambiguity, relevance to the topic, and the items' appropriateness. After scrutinizing the instruments, the experts' constructive suggestions and corrections were effected before producing the final draft of the instruments.

4.1. Administration of the Scale

The content validated and modified the final draft of the scale was administered to the sample by the researcher after given specific instructions for the survey with the help of some residents in the selected areas. The questionnaires were retrieved directly, scored, entered, and used as data in this pilot study.

4.2. Data Analysis

Examine the research instrument's internal consistency reliability in this study. The data collected from the pilot testing were analyzed using SPSS 25 to conduct a test of the instrument's reliability using Item-Total Statistics with Cronbach's Alpha coefficient. The results of the analysis provide preliminary information on the suitability or otherwise of the research instrument.

5. Results

5.1. Summary Statistics

The Scale reliability was used to estimate the reliability of the ‘Awareness of earth's thermal performance as wall material and sustainable benefit questionnaire (ATPEWSBQ).’ The summary statistics are the descriptive information generated using descriptive statistical analyses. Summary statistics are presented in table 2. The results show Mean, Minimum, Maximum, and Variance.

Table 2- Summary of Item Statistics

Construct	Mean	Min	Max	Variance	N of Items
Benefits of Compressed Earth Brick	4.06	3.08	4.320	0.50	08
Application of Compressed Earth Brick	3.66	3.17	3.95	0.03	17

5.2. Item-Total Statistics (Reliability/Internal Consistency)

The results of the scale reliability analysis were conducted using item-total statistics with the Cronbach’s Alpha coefficient. The analyses were run in two different stages: (i) Initial, which was obtained at the first stage of the validation that includes all items, including the poor ones. (ii) Modified which were obtained after removing the poor items that are not contributing to the instruments' overall reliability. The results are presented in the following order:

a. Benefits of Compressed Earth Brick

As presented in Table 3, the result of the analysis revealed the items' Cronbach's Alpha reliability coefficients of 0.800. This parameter is considered satisfactory reliability because according to [13, 14], a Cronbach's alpha scale of at least 0.70 is acceptable for the internal consistency reliability of the items and can therefore be accepted for study's purpose. These criteria served as the guidelines in interpreting the internal consistency-reliability coefficients in this research.

Table 3- Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.800	0.798	08

As established by the result of analysis based on reliability statistics, the Benefits of Compressed Earth Brick sub-scale showed that all the 08 items are retained and used in the final draft of the questionnaire.

The item-total statistics presented in Table 4 show no need for deleting any of the 08 items since the Cronbach's Alpha value is adequate for the entire items.

Table 4- Item-Total Statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
B1	28.18	28.477	.155	.822
B2	28.64	27.419	.146	.837
B3	28.22	24.787	.505	.779
B4	28.56	21.435	.706	.744
B5	28.26	24.809	.577	.771
B6	28.64	21.051	.768	.733
B7	28.32	24.793	.509	.778
B8	28.68	20.916	.788	.729

b. Application of Compressed Earth Brick (Initial and Modified)

As presented in Table 5, the result of the analysis revealed the items' Cronbach's Alpha reliability coefficients of 0.769 at the initial stage. The result, though, is around the acceptable threshold. However, the removal of the last item (Q20), therefore the item Q20 is recommended for deletion to improve the reliability. The analysis was run after removing the 1 (Item, Q20).

Table 5- Reliability Statistics (Initial)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.769	0.762	12

The new reliability coefficient after removing the 4 items is presented in Table 6. The items' Cronbach's Alpha reliability coefficients became 0.842 after modification. This parameter (0.842) is considered satisfactory reliability because according to [13, 14], a Cronbach's alpha scale of at least 0.70 is acceptable for the internal consistency reliability of the items and can therefore be accepted for study's purpose. These criteria served as the guidelines in interpreting the internal consistency-reliability coefficients in this research.

Table 6- Reliability Statistics (Modified)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.842	0.829	11

As established by the result of analysis based on reliability statistics, the Application of Compressed Earth Brick sub-scale showed that, 11 out of 12 items are to be retained in the final draft of the scale.

The item-total statistics presented in table 7 revealed that there is no need for further deletion of any items among the remaining 11 since the Cronbach's Alpha value is sufficient for the entire items.

Table 7- Item-Total Statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
AC9	32.40	48.000	-.135	.855
AC10	30.24	41.043	.197	.877
AC11	30.12	37.781	.747	.810
AC12	30.22	37.685	.736	.811
AC13	29.90	37.806	.719	.812
AC14	30.06	37.037	.833	.803
AC15	30.00	41.143	.451	.834
AC16	30.34	36.188	.795	.804
AC17	29.90	37.520	.710	.812
AC18	30.56	38.292	.646	.818
AC19	31.06	46.711	.022	.860

6. Conclusion

Buildings built with the earth in the past are known for the excellent indoor thermal environment, which enhances conducive learning activities in school buildings in northwestern Nigeria's hot dry climate zone. However, an in-depth study of the awareness of the earth's thermal performance as wall material and its sustainable benefit in North-western Nigeria is neither determined nor fully documented. Thus, this pilot study provides the validation report of 'Awareness of Thermal Performance of Earth and Sustainable Benefit Assessment Scale (ATESBAS)' that is proposed to be used in the investigation of the Awareness of Thermal Performance of Earth as a Wall Material and Sustainable Benefit, among Professional Architects. Therefore, the reliability studies results show that based on the established standards, the instrument is reliable and can be considered a valid measuring instrument to collect relevant data in the present study.

References

Joseph, M., Jose, V., & Habeeb, A. (2015). Thermal performance of buildings: Case study and experimental validation of educational building. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 4*(6), 4968-4974.

https://doi.org/10.15662/ijareeie.2015.0406011

Taylor, P. (2015). *Thermal Performance of Buildings.*

Korniyenko, S. (2015). Evaluation of Thermal Performance of Residential Building Envelope. *Procedia Engineering, 117*(8 442), 191–196. https://doi.org/10.1016/j.proeng.2015.08.140

Ahsan, T. (2017). *Passive Design Features for Energy-Efficient Residential Buildings in Tropical Climates:* the context of Dhaka, Bangladesh.

Akande, O.K. (2010). Passive design strategies for residential buildings in a hot dry climate in Nigeria. *WIT Transactions on Ecology and the Environment, 128,* 61-71.

https://doi.org/10.2495/ARC100061

Sharma, R. (2016). Sustainable buildings in hot and dry climate of India. *Journal of Engineering Research and Applications*, *6*(1), 134-144.

Press, W.I.T., & Range, P. (2018). *Hot Dry Climate in Nigeria,* 2018–2019.

Musa, A.B., Abdullahi M. Lawal, A.Y., & T.A. (2018). The orientation of hotel rooms paces for energy conservation in the hot- dry climate of Birnin kebbi, *Nigeria, 2,* 1–10.

Olaniyan, S. A., Ayinla, A. K., & Odetoye, A. S. (2013). Building envelope vis-a-vis indoor thermal discomfort in tropical design: How vulnerable are the constituent elements? *Journal of Science, Environment and Technology, 2*(5), 1370-1379.

Kwag, B.C., Adamu, B.M., & Krarti, M. (2019). Analysis of high-energy performance residences in Nigeria. *Energy Efficiency*, *12*(3), 681-695. https://doi.org/10.1007/s12053-018-9675-z

Gorse, C., Stafford, A., Shenton, D.M., Johnston, D., Sutton, R., & Farmer, D. (2016). *Thermal Performance of Buildings and the Management Process,* 1413–1422.

Baker, T.L. (1994). *Doing Social research* (2nd Edn.), New York: McGraw-Hill Inc.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., & Tatham, R.L. (1998). *Multivariate data analysis.* Upper Saddle River, NJ: Prentice-Hall, 5(3), 207-219.

Dewey, J., Hana, G., Russell, T., Price, J., McCaffrey, D., Harezlak, J., & Cohen, R. (2010). Reliability and validity of MRI-based automated volumetry software relative to auto-assisted manual measurement of subcortical structures in HIV-infected patients from a multisite study. *Neuroimage, 51*(4), 1334-1344.