

How to Cite:

Alcívar, M. A. A., Ramos, J. L. M., & Velez, D. E. A. (2022). Influence of the orientation and the angle of inclination in the metal roof. *Linguistics and Culture Review*, 6(S3), 140-157. <https://doi.org/10.21744/lingcure.v6nS3.2110>

Influence of the Orientation and the Angle of Inclination in the Metal Roof

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Abstract--- Postmodern architecture is responsible for carrying out the building distributions of the urban canyon of cities; for this, it provides the tools required to adjust the territory to social, economic, and environmental needs. One of these tools is aimed at the applicability of construction strategies such as the correct solar orientation. The present investigation of an experimental nature, carried out in the Crucita parish of Ecuador, evaluates the thermal temperatures inside two houses in their current state, assessing it in two prototypes with one water and two waters on the four cardinal orientations: with four different angles of inclination of the cover. Where it was determined that the thermal comfort inside that provides the least increase in temperature is for the house with a roof facing west, with an angle of inclination greater than 20°.

Keywords---Ecuador, housing, interior, thermal behavior, warm areas.

Introduction

The discipline of architecture is responsible for carrying out the correct building distributions of the urban canyon of cities, relating the distribution of spaces and the conditioning factors of the transformed environment in the environment, so it must provide the tools to adjust the territory to social, economic, and environmental needs. If it is possible to establish an objective scan of the environmental comfort conditions, depending on the user's perception

Espinosa Cancino & Cortés Fuentes (2015), obtaining with them more exact indicators of the possible modifications of the construction ordinances in future solutions. Housing Sosa (2013), with which sustainable and sustainable built environments would be achieved, helping to reduce carbon emissions into the environment. There are several types of roofs such as: sloped, light, heavy, domes, etc., and of both natural and industrial varieties (Torres-Corredor et al., 2017). In the mid-20th century, these were introduced by the construction industry as new construction methods, which replaced natural roofing materials with zinc-coated steel sheets Quezada (2018), which together with a simple supporting structure constituted a new modality. of roofs (Tapia-Armijos et al., 2017; Del Brutto et al., 2019).

This structural element has the main function of protecting its occupants from the different climates and animals, as well as from heat, wind, and solar radiation, being known as: the fifth façade, defined as a part of the envelope adaptable in its form and function. The construction of this type of roof is one of the most popular in tropical regions Véliz-Párraga & González-Couret (2019), due to its low cost and easy installation. However, they have a very unfavorable transmittance due to their specific heat and high thermal conductivity Medina et al. (2021) compared to other types of building materials (Calderon Uribe, 2019). The external agents that mainly influence the ability to transmit high thermal loads through this material are solar radiation and air temperature, which, being in continuous thermal exchange with its immediate surroundings in hot and tropical climates, such as in the case of the Ecuadorian coasts, they induce an uncomfortable environment inside buildings Motta et al. (2017), which leads to the use of Heating, Ventilation and Air Conditioning (HVAC) systems. However, mitigating this effect produced by the convection of fluids is possible, with proper use and management of the openings of the house through natural ventilation Andreoni Trentacoste & Ganem Karlen (2017), and the use of passive strategies for roofs (Leung, 2004; Würbel, 2001).

According to some studies, in hot climate zones; materials, insulation, surface color and the effect of roof orientation; directly influences the maximum interior temperature of housing solutions Jayasinghe et al. (2003); Melisa Viegas et al. (2016); Cobo Fray & Montoya Flórez (2021), which causes thermal discomfort to the occupants, This is due to prolonged exposure to environmental conditions of poor thermal comfort, which can lead to loss of motor coordination and concentration capabilities Cújar-Vertel & Julio-Espitia (2016), and depending on the loss of metabolic energy, physical activity and the thermal resistance of clothing could produce thermal stress (Gutiérrez et al., 2018; Rivera Roma, 2020). however, this consequence of the increase in temperature can be reduced through the use of passive design strategies (Huellas de Arquitectura, 2018). There are a wide variety of these that help maintain the interior thermal comfort of the home, among the least expensive that would produce a positive effect on the thermal response towards the occupied interior, there is the strategy that focuses on the use of adequate orientation and azimuth angles of the cover element (Mazzeo & Kontoleon, 2020).

Materials and Method

This experimental study addresses the line of research of thermal comfort, inside the residential homes of the Crucita parish, where as a first methodological step, with the help of the bibliographic record, it was determined that 49, 83% of the houses use zinc as roofing material, on which the probabilistic formula mentioned by Flores (2014) was applied, see equation 1, whose result reflects, 328 houses, which represent the study sample (figure 2), the which, through systematic observation, were grouped, based on their roof typology, type, orientation, slope and internal constitution; where it was evidenced that the most used roofing material is zinc sheet with slopes between 0-30%, with a brick envelope material (table 1), of which the variables of number of floors and building material were delimited. the envelope and, the object of study to be tested was defined, likewise, two houses with similar building characteristics were selected to determine the current thermal state of the houses in the study area. It was based on a systematic observation of the building characteristics of the study area and on field measurements in real situations and on scale models (Hochmannova & Vytrasova, 2010; Miller et al., 1987).

Analysis and discussion of the results

One of the first activities that an architect who dedicates himself to bioclimatic architecture in his profession should know is the solar trajectory, since this gives him the guidelines for the design of what he wants to project for the use of the benefits of the sun. The investigation was developed in two stages, in the first part the current state of the internal temperatures of the buildings was analyzed; As a measurement range, the height according to the average height of the people and the activity carried out by the users, in turn, two prototypes of houses were designed, where, temperature evaluations were carried out inside; under the influence of the inclination angles and the cardinal orientations for the houses in the coastal region with hot dry climates (Cheng et al., 2012; Griffith et al., 1999).

Solar trajectory in bioclimatic architecture

More than 411 years ago, Kepler determined the speed, time and elliptical movement of the planets and other celestial bodies around the sun, with which, at present, the movements of rotation (rotational movement of the earth from east to west) and translation (movement of the earth on its own axis), among the most relevant, likewise, there is an understanding of the geographical position of this star (latitude and longitude) during the whole year (Plazola et al., 1990). In the construction practice where the criteria of Bioclimatic architecture are applied, to create thermally comfortable environments, where the occupant feels neither cold nor heat del Campo Saray & Morales (2021), it is imperative to know the solar path since it allows determining the impact of the solar rays on the envelope of the house Echeverri (2020) and especially on the roof, which helps to specify the correct orientation of the solar protections, gains in light and solar energy on this element; being the one that adapts to the environment in which it develops, taking advantage of the available resources of the inhabited environment, with the primary objective of reducing energy consumption Sanches-Montañes (2019), among the methodological parameters of bioclimatic design, the study of local

technology together with socio-cultural analysis influences the choice of accessible construction materials in the region; which, with its thermo-physical qualities and correct spatial configuration, adding to the peculiarities of the site, determine the thermal behavior of the buildings (Conforme-Zambrano & Castro-Mero, 2020). For the execution of sustainable constructions focused on the roof element, it is imperative to take into account the correct spatial configuration of the roofs, where agents such as the cardinal points based on their orientation and the angles of inclination depending on their percentage are the most determinants (Mazzeo & Kontoleon, 2020).

Due to the aforementioned, the question arises: When comparing two types of similar houses with gabled and gabled roofs, would the gabled roof present the best thermal comfort inside, due to which it would reflect both the sun's rays from the in the morning as in the afternoon and in what percentage does the floor-to-ceiling height influence the perception of heat inside, in reference to the horizontal axis occupied in daily activities inside the house? Therefore, this research will evaluate the thermal behavior inside a house with a metal roof, with a drop to a pitch and a gable in a hot dry climate, relating its typology, orientation, and inclination (Hilmo et al., 2014; Bratincsak & Palkovits, 2004).

Geographic universe, case study: Parroquia Crucita

The Republic of Ecuador is in South America, on the equator, divided into four regions (coast, mountains, east and Galapagos), where 24 provinces are distributed (Program of the Nations for Development, 2021); in the coastal region, the province of Manabi with its capital is located; the city of Portoviejo, where the Crucita rural parish is located (figure 1).

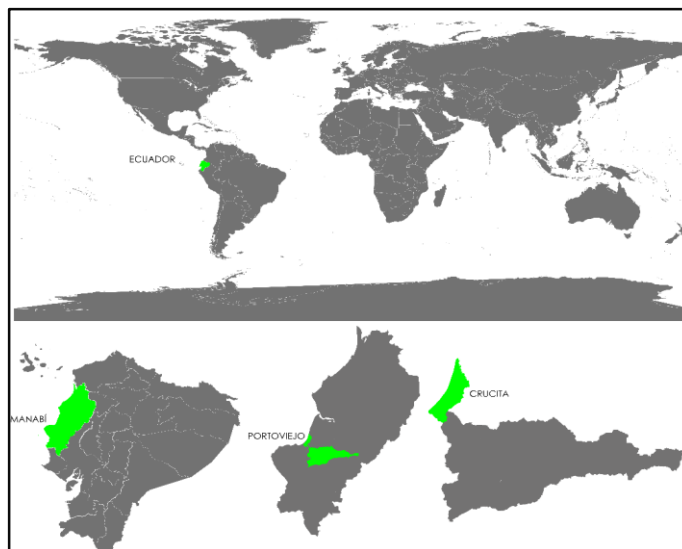


Figure 1. Geographic location of the case study
Source: Prepared by the Authors.

Known as an artisanal fishing zone with a high tourist potential, it has an area of 6,333.62 hectares and is geographically located at coordinates 0° 52' 15.80" S 80° 32' 13.52" W (Coral, 2015). It has a dry climate in summer and warm-rainy in winter, with an oscillating temperature of 23 and 28 °C, with annual rainfall between 800 and 1,100 mm and an average annual relative humidity of 65.24% (GAD Crucita, 2021). According to the last national census, it has 3,636 dwellings, of which 1,812 have zinc or similar roofing material. To determine the probabilistic sample, the equation 1.

$$n = \frac{PQ*N}{(N-1)\frac{E^2}{K^2} + PQ} \quad (1)$$

Where:

- n → Is the size of the probability sample whose value is sought.
- PQ → It is a constant of 0.25 of the population variances.
- N → Is the size of the total population.
- (N-1) → It is a relative constant for samples greater than 30
- E → It is the maximum admissible error that varies from 0.01 to 0.09.
- K → Is the error correction coefficient is a constant equal to 2.

Figure 2 shows the study area in the La Sequita sector of the Crucita parish. The selected dwellings are identified in the red spots generated in the image.



Figure 2. Study area in the La Sequita sector of the Crucita parish.

Table 1 shows the building characterization of the study sample, the data obtained from the information gathering carried out at the study site in the month of October 2020. The houses (*Mixed) are houses built with concrete blocks and brick.)

Table 1
Building characterization of the sample

		Shed roof		Gable roof	
		One-story	Two-story	One-story	Two-story
Roof materials	Sheet zinc	79	3	96	32
	Sheet Galvalume	12	5	36	7
	Asbestos	0	0	2	5
	Slab	3	21	4	23
Roof pitch	0° ≥ 10°	69	38	25	31
	11° ≥ 15°	32	1	6	1
	16° ≥ 20°	5	0	1	4
	21° ≥ 25°	23	0	50	32
	26° ≥ 30°	2	0	4	4
Envelope material	Brick	43	12	75	18
	Concrete block	23	0	1	0
	Gadua bamboo	8	6	16	15
	* Mixed	48	38	1	24
Total, sample= 328 households					

Design and orientation of the objects to be tested

Within the second phase of the investigation, to confront the thermal behavior inside buildings with metal roofs at one and two sides. Two prototypes were designed to scale volumetric dimensions of 1m³ (1m × 1m × 1m), in which the materials used were mainly wood, gypsum and paint, which were built to give similarity to the thermal characteristics within the most predominant typologies of the study area. In turn, for the construction of the roofs, a manual system was implemented that allowed to regulate the slope from 15° to 45° shown in figure 3 (Wong, 2021; Nyandra et al., 2018). The location of the prototypes was distributed in the months of October and November 2020, for each cardinal orientation. To carry out the temperature measurements, four digital thermo-hygrometers (HTC-2) were used, at a height of 1.35 ± 0.10 m and 1.75 ± 0.10 m, for reasons of average height of people Neufert (2007) and according to the activity that is carried out at the same time. interior of the house; For experimental purposes, measurements were taken inside the cores of (0.30m ± .10m and 0.55m ± 0.10m), which allowed us to generate a database from which an information matrix was developed that was used to confront the thermal variations inside (vti) and the slopes of the roof (β) in a hot dry climate.



Figure 3. Witness built for thermal data collection, with a modification system for changing the roof slope.

The data obtained from the systematic observation expresses the geographical distribution of the buildings that made up the Universe of study, denoting a disorganized spatial structure in the urban fabric and in the roofs, of this amalgam of houses with different building characteristics, see table 1, were selected two types of buildings (A and B), which share the greatest number of similarities, in which the V_{ti} were analyzed, at heights of: 0.90 ± 0.10 m (X') and 1.70 ± 0.10 m (Y'), in order to compare the variance of temperature inside on pitched and pitched roofs and determine which of the two heights X' or Y' influences the thermal comfort inside (Pérez et al., 2021; Moreira & Montes, 2021).

Situational status of buildings A and B house

A, with a pitched roof, is oriented at 1° N, with a roof slope of 25° , with a zinc roofing material and a block envelope with a thickness of 0.10 m, plastered on both sides. House B, with a gabled roof, oriented at 302° NW, with a 25° slope, with zinc roofing material and a 0.07 m thick brick envelope with interior plaster, observed in figure 4; which were evaluated, during 3 days of the month of October in the period from 10:00 a.m. to 3:00 p.m., hours of greatest solar incidence on the roof (Parrales et al., 2020; Vera et al., 2019). Dwelling A presented similar V_{ti} between X' and Y' from 10:00 a.m. to 12:00 p.m. and, with a variation of 0.1°C from 12:00 p.m. to 3:00 p.m., in contrast to dwelling B, showed variations of 0.1°C to 0.2°C , from 11 a.m. to 3 p.m.; with which the first part of the investigation was concluded, where the following stand out; In general, the one-pitch house presents the best thermal behavior inside and an almost imperceptible thermal distortion. Regarding the sample in general, under qualitative aspects, greater heat is perceived in the gabled dwellings. However, buildings with water with a β lower than 10° showed greater discomfort inside, reaching temperatures exceeding 50°C on their roofs.



Figure 4. Dwellings selected for taking interior variations, in reference to the average height and activity of the users

In this section, the effects produced by the slopes of the roof (β) at one pitch and two pitches are illustrated, in the Thermal variations inside the prototypes, being the cardinal orientations (North, South, East and West) the control guide.

North orientation

Data collection was carried out for 12 days, distributed in periods of 3 days for each slope of the roof (β), during the first 15 days of October, from 08:00 to 17:00, at 60-minute intervals. In Figure 5, we can see that β of 45° presents the lowest average values of V_{ti} ; 30.3°C and 30.8°C , at one pitch and two pitches, respectively, and the highest temperatures of 31°C in β of 15° and 20° in pitched roofs. The internal temperature distortion between the one-pitch and two-pitch roof for β of 15° is 0.1°C , for β of 20° and 30° it is 0.15°C and for β of 45° it is 0.25°C

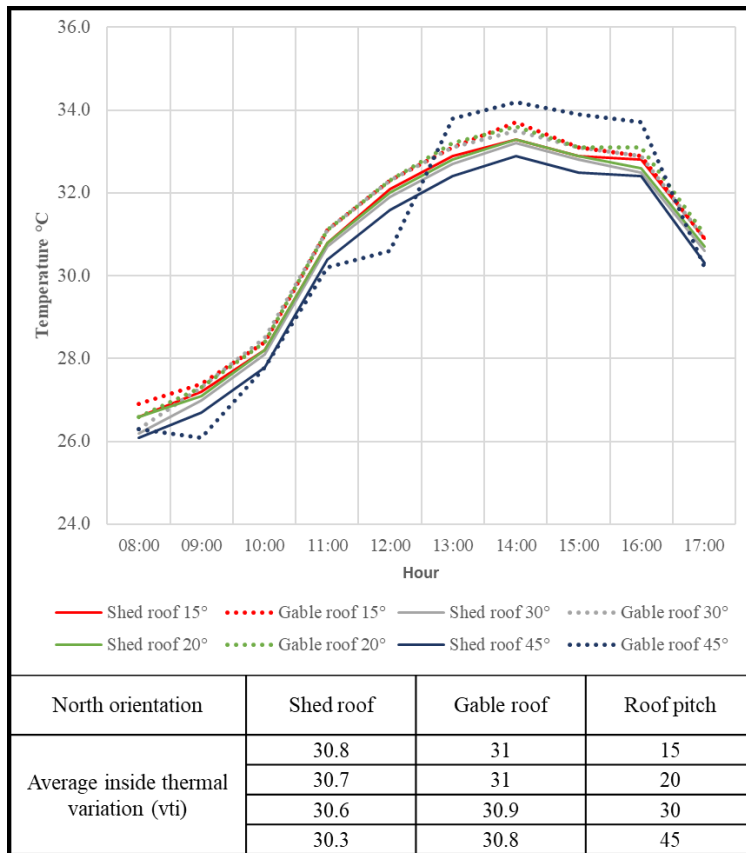


Figure 5. Variation of the internal temperature in the north orientation, to a pitch and two pitches in reference to the slope of the roof.

South orientation

Data collection was carried out over 12 days, distributed in 3-day periods for each roof slope (β), during the last 15 days of October, from 08:00 a.m. to 05:00 p.m., at 60-minute intervals. In Figure 6, β of 45° presents the lowest average values of Vti; 30.4°C and 30.8°C, at one pitch and two pitches, respectively, and the highest temperatures of 31°C in β of 15° and 20° on pitched roofs. The internal temperature distortion between the one-pitch and two-pitch roof for β of 15° is 0.05 °C, for β of 20°, 30°, 45° it is 0.10 °C, 0.15 °C and 0.20 °C, respectively.

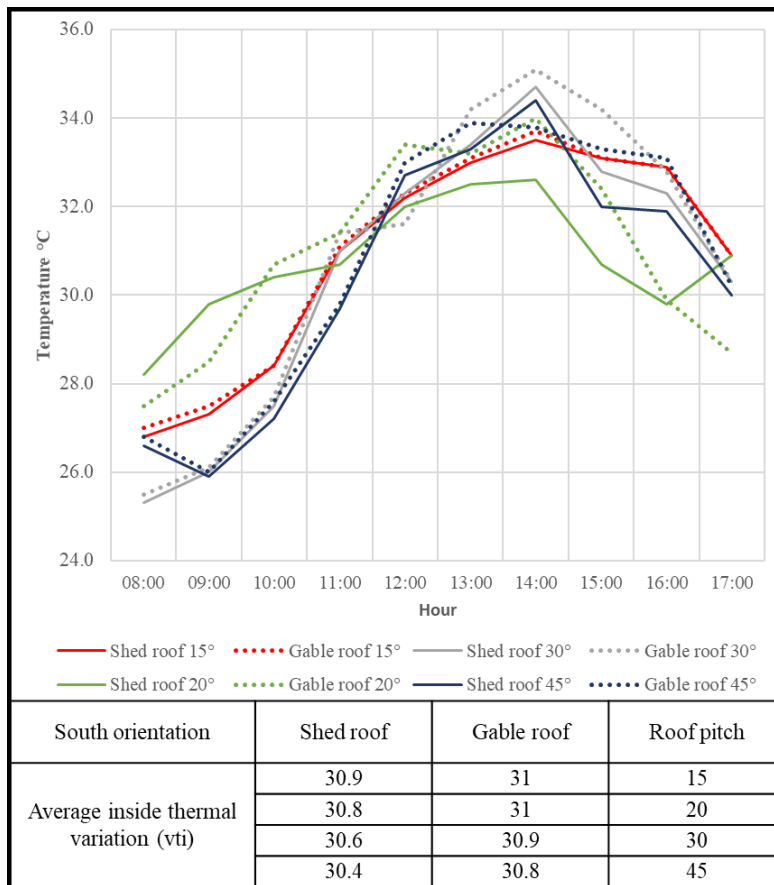


Figure 6. Variation of the internal temperature in the south orientation, one water and two waters in reference to the slope of the roof.

East orientation

The data collection for the East orientation was carried out for 12 days, distributed in periods of 3 days for each slope of the roof (β), during the first 15 days of the month of November, from 08:00 to 17:00, at intervals of 60 minutes. In figure 7, it will be observed that β of 45° presents the lowest average values of V_{ti} ; 30.5°C and 30.7°C, at one pitch and two pitches, respectively, and the highest temperatures of 31°C in β of 15° and 20° on pitched roofs. The internal temperature distortion between the one-pitch and two-pitch roof for β of 15° is 0.05 °C, for β of 20°, 30° and 45° it is 0.10 °C.

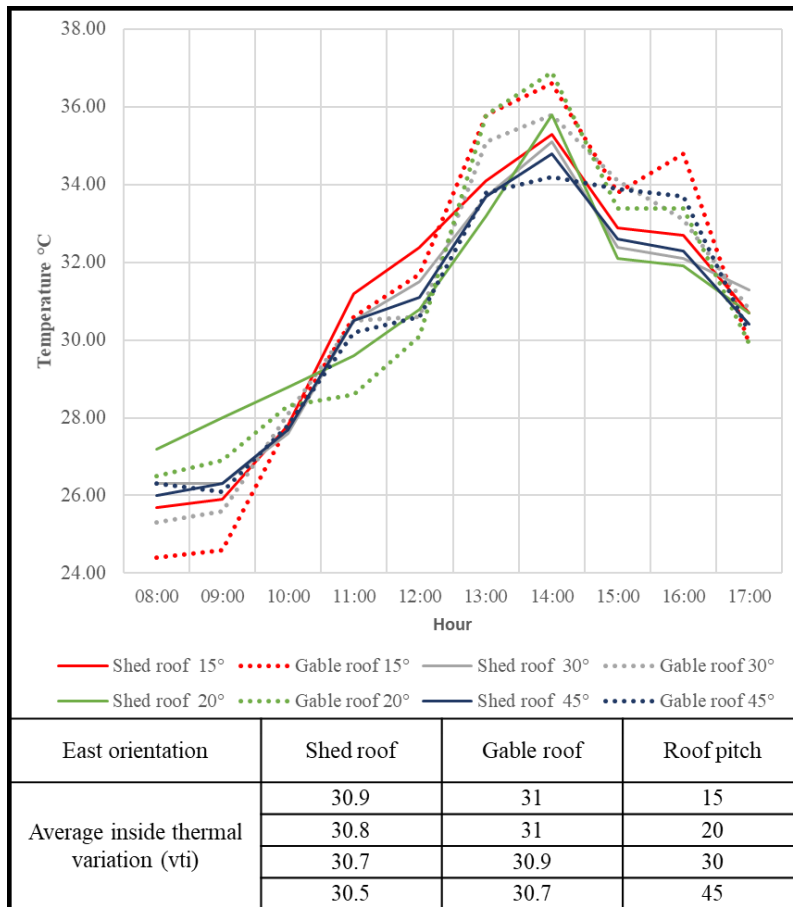


Figure 7. Variation of the internal temperature in the East orientation, to a water and two waters in reference to the slope of the roof.

West orientation

The data collection for the West orientation was carried out for 12 days, distributed in periods of 3 days for each slope of the roof (β), during the last 15 days of the month of November, from 08:00 a.m. to 5:00 p.m., at intervals of 60 minutes. Figure 8 shows that β of 45° presents the lowest average values of Vti; 30.1°C and 30.7°C, at one pitch and two pitches, respectively, and the highest temperatures of 31°C in β of 15° and 20° on pitched roofs. The average internal temperature distortion between the single and gabled roof for β of 15° is 0.15 °C, for slopes of 20°, 30°, 45° it is 0.20 °C, 0.25 °C and 0.30 °C, respectively.

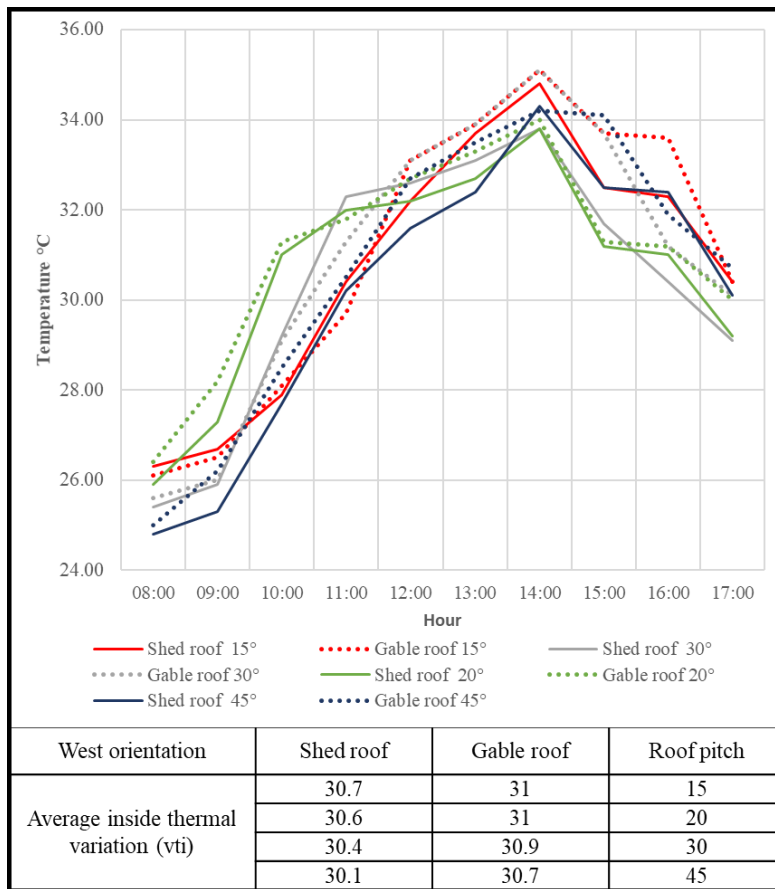


Figure 8. Variation of the internal temperature in the West orientation, to one water and two waters in reference to the slope of the roof.

Comparison of one-and two-roofs in reference to the four orientations

Based on the field study carried out, in qualitative aspects the best thermal variation inside in summer occurs in the evening and night hours, that is, the farthest from the daylight hours. Quantitatively, in general aspects, the one-pitch roof presents a better variance of 0.3 °C, this quantifiable value exposes it as the best type of roof, in turn, it was identified that the orientation to one water with the highest part of the roof towards the West presents the least thermal variation inside with 49.63%, followed by the North, South and East orientation with values of 49.74%, 49.80% and 49.86% respectively. In reference to the internal temperature distortion for both the one-pitch and two-pitch roofs, the South orientation exhibits the best results, which disagree with [Mazzeo & Kontoleon \(2020\)](#), who in their research affirm; that North generally guarantees the least internal and external distortion regardless of ceiling configuration. Result that provide the least distortion for orientation South, East, North and West, in descending degree.

In general, β of 15° and 20° influences the V_{ti} with a variance of $+ 0.1^\circ\text{C}$ for one water and is damped for two waters. For β of 30° and 45° , it presents a greater temperature variation for orientation west. The highest and lowest variance for the two roof types is for β equal to 45° and 15° , respectively.

Single pitch roof

Under the geographical parameters where the study was carried out, all the increasing variations of β are inversely proportional to the thermal variations inside; for the North orientation, the increase β from 15° to 30° determines a linear reduction of 0.1°C , then it decreases slightly by 0.3°C . The South orientation, for β from 15° to 20° decreases by 0.1°C and for the variation from 20° to 45° it decreases by 0.2°C . The East orientation shows a linear reduction of 0.1°C up to $\beta 30^\circ$, then it decreases slightly by 0.2°C . The West orientation, for β from 15° to 20° decreases by 0.1°C , then decreases slightly by 0.2°C and 0.3°C for $\beta 30^\circ$ and 45° , respectively, can be seen in Figure 9. Under these results it is defined that: the worst thermal conditions are for the East orientation, followed respectively by the roofs facing South, North and West, this result agrees to a certain degree with [Mazzeo & Kontoleon \(2020\)](#), who states that generally, the lowest values of the component are obtained for roofs with orientations East, South, West, North.

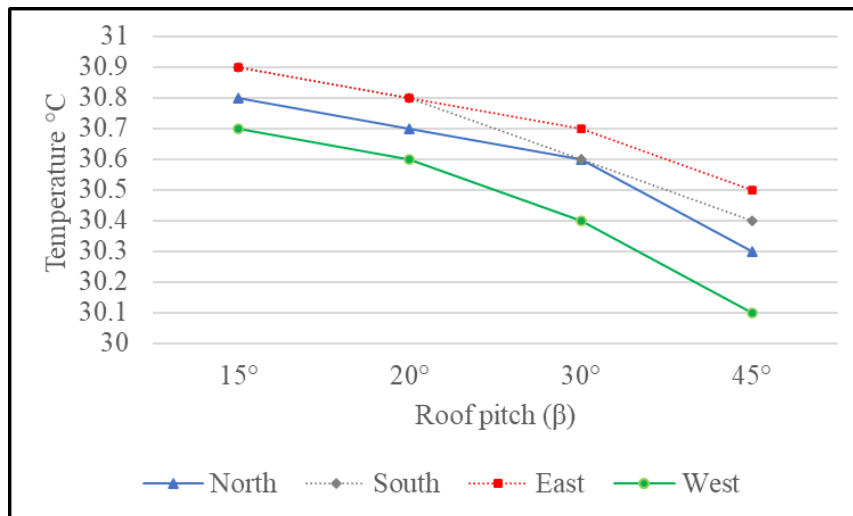


Figure 9. Internal variations of average temperature of the roof with drop to a pitch, for the different angles of orientation in the period of October and November

Gable roof

The variations of β from 15° to 30° are constant in reference to the thermal variations inside then, for variations of β of 30° and 45° decrease by 0.1°C , with respect to the North and South orientation. Likewise, it was determined that the V_{ti} for the North and South orientations are symmetrical, the same occurs with the East and West orientations, observed in figure 10, this effect is due to the symmetry of the roof, which is consistent with [Plazola et al. \(1990\)](#), who evidences in his notes that there is symmetry of the solar rays in the insolation of the

vertical angles in the northern hemisphere and more explicitly for the case of Ecuador.

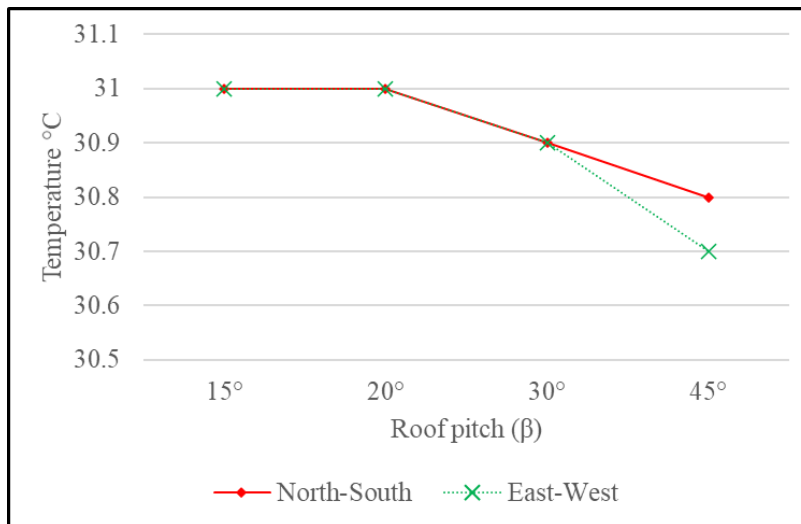


Figure 10. Internal variations of average temperature of the gabled roof, for the different angles of orientation in the period of October and November

Under this context, the V_{ti} , which show the worst thermal behavior are for the North-South orientations, followed by the roofs oriented to the East-West, In this type of roof, the V_{ti} trend depends to a large extent on the type of roof, while the effect of orientation is not definitive, a result that agrees with [Mazzeo & Kontoleon \(2020\)](#), who states that “the amount of roof capacity determines the shape of the trend, while the thermal resistance of the roof influences the fluctuation amplitude” (p. twenty). All these results can be easily used to implement design regulations in the spatial configuration of roofs with the aim of achieving a high level of comfort and mitigating carbon emissions by reducing the use of HVAC systems.

The housing solutions of the study area do not present a regular structure in their implementations, the same occurs with the orientations and inclinations of the roof, in the 328 observed homes, it was identified that the most predominant material in the buildings is the zinc sheet With 64.02%, these results agree in qualitative terms with [Véliz-Párraga & González-Couret \(2019\)](#), and agree to a certain degree with the INEC, who states that the use of zinc material on roofs is 49.83%. , however, this data is from the 2010 census and the present study was carried out in 2020. The most used angle of inclination is for values of β between $0^\circ \geq 10^\circ$ with 49.70% followed by β between $21^\circ \geq 25^\circ$ with 32.01% and, the most predominant material of the envelope is fired brick with 45.12%, followed by housing constructions with concrete blocks and brick with 33.84%.

Regarding the evaluation made to the two room solutions, it was determined that the influence of the heights of X' and Y' is not decisive in the V_{ti} of the buildings in the study area. The field study determined that the orientation to a pitch with the highest part of the roof to the West presents the lowest V_{ti} and that the south

orientation exhibits less internal temperature distortions both for a pitched roof and for roofs likewise, it was shown that for the one-pitch roof, all the increasing variations of β are inversely proportional to V_{ti} , where the smallest β presents higher V_{ti} , noting that for buildings with the highest part of the Roofs facing East present the worst thermal conditions. For gabled roofs, it was shown that the V_{ti} are symmetric both for the North-South direction and for the East-West direction.

The work carried out discards the proposed hypothesis, because the best thermal conditions are found in housing solutions with a pitched roof and that under real conditions the ceiling floor height does not influence the perception of heat inside the house, in reference to the zone occupiers (1.70 ± 0.10 m). Based on this evidence, it is considered feasible to increase the knowledge of the relationships between the angles of inclination, height and the orientation of the roof; in the different types of climates on the globe; Likewise, the question arises as to what would happen if the different types of passive strategies were applied, focused on the cover element. Knowing that discomfort inside the home generates sensations of discomfort and increases the use of HVAC systems; This study recommends replicating these evaluations in the winter season to obtain annual results, with which it will be feasible to implement the design regulations for the roofs. The limitation of the investigation was to determine the temperature variation inside the prototypes due to the proximity of their heights.

Conclusion

Two housing prototypes were designed, where temperature evaluations were carried out inside; Under the influence of the inclination angles and cardinal orientations for homes in the coastal region with hot dry climates, these evaluations will allow the implementation of design regulations in the spatial configuration of the roofs, helping to increase the level of comfort. The best thermal behavior inside the house is from the pitched roof orienting the highest part of the roof towards the West with inclination angles greater than 20° where all the increasing variations of the inclination angles are inversely proportional to the thermal variations inside, in addition to the fact that, for gabled roofs, the temperature variations inside are symmetric both for the North-South direction and for the East-West direction.

References

- Andreoni Trentacoste, S. E., & Ganem Karlen, C. (2017). The Influence Of The Use And Management Of The Envelope On The Thermal Behavior Of A Dwelling In Summer In The City Of Mendoza, Argentina. *Revista Habitat Sustentable*, 7(2), 65-75.
- Bratincsak, A., & Palkovits, M. (2004). Activation of brain areas in rat following warm and cold ambient exposure. *Neuroscience*, 127(2), 385-397. <https://doi.org/10.1016/j.neuroscience.2004.05.016>
- Calderon Uribe, F. (2019). Evaluación del mejoramiento del confort térmico con la incorporación de materiales sostenibles en viviendas en autoconstrucción en Bosa, Bogotá. *Revista hábitat sustentable*, 9(2), 30-41.

- Cheng, H., Liu, Q., Yang, J., Ma, S., & Frost, R. L. (2012). The thermal behavior of kaolinite intercalation complexes-A review. *Thermochimica Acta*, 545, 1-13. <https://doi.org/10.1016/j.tca.2012.04.005>
- Cobo Fray, C., & Montoya Flórez, OL (2021). Tuhouse: high-density sustainable social housing prototype for the tropics. *Sustainable Habitat Magazine*, 11 (1), 32-43.
- Conforme-Zambrano, G. D. C., & Castro-Mero, J. L. (2020). Arquitectura bioclimática Bioclimatic architecture Arqitutura bioclimática.
- Coral, S. (2015). Territorial Planning and Development Plan for the Crucita parish.
- Cújar-Vertel, A. D. C., & Julio-Espitia, G. P. (2016). Evaluación de las condiciones térmicas ambientales del área de producción en una panadería en Cereté (Córdoba). *Entramado*, 12(1), 332-343.
- Del Brutto, O. H., Mera, R. M., Zambrano, M., & Sedler, M. J. (2019). Influence of frailty on cognitive decline: a population-based cohort study in rural Ecuador. *Journal of the American Medical Directors Association*, 20(2), 213-216. <https://doi.org/10.1016/j.jamda.2018.09.023>
- del Campo Saray, F. J. M., & Morales, G. B. (2021). Confort térmico en interiores y exteriores de espacio educativo en clima cálido semi-seco. *REVISTARQUIS*, 9(1), 96-111.
- Echeverri, P. (2020). Importancia de la trayectoria solar en la arquitectura.
- Espinosa Cancino, C. F., & Cortés Fuentes, A. (2015). Confort higro-térmico en vivienda social y la percepción del habitante. *Revista Invi*, 30(85), 227-242.
- Flores, C. (2014). Introducción a la Estadística. *Manta: Mar Abierto*.
- GAD Crucita. (2021). Crucita la bella.
- Griffith, M. L., Schlienger, M. E., Harwell, L. D., Oliver, M. S., Baldwin, M. D., Ensz, M. T., ... & Nelson, D. V. (1999). Understanding thermal behavior in the LENS process. *Materials & design*, 20(2-3), 107-113. [https://doi.org/10.1016/S0261-3069\(99\)00016-3](https://doi.org/10.1016/S0261-3069(99)00016-3)
- Gutiérrez, R. E., Guerra, K. B., & Gutiérrez, M. D. (2018). Evaluación de riesgo por estrés térmico en trabajadores de los procesos de incineración y secado de una empresa de tableros contrachapados. *Información tecnológica*, 29(3), 133-144.
- Hilmo, J., Naesheim, T., & Gilbert, M. (2014). "Nobody is dead until warm and dead": Prolonged resuscitation is warranted in arrested hypothermic victims also in remote areas-A retrospective study from northern Norway. *Resuscitation*, 85(9), 1204-1211. <https://doi.org/10.1016/j.resuscitation.2014.04.029>
- Hochmannova, L., & Vytrasova, J. (2010). Photocatalytic and antimicrobial effects of interior paints. *Progress in Organic Coatings*, 67(1), 1-5. <https://doi.org/10.1016/j.porgcoat.2009.09.016>
- Huellas De Arquitectura. (2018). Medidas activas y pasivas en la Arquitectura Bioclimática.
- Jayasinghe, M. T. R., Attalage, R. A., & Jayawardena, A. I. (2003). Roof orientation, roofing materials and roof surface colour: their influence on indoor thermal comfort in warm humid climates. *Energy for Sustainable Development*, 7(1), 16-27.
- Leung, C. (2004). Macroeconomics and housing: a review of the literature. *Journal of Housing Economics*, 13(4), 249-267. <https://doi.org/10.1016/j.jhe.2004.09.002>

- Mazzeo, D., & Kontoleon, K. J. (2020). The role of inclination and orientation of different building roof typologies on indoor and outdoor environment thermal comfort in Italy and Greece. *Sustainable Cities and Society*, 60, 102111.
- Medina, M., Kaiser, E., López, R., Domizio, C., & Santillán, L. (2021). Use of the thermal inertia of concrete for energy savings in buildings. *Technological Ingenuity*, 3, e018-e018.
- Melisa Viegas, G., Walsh, C., & Barros, M.V. (2016). Qualitative-quantitative evaluation of alternative thermal insulation for housing: The case of family farming. *INVI Magazine*, 31 (86), 89-117.
- Miller, S., Janin, J., Lesk, A. M., & Chothia, C. (1987). Interior and surface of monomeric proteins. *Journal of molecular biology*, 196(3), 641-656. [https://doi.org/10.1016/0022-2836\(87\)90038-6](https://doi.org/10.1016/0022-2836(87)90038-6)
- Moreira, D. M. M., & Montes, L. C. Z. (2021). Active listening techniques in the language skills of the upper basic of the San Cayetano Chone educational unit. *Linguistics and Culture Review*, 5(S2), 934-947. <https://doi.org/10.21744/lingcure.v5nS2.1617>
- Motta, I. O., Cáceres, C. H., & Bernal, O. L. (2017). Techo plantado como dispositivo de climatización pasiva en el trópico. *Revista de arquitectura*, Vol. 19, no. 1 (ene.-jun. 2017); p. 42-55.
- Neufert, E. (2007). Arte de proyectar en arquitectura.
- Nyandra, M., Kartiko, B.H., Susanto, P.C., Supriyati, A., Suryasa, W. (2018). Education and training improve quality of life and decrease depression score in elderly population. *Eurasian Journal of Analytical Chemistry*, 13(2), 371-377.
- Parrales, E. B. A., Palma, J. K. T., Álava, R. A. Q., & Campuzano, M. F. P. (2020). The cognitive process and influence in learning. *International Journal of Linguistics, Literature and Culture*, 6(2), 59-66. <https://doi.org/10.21744/ijllc.v6n2.875>
- Pérez, A. V., Ramos, J. L. M., Gámez, M. R., Giler, B. I. C., Villavicencio, C. I. P., & Mendoza, M. E. C. (2021). Use of the local energy resource in the El Carmen canton of the Manabí province. *Linguistics and Culture Review*, 5(S4), 645-656. <https://doi.org/10.21744/lingcure.v5nS4.1700>
- Plazola, A., Plazola, A., & y Plazola, G. (1990). *Arquitectura habitacional*. volumen II quinta edición complementada. Editorial Plazola. México
- Quezada, J. E. T. (2018). *Comportamiento térmico de la cubierta en un clima cálido húmedo. Repercusión energética en el edificio* (Doctoral dissertation, Universitat Politècnica de Catalunya (UPC)).
- Rivera Roma, J. M. (2020). Riesgo de estrés térmico en trabajadores expuestos al calor en un proceso térmico.
- Sanches-Montañes, B. M. (2019). *Arquitectura bioclimática: conceptos y técnicas*.
- Sosa, L. H. (2013). Temperatura y rangos de confort térmico en viviendas de bajo costo en clima árido seco. *Hábitat Sustentable*, 26-36.
- Tapia-Armijos, M. F., Homeier, J., & Munt, D. D. (2017). Spatio-temporal analysis of the human footprint in South Ecuador: Influence of human pressure on ecosystems and effectiveness of protected areas. *Applied Geography*, 78, 22-32. <https://doi.org/10.1016/j.apgeog.2016.10.007>
- Torres-Corredor, R. A., Ponce-Villarreal, P., & Gómez-Martínez, D. M. (2017). Vulnerabilidad física de cubiertas de edificaciones de uso de ocupación normal ante caídas de ceniza en la zona de influencia del Volcán Galeras. *Boletín de Geología*, 39(2), 67-82.

- Véliz-Párraga, J., & González-Couret, D. (2019). Vivienda de interés social en Portoviejo. Ambiente térmico interior. *AUS [Arquitectura/Urbanismo/Sustentabilidad]*, (26), 35-41.
- Vera, A. B. G., Vera, M. K. G., Garcia, A. M. R., & Miranda, M. J. V. (2019). Application of self-evaluation and co-evaluation on learning processes. *International Journal of Linguistics, Literature and Culture*, 5(5), 7-14. <https://doi.org/10.21744/ijllc.v5n5.727>
- Wong, Y. Z. (2021). Written, scratch and spelling languages. *Macrolinguistics and Microlinguistics*, 2(1), 51-65. Retrieved from <https://mami.nyc/index.php/journal/article/view/15>
- Würbel, H. (2001). Ideal homes? Housing effects on rodent brain and behaviour. *Trends in neurosciences*, 24(4), 207-211. [https://doi.org/10.1016/S0166-2236\(00\)01718-5](https://doi.org/10.1016/S0166-2236(00)01718-5)