The behavior and thermal comfort of housing in the sustainable rural city of Nuevo Juan Del Grijalva , Chiapas , Mexico.

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Abstract

This paper presents results on the behavior and thermal comfort in the rural sustainable housing community of Nuevo Juan de Grijalva, located in Chiapas, Mexico, during the month of January. In order to measure thermal behavior, Dry Bulb Temperature Variables and Superficial Interior Temperatures were measured; Thermal comfort was analyzed using the adaptive approach, using a questionnaire designed under regulation ISO 10551. This information allowed for the development of proposals to improve the housing design, principally for the use of passive means oriented towards thermal comfort in future developments.

keywords: Thermal comfort, wet weather, rural housing.

Introduction

This document presents the results of the research project entitled "The components and conditions of housing in sustainable rural cities of Chiapas. Case Study Nuevo Juan del Grijalva" by the Academic Body Components and Determinants of Housing (Cocovi) from the School of Architecture at the Autonomous University of Chiapas (UNACH). This paper seeks to contribute knowledge when considering improvements to the homes in the community.

The city is located in the municipality of Ostuacán , in the northern region of the state of Chiapas. It has a warm humid climate with rains in the summer, and an altitude of 320 m above sea level. The project was proposed for a two year period, as the city filled with people for the study who originated from different locations. The majority of the new population was relocated because their homes suffered damage by the collapse of a mountain, causing irreversible damage to the settlement that was originally called Juan del Grijalva .

Background

As part of the extension activities of the UNACH, through Cocovi , a research line was outlined entitled Technology Transfer for Bioclimatic Housing. A project was developed that included the evaluation of various aspects of the rural town Nuevo Juan del Grijalva , looking at the physical aspects of the housing and the settlement as a whole.

This article only deals with the results of the evaluation of the thermal behavior of housing and the thermal comfort experienced by its inhabitants , with the goal to generate a document that particularly serves to train students in the School of Architecture , and if the case, may result in proposals for the improvement of the new settlement houses.

Due to logistical conditions of the project, field work was carried out during the hottest period for the region, however the results will be compared later during awarmer period from April 15 to May 15.

General Objective

Evaluate the thermal performance of housing in the sustainable rural city of Nuevo Juan de Grijalva, and determine the Neutral Temperature (Tn) and comfort zone of people living in the homes for the month of January using the adaptive approach.

Materials and methods

Location of Nuevo Juan del Grijalva

The sustainable rural city of Nuevo Juan de Grijalva is located in the northern region of the state of Chiapas , 17 ° 25’38 ’’ North Latitude and 93 ° 22’20 ’’ west longitude. It is located at an average altitude of 320 m above sea level. The area maintains a warm humid climate with rain throughout the year (Fig. 1) . There are currently 410 homes, as well as infrastructure , services and equipment that characterize a city.

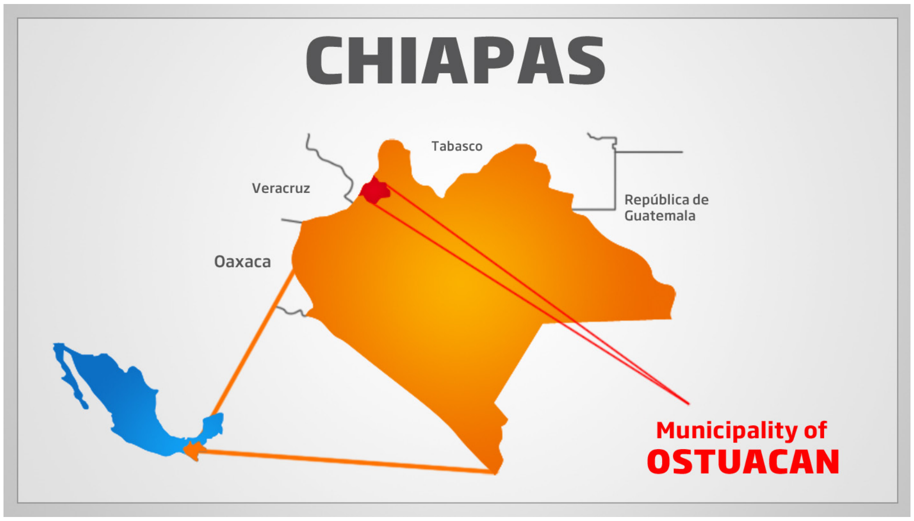

Fig. 1 Location of the municipality of Ostuacan in the State of Chiapas, Mexico. Source: Institute of Population and Rural Cities of the State of Chiapas, 2012.

This settlement was built on the tract of land called "El Cinco" , seven kilometers from the county seat . Fig. 2

Figure 2.

The settlement

The amount of land dedicated for the new town was 80 hectares , 7 kilometers from the county seat of Ostuacán . 50 hectares were used for the urban settlement where 410 homes were built along with facilities and city services. 30 hectares were added that were used for productive projects such as greenhouses to produce habanero chilies, dairy processing, cocoa processing a packing facility, etc. (fig. 3)

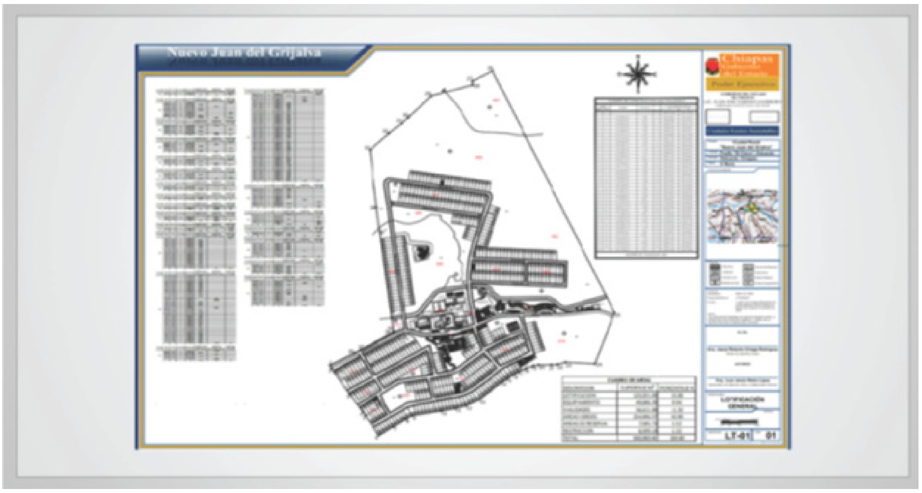

Figure 3.Urban plan for the rural city of Nuevo Juan del Grijalva. Source: Government of the State of Chiapas, 2012

Housing

Permanent housing was built of soil-cement walls with a double layer fibercement roof with a five centimeter expanded polystyrene core for thermal insulation. This design was coupled with the closure of the corridor area, which was insisted upon by as a requirement by the population (Figs. 4, 5 and 6).These changes were considered as final project factors.

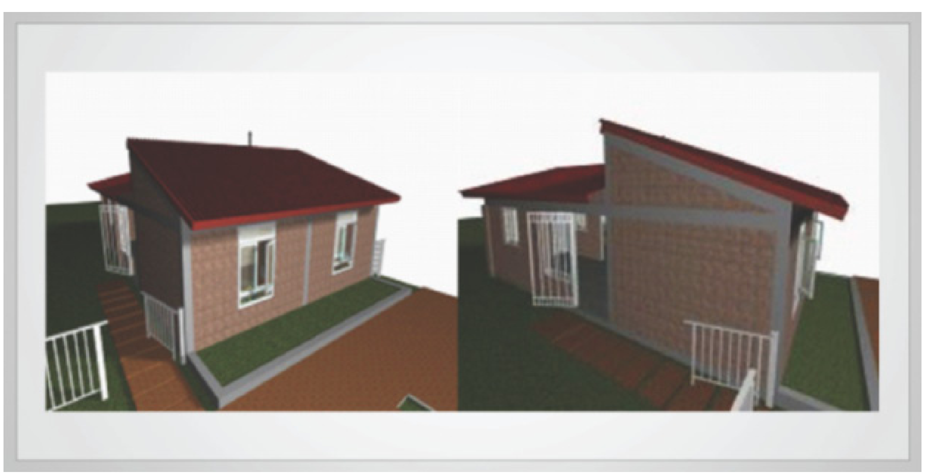

Fig. 4.Housing proposal with a roof of insulated fiber cement sheets and the closed corridor in order to increase the interior of the home. Source: Castaneda Nolasco, 2008.

Fig. 5 Material used in the walls and roof. Blocks of improved (cement) adobe and fiber cement sheets with a 5 cm expanded polystyrene core, with the objective to reduce exterior thermal gain.

Fig. 6. Panaoramic view of the Nuevo Juan de Grijalva settlement. Source: Castaneda Nolasco, 2008.

Thermal evaluation

A home was chosen for the evaluation of thermal behavior and HOBO automatic data collection equipment was placed to measure the internal temperature and dry bulb surface temperature.Measurements were taken during 36 continuous hours, taking automatic readings every 20 seconds approximately every half hour.

For the comfort study, households were randomly selected in different parts of the city. 35 people agreed to participate in the study.

The data collection was conducted during the 16 and 17 of January in morning and evening periods. The method for selecting participants who conducted the field work was through direct sampling, since it was a priority to have people who were serious when answering the questionnaires as well as have confidence when deciding where to install the heat stress monitor, which is fragile. Therefore, it was important to choose subjects with certain specific characteristics in a careful and in a controlled manner.

Aspects that were considered for the selection of subjects for the sample

It is important to mention that the characteristics presented are quite synthesized, and are developed according to internal and external factors that influence people's thermal preference.

The aspects considered for selecting people to interview were:

- People aged 11 to 75 years old were surveyed.
- People were living in the city for a minimum of six months prior to the study.
- They are willing to answer the questionnaire.
- Their houses were naturally ventilated.
- That the homes of the selected subjects were located in different parts of the rural city.

Equipment used for monitoring thermal comfort

The data recorded inside the houses were the dry bulb temperature, wet bulb temperature, globe temperature, relative humidity and wind speed. A heat stress monitor QUESTemp 36 was used for indoor monitoring.

Figure 7: Thermal stress monitor and multidirectional anemometer.

Equipment used for monitoring the thermal behavior

A HOBO DATA LOGGER (ONSET) was used (fig. 8) , measuring the Dry Bulb Temperature (DBT) and Interior Surface Temperature (IST) with an external sensor from the data logger .

The questionnaire was developed from the questionnaire used in the project "Thermal comfort and energy savings in affordable housing in Mexico, warm dry and warm wet climates " (CONAVI , 2005). Other related research was also revised and modifications were made to suit the aims of this study. The questionnaire used was adapted in the doctoral thesis of Pavel Ruiz (2011) . The objective of this survey was to establish the thermal sensation and thermal preference of those occupying the housing.

The survey is divided into 5 parts, which are explained in the following paragraphs :

1) Control data :

Used for recording the dates, the pages of each questionnaire, the monitoring period and the registry of who recorded the survey.

2)General information of the inhabitant :

Filled out in the office, it contains data identifying the inhabitant as well as constants during the monitoring period such as height, weight, and age.

3) Data filled for each answer session:

Temporal data is recorded such as the date and time , and a questionnaire is filled every hour. We want to know the date and time for each response in order to be able to compare the data recorded by the equipment.

Figure 8. HOBO data logger

Factors that change are registered over time such as the type of clothing worn and climate control devices activated on site, the time spent being in the house and the activity done before answering the questionnaire.

The type of clothing was classified according to the style of dress used at home inthe town. For this classification factor we were helped by the " Clo " factor (Innova , 1997) for further later analysis . The activity prior to filling the questionnaire was based on the ISO 8996 (1989) . This guideline is part of a series of international standards that refer to the thermal environment. It describes the different methods for determining energy consumption, indicating a level of accuracy for each method.

4) Perception of hygrothermal environment inside the home :

This contains data for the identification of sensation: the preference and tolerance of people living in the household regarding the hygrothermal environment. The thermal sensation, sense of humidity, ventilation , radiation, temperature preference , preference of humidity, ventilation preference, radiation preference and personal tolerance to the thermal environment are asked . The sensation and preference range are taken according to ISO 10551 (Standard which marks the elements needed to make an assessment of the thermal environment based on subjective questions)

5) Physical monitoring data :

This is filled in the office and records the data registered by the heat stress monitor. There are two columns, one for data recorded indoors and another for outdoor data. The recorded data that are measured indoors are the dry bulb temperature , wet bulb temperature , globe temperature , relative humidity and wind speed. The data recorded outdoors are dry bulb temperature , relative humidity and dew point .

Below you can see some photos of data being collected in the homes (see Figures 9 and 10) .

Analysis method

For data analysis we used Excel. With this software neutral comfort temperature was found taken from a least square regression. In order to obtain the thermal comfort zone ± 2.5 was added to define the limits of the area.

Figure 9 & 190

Results of the analysis of thermal comfort

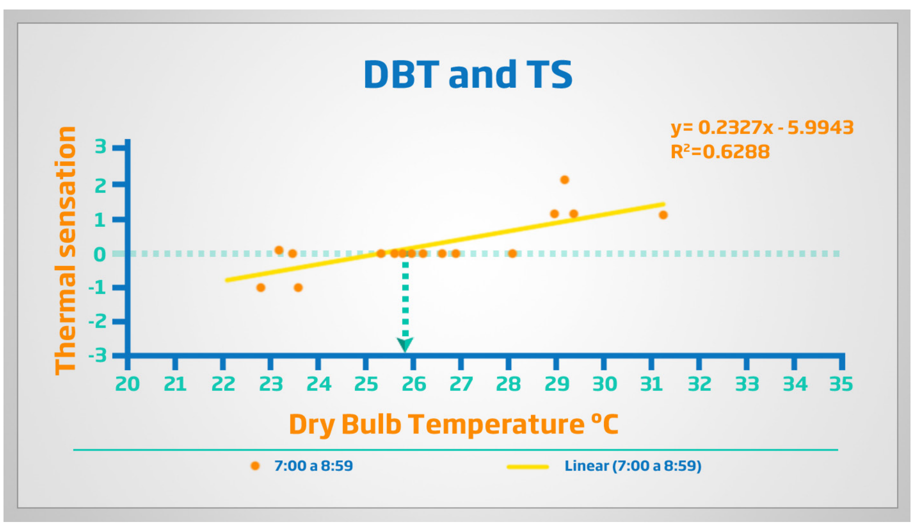

Figure 11.Data analysis by regression of minimal squares. Thermal sensation (TS) and Dry Bulb Temperature (DBT).

In Figure 11 peoples thermal sensation is plotted on the y-axis and at " X " axis the Dry Bulb Temperature (DBT) .

Once the data are entered a trend line is added asking for a R-value to determine the degree of correlation between the data. The R-value of 0.6288 indicates that there is a relationship between the data and they are not fortuitous. It is important to note that the ideal R is the value 0.9 , but with the limited data obtained in the field the value is high since by increasing it by 100 cases it is likely to be around 0.8 or 0.9 . After obtaining the trend line you can get the neutral temperature (Nt),which can be expressed graphically as seen in Figure 11 or by replacing the "zero" value in the line equation , clearing the value of " X " . The resulting Nt is 25.8 ° C , which for practical purposes is rounded to 26 ° C. Once you get the Nt it is added and 2.5 is subtracted to determine the limits of the comfort zone . Finally, the comfort zone that was obtained was between 23.5 ° C to 28.5 ° C. Nt is 26 ° C.

Nt was compared with two adaptive models obtained in similar climates. The results are as follows: In Brager-De Dear (1998) , the formula is Nt = 17.38 + ((0.31 * Tm)) , Tm being the middle of the month for analysis or in this case, annually. For Humphreys -Nicol (2000) , the formula is Nt = 13.5 + ((0.51 * Tm)) . The substitute value what was chosen was the TBS average for January, obtaining the historic SMN from climatological norms, which in January for Ostuacan the At is 25.7 ° C.

The results in Table 1 indicate that obtained in " Tn " complies with the parameters mentioned under adaptive approach , the difference between the models is minimal, thus could be used to preliminarily evaluate thermal behavior conditions dwellings rural town , staying with Tn = 26 ° C with a comfort zone that ranges from 23.5 ° C to 28.5 ° C.

Brager-De Dear (1998)	Tn=	25.3
Humpreys - Nicol (2000)	Tn=	26.6

Table 1:Calculation of Nt with two adaptive models for the month of January.

Results of the thermal behavior

The result of the housing evaluation in reference to comfort zone obtained from this investigation indicates that there are comfortable conditions practically all day, with the exception of the early morning hours when there were feelings of cold . It is noteworthy that no critical cold conditions were present considering the type of climate that prevails in the region.

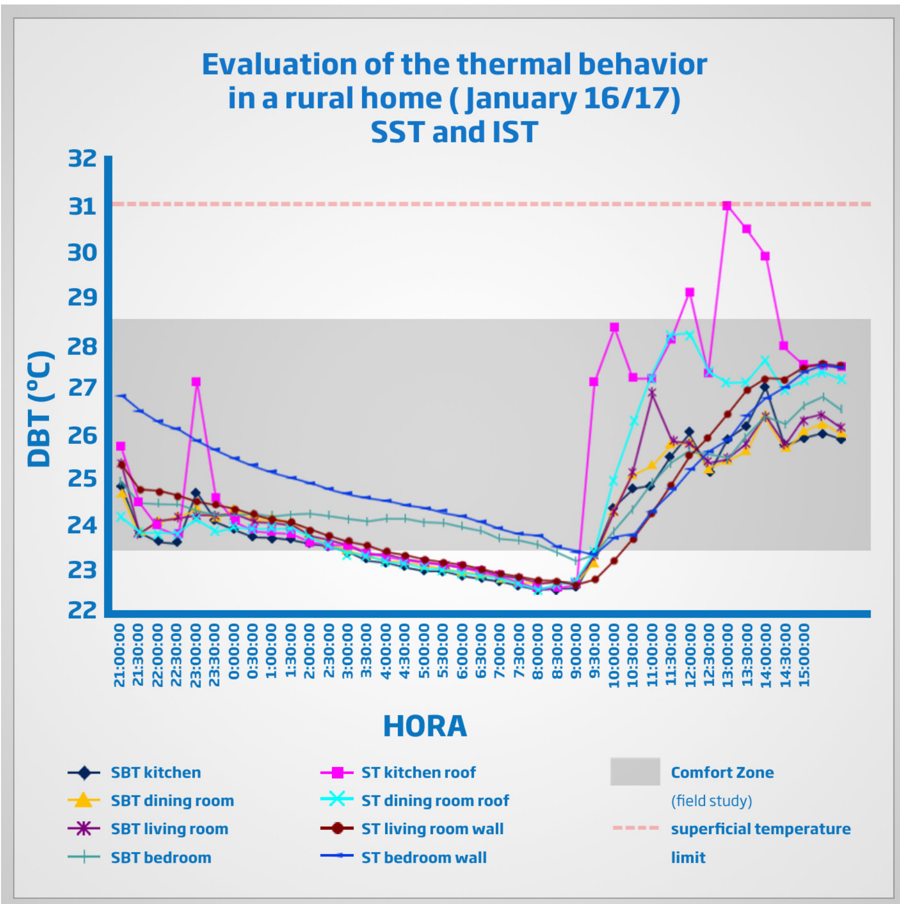

Figure 12: Evaluation of the thermal behavior in a rural home (January 16/17) SST and IST

The inner surface temperature was compared with the skin surface temperature (31 ° C to 34 ° C according to Auliciems and Szokolay, 1999). This parameter is indicated in Figure 12 by a red line , and as can be observed, the surface temperatures of the roofs and walls do not exceed this limit. The system infers that the roof sandwich, which is composed of two layers of fiber cement with two inches of polystyrene, mitigates solar radiation gain in the roof .

Conclusions

The evaluation of the thermal behavior of the rural city housing in Nuevo Juan de Grijalva for the month of January presents comfortable conditions during the day. This was checked by analyzing the comfort of the inhabitants using a comfort zone obtained under the adaptive approach, which is usually above international standards with the premise that people tend to adapt to the weather conditions they experience. However, the comfort zone and neutral temperature coincide with adaptive models used more often in thermal comfort studies. On the other hand, the surface temperature of the roof and walls presented optimal conditions regarding their thermal performance since they did not exceed the limit of the surface skin temperature.

These results will be compared with future studies which will be conducted in the warmer months, but it can be inferred that the results will be similar regarding the surface temperature variable, the opposite can be expected for the interior dry bulb temperature because this is directly influenced by the outside air temperature.

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