Thermal Performance and the Inhabitants' Response:
The case of the Palapa in Colima, Mexico

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ABSTRACT: In Mexico, a constructive system denominated "palapa" exists. This system is very typical of the Pacific Ocean coast. A group of Filipinos brought by Spaniards to the state of Colima to produce "coconut wine" (lambanog) introduced its construction technique to Mexico during the XVI century. Palapa constructions are basically housing buildings made either of reeds or palm tree veins. The reeds are sometimes intertwined and sometimes tied up with fibers. They are mostly uncovered to allow free airflow. These houses are roofed with cayaco palm tree leaves (attalea cohune). The houses built with this system present some advantages within the high temperature and humidity conditions in places where they were constructed. The isolated architectural scheme that implies this construction type, and its permeable materials to the ventilation, allows an intense relationship with the outdoor conditions, even though it represents a different lifestyle from that of the city. Inhabitants of this type of construction have developed a very particular way to live, selecting spaces with larger or smaller openings according to climatic conditions. This essay shows a preference of inhabitants toward more open spaces when the outdoor temperature rises.
Keywords: warm-humid climate, traditional construction, inhabitants' preference.

INTRODUCTION

The *Palapa*, or the Palm Leaf Roof, had its origins in the distant islands of the Asian Pacific. Its use in Mexico first started in Colima. Its development was due to a group of Filipinos brought by Spaniards to produce "vino de cocos", a liqueur made of coconut palm tree *(Cocos nucifera)* sap that would be greatly consumed during the Mexican Vice royal period (Gómez, 2000).

The Filipinos' experience with coconut palm trees allowed them to develop other cultural abilities, such as architecture. Asian technology was adapted by Filipinos and adopted by the native inhabitants. The palapa was greatly accepted in the region for its adaptation to local conditions, for its similarity with local technology, and for its familiar morphology with the indigenous architecture of the Mesoamerican Occidental cultures. This was contrary to European constructive technology, which was quite inappropriate for the environmental conditions of the same area. (Alcántara & Gómez, 2000)

The palapa is the most complex structure of the traditional architectural technology found in Colima. A group of pyramidal elements called "monos" (apes) integrates the roof. Four bound logs at the superior end form a mono. "Some palapas are closed completely and others are left open to allow ventilation, depending on people's liking," so say palapa roofers. See figures 2, 3 and 4.

Figure 1: A typical palapa on the coast of Colima.

This complex structure allows the palapa to be well-ventilated. The openings in the gable roof, the constructive system of the "bajareque" walls without a covering of clay and the walls of palm vein that leave numerous spaces, all contribute to facilitate ventilation Gómez, Alcántara & Delgado, 2008). See figures 2, 3 and 4.

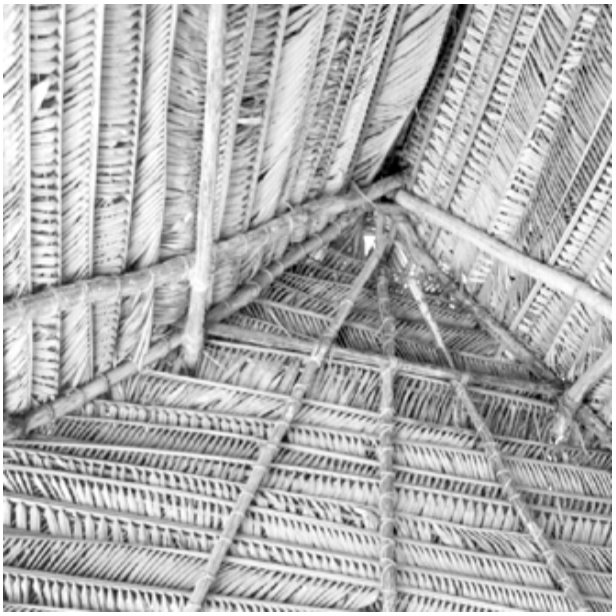

Figure 2: Inner view of closed simple gable.
Note the continuous treatment of split palm tree leaves all the way to the tympanum tip. This technique allows a permanent enclosed roof.

Figure 3: Inner view of closed gable with a "nido" (nest).
Note how the palm tree leaves are fan-shaped hanging from a log. This technique allows this part of the ceiling to be opened or closed depending on climate conditions.

Figure 4: Inner view of opened gable.
Note the lack of material at the tympanum tip. This technique allows a permanent opening, even when temperatures drop below the comfort temperature.

Previous research has demonstrated that palapa buildings behave in a very close way to the outdoor temperature (Alcántara, 2003). It has also been proved that thermal behavior of the palapa buildings is even better than the comfort of the conventional building methods based on brick masonry and concrete roofs (Alizo, 2003).

Despite the fact that internal wind velocity has not been measured yet, supposedly the ventilation conditions of palapa buildings are better than conventional ones. It has been found that permeability of materials is a determining factor of temporal conditions of comfort, considering that a 3% rise in the rank of permeability of the boundary elements is needed in order to get an additional hour of comfort. While the palapa has an average of sixteen hours of comfort, conventional houses barely get one or two comfort hours per day (Delgado, 2007).

METHOD

The temperature of 4 houses was measured; 2 of palapa and 2 conventional concrete constructions. The houses were located on the coast of the state of Colima, in the town of "La Central", located 16 km to the northwest of the port of Manzanillo, on the Pacific Ocean, a scarce 4 km from the beach, at 19°08'34 latitude, 104°26'16 longitude, and 50 meters above sea level.

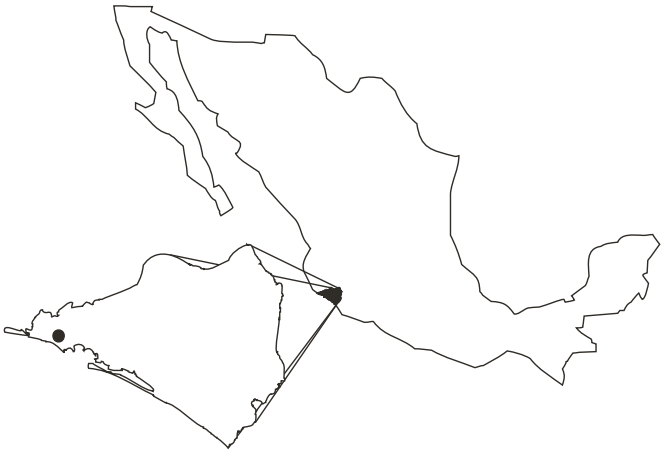

Figure 5: Location of La Central, Manzanillo, Colima, México.

This area has an annual average temperature of 29.6° C maximum, 22.5° C medium, and a minimum of 15.5° C, with a variation of 14.1 degrees. May is the warmest month at 32° C and February is the coolest month at 11.5° C. The annual average relative humidity is 88.1% maximum, 66.1% medium, and 44.1% minimum. July is the most humid month with 97.2 % humidity and March is the driest month with 32.8 % humidity.

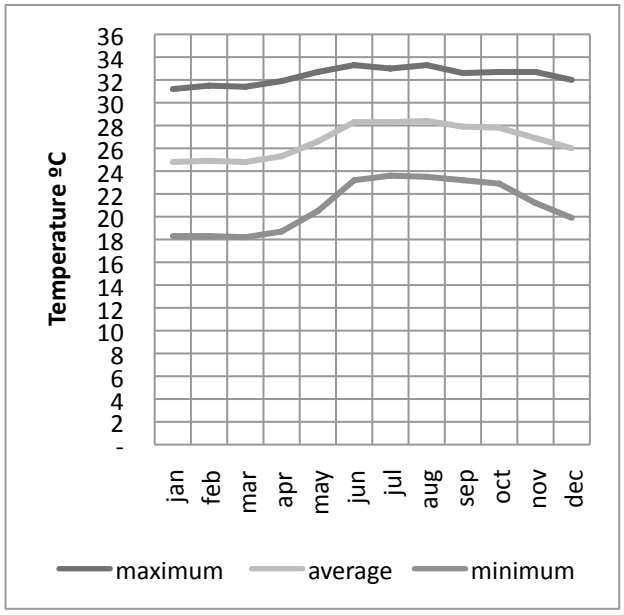

Figure 6: minimal, maximal and average external annual temperature in Cihuatlán Jalisco, the nearest meteorological station to La Central.

Temperature data as well as inhabitant's answers were collected during the three weather seasons shown in the Colima area: warm-dry season (March-June), warm-humid season (July-October), and mild season (November-February).

Houses chosen for the research had the following traits: Palapa houses had coconut palm tree roofs and wooden and fibered walls; conventional houses had brick walls and concrete roofs. In both cases the houses had confined rooms and open rooms delimited by a roof only or with a single wall.

To collect data an Onset 4-channel logger for temperature, relative humidity, light intensity and one additional external input was used (Hobo H8-004-02, Onset Computer Co.). Air temperature was registered by an external 1.5 cm-long sensor connected to the 4th channel. The logger had a ±0.4o C precision. All instruments were placed in a central area inside each house avoiding direct radiation from heat-generating appliances. The instruments were placed 2.10 meters high to avoid becoming obstacles for the normal daily activities of inhabitants.

The instruments were placed in common usage areas such as living rooms or dining rooms. The measured time period was a week during each season. In addition a measuring instrument was placed outside to log external conditions, away from direct sunlight.

A questionnaire was applied to learn about the interaction between inhabitants and their homes. The questionnaire was divided into seven sections with closed questions to obtain quantitative and qualitative information about personal activities of inhabitants. The questionnaire's last section included questions about the conditioning of the house, e.g. what do you do when it is hot? In each section of the questionnaire inhabitants were asked about their activities, where do they perform such activities, why do they perform such activities in any named location, at what time, for how long, what tools do they use, which activities are performed at the same time, etc.

The questionnaires' information was entered on a Statistical Package for Social Sciences (SPSS, Inc.) to create contingency charts that allowed comparisons among houses to find similarities and differences.

The weather data was compared to daily activities and place of performance as well as the actions or adjustments done to the houses. A space usage intensity matrix was created subsequently with the collected data.

HABITABILITY

An important aspect is that the way of life of inhabitants in all houses is relatively similar considering the different materials used to build the houses. The architectural scheme is very similar in all the cases.

The thermal behavior of palapas proved to be better than conventional concrete buildings. While the palapa buildings registered an average of 15 daily hours of comfort, those of concrete scarcely had an average of 2 daily hours of comfort.

The inhabitants' preferred usage of certain spaces is analyzed from the-amount-of-time-spent-on-them point of view, particularly the relationship between the usage of areas within the house and the average air temperature in each house. The areas were classified according to the degree of openings. Group A included all open areas whose only delimitation is the roof and one of its sides. Group B included all the areas with one of its sides open. Group C contained the areas that were totally defined with two or more openings that remained open all the time. Group D compromised the areas that were totally defined with only one side that faced outside and remained open.

Group A was made up of dining rooms or terraces; group B consisted of kitchens and laundries; group C were bedrooms, and group D included diverse spaces like living rooms or meeting areas. Since areas in groups B and C were spaces used in the same way all the time, their correlation was almost null. The analysis of the spaces whose usage was optional for the inhabitants was evaluated.

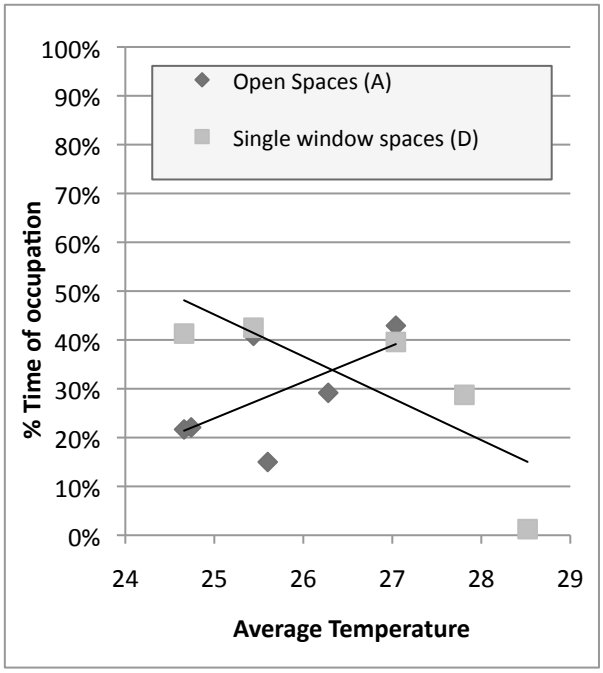

Figure 7: Comparative correlation between time of occupation and average temperature of selected spaces.

A clear tendency to occupy the spaces according to their temperature was observed. The spaces with a single window were abandoned as the temperature increased. Proportionally, the open spaces were occupied in response to temperature elevation.

Open spaces have a lower temperature scope than single-windowed rooms. The open space average temperature ranges from 24.2º to 27º C whereas single-window room average temperature ranges from 24.5º to 28.5º C. The comfort temperature is about 26º C and within this temperature scope both open space and single-window space tendency lines cross. Below 26º C inhabitants preferred single-window spaces. Above 26º C inhabitants preferred open spaces because air flows better.

The inhabitants of warm-humid regions tend to occupy well-ventilated areas. This reflects a constructive wisdom in the use of materials and traditional systems as the *palapa*. Even those who have changed housing construction technologies have not abandoned construction schemes or residential customs. They have kept a housing wisdom that allows them better environmental adaptation.

Both architects and designers had abandoned these traditional schemes to construct houses. New houses no longer have open spaces. Inhabitants are doomed to live in single-window enclosed rooms despite climate conditions. It would be convenient if housing councils in charge of financing popular house construction, as well as designers, would account for these usage patterns in order to provide better living conditions.

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