

# Traditional Mayan Architecture According to Latitude and Altitude

**Manuel Rodríguez Viqueira and Víctor Fuentes Freixanet**

Universidad Autónoma Metropolitana, Unidad Azcapotzalco, CYAD  
Laboratorio de Arquitectura Bioclimática, Departamento de Medio Ambiente  
Av. San Pablo 180, Col. Reynosa Tamaulipas, Azcapotzalco  
MÉXICO D.F., C.P. 02 2000, MEXICO  
mrv@correo.azc.uam.mx, ffva@correo.azc.uam.mx

**ABSTRACT:** In Mexico, a country with a very uneven land, the rainy regime in combination with latitude and the very diverse heights produces countless microclimates which can be grouped in three big macro climatic regions: Wet tropical, temperate and dry warm climates.

The aim of this work is to analyze the traditional architecture of the Mayan region and its geographical-environmental conditions, focus on the aspects of the relationship between the altitude and the architectural characteristics.

The current Mayan house keeps the same form and characteristics, just as the prehispanic house is represented in old paintings and sculptures; almost always it is placed on a platform whose height varies according with the slope of the land.

In the lower areas the plant of the house is characterized for the apses that round off the lateral parts, giving him an elliptic form. In contrast, the Mayan house in the high lands presents a rectangular plant. Climate defines different requirements of protection: from excessive radiation, heat, cold, rainfall, undesirable winds, floods and other natural phenomena. Place determines available resources and constructive materials. Therefore typical and regional architectural characteristic come up from climate and location.

In spite of the climatic differences due to altitude and some materials, the characteristic form and the outline of the constructive system remain. Therefore, we can define this architecture as a cultural phenomenon with an appropriate regional answer according to the particular climatic and environmental conditions.

**Keywords:** Architecture, Traditional Architecture, Vernacular, Mayan, Bio-climate,

## 1. INTRODUCTION

In Mexico, a rugged-topography country, the rain, together with latitude and the different heights, creates several microclimates categorized in three climatic macroregions: the wet tropical region, the temperate region and the dry hot region.

This kind of studies comes from the idea to create a Mexican bioclimatic architecture atlas [1]. The tradition loss in the use of vernacular construction systems has resulted in the neglect of empirical expertise and knowledge, so the need to recover it has arisen and so has the analysis of its bioclimatic operation. This work analyzes the traditional architecture of the Mayan region and its geographical-environmental conditions, with special focus on the connection between altitude and architectural characteristics.

Today, Mayan houses are the same as the ones represented in paints and sculptures: most of the times, they are placed over a platform, the height of which varies depending on the land topography. In the low areas, its floor plan features apses that finish the side walls, turning it into an ellipsis; in the high

areas, the floor plan is characterized by its rectangular scheme.

Climate defines the protection requirements against excessive radiation, hot, cold, rain, wind, flooding and other natural phenomena. The place determines the resources and materials that will be used in the construction. Therefore, as of the climate and place, the regional and typical characteristics arise.

The wet tropical climates are found mainly in the Mexican Coast of the Pacific Ocean and the Gulf of Mexico, as well as in the southeast region. In this case, we can talk about two main geographical areas:

The Yucatan peninsula, covering Campeche, Quintana Roo, and Yucatán.

The Itsmo the Tehuantepec area, and Chiapas and Tabasco.

The main cities of the Mayan culture are found in these regions. The climate in altitudes at the sea level is characterized by heat and humidity, so the architectural structures are softer, and the settlements more distant from one another. Walls and ceilings are made of materials allowing the "perspiration", sloping and high ceilings with holes in the ridge board to



**Figure 1:** Funeral monument with the shape of a traditional Mayan house.

enhance air flow. In higher zones there are combinations of clayey materials and vegetal roofs. At an altitude of 1,000 meters above the sea level, the climate is temperate and wet, so there are enveloping adobe walls and vegetal roofs. In Chiapas, in the Sierra Madre Occidental area, at an altitude of 2,000 meters above the sea level, in a wet, semi-cold microclimate, there are enveloping trunk walls with vertical wood planks and vegetal roofs with a lower slope, thus with a lower height.

However, despite the materials used and the climate differences due to altitude, the formal characteristics and the constructive system scheme remain, reason for which this architecture is identified as a cultural phenomenon, with a suitable response to the latitude and altitude particular conditions, i.e., climate.

## 2. ANALYZED LOCATIONS

For this study we have selected three locations: Tulum, in Quintana Roo, eight meters above the sea level; Ocosingo and Amatenango, in Chiapas, 856 and 1,750 meters above the sea level, respectively. According to National Observatory data, they can be described as follows:

### 2.1 TULUM

#### 2.1.1 Climate

This town is located in the Yucatan peninsula, with 20°13' in latitude, 87°28' in length, and 8 meters above the sea level.

According to Köppen classification, Tulum has a *Ax'(w1)iw''* climate, and it is characterized by annual averages of 26°C in temperature, almost 80% in humidity and 1,200 mm in rain, that make it a wet hot climate [2].

#### 2.1.2 Psychrometric Chart and Mahoney Indicators

Design strategies derived from the psychrometric chart are found in the natural ventilation area. Neutral temperature considered in winter is of 24.9°C, and in summer of 26.2°C.

According to Mahoney indicators, the space distribution should be positioned in a North-South

direction, and the large axis in an East-West direction. The distribution must be extended in order to favour ventilation. In order to reach constant ventilation, rooms will occupy one corridor. The spacious openings will be of 50-80% at the occupants' height, and they must be completely shaded and protected against rain. It is suggested that the walls should be light and have a low heat storage capacity (low thermal inertia); roofs must also be light, reflective and with cavities. Finally, due to climatic features, significant slopes and rain drainages are needed.

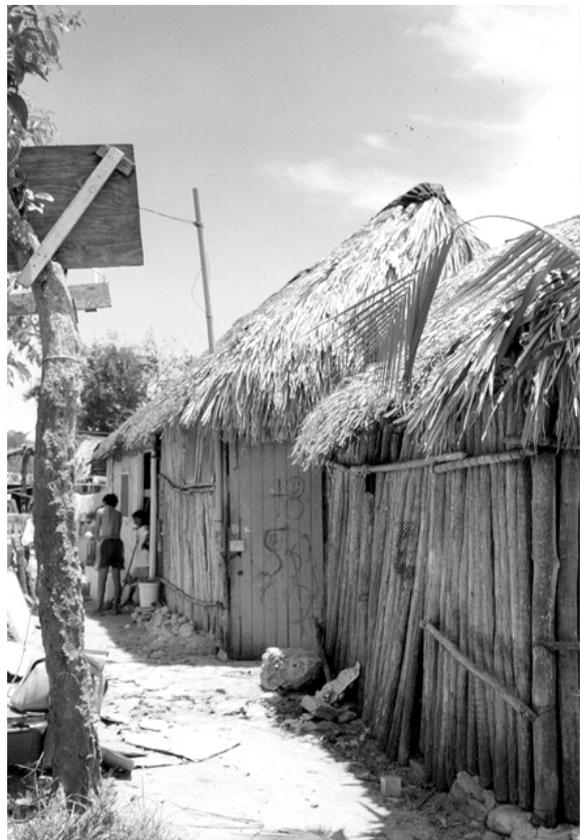
#### 2.1.3 Traditional Architecture

The apse house is an excellent solution to Gulf of Mexico and Caribe wet hot climate and cyclones. It protects against insolation and enhances cross-ventilation, resulting in comfort conditions which would be very difficult to reach with a different structure and low cost and local materials.

This kind of house features apses finishing its elliptic floor plan and a sloping roof, with two half cones by the sides to cover the apses.

The house is one-piece, and has a rectangular floor plan and semicircular headers, and it is directed towards the prevailing winds. It has no windows and only one central door heading east. Sometimes there is one more door heading west. Doors are positioned opposite one another so as to enhance cross-ventilation. The walls constructive system leaves openings, favoring wind circulation and freshness.

Floors are made of flattened white sand over a cobbled paving surface. The walls have a skeleton



**Figure 2:** House with vertical stick walls in Tulum.

PSYCHROMETRIC CHART

Town: Tulum, Quintana Roo  
 Tn (winter) = 24.9°  
 Tn (summer) = 26.2°

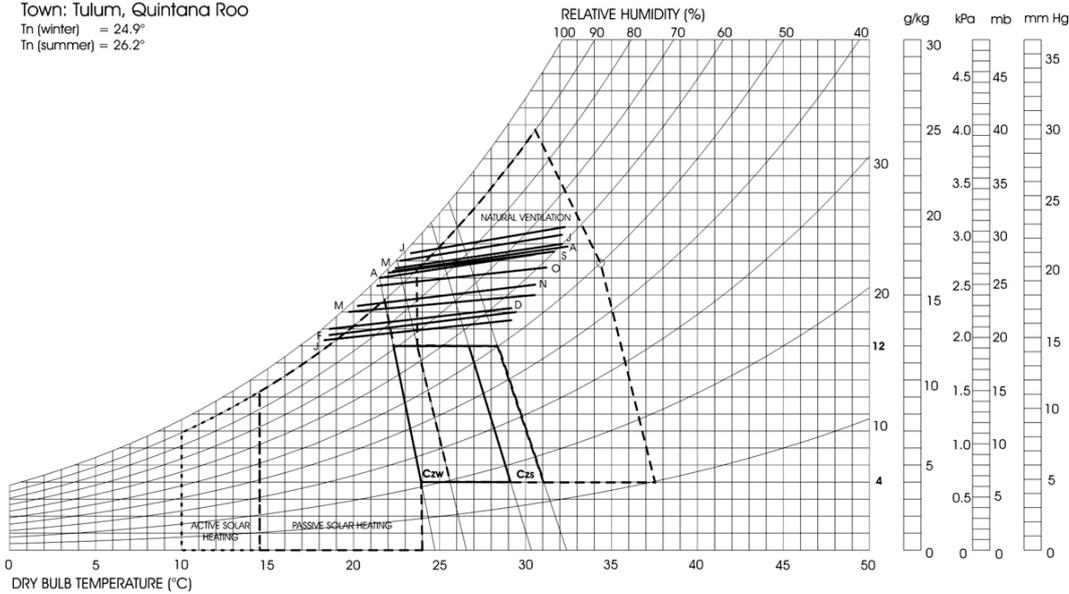


Figure 3: Psychrometric Chart - Tulum, Quintana Roo.

made of wooden posts and sticks, and the roof features a wooden structure covered with palm leaves and grass.

Roofs are hipped due to the rainy climate, and they feature a significant slope; eaves are spacious in order to prevent flooding and reduce insolation.

The roof height enables the accumulation of hot air in the upper parts, while the lower ones remain fresh and comfortable.

Sometimes some holes are left at the ridge level in order to enhance the flow of the air accumulated in the upper part of the house, stimulating its circulation.

The radiation of the heat absorbed by the roof into the house is also reduced thanks to the material it is made of, specially the vegetal elements, which due to

its low thermal conduction create thousands of air bags that remain between the layers of the material used.

The apse roof, without aris, offer less resistance to cyclones, so it is harder that it is tore off [3].

2.2 OCOSINGO

2.2.1 Climate

Ocosingo is located in Chiapas, at 16° 54' latitude, 92° 06' in longitude, and 856 meters above the sea level.

According to Köppen classification, Ocosingo has a Ax'(w1)iw'' climate, and it is characterized by annual averages of 22°C in temperature, 67% in humidity

PSYCHROMETRIC CHART

Town: Ocosingo, Chiapas  
 Tn (winter) = 23.6°  
 Tn (summer) = 25.0°

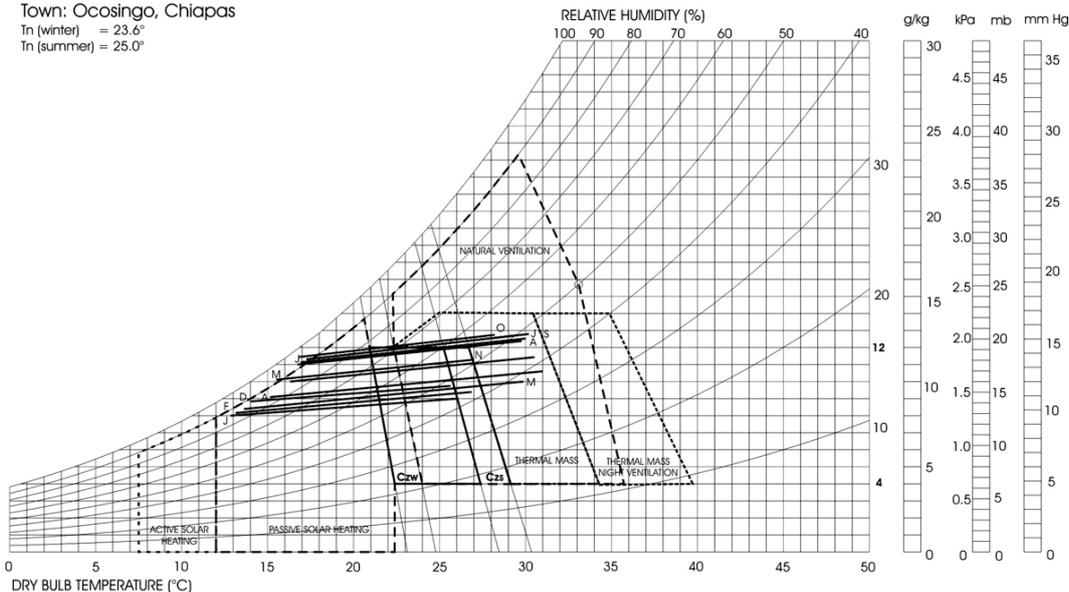


Figure 4: Psychrometric Chart - Ocosingo, Chiapas.



**Figure 5:** House with a wooden skeleton and filled with adobe.

and 1,350 mm in rain, that make it a wet hot climate. Neutral temperature in winter is of 23.6°C, and in summer of 25°C.

#### 2.2.2 Psychrometric Chart and Mahoney Indicators

The main strategies defined by the psychrometric chart for Ocosingo are the use of thermal mass together with passive sun warming during winter, and with natural ventilation during the rainy season.

Mahoney indicators recommend the use of the large axis in an east-west direction, and developing an extended distribution to enhance air flow and wind protection. The relationship between the openings and the walls of the house, the latter must prevail, and the openings must be little, and placed in the north and south walls, at the occupiers' height, windward; its surface must not be greater than 20-30% of the wall.

The openings must be protected so as to obtain total and permanent shading, and to keep them from the rain.

Walls and floors must be big, with a thermal time delay of at least eight hours. Due to rain levels, roofs must be sloped, and the rain drainages must be big.

#### 2.2.3 Traditional Architecture

The temperate climate conditions do not modify significantly the traditional house scheme. The one-piece house with a rectangular floor plan remains; it has a wooden structure, no foundations, one door, and one or two windows, generally arranged in a way that avoids cross-drafts. Walls have a wooden skeleton and are filled with adobe or, in warmer climates, with giant reed with clay covering on both sides, whitened with lime. Sometimes it also includes a dado. The houses are mostly parallelepiped-shaped. The floors are made of flattened earth over a cobbled paving surface, and the gable or hipped roof features a wooden structure covered with palm leaves and grass, and it has a significant slope.

The roof is positioned in such a way that it is separated from the walls over which it lies, and which carry the load along the four sides.

The steep slope of the roof results in a considerable room height. It is suitable for rainy climates because due to the width of the hipped roof surface, rain drains away faster. This roof provides the four sides of the house with eaves, which protect the walls from the water and the sun.

### 2.3 AMATENANGO

#### 2.3.1 Climate

Amatenango is located in Chiapas, at a latitude of 16° 33', 92° 28' in length, at a height of 1,750 above the sea level.

Due to its characteristics and according to Köppen classification, the definition of its climate is Cbw2(w)iw'', with annual averages of 16.4° C in temperature, 62.5% in humidity and 1,350 mm in rain, which make it a wet, semi-cold bioclimate. Electric storms and fog are frequent phenomena.

#### 2.3.2 Psychrometric Chart and Mahoney Indicators

The main strategies defined by the psychrometric chart are the use of solar radiation to increase temperature and reduce humidity.

Suggestions derived from Mahoney indicators are to take advantage of the south direction and develop a small configuration in order to protect the house against winds. Ventilation is not needed and the size of the openings must be little, in a ratio of 10 to 20% compared to the walls.

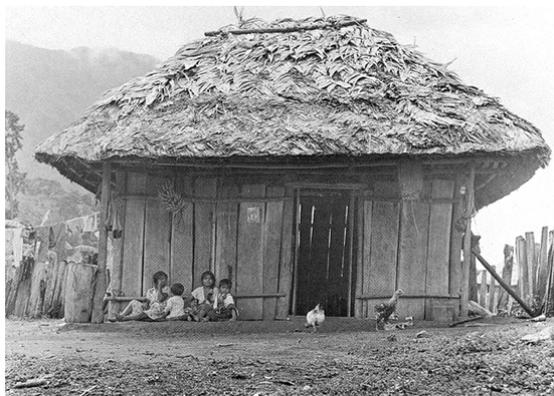
Openings must be protected by horizontal sun control systems to guarantee total shading during the heat season and to enhance radiation gain during winter. They must be protected against rain.

It is recommended roofs, walls and floors with a thermal time of at least eight hours. Due to rain levels, roofs must be sloped, and the rain drainages must be big.

#### 2.3.3 Traditional Architecture

This climate is characterized by woods with big trees and important diameters. Derived from that, there is the use of wooden trunks and vertical planks.

The house is one piece with a rectangular floor plan. Its direction aims to get as much radiation as possible. It has no foundations, and floors are made of flattened earth over a cobbled paving surface,



**Figure 6:** House made of planks.

## PSYCHROMETRIC CHART

Town: Amatenango, Chiapas  
 Tn (winter) = 21.8°  
 Tn (summer) = 23.2°

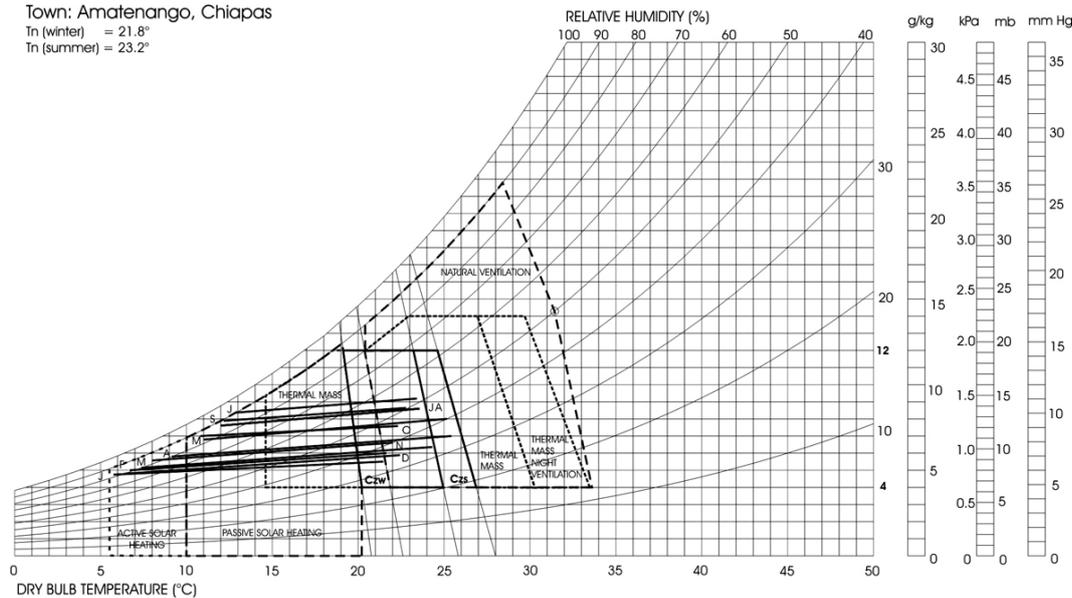


Figure 7: Psychrometric Chart - Amatenango, Chiapas.

creating a step between 15 and 20 centimeters. The walls have a skeleton made of wooden posts and sticks, which carry the roof load. The isolated supports compose the different structures that carry the load of the roof.

The walls are not shear and are made of planks. Generally, these planks are hammered and pressed with two sticks so as to obtain higher strength. Another way is to cover the planks leader line with a little board.

Planks are also used in doors and windows, both for the doorframes and for the sheets with which the openings are closed.

As in extremely rainy climates, hipped roofs are sloped, with eaves on the four sides, which protect walls from sun and rain.

The roof is assembled in such a way that it is separated from the walls, and the wooden posts carry its load. It is built with a horizontal frame with a scissor truss composed of two joists extending from the ridge to the eave. The last pair ends before the edge so as to place the joists that constitute the lateral slope of the roof.

In order to ensure the good working of the structure, some bottom chords and crossbeams are included, so as to keep the end of the scissor truss fixed.

Besides, between the structure supporting frame and the ridge, medium frames are built, in order to obtain higher strength. This is used to support the exterior finish, the palm leaves or grass.

A ceiling rose is placed in the interior; it is supported by bottom chords and crossbeams, and made of planks and rollers that constitute the attic, which is used as a storage room, but works as an air chamber providing the interior of the room with thermal stability.

### 3. COMPARATIVE ANALYSIS

Notwithstanding the climate conditions, the traditional house in the Mayan region has certain

common features, such as the use of exteriors as a part of the house, the floor plan, the hipped roofs, and the use of local building materials. All these common characteristics make it a cultural phenomenon.

However, a comparative analysis would allow us to identify the main formal and functional differences derived from the factors determining climate, altitude above all.

In general, we can say that the main formal difference is the height of the hipped roof: the houses in wet hot climates have a higher hipped roof than the ones in wet semi-cold climates.

In particular, the main differences are found in the use of vegetal building materials, the most important of them being wood, palm leaves, and grass for roofs.

Wood has several names according to its characteristics and uses: when the diameter is little, it is called "stick"; when the diameter is larger, it is called "trunk", and it can be used as a roller, a firelog, or a plank. The structure and the walls are made of wood. The structure is composed of trunks used as vertical supports: ledgers, crossbeams, bottom chords, and top chords; the walls depend on the climate. In the lower heights, the use of sticks prevails; in the medium heights, the use of stick framework with clay on both sides, and in the high heights, the use of planks five to seven centimetres thick.

The use of sticks in walls and secondary structures prevails in wet hot areas, and it has a varied vegetal origin. The shape irregularity and the mooring system create holes between them, favoring cross-ventilation.

The solution in walls made of plaited cane and mud appears in temperate areas, where medium ventilation is recommended.

Despite the fact that Mexico has a wide variety of woods, the most used in traditional construction is pine, which is found in most parts of the country. In the walls, it appears as a firelog or plank.

Another important vegetal material in traditional Mayan construction is the palm leaves. They do not

need to be processed, and its decomposition is very slow. Besides, they are impermeable and corrugated, so they help the rain to drain away; they are also flexible, which favors its incorporation to the shear walls.

Undoubtedly, one of the most important advantages is related to the thermal behaviour; the radiation and conduction gains in the horizontal or upper part elements are low, so they make a significant contribution to the reduction of thermal loads in the roof elements. Besides, as of its compaction, the framework generates a great many cavities, which enhance thermal isolation and interior ventilation.

Another vegetal material used in the roofs is grass or straw (which use is wide spread these days), and corn leaves. They have similar features, but the renovation cycles are different.

It is worth to say that as simple as they may seem, the construction techniques used to face climate conditions contribute significantly to the building characteristics.

The essence of any typology lies in the specific use of the shapes, the spaces and the volume incorporation; it is the combination of characteristics and inflections of the vocabulary individual elements. Although architecture shares individual features, only through their description may we understand them satisfactorily.

Comparison between the thermal resistance of the stick framework with clay and the wood planks in walls

Wall of stick framework and clay, considering a 2.5 stick framework, and a 1.5 cm. clay layer in both sides:

$$R_t = \frac{1}{f_e} + \frac{b_1}{k_1} + \frac{b_2}{k_2} + \frac{b_3}{k_3} + \frac{1}{f_i}$$

$$R_t = \frac{1}{17.08} + \frac{0.015}{0.58} + \frac{0.025}{0.13} + \frac{0.015}{0.58} + \frac{1}{8.13}$$

$$R_t = 0.4256 \text{ m}^2 \text{ } ^\circ\text{C/W}$$

$$U = 2.35 \text{ W/m}^2 \text{ } ^\circ\text{C}$$

Wall of planks, considering 5 cm-thick planks:

$$R_t = \frac{1}{f_e} + \frac{b_1}{k_1} + \frac{1}{f_i}$$

$$R_t = \frac{1}{17.08} + \frac{0.05}{0.13} + \frac{1}{8.13}$$

$$R_t = 0.5662 \text{ m}^2 \text{ } ^\circ\text{C/W}$$

$$U = 1.77 \text{ W/m}^2 \text{ } ^\circ\text{C}$$

As it is shown, the planks offer a higher resistance (Rt) to heat, so its thermal transmission coefficient "U" is higher.

Vegetal materials	Density (kg/m <sup>3</sup> )	Thermal capacity (J/kg <sup>o</sup> C)	Conductivity (W/m <sup>o</sup> C)
Oak	770		0.160
Pine	570		0.138
Hardwood (maple, oak)	720	1255	0.160
Softwood (pine, fir)	510	1380	0.120
Douglas Fir	490		0.151
Silver fir	460		0.144
Pine	420		0.130
Palm			0.400 – 0.480
Coconut fibre			0.450
Coconut copra			0.920

**Table 1:** Thermal conductivity of some thermal materials [6, 7]

## REFERENCES

- [1] Some years ago, the authors have been working in the creation of a Mexican Bioclimatic Architecture Atlas.
- [2] According to the classification proposed for Mexican Republic, by Fuentes V. y Figueroa A. (1990) in *Criterios de Adecuación Bioclimática en la Arquitectura*, ed. IMSS, México.
- [3] Prieto V., Coordinadora (1994), *Vivienda Campesina en México*, pp 56-63, SECTUR, México.
- [4] Rodríguez M., Fuentes V., (2004) La geometría solar del observatorio de horizonte en Calakmul, en *Memorias de la XXVIII Semana Nacional de Energía Solar*, ANES, Oaxaca, Oax
- [5] Prieto V., Op. Cit. pp. 106-125, México (1994).
- [6] Prieto V., Op. Cit. pp. 156-188, México (1994).
- [7] Canadian Wood Council./ Physical Properties of Canadian softwood species. [http://www.cwc.ca/products/lumber/visually\\_graded/species.php](http://www.cwc.ca/products/lumber/visually_graded/species.php)
- [7] Alavéz R., Dorantes R., Medel L.H., (2004) "Propuesta de diseño y pruebas térmicas de techos escudos multicompuestos con el uso de materiales vegetales e industrializados para climas cálido húmedos", *Memorias de la XXVIII Semana Nacional de Energía Solar* pp. 65-70, ANES, Oaxaca, Oax.