Natural Ventilation in a Traditional Lattice in Colima, Mexico

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ABSTRACT: Colima is a state on the mid western coast of Mexico, with a mainly warm sub-humid climate. Natural ventilation is one of the most important bioclimatic strategies needed here, as well as protection against solar radiation. The problem is when solar protection reduces air movement and free ventilation allows solar radiation. In some rural areas of Colima there is a constructive element which allows ventilation and interior protection from solar radiation. This element is a lattice called "jarana". "Jarana" lattices can be built from three different materials: raw adobe brick, hard-fired clay brick, and "loseta" (which is a thin paving hard-fired clay brick). Each lattice has its own characteristics: opening size, material thickness, and wall depth. These variables produce differences in their environmental performance. To compare the performance of these lattice modalities we reproduced them in experimental modules, then we registered their responses to these functions and they were compared with the results of the ventilation of an open window.

The prototypes were oriented for maximum radiation and minimum ventilation. After monitoring, analyzing, and evaluating results of the performance of each one, the following was identified: raw adobe brick lattice maintains a constant wind velocity, while hard-fired clay brick lattice allows a variable wind velocity. Therefore raw adobe brick lattice has a better performance because under both conditions internal wind speed remains the same. Additionally, raw adobe brick lattices reduce temperatures to about 2º Celsius in relation with other lattices, and about 4º Celsius with a window opened.

INTRODUCTION

Colima is a state on the mid western coast of Mexico, with a mainly warm sub-humid climate. Colima was founded in 1523, just three years after the conquest of Tenochtitlán (Mexico City). It is one of the oldest cities founded by Spaniards. Traditional architecture from Colima is the result of the influence of these four different peoples. This traditional architecture has a better weather performance than modern architecture. This better weather performance is due to the materials as well as to the series of mechanisms that have always been part of the surroundings. The mechanisms of environmental control are complex and fulfil multiple functions. Not only because of environmental adaptation, but in hot humid conditions their role as a climate control element is prominent. The mechanisms can be classified in different ways: according to the kind of control, the constructive process, the degree of integration and its position. The following chart shows the typology some devices of control found in Colima's traditional architecture. (Table 1)

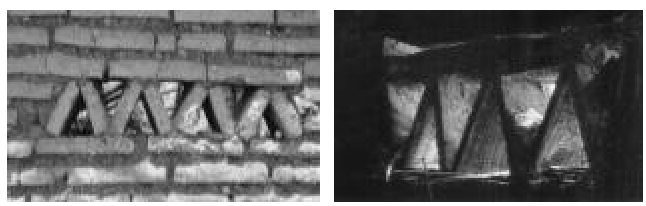

Figure 1. External jarana view (left) and internal jarana view (right). Examples found in Colima's rural area.

Table 1. Typology of Devices

Control Type	Constructive Process	Integration	Position	Element
Fixed	Carved	Isolated	Spot	Window Opening
				Óculo
				Tronera
		Serial	Linear	
				Jarana
			Superficial	Celosía
	Added Later On			Palizada
Mobile		Isolated	Local	Door
				Nido
				Window Shutter

Jarana is a kind of celosia on part of the wall. Either by pieces set in triangular shape or jacaleado in a stone wall. Its main characteristic is that it is only one line of latticework. (Figure 1)

Celosía is a lattice filter of interlaced crisscrosses, checkerboard, and inverse triangle patterns that make up part of a wall. (Figure 2 and 3)

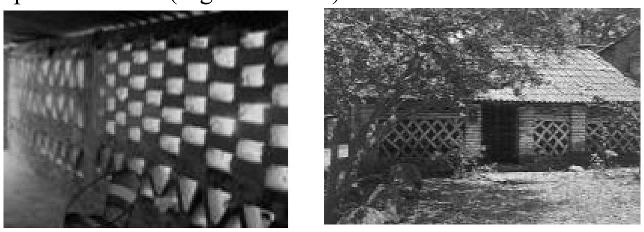

Figure 2. Internal view of huacaleados walls (left) and diagonal celosía (right). Examples found in Colima's rural area.

Figure 3. Internal view (left) and external view (right) of irregular huacaleada celosia.

From the aforementioned mechanisms a wide number of uses are displayed with the purpose of solving one or more required needs between interior and exterior: either to provide light, to have visual contact, but overall to evacuate indoor hot air and renew it with fresh air to cool the room by evaporation and therefore widen the comfort range of users.

Traditional architecture is more open than contemporary conventional architecture. Indoor temperatures are similar to outdoor temperatures, due to the strategy to intensify the indoor-outdoor relation. More ventilation is accomplished but it requires controlled sunlight to avoid excessive heat by direct radiation.

OBJECT OF STUDY

The two problems to solve in Colima's architecture are ventilation, and at the same time protect houses from radiation. Something windows cannot solve by themselves, but celosias can.

Celosias are filters with selective possibilities. Blocking radiation in general creates an obstacle for wind flow. An appropriate design could offer both advantages.

The kind of celosia with the most defined traits and found in several buildings is *jarana*, which is a pattern of triangles. *Jaranas* are made up of raw adobe brick, hard-fired clay brick or Thin paving hard-fired clay brick.

METHOD

Placement: Four experimental Panel W modules were placed within the University of Colima Campus. The Panel W had a building system based on a tridimensional steel wire structure with a polystyrene nucleus having a thickness of 7.5 cm. The modules were 2.44 m. in height, 1.22 m. in width, and 1.22 m. in depth.

In Colima city and its surrounding area, dominant winds come from the north and average wind speed is 2 m/s. (Figure 4)

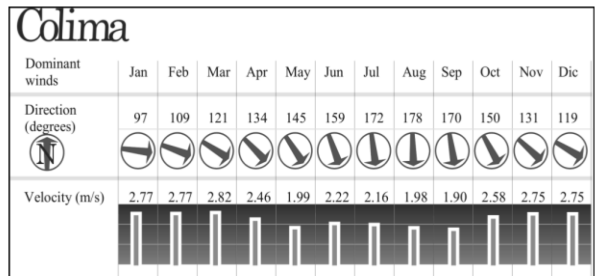

Figure 4. Dominant wind direction and velocity in Colima's urban area

Celosias were placed on the west side of panels because the scarce wind and high radiation conditions were extreme. The west side opening on each module was 1.10 m. by 1.00 m. Module one was left without celosia. A *jarana* lattice was built in modules two, three, and four. Module two had a lattice made up of thin paving hard-fired clay tile. The measurements of the tile were 0.23 m. in length, 0.11 m. in width, and 0.02 m. in thickness. Module three had a lattice of hard-fired clay brick. (Figure 5) The measurements of the brick were 0.26 m. in length, 0.13 m. in width, and 0.05 m. in thickness. Module four had a lattice of raw adobe brick. The measurements of the brick were 0.40 m. in length, 0.27 m. in width, and 0.09 m. in thickness. (Table 1)

The back side was left open to place monitor devices. During the collection of data, this back side was covered with isolating panels.

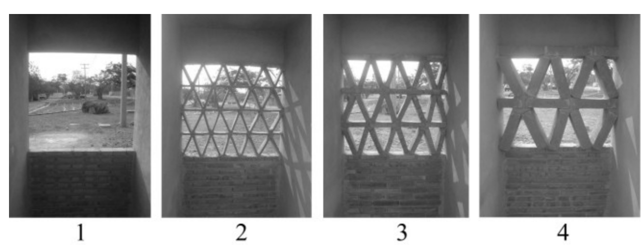

Figure 5. Experimental modules and assigned id numbers.

Table 2: Physical characteristics of lattices

Module	1	2	3	4
Opening Percentage	100	71	52	39
Blocking Percentage	0	29	48	61
Thickness	-	0.11m	0.13m	0.27m
Interstice	1.00m2	0.018m2	0.025m2	0.047m2

Monitoring Equipment: A one squared meter caliber 22 steel sheet was used to measure radiation. The steel sheet was placed inside the module in a parallel plane to the lattice. The steel sheet received the radiation coming through the lattice and transmitted it to a black body sensor data logger.
A unidirectional windmill anemometer was used to measure wind speed. Also a device to concentrate wind was designed. It was shaped as a truncated pyramid, based on the idea of funnelling wind from a larger area into a smaller area. The purpose of this device was to avoid either direct current readings or obstructed ventilation readings. With this device, the obtained readings were concentrated at a single point from the lattice. The funnelling device had a capturing area of 1 x 1 m., a 45^o reducing angle and a 20 x 20 cm. exit area.

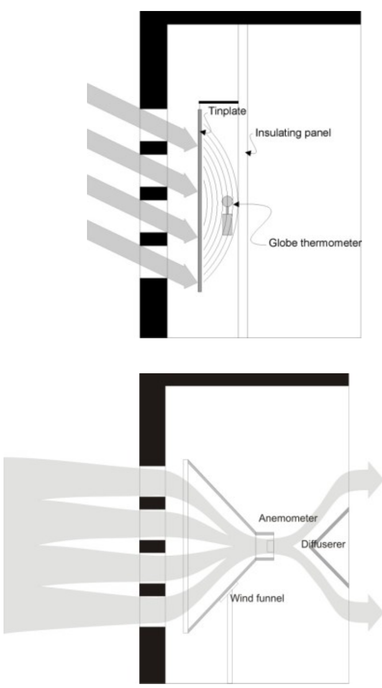

Figure 6. Side view diagram of radiation and ventilation

RESULTS
Radiation Measurement: Tables were made with data obtained from one week. Maximum and minimum temperatures per day and per module, as well as the average of each module, were charted. (Table 3)

Table 3. Five day average globe temperatures (maximum and minimum)

Module	Material	Max Temp.	Min Temp
1	No lattice opening	36.3ºC	24.9ºC
2	Thin paving hard-fired clay	35.1 ºC	24.9 ºC
3	Hard-fired clay brick	35.1 ºC	25.0 ºC
4	Raw adobe brick	34.2 ºC	24.6 ºC

The following remarks were made by comparing latticed modules to the non latticed module: module 2 and module 3 reduced the maximum temperature by 1.24o C. module 4 reduced the maximum temperature by 2.17o C. Minimum temperatures had no substantial differences.
In the maximum temperature comparison between 14:00 and 15:00 hours, module 2 and module 3, recorded a smaller difference to module 1 (witness module), than the difference recorded by module 4. With minimum temperatures, the difference is practically nonexistent.

Ventilation Measurement: Ventilation records were programmed in identical ways to those of the radiation. Data Recordings were taken using specific time parameters for each module, but since the nature of wind behavior is erratic and this variable was not controlled for the experiment, the comparison was made exclusively with average records from obtained measurements.

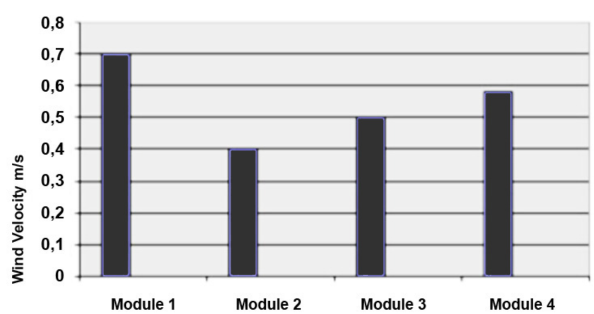

Figure 7. Results of average wind velocity from the four modules. The velocities are measured in meters per second.

The ventilation results show an interesting phenomenon. The lattice performance improved when the blocked area increased, therefore the thickness of the screen nor its density explained ventilation behavior, but it better explained wind velocities in the interstice area or gap size. The lattice made of raw adobe brick had a better performance, and the lattice made of thin paving hard-fired clay brick had the worst.

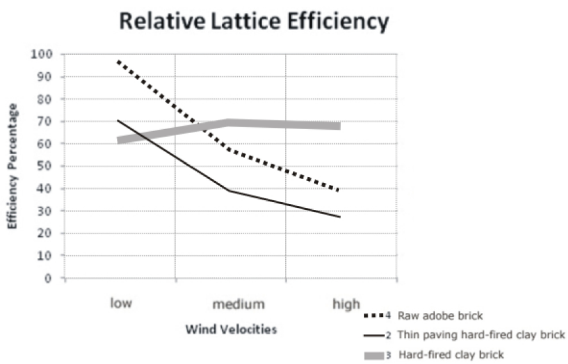

Figure 8: Wind Velocity Percentage recorded simultaneously when going through the lattices in comparison to the wind velocity recorded from module one.

The following chart was made to illustrate lattice performance interrelation. The recorded values are shown according to the highest temperatures and the lowest wind velocities.

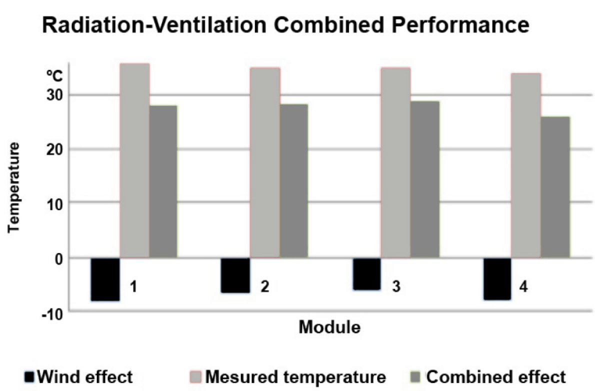

Figure 9. General Performance of the cumulative effect of solar protection temperature reduction and allowed ventilation

Table 4. Perceived Temperatures Compared to Comfort Sensation

Lattice Treatment	Perceived Temperature	Neutral Temperature Difference
1 Window (Opening)	28.1 ºC	2.46 ºC
2 Thin Paving Hard-Fired Clay Brick	28.4 ºC	2.76 ºC
3 Hard-Fired Clay Brick	29.0 ºC	3.4 ºC
4 Raw Adobe Brick	26.2 ºC	0.6 ºC

Figure 10: Jarana Lattice on contemporarary architecture

CONCLUSION

When making lattice performance interrelation in the humid tropics as a device that allows ventilation and protects from sun ray incidence, the results show that the raw adobe brick lattice is the most efficient one. The usage of a lattice with these characteristics is proposed to obtain a successful performance.

Even though all lattices have a relative efficiency the results show that the lattices with similar characteristics to the ones used in the oldest construction traditions are the ones with a superior environmental performance.

The adobe characteristics provide higher lattice efficiency. However, it is known that adobe was an answer to construction needs to available technological resources at the time. Its dimensions are linked to the making of adobe brick's process and to the mechanical properties of the adobe material itself.

After all, the elements from traditional architecture from a given place are the product of wise adaptation. Traditional architecture still has a lot to teach, and if a contemporary interpretation of lattice work (figure 10) has to be made, traditional perspectives would have to be respected.

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GLOSSARY

Óculo: A single window without shutters similar to an oxeye. Located at the top of the room

Jarana: A kind of lattice on part of the wall.

Nido: An open window similar to a gable window.

Palizada: A wall made of sticks without coating to allow wind-flow and light.

Tronera: One of a series of small windows placed on top of the room to draw hot air.

Huacaleado, or *jacaleado:* Kind of irregular lattice made suppressing parts of masonry on the wall

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