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THERMAL PROCESSES IN BUILDING ENVELOPES TO IMPROVE SUMMER COMFORT.

by

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Abstract.

This study intends to present the behaviour of the building envelope treated by ambient air ventilation or by evaporatively cooled air ventilation. A mathematical model for a test was developed and simulations were carried out for different stratergies of applications.

1 - Intoduction.

The specific climatic conditions in hot regions, play an important role for the passive tools in building design. The combined action of wide temperature fluctuations between night and day - timeleads to a rapid transient thermal behaviour of the walls.

The need for a more economical method of cooling in summer season than that available at present is becoming necessary with the increase of the need for comfort and the development in the world, especially in hot or desert regions.

The thermal storage in building material for passive solar construction has generated considerable interest in recent years. The use of walls and floors for thermal storage for solar heating has been successfully demonstrated and has gained some acceptance by the public why not cooling also. The object is to make use of the thermal mass, which can be well adapted in hot climates, not only to change the time lag but also to allow for the night time storage cooling.

In general the thermal load of the wall structure in buildings present a considerable percentage of the total thermal load. So, the treatment in the wall construction proves to be an efficient way for reducing cooling load in buildings.

The use of night time ventilation or evaporative cooling may be utilised to reduce the thermal load and to improve the comfort in buildings.

This study intends to present the behaviour of a building envelope in view of reducing the cooling load and improving the comfort inside the building.

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2 - Modelling and simulation of a test cell.

In order to illustrate the applicability of the treatment of the building walls as a means of improving the thermal comfort in buildings using nocturnal operation of ventlation and evaporative cooling, we have tried to simulate a ficticiuos test cell of which one or several walls are formed as a cooling storage. As a preliminary study the test cell is considered to be comprised of six identical walls (3m x 3m) of which the cross section and the isometric view are shown in Fig.1. In addition, the nothern wall contains a window pane of dimension 3m x 1.5m. The blocks are considered to be filled with rock particles of a certain porosity when the wall acts as a storage.

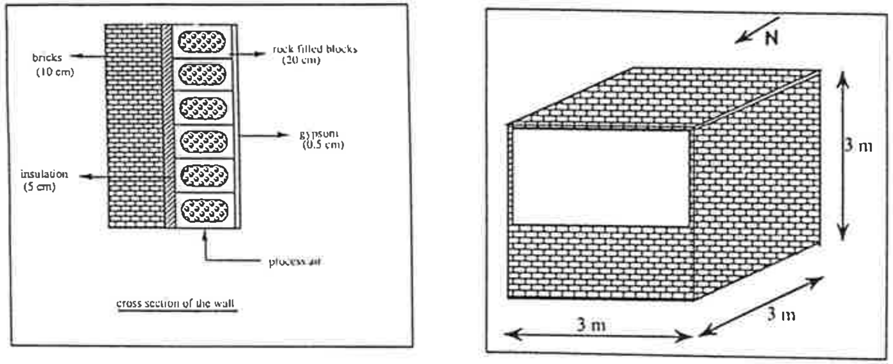


Fig.(1) cross section of the wall being analysed.

We have adapted the technique of nodal discretisation of the space variable by finite differences, in order to solve the set of equations containing partial dervetives of time and space describing the behaviour of building.

For each node, conservation of energy is applied taking into consideration the boundry conditions of imposed temperature or flux type. All nodes of heat transfer condition convection,radiation and transport of heat by mass transfer (only for cooled walls) are included in the analysis. We have assumed
(i) the properties to be isotropic and homogeneous independent of temperature.
(ii) emmission and reflection of long wave radiation to be diffused and isotropic.
In addition the mass of air inside the test cell is represented by single thermal capacity at the centre of the cell.
These yield a system of non-linear algebraic first order differential equations in node temperatures.

for node i, the equation with classical notations is

$$m_i C_{pi} \frac{dT_i}{dt} = \sum_{j=1}^{N} \phi_{ij}(A) + P_i$$

where

$$\phi_{ij}(A) = \frac{\lambda_i}{\Delta x_{ij}} A_{ij} (T_j - T_i) \quad \text{for conduction}$$

$$\phi_{ij}(A) = h_{ij} A_{ij} (T_j - T_i) \quad \text{for convection}$$

$$\phi_{ij}(A) = \varepsilon_i \sigma A_{ij} F_{ij} (T_i^4 - T_j^4) \quad \text{for radiation}$$

$$\phi_{ij}(A) = \rho_a C_a v_i A_{ij} (T_i - T_j) \quad \text{for mass transfer}$$

P_i - external heat gain

The heat transfer coefficient between the air and the masonary block is taken as (2.4 W/m^2.k) (3), where is the volumetric heat transfer coefficient between the humid cold air and the rockbed is taken from this formula (4).

$$\frac{h_v . d_e^2}{k} = 1.56 \left(\frac{\rho . v . d_e}{\mu}\right)^{0.7}$$

where d_e is the equivalent diametre of the rock (m)
k is the conductivity of the rock (W/m.K)
v air velocity (m/s)

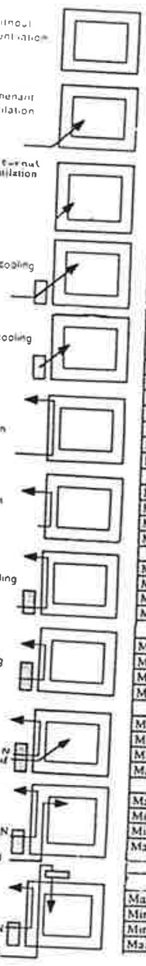
As the means of solving the system of equations, we have made use of the simulate NEPTUNIX , which is based on the technique of Newton-Raphson as the mode of resolution.

The results concerning the daily maximum and minimum temperatures and relative humidity inside the test cell are presented in Tab.1. for different processes of treating the system for different climatic conditions, treated air ventilation and building inertia.

3 - Discussion and Conclusion.

This study serves as a preliminary presentation of several treatments of the building envelope by air ventilation or by simple evaporative cooling system to improve the comfort.

The research on improving and optimizing a simple air conditioning system which can operate efficiently are carried out and on the other hand the research for new materials such as PCM (phase changing material) which can replace the traditional rocks in the storage are continuing.



Configuration	vol/h	HOT - ARID CLIMATE low inertia 5	10	25	high inertia 5	10	25	MODERATE CLIMATE low inertia 5	10	25	high inertia 5	10	25
without ventilation	Max. Temperature °C	46.6				39.0			32.6			38.0	
	Min. Humidity %	14.0				20.6			47			19	
	Min. Temperature °C	32.7				32			25.4			26	
	Max. Humidity %	29.0				24.0			71			70	
permenant ventilation	Max. Temperature °C	45.7		45.4		42.7	39.0		31.7	31.0		30.7	30.6
	Min. Humidity %	15.0		14.7		12.7	21.0		52	52		51	51
	Min. Temperature °C	32.0		31.0		19.7	34.0		24.7	24.0		25.7	25.0
	Max. Humidity %	29.7		32.0		22.0	22.4		22	24		71	71
nocturnal ventilation	Max. Temperature °C	45.4		44.7		41.0	40.7		31.7	31.4		31.2	31.0
	Min. Humidity %	15.2		15.0		21.7	21.7		51.6	51.6		51	51
	Min. Temperature °C	29.4		29.7		30.4	30.4		26.2	25.7		26.4	26.0
	Max. Humidity %	27		27.2		26.4	26.4		69	77		69	69
permenant evaporative cooling	Max. Temperature °C				37.7	36.0	32.2				29.0	28.4	
	Min. Humidity %				42.7	50.0	60.0				77.0	81.0	
	Min. Temperature °C				28.4	25.7	25.0				22.4	22.0	
	Max. Humidity %				56.0	60.0	90.0				95.4	96.0	
nocturnal evaporative cooling	Max. Temperature °C		42.7	41.6		39.7	38.4		31.4	31.0		29.4	29.0
	Min. Humidity %		36.0	41.0		19.6	20.0		52	52		61	61.6
	Min. Temperature °C		27.7	23.0		28.7	24.0		22.7	21.4		23.0	27.0
	Max. Humidity		66.0	91.0		70.0	91.0		77	79		74	62
permenant wall ventilation	Max. Temperature °C	45.2			44.2			30.7			30.4		
	Min. Humidity %	14.7			15.7			57.0			57.7		
	Min. Temperature °C	34.4			40.0			24.0			24.4		
	Max. Humidity %	22.4			21.0			77.0			76.4		
nocturnal wall ventilation	Max. Temperature °C	43			42.4			32			31.7		
	Min. Humidity %	12.7			12.6			54			56.0		
	Min. Temperature °C	34.4			38.6			24.2			25.0		
	Max. Humidity %	22.1			22			77			76.6		
permenant wall evaporative cooling	Max. Temperature °C				37.0	38.0					28.7	28.4	
	Min. Humidity %				41.7	41.4					24.6	24.4	
	Min. Temperature °C				27.0	27.4					24.4	24.4	
	Max. Humidity %				36	36.6					77	77	
nocturnal wall evaporative cooling	Max. Temperature °C				44						31.0		
	Min. Humidity %				15.0						57.0		
	Min. Temperature °C				27.6						26.0		
	Max. Humidity %				36.0						74.0		
nocturnal wall evaporative cooling + daily direct evaporative cooling	Max. Temperature °C				35.6	33.7	31.4				28.1	27.7	
	Min. Humidity %				47.0	53.0	61.0				76.4	77.	
	Min. Temperature °C				25.0	23.7	21.0				22	[illegible]	
	Max. Humidity %				57.0	67.0	91.0				94	95	
nocturnal wall evaporative cooling +daily air ventilation through the wall	Max. Temperature °C					40.6	41.2					28.0	28.2
	Min. Humidity %					20.0	21					76.0	77.0
	Min. Temperature °C					28.0	27.6					23.4	23.0
	Max. Humidity %					57.0	91.0					87	87
nocturnal wall evaporative cooling +daily air ventilation through the wall+ evaprative cooling	Max. Temperature °C				31.2	30.0	29.0				27.0	27.9	
	Min. Humidity %				64.0	66.0	70.0				77.0	77.7	
	Min. Temperature °C				24.7	24.6	24.6				23.0	23.0	
	Max. Humidity				34.0	35.0	36.0				86	86	

Tab.1.

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