IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND DEVELOPMENT PROTOTYPE EXIBITING ANCIENT WAY OF COOLING

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Abstract:-This article presents useful ancient energy technologies that have been used many years for natural cooling of buildings during summer in a hot and humid province in the worldwide. By use of these technologies, people were able to live in comfort without any electrical air conditioning system.

These technologies include use of color glazed windows, wooden windows frames, light colored walls and roofs, insulated walls, wooden roofs covered with leaves and mud. In addition, these technologies made use of terraces, use of louvers, constructing the lanes as narrow as possible and shading the buildings with the nearby buildings, all of which are now the modern experienced technologies.

I. INTRODUCTION

Evaporative cooling systems are used in broiler houses to reduce the undesirable effects of high temperatures. However, the cooling efficiency of these systems varies according to regional climatic conditions. Therefore, knowledge of cooling efficiency is an important criterion for the prediction of investment and production costs in the design of such systems. In this study, two different broiler houses with the same characteristics were utilised. One broiler house was used to test the traditional fan-pad, while in the other; a water spray evaporative cooling system was tested.

In this topic we will present the basics of evaporative cooling walls. Water evaporative cooling systems exploit the latent heat of evaporation of water to reduce sensible heat of air, and therefore its temperature. Based on this principle, both direct and indirect approaches can be developed. Their adoption may dramatically decrease (and sometimes even cancel) cooling loads in warm and hot seasons. So these walls are the best candidates for adoption in mild climates with relatively long summer seasons, where the use of highly insulated walls to limit heating loads may cause internal overheating in hot periods and make the indoors quite uncomfortable and unhealthy.

Not only can this technology considerably decrease incoming cooling loads, which is beneficial during warm and hot seasons, but it also keeps high insulation standards against heat dispersion in winter. More specifically, evaporative cooling walls represent an example of a hybrid solution deriving from the combination of ventilated facades and water evaporative cavity walls.

Intelligent ventilation is a process to continually adjust the ventilation system in time, and optionally by location, to provide the desired IAQ benefits while minimizing energy consumption, utility bills and other non-IAQ costs (such as thermal discomfort or noise).

A smart ventilation system adjusts ventilation rates in time or by location in a building to be responsive to one or more of the following: occupancy, outdoor thermal and air quality conditions, electricity grid needs, direct sensing of contaminants, operation of other air moving and air cleaning systems.

II. Problem Statement

Conventional air conditioning system has high power requirement, approximately 3-5 horsepower (HP).

The high electricity demand for cooling purpose increase the electricity bills, which will lead to increase in living cost.

In order to utilize the electricity efficiently, the need to design an alternative cooling system is inevitable.

The development of Evaporative Cooler System is a reasonably good solution to provide low power and low cost cooling system for domestic sector.

III. Objective

1) Evaporative cooling

The conversion of liquid water into vapour using the thermal energy in the air, resulting in a lower air temperature. A simple example of natural evaporative cooling is perspiration, or sweat, secreted by the body, evaporation of which cools the Evaporative-cooling air conditioning systems use the cooling effect of the evaporation of liquid water to cool an air stream directly or indirectly.

2) Intelligent ventilation

Ventilation is the intentional introduction of outdoor air into a space. Ventilation is mainly used to control indoor air quality by diluting and displacing indoor pollutants; it can also be used to control indoor temperature,humidity, and air motion to benefit thermal comfort, satisfaction with other aspects of indoor environment, or other objectives.

3) Raised structure

The installation of a raised floor system can change the thermal behaviour of the building by reducing the interaction between the heat gains and the thermally massive concrete slab.The zone cooling load profiles and the thermal performance with and without the raised floor are compared and analysed. The effects of structure type, window-to-wall ratio and the presence of carpet on the thermal behaviour of the raised floor are also investigated.

IV. Literature survey

Radiative cooling technology has developed rapidly, but to achieve more significant cooling performance, most of the radiative cooling experiments employ a thin polyethylene film WC to reduce non-radiative heat exchange.

The dynamics of coaxial plumes that consist of an inner, humid plume and an outer, less humid plume has been studied analytically, however, only for the case of a stationary ambient. The present study extends the previous theoretical model by incorporating the effect of a windy ambient for both single and multiple cooling tower cell cases.

The method Passive Cooling Load Ratio (PCLR) is an innovative simplified method which calculates the monthly cooling energy needs of a thermal zone where passive cooling systems are installed using the variables: cooling energy load and passive cooling potential. This new method is based on the Solar Load Ratio (SLR) that was previously developed for solar heating systems. Although, PCLR was theoretically developed for any passive cooling system, here it is applied to passive cooling based on ventilation strategies.

The leading passive cooling technique is the use of upper openings created in peripheral walls. It can be implemented in the external walls of all indoor spaces and is associated with different passive technologies, as shown in Figure 2. Therefore, architects should recruit this technique in new buildings in order to create thermal comfort zones. This technique can also be created easily in existing buildings ex post facto because it does not have economic, spatial, socio-cultural, or legislative impediments.

It is worth mentioning that the upper openings may need to be fitted with electrical fans to maximize heat suction from the indoor spaces. The upper openings can be used without the need for further insulation material in the bearing wall system; however, if architects need to recruit this technique in the skeletal building structures, the external walls would need to be insulated by thermal materials such as polystyrene, in order to decrease the thickness of these walls and cope with the spatial limitations.

This paper reviews passive design strategies and the benefits of usingsuch strategies not only in the building design but also related to the urban context and human factors, which would be linked to urban sustainable design, policies and strategies. The key to designing a passive building is by taking advantage of the local climate (micro-climate) and therefore, climate characteristics and classification can help with identifying approaches as early as site planning and analysis. Therefore, climate and comfort are the two fundamental measures in passive design that require attention. Passive design is a major part of environmental design, andapproaches utilising several techniques and strategies that can be employed to thebuildings in all types of climates around the world such as orientation, ventilation, shading devices, thermal mass, insulation, day lighting and so on. These techniques and strategies can also be supported by various other parameters such as using technologies (passive and/or active) and customisable controls as well as enhanced by patterns of biophilic design for improving health and well-being in the built environment. There are also passive solar technologies including direct and indirectsolar gains for space heating, solar water heating systems, solar cookers, use ofthermal mass and phase-change materials for slowing indoor air temperature swings, solar chimney for enhancing natural ventilation, and earth sheltering that can be considered as part of the actual design. Today, passive design strategies can be easily evaluated with the use of either simple or more sophisticated Building

Performance Simulation (BPS) tools such as Ecotect, IES VE, etc.

V. Novelty Of The Concept

Basically, an evaporative wall (EW) is a ventilated facade with air-spray devices and an absorbing sheet useful for absorbing liquid water and heat during water evaporation. There are several ways to realize an EW. A possible functional model of the envelope, coming from the experience gained by the authors in the development of an active evaporative cooling envelope, while depicts its typical operational conditions in summer periods. The functional stratification from exterior to interior is made up of an external covering layer with an inner waterproofing finishing, a ventilated cavity equipped with a water spraying system, a porous absorbing insulation layer, and the main bearing structure of the wall. The porous insulation layer is fixed on a regularization layer towards the interior, providing a smooth surface. This is supported by the bearing structure of the wall. The system integrated in the wall sprays fine water particles on a porous layer, whose latent heat of evaporation will be exploited to absorb incoming heat fluxes.

1) Direct Evaporative Cooling

Direct evaporative cooling (open circuit) is used to lower the temperature and increase the humidity of air by using latent heat of evaporation, changing liquid water to water vapour. In this process, the energy in the air does not change. Warm dry air is changed to cool moist air. The heat of the outside air is used to evaporate water. The RH increases to 70 to 90% which reduces the cooling effect of human perspiration. The moist air has to be continually released to outside or else the air becomes saturated and evaporation stops.

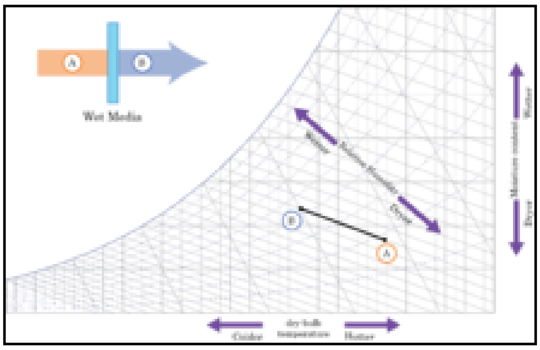

Figure 1: Direct Evaporative Cooling

2) Indirect Evaporative Cooling

Indirect evaporative cooling (closed circuit) is a cooling process that uses direct evaporative cooling in addition to some heat exchanger to transfer the cool energy to the supply air. The cooled moist air from the direct evaporative cooling process never comes in direct contact with the conditioned supply air. The moist air stream is released outside or used to cool other external devices such as solar cells which are more efficient if kept cool. This is done to avoid excess humidity in enclosed spaces, which is not appropriate for residential systems.

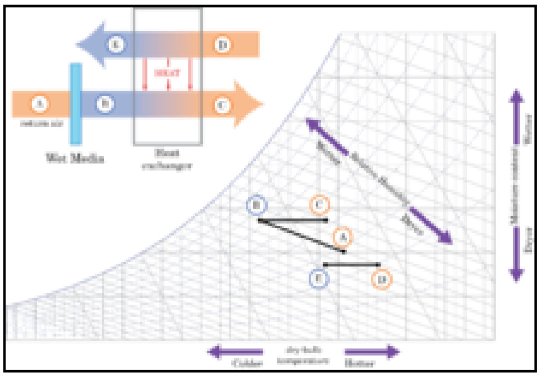

Figure 2: Indirect Evaporative Cooling

VI. Methodology

This study/project would be consisting of following chronological step of working:

Selection of topic

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Research and development on the selected topic

Problem statement of model

↓

Working on the objective of the project

↓

2d drawing of project using software

↓

Preparing CAD Model Design

↓

Analysis of the model

↓

Making of prototype

↓

Testing of the model

Components Used in the prototype

1) House Exhibiting Ancient Way of Cooling
2) Cooling Pad
3) Electric Fan
4) Tray
5) Water Tank
6) Square Pipe

1)House Exhibiting Ancient Way of Cooling

The house exhibiting ancient way of cooling is a structure of a house such that it will help to maintain house temperature eco-friendly. For this we use towers, exhaust towers air inlets and outlets, cooling pads. By using of these parts we maintain house temperature and freshness in the house.

Figure 3 shows the CAD model of the house. From that figure we can easily understand the flow of air.

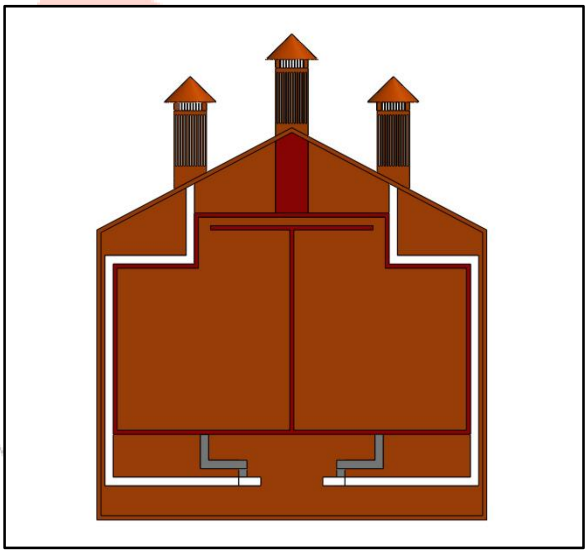


Figure 3: CAD Model of House

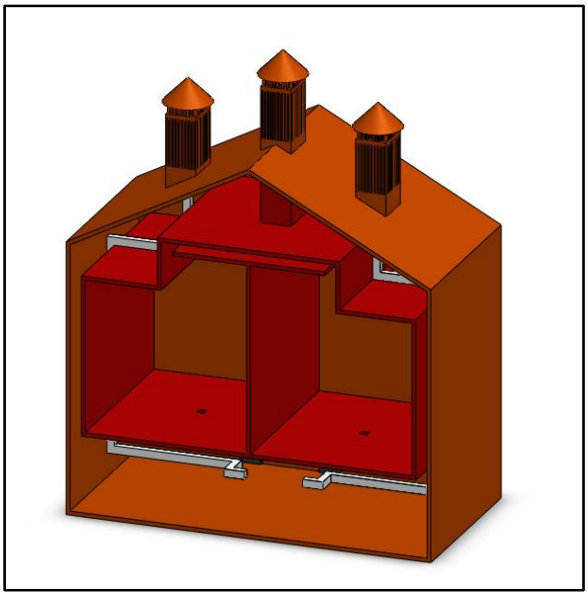


Figure 4: Isometric View of House

2) Cooling Pad

Cooling pad is specially designed with small size of pot like structure and is made up of clay and it's totally eco-friendly. Water pasteurize through the pads and helps in cooling. Due to fan, fan suck air from cooling pad which is cold and supply to the house.

Figure 5 shows the CAD model of cooling pad.

Figure 5: CAD Model of Cooling Pad

3) Electric Fan

Electric fan is general type of fan which is used to suck the air as well as to throw the air it suck cold air from cooling pad and supply to the house. Because of fans supply of air increases and air circulates easily.

Figure 6 shows the CAD model of electric fan used for circulation of air in the house.

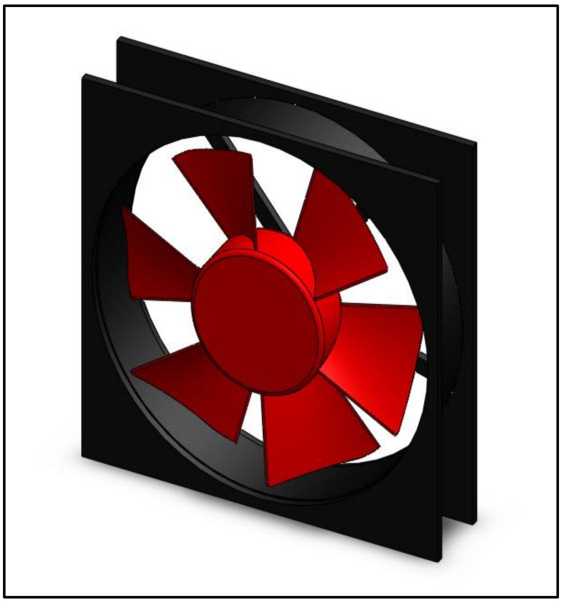


Figure 6: CAD Model of Electric Fan

4) Tray

Tray plays an important role in cooling system. In this system we suck air from surrounding throw the towers and towers to pipe. To increase efficiency we design a tray which is attached to the intake of cooling system to the pipe. So fan whatever suck it sucks from towers. Similarly to the output of cooling system there is also a tray which attached to the system to pipes so cold airs directly get into the rooms.

Figure 7 shows the CAD model of tray. It has two holes, for inlet and outlet pipes which will supply the air.

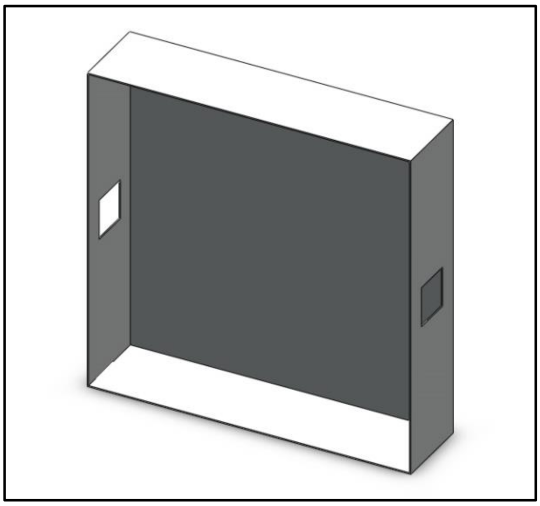


Figure 7: CAD Model of Tray

5) Water Tank

Water tank is a reservoir of water in this system. Water plays a role of coolant in the system. To make cold air water is used and water is continuously circulating through the cooling pads. At the bottom of the water tank holes are provided to circulate the water through the cooling pad. This water is reserved in a tank.

Figure 8 shows the CAD model of water tank.

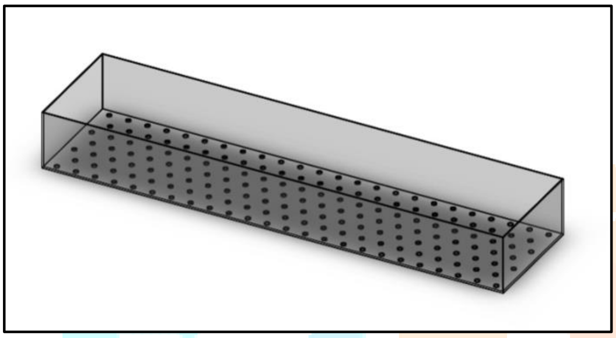


Figure 8: CAD Model of Water Tank

6) Square Pipe

Pipes are used to supply the air from tower to cooling system. From coolingsystem to room and room to exhaust tower.Pipes are made up of insulating material so that minimum amount of heat will be absorbed through it and gives more efficiency.

Figure 9 shows the CAD model of square bar.

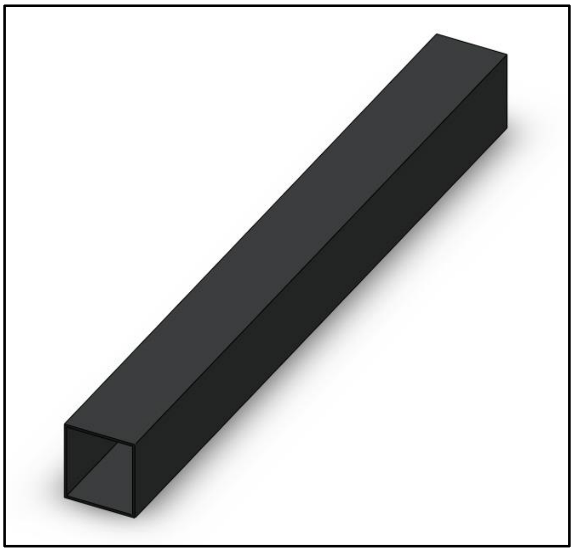


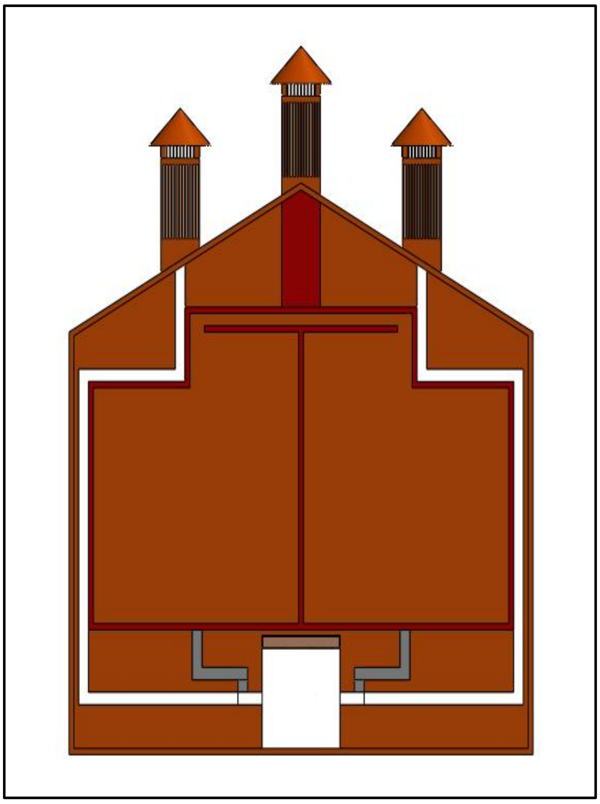
Figure 9: CAD Model of Square Pipe

VII. Working of the model:

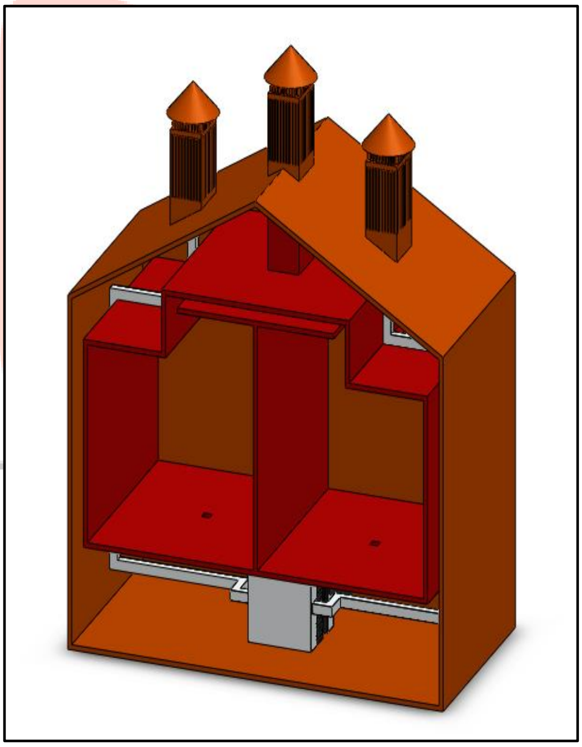
- In a wind tower, the hot air enters the tower through the opening in the tower, gets cooled, and thus becomes heavier and sinks down.
- The inlet and outlet if rooms induce cool air movement.
- In the presence of wind, air is cooled more effectively and flows faster down the tower.
- After a whole day of air exchanges, the tower becomes warm in the evenings.
- During the night, cooler ambient air comes in contact with the bottom of the tower through the rooms.
- The tower walls absorb heat during daytime and release it at night, warming the cool night air in the tower.
- Warm air moves up, creating an upward draft, and draws cool night air thorough the doors and windows into the building.

- The system works effectively in hot and dry climates where fluctuations are high.
- A wind tower works well for individual units not for multi-storeyed apartments.
- In dense urban area, the wind tower has to be long enough to be able to catch enough air.
- Also protection from driving rain is difficult.

VIII. Final Assembly of the Prototype



(i) Front View of Assembly



(ii) Isometric View of Assembly

Figure 10:CAD Model of Assembly of Prototype

- Above figure 10 shows the assembly of the prototype.

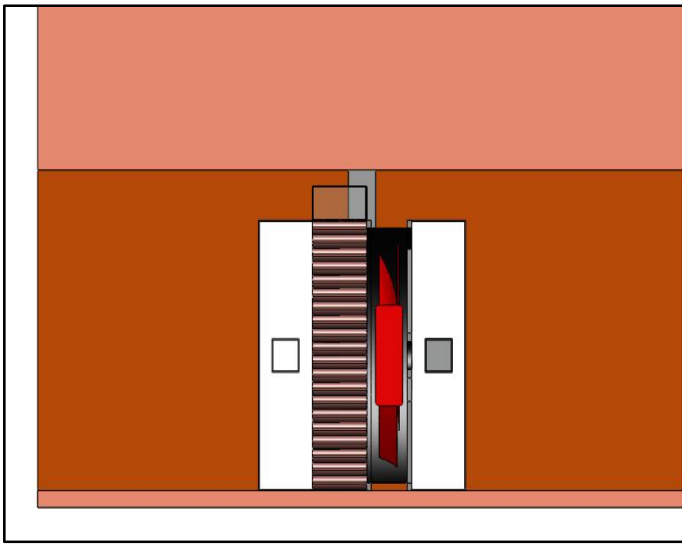


Figure 11: Section View of Assembly

- Figure 11 shows the section view of assembly. In which the position of the cooling pad, electric fan and trays is shown.

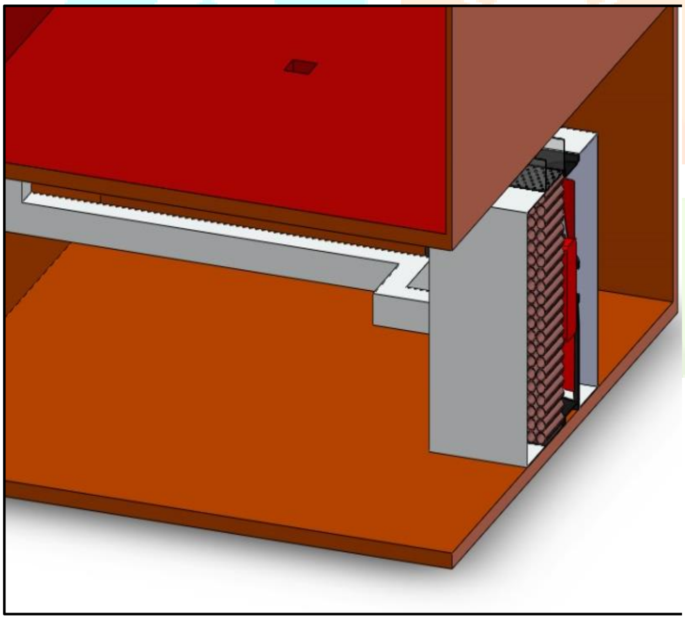


Figure 12: Isometric View of Assembly

- Figure 12 shows isometric view of assembly of cooling pad, electric fan and trays.

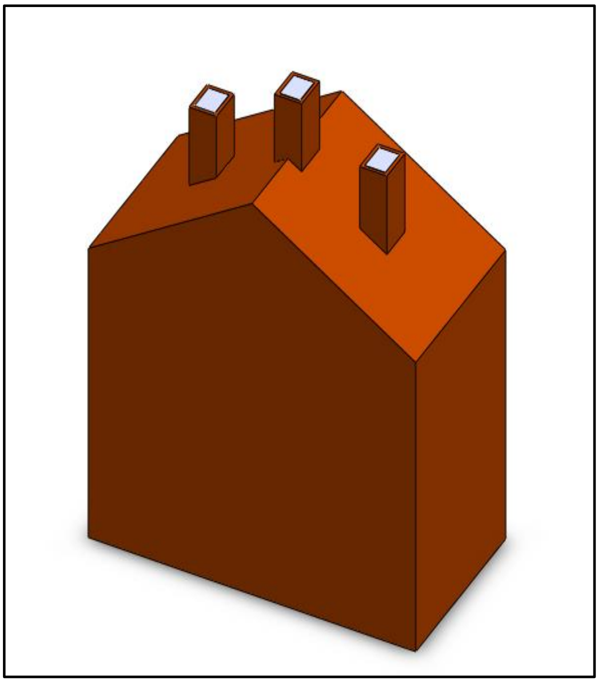


Figure 13: Complete Assembly of Prototype

- Above figure shows complete assembly of the prototype and which is used for CFD analysis.

CFD Analysis of Project Setup:

Specifications:

Parameters	Values
Gravity	9.81 m/s
Fluid Type	Air (Gases)
Flow Type	Turbulent Only
Pressure	101325 Pa
Ambient Temperature	30°C
Velocity	5 km/hr

Table No. 1

- Above table shows the initial and ambient conditions used for CFD analysis of the project

IX. Calculation and result

Transmission load

- The dimensions of our room are 3.23m long, 3.65m wide and 3m high.
- The ambient air is 42°c at 50% RH, The internal air is 30°C.
- The walls, roof and floor are all insulated with 80mm polyurethane with a U value of 0.28W/m2.K

To calculate the transmission load we will be using the formula

Q = U x A x (Temp out – Temp in) x 24 ÷ 1000

Where,

Q= kWh/day heat load

U = U value of insulation (we already know this value) (W/m2.K)

A = surface area of walls roof and floor (we will calculate this) (m2)

Temp in = The air temperature inside the room (°C) = 30°C

Temp out = The ambient external air temperature (°C) = 42°C

24 = Hours in a day

1000 = conversion from Watts to kW.

To calculate "A" is fairly easy, it's just the size of each internal wall, so drop the numbers in to find the area of each wall, roof and floor.

Side 1 = 3.23 m x 3 m = 9.69 m2

Side 2 = 3.23 m x 3 m = 9.69 m2

Side 3 = 3.65 m x 3 m = 10.95 m2

Side 4 = 3.65 m x 3 m = 10.95 m2

Roof = 3.23 m x 3.65 m = 11.7895 m2

Floor = 3.23 m x 3.65 m = 11.7895 m2

Then we can run these numbers in the formula we saw earlier, you'll need to calculate the floor separately to the walls and roof as the temperature difference is different under the floor so the heat transfer will therefore be different.

Walls and roof

Q = U x A x (Temp out – Temp in) x 24 ÷ 1000
Q = 0.28 W/m2.K x 64.859 m2 x (42°C – 30°C) x 24 ÷ 1000
Q = 5.23 kWh/day

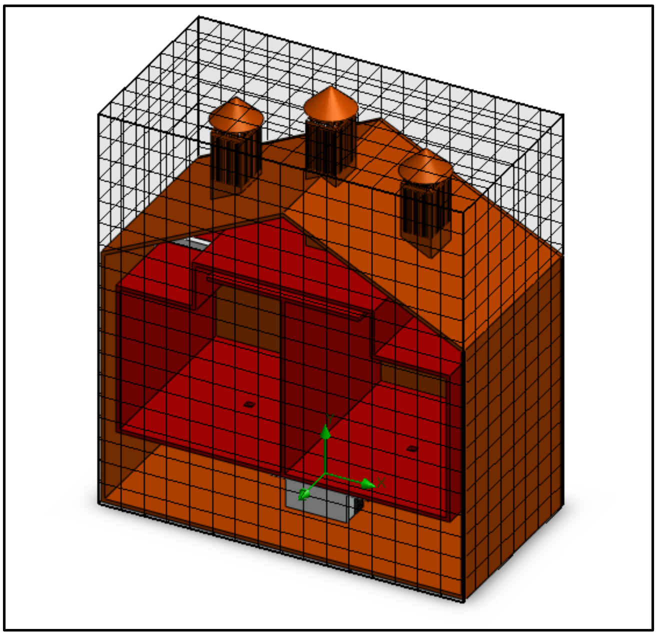
[64.859 m2 = 9.69 m2 + 9.69 m2 + 10.95 m2 + 10.95 m2 + 11.7895 m2 + 11.7895 m2]

Floor

Q = U x A x (Temp out – Temp in) x 24 ÷ 1000
Q = 0.28W/m2.K x 11.7895 m2 x (32°C – 30°C) x 24 ÷ 1000
Q = 0.95 kWh/day

Total daily transmission heat gain = 5.23 kWh/day + 0.95 kWh/day = 6.18 kWh/day

Mesh result



Conclusion

From these model we conclude that,
The key of designing a passive building is to take advantage of the local climate and therefore, climate characteristic and classification can help with identifying approaches as early as side planning and analysis.Therefore, climate and confort are the two fundamentals measure in passive design that require attention.

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