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House Design for Utilizing Passive Solar Energy

Introduction to Design of Passive Solar Feature for House

Passive solar design is defined as the use of the sun's energy for the heating and cooling of living spaces. Here, the building itself or some element of it takes advantage of natural energy characteristics in materials and air present due to exposure to the sun's radiation. The advantage of using the Passive systems is that it's simple, has very less moving parts, and needs less operating and maintenance also it doesn't require any mechanical operation. Windows, thermal mass and thermal chimneys are common features present in passive design. Operable windows are windows that can be kept opened. Thermal mass considers the materials such as masonry and water that can store heat contained for a longer duration. Thermal mass helps in preventing the temperature fluctuations at repaid rate/ slower the temperature changes if any.

The passive solar house design is considered around the concept of maximizing solar heat gain when and wherever needed and minimizing to avoid the losses if any. We see that there is a well-designed passive solar home that minimizes the heating and cooling loads through energy-efficiency plans and then meets the reduced loads along with solar energy. As there is a small heating load in modern homes it's most important in orderto avoid oversizing south faced glasses.

The type of passive solar configuration used for the house design consists of solar water heating systems that operates on the thermosiphon, making use of thermal mass and phase-change materials for decreasing the air temperature changes inside house, making use of the solar cookers, the solar chimney for ensuring the natural ventilation, and also sheltering of the earth surface.

Process:

The passive solar energy heating process involves the following steps:

- The collection of solar energy using the properly-oriented, south-facing windows.
- The storage of this energy in "thermal mass," that constitutes building materials having high heat capacity such as concrete slabs, brick walls.
- The natural distribution of the stored solar energy in the living area, when required, which uses the process of **natural convection** and radiation.
- Window specifications to ensure that there is higher solar heat gain coefficient in south glazing.

Key features of the passive design approach:

The first step is to ensure that the right amount of solar access is much more enough to provide warmth during cooler days and also to prevent overheating in summer. This is done by using the approach of using combination of location and direction of house placed, room layout, window design and shading.Insulation and thermal mass helps to ensure that the temperature is kept uniform and uniformly distributed throughout the house and also the ventilation provides passive cooling and also improved the total indoor air inflow quality.

In the case of the large windows, the large windows can admit high levels of natural light this might also result in excessive heat gain, during the case where the cast light on an area of thermal mass regions, Similarly, opening of the house windows aims to provide ventilation which will also cause noise to enter the house through open windows.

Data sets:

Area of the floor space = 2500 ft^2

NLC range 6 to 8 Btu/FHDD-ft^2

Ap range from 200 to 500 ft^2

Home location: Nashville, TN

Base house cost: $95/ft^2

Natural gas cost: $12.50 /MMBtu (million BTU)

Electricity cost: $0.105 KW-hr

Target SSF = 0.4

Some of the design parameters considered for a house design for passive solar features are:

- Proper Insulation and air sealing

- Ensuring appropriate Window location, glazing type, and window shading
- Using the best thermal mass location and type
- Making use of auxiliary heating and cooling systems

Considering Ap = 200, NLC = 6 (Linear variation between the two extremities are considered in designing)

Fig 1 - Venting Thermal Mass Wall for Home Design for Passive Solar

Concept study:

In the case of house Building Orientation if the building's axis is present on the east-west direction with its longest dimension facing the south, then it's seen that the building is situated to absorb the sun's heat energy.The Passive solar design is the collecting of the sun's energy to maximum extent , the geographical climate, and the properties of different materials to ensure that the building is heated up or its cooled . This approach do not need any mechanical equipment's but just human based approach to collect the maximum energy and also it can reduce the heating and cooling energies by large extent.

Fig-2 Five elements of passive solar design for house

It is found that most successful human-engineered that makes use of the sun's heat energy for heating is termed as the solar wall. Here the construction of the equipment designed makes the use of the high intensity sunlight to heat up metal panels from a short distance away from the wall of the house. The air present in open space between areas of panels and the building heats up because the metal panels gets heated up at the beginning and is transferred inside walls. The heated air naturally goes up till the top of the building and also goes into the heating ducts which get distributed later throughout the building. A Solar wall makes use of no energy to perform its operation and also it can displace the heat away around 50% consumed.

Using a well-designed passive solar home it first decreases the heating and cooling loads using the approach of energy-efficiency strategies and then uses reduced load for solar energy capture

Fig-3 Usage of windows that can increase the efficiency of house energy usage:

- Increasing the net solar heat gains to the building through larger and better-oriented windows
- Reducing the total heat loss using large number of insulating windows
- Increasing or decreasing the solar gains by using appropriate glazing; and
- Reducing the cooling energy demand due using the improvised shading

Fig-4 Flowchart showing the Passive solar heating energy process

Total operating house cost = base house cost + natural gas cost + electricity operating cost
= ($95*2500) + ($12.50*6) + ($0.015)
= $237500 + $75 + $0.015
=$237575.015
Net building load coefficient = 6
Window area = A p =
Heating degree days
Annual heating cost =
Cost of implementing the configuration =

Conclusion:

There is a significant reduction in price of the actual house is due to the homeowners performing the routine manual labor as directed by the on-site general contractor.Concentrating solar power is in development stage this is Used in production, but costs not competitive without incentives

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