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A CASE STUDY

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Application of solar energy for thermal comfort in the house

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ABSTRACT

Solar energy is one of the forms of energy which can be effectively used to create thermally comfortable indoor situations. Solar energy is available in abundant quantity. It can be used for heating and cooling of building. According to use of any mechanical device or fan, the systems can be classified as passive system or active system. This paper covers different methods to be adopted for various situations and their comparative analysis for proper selection for prevailing environmental outdoor conditions.

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Key words : Solar architecture, Active and Passive architecture

INTRODUCTION

Sun is major source of energy on the Earth. Solar energy, wind energy, bioenergy, hydro energy, wave and tidal energy are derived from sun. All biological activities including human life is possible with sun only. Solar energy received on the earth in the form of solar radiations. Wind energy is generated by uneven heating of earth surface. For hydro energy the water cycle derived by heat received from sun. Wave and tidal energies are created through solar and lunar pressure. Solar thermal power available on average outside earth's atmosphere is estimated about 1353 W/m2. This estimate total quantity of solar power received on earth surface about 17.7 x 10^{16} W which is 10^{5} times of world's electric power capacity. Solar energy received on roof is 10 times the heat demand of the house.

Solar architecture:

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"Solar architecture implies buildings whose design integrates the thermal, directional and seasonal aspects of sun". Solar energy can be used for heating and cooling of buildings. From ancient ages solar energy is being used for this purpose.

MATERIALS AND METHODS

In this paper details of the different components of the thermally comfortable building were studied. Their importance and precautions are also discussed at relevant places.

Basic elements of solar building:

- Space – to be heated or cooled
- Solar collector for heating system or sink for cooling system
- Thermal storage

Principles of solar architect:

- Face south where sun spends winter
- Keep the winter winds away - embankments or vegetation
- Shade against the summer sun
- Cooling be done by evaporating water
- Work with nature

Solar architectural systems:

– Passive solar system , Active solar system , Hybrid system.

Passive solar heating systems:

Any building component window/opening and walls admit sunlight in passive system. Everything in building material get heated with sunlight and radiates heat in space. Term passive solar systems - absorb, store and distribute sun's energy without relying on mechanical devices. It reduces energy requirements for cooling, heating and lighting needs using. It involves method of collecting, storing, distributing and controlling thermal energy flow by means of natural of heat transfer.

Classification based on nature of function:

– Passive heating system
– Passive cooling system

Classification based on relationship between sun, the storage mass and living space:

– The direct gain
– The indirect gain
–The isolated gain

Site considerations for passive heating system:

– The building should be surrounded by some barrier (mechanical or vegetative) to prevent winds.
– During winter north oriented building receives little direct impact of available sun.
– South orientation uses low sun in better way.
– Site conditions should permit to use sun in between 9:00 a.m. and 3:00 p.m. during winter months.
– Building location in northern extremity should have sunny area

RESULTS AND ANALYSIS

The results are summarized below according to objectives of the study:

Building shape and orientation:

– Generally oriented in east-west axis is efficient for winter heating and summer cooling as shown in Fig. 1.
– Allows maximum solar glazing in south to capture solar radiations for heating.
– This design is advantageous for summer cooling also.
– For most climates east-west axis is efficient for heating and cooling.

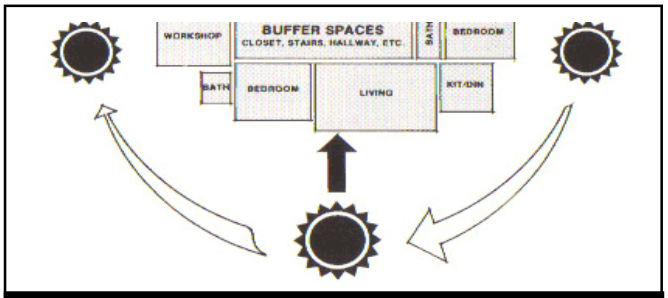

Fig. 1 : Orientation of solar building

Entryways in buildings:

– Doors, windows and ventilators in the building are the entryways in the building envelope.
– Entries account for heat losses.
– Heat lost through opening and closing doors / windows.
– Heat lost by seeping between doorframe, the door and windows.
– Infiltration of heat in the building structure.

Windows:

– Least effective heat flow control through windows. Building is letting heat out in the winter while letting heat in the summer.
– South facing windows are most effective.
– Window areas may be in east and west.
– Windows on north walls should be small.
– Windows should be double-glazed for retaining heat in the building.

Storing heat in masonry:

– Masonry and concrete floors, walls, ceilings act
as heat storages - 4 inches thick.
– Use light coloured surfaces to reflect sunlight on thermal storage mass elements for cooling.
– Thermal storage should be dark coloured.
– Masonry floors thermal mass should not be covered by wall to wall carpeting
– Direct sunlight should not hit- dark colored masonry for long period

Solar passive heating systems:

Direct gain system: (Fig. 2)

– Solar radiation are directly admitted in living space storing heat into thermal storage mass.
– Living place serves as solar collector.
– This system uses both direct and diffuse radiations.

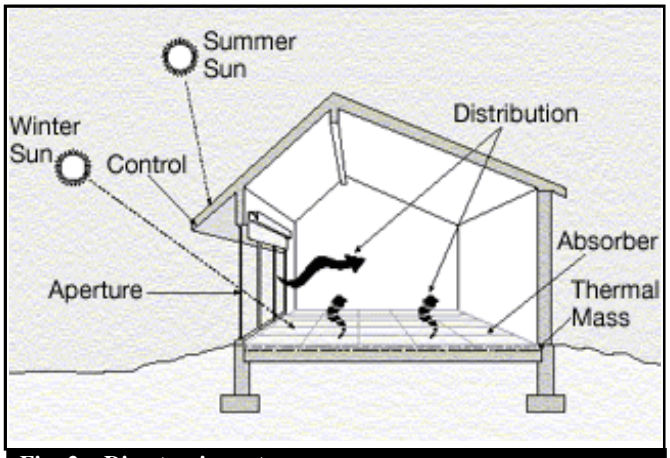

Fig. 2 : Direct gain system

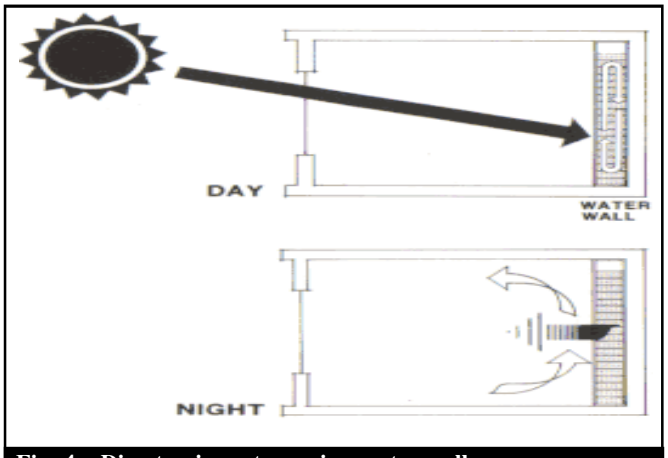

Fig. 4 : Direct gain system using water wall

– Unlike active system , the system works in both sunny and cloudy climates.

Controls in direct gain system:

This system causes discomfort due to direct exposure to sun. There is unwanted winter heat loss and overheating in summer through glazed opening. Use of shutters or movable insulator during night in winter while during day in summer. Reflectors in summer also reduces the interception of solar radiations in summer. Overhangs are provided to keep away the summer sun. Exhaust and vents keep cool interior spaces in summer. Summer ventilators also induce air exchange to remove the heat from living space. Use of shading devices also keep the summer sun away. For better performance the system should be well insulated. The major advantage of passive system is it's simplicity in construction and low cost though this system faces large temperature variation in the building. (Fig. 3 and 4).

Indirect gain techniques:

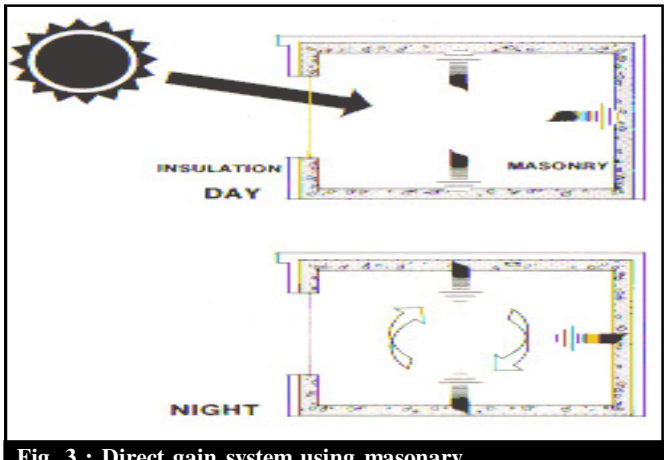

Fig. 3 : Direct gain system using masonary

– Heat energy get collected and stored in on part of the house and uses natural heat movement to warm the rest part of building.
– Thermal storage materials is used.
– No direct heating of interior space with sun.
– Heat transferred by conduction, convection or radiation.
– There are two types of indirect gain system
– Thermal storage wall
– Thermal storage roof
– Storage material used for thermal storage.
– Masonry material
– Water in container
– Roof pond can be use for winter heating and summer cooling.

Thermal storage wall:

The concept was used by a builder Mr. Morse (USA) in 1881. He used a darked, glazed south wall for collection, storage and transfer of heat inside the building. The concept revived by *Felix Trombe (1972)*. Hence it is known as "Trombe wall". Trombe wall is used for thermal storage. It may be of masonry or water wall.

Mass trombe wall:

– It is a thick masonary wall. (Fig. 5).
– It may be made up of concrete, adobe, stone, composite of brick, block and sand.
– For heat gain the outer surface is painted black and double glazed.
– Solar radiations are absorbed and stored in the wall and then heat is transferred to interior living space.
– Energy transfer takes place by conduction in wall from outer surface to inner surface. While convection and radiation mode of heat transfer

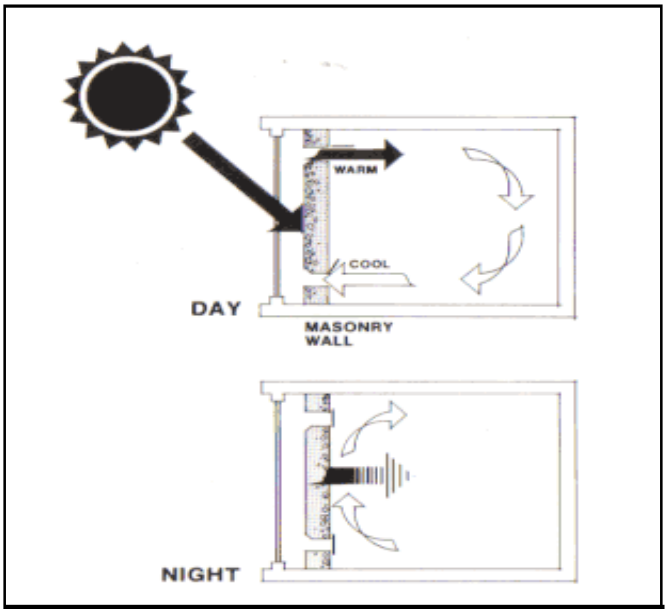

Fig. 5 : Masonary Trombe wall

occur during the heat transfer from wall to space.

– During winter the wall should be insulated during non sun shine hours to reduce heat loss.
– During summer the glazing should be removed and use of reflecting insulation reduce the heat gain.
– Air vents can be used during summer for air circulation.

Water trombe wall:

– Water is used as thermal storage material. (Fig. 6).

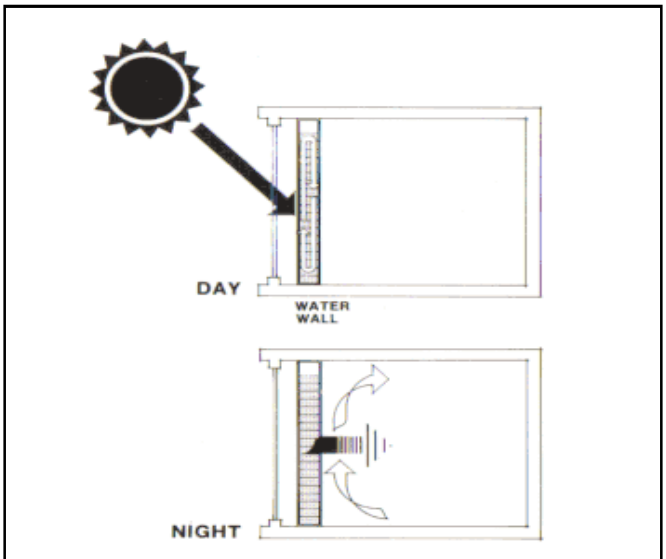

Fig. 6 : Water Tronbe wall

– Drums are stacked as a wall.
– The solar radiation get intercepted in the drum and absorbed in water.
– The heat transfer takes place by convection and radiation which is faster than conduction.
– The exterior surface of drums is painted black for increasing the absorptivity.
– As heat is stored in convective body, the heat transfer is faster.
– Top vent and bottom vents are provided for control and distribution of the heat in the interior space.
– Fluctuating interior temperatures is not problem when water walls are used for heat storage.

Thermal storage roof:

The heat from sun can be stored in roof in the form of sensible heat. This stored heat can be used in non sun shine hours . There are different types of thermal storage roof system. Roof pond is most adopted thermal roof storage system.

Roof pond:

– Water body located on roof as insulation.
– Water mass a open pond act as moving insulation.
– Solar radiations are absorbed in the water increasing it's sensible heat
– The heat transfer in the living space takes place by radiation.
– For creating roof pond the ceiling height is kept normal.
– Storage mass as water spreads uniformly creating uniform environment in the living space.

Summer cooling

– The same roof pond can be used for summer cooling also by reducing the depth of the pond.
– Day insulation keeps sun away by water.
– The disadvantage is that the system receive heat through roof in the leaving space when used for cooling.
– During night when insulation is removed it remove it from living space by evaporative cooling.

Winter heating:

–During day water is exposed to solar radiation and stores heat.
– Living space receives heat from roof.

– In night movable insulation prevent heat losses.

Limitations:

– Single story structure and flat concrete roof is required for installation of roof pond.
– It require high capital investment.

Solarium: (Fig.7)

– It provides a sun space/greenhouse on south side as thick mass wall linking two spaces.

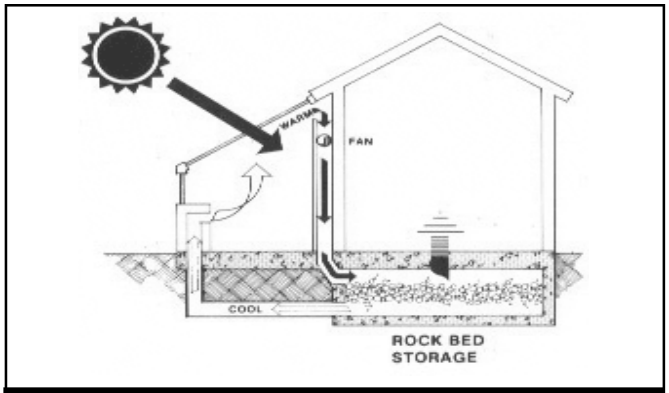

Fig. 7 : Solarium

– The sun space act as direct gain system
– In living space heating through is done through mass wall as indirect gain.
– Whole system resembles a thermal storage wall with large air space between glazing and wall.
– Solar radiations received on wall and floor are converted into heat
– Wall may be of water or masonry.
– Sunspace location building design and sun orientation is important.
– Provides pleasant space for recreation in greenhouse.
– Shading minimizes overheating in summer.
– Insulation / shutter minimize heat loss in winter.

Isolated gain system: (Fig. 8)

– Solar collection and storage is isolated from living space.

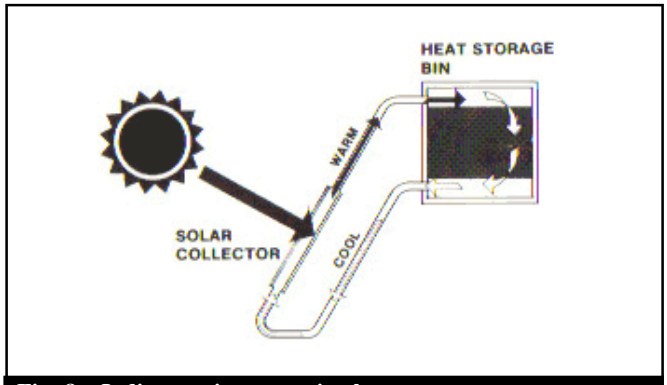

Fig. 8 : Indirect gain-convective loop system

– Contrast from direct / indirect gain.
– Solar energy is absorbed in separate are and distributed in living place through ducts.
– Heat transferred through ducts by natural convection from storage area.
– Since building is isolated from collector and storage, a more suitable location of collector can be selected.
– Building can be designed in any fashion.
– Flexibility in storage location.
– Contact area, collector space and storage can be disconnected for good control.

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