CERAMIC TILE INSTITUTE OF AMERICA, INC.

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CTIOA Field Report 84-1-1 (R-85)

SUBJECT: PASSIVE SOLAR DESIGN AND CERAMIC TILE

A. **INTRODUCTION**

1. As fossil fuels become increasingly expensive and scarce, the need for an inexhaustible, efficient and reasonably priced fuel becomes imperative.

2. Although effective use of active solar energy for powering cars and generating electricity is still years away, the use of passive solar design in construction is today a reality as well as a necessity

3. There are many systems available to the architect, builder and designer to fit.all types of new construction as well as retrofit or remodel.

4. The following is not intended to be a definitive study on passive solar design. We will, however, address the major design concepts, system construction and thermal qualities of ceramic tile.

B. **GENERAL DISCUSSION**

1. About the sun.

   a. The sun as a generating plant converts mass to energy at a rate of over 252,000,000 tons per minute.

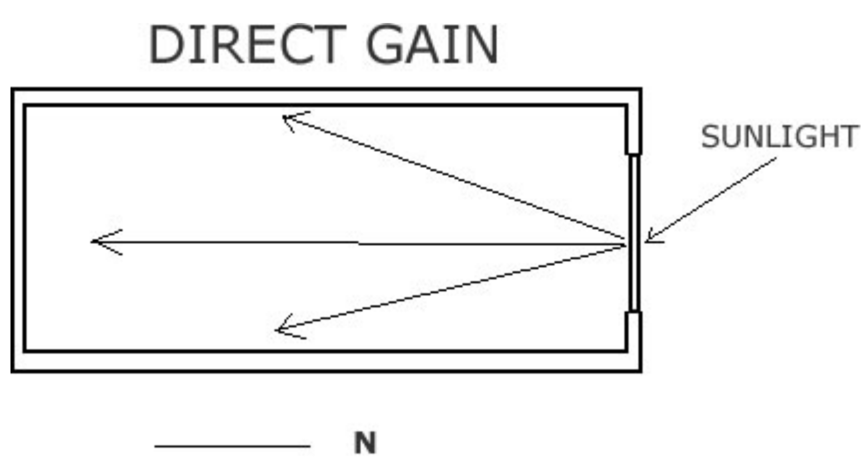
   b. Forty-nine percent of this energy is emitted in the infra red end of the spectrum. This energy reaches the earths outer atmosphere creating a constant measurable heat of 429.2 Btu per square foot.

c. For purposes of solar design, sun charts for a particular geographic area must be prepared to determine the incident, angle of the sun at the different times of year. Passive designs must vary with the latitudinal position of the structure. Reference material will be cited in the bibliography of this report where sun charts and other technical literature can be found.

d. Heat is absorbed by all materials. Some materials absorb and dissipate heat very quickly, others absorb and radiate the heat more slowly. Masonry, block, concrete, ceramic tile and water seem to be the best materials for use in conjunction with passive designs.

e. Materials transmit heat in three ways; conduction, the process by which heat energy is transferred through materials by the excitation of adjacent molecules; conversion, the transfer of heat between a moving fluid and a surface or the transfer of heat within a fluid by movements within a fluid and;radiation, the direct transport of energy through space by means of electromagnetic waves. As all materials radiate heat all of the time, what must be considered is the rate at which the material releases the energy. This release rate is called emmissivity.

f. The properties of thermal storage materials are critical to the design. Specific heat, (the number of Btu's to raise the temperature of one pound of material 1°F), density, (the mass of a substance expressed in pounds per cubic foot) and heat capacity,(the number of Btu's a cubic foot of material can store with a 1°F increase in temperature) are values which are critical to the consideration of materials used in passive design.



2. Approaches to passive solar heating and cooling.

   a. Passive systems are designed to absorb, store and transmit heat by non-mechanical means.

   b. There are three basic systems in passive design. They are; direct gain, indirect gain and isolated gain.

C. **Basic Design Systems.**

1. Direct Gain

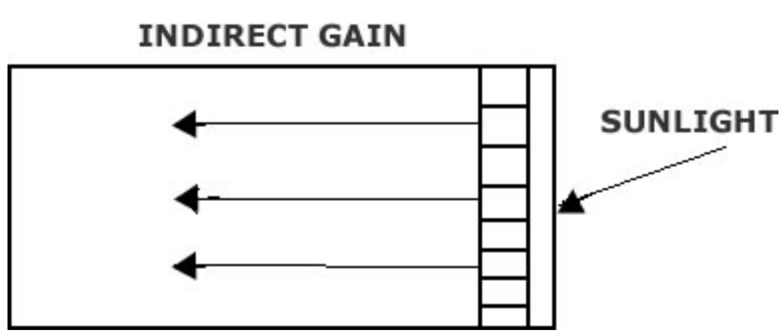
   a. This system utilizes the structure as the collector, storage unit and distributor.

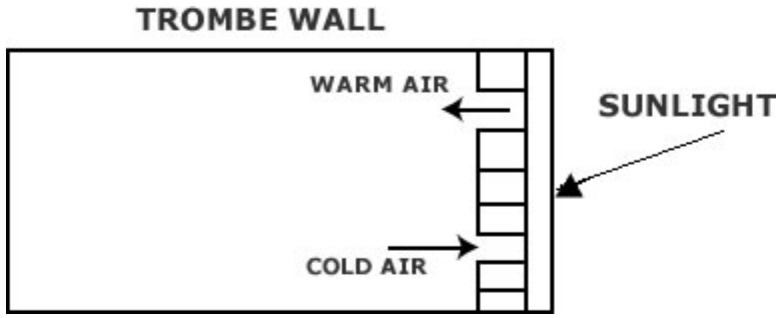
   b. The design concept involves a large south facing window expanse with interior walls and floor acting as thermal collectors.

   c. The storage mass must consist of thick masonry (7"-10") or water walls. Water walls are designed usually with masonry into which 50 gal. containers of water are sealed.

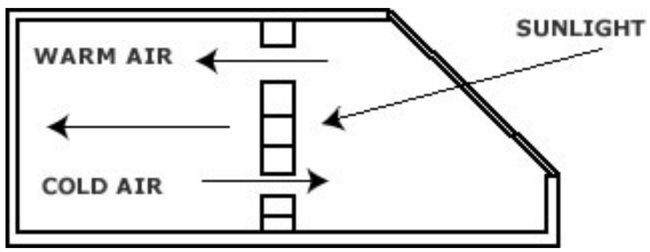
   d. The glass wall is generally two layers. A clear exterior pane allows easy sunlight penetration while an interior translucent pane is used to diffuse the light more uniformly.

   e. This heavy masonry construction stabilizes the daily temperature variations. It has been noted in several cases where properly designed systems of this kind can supply enough heat to render an adequate interior comfort level, even without active heating systems in marginal solar climates.





f. Temperature variations exteriorally may range 40°F where as interior temperatures may fluctuate 7° to 8°F in the same time period. These values change of course with the latitudinal orientation of the building.



2. Indirect Gain.

   a. For indirect solar design, the thermal storage is placed between the sun and the living area. Again, the thermal wall can be thick masonry or water.

   b. Typical construction locates a thick masonry wall behind a large expanse of glass. An air gap of 4" is normally placed between the glass and the wall.

   c. The most recognizable name associated with this design is Felix Trombe. The Trombe wall is essentially a storage wall with vents located at the top and bottom of the wall. As the wall heats the air between the glass and wall, a natural convection condition is created. At night the upper vents are closed stopping the convection, yet the thermal wall continues to radiate heat into the living area.

   d. A water wall would work in the same way, only the heat would be transmitted through convection rather than conduction.

   e. Modified Trombe walls can be used, such as separating the thermal mass by a pain of insulating glass.

f. A green house design is somewhat of a combination o£ direct and indirect design. The following drawing emphasizes this concept.

g. At night the vents would be closed and the thermal wall would continue to heat both rooms by conduction.

3. Isolated Gain

a. As the name would suggest, the isolated gain system is designed to be isolated from the living quarters.

b. The most common design concept is the convective loop, a storage area comprised of water or air and rock. The loop is attached to the top and bottom o£ the storage unit. A solar panel located on the loop heats the air or water and through convection heats the storage mass.

D. **Technical**

1. Design Considerations

a. The following components of solar design must be considered thoroughly if the system is to ultimately perform properly:

Plotting of sun path (summer-fall-winter-spring).

Daily radiation chart - this is to determine the amount of heat generated at a given time.

Radiation absorption.

Average temperature in the building latitude

Specific heat (Btu/lb.L°F), density (lb./ft.3), and heat capacity (Btu/ft. /°F) of the various materials used in the thermal system.

Shading mask - This factor is involved in planning summer cooling. Sun shielding,in the form of fixed or movable separations, as well as landscaping, falls into this section. The objective in masking is to allow the maximum sunlight penetration during the winter, while blocking it in the summer.

2. Wall Size

a. In cold climates where winter temperatures average 20°F-30°F, a ratio of .43-1 sq. foot of double glazed glass per square foot of floor area is used. For water wall .31-.85 per 1 sq. foot is used.

b. Determining size or thickness is qualified by climate, latitude and space heating requirements.

c. Heat loss is determined by the difference between the interior and exterior temperatures.

d. The walls should be designed to maintain an average interior temperature of between 65°F and 75°F.

3. Properties. of Thermal Storage Materials.

E. **Ceramic Tile and Passive Design.**

1. Ceramic Tile a Major Role in Passive Designs

a. With direct gain systems, ceramic tile, with it's many textures, colors and patterns can blend in subtle transition from floor to ceiling. The flexibility of tile can lend itself perfectly with any decor.

b. Ceramic tile adds beauty and warmth to lifeless masonry walls without effecting the performance o£ the system.

c. Consider the outfacing cement wall in indirect design. This wall, rather than painted black, could be surfaced with dark tile. When measured with thermocouples on a sunny day, black glazed tile will generate surface temperatures of 180°F. As the tile would be bonded directly to the thermal storage wall, these temperatures would transmit directly into the wall.

d. When considering other surfacing materials, no other compares to ceramic tile, when judged for thermal properties, flexibility, color, design, texture and beauty.

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