Abstract

Trombe Wall is an active or passive (depending on type of construction) solar building design technique used for heating spaces in cold regions. The following paper aims to study different typologies of trombe walls and study their usages according to their typologies. The paper explores the possibility of usage of trombe in hot and dry climate.

TROMBE WALL

Trombe Wall can be an active as well as passive solar building design techniques used for heating up spaces in cold climatic zones. The concept was first proposed by Edward S. Morse and was patented in 1881. In the year 1966 it was available as an element which can be applied in architecture.

Trombe wall works on the fundamental that the heat from the sun having shorter wavelength and high energy is allowed to pass through transparent layer, thus heating the thermal mass and the radiated heat from thermal mass having long wavelength and low energy is trapped inside or is not allowed to escape outside.

It is a two layered system, which consists of glass, fibre or any transparent material on outer façade followed by air cavity and then wall of thermal mass. These types of walls are constructed on the sun facing side (South side in northern hemisphere) of buildings such that winter sun radiation is allowed for the maximum duration of time to enter the building, thus absorbing heat throughout sunshine hours. The thermal mass wall is generally 8 in. to 16 in. thick, coated with dark absorptive material and air cavity of ¾ in. to 6in. between wall and exterior transparent surface. Solar energy that falls on the glass is absorbed by the wall during the day and released into the house during the
later hours of the day. Air is heated during day time by convection or induced air circulation through the open able vents which are provided on top and bottom of the system.

Typology:

There are different ways for construction of Trombe wall along with a variety of materials which can be used for some of which are as follows:

Typology

1. Full height trombe wall
   a) 2 Vent
   b) 3 Vent
   c) 4 Vent
   d) Special Type Trombe Wall
      i) Water Trombe wall
      ii) Solar trans wall
      iii) Solar hybrid wall
      iv) Trombe wall with phase-change material
      v) Composite Trombe wall
      vi) Fluidised Trombe wall

2. Half height trombe wall.
   1. **Full height trombe wall**: They are the regular type which starts from finished floor level and runs till finished ceiling level.
a) **2 Vent trombe wall:** In such type of wall two openings are provided, one at the bottom and other at top of thermal mass.

![Fig. 2. Two-Vent Trombe Wall](image)

b) **3 Vent trombe wall:** This type of wall contains three openings provided two at top, one on external transparent layer, other on internal thermal mass and one provided at bottom on the internal thermal mass. It can be used in cold climatic conditions where summer temperature is higher.

![Fig. 3. Three-Vent Trombe Wall](image)

c) **4 Vent trombe wall:** In such type of wall four openings are provided two at the top, one on external transparent layer, other on internal thermal mass and two are provided at the bottom, one on external transparent layer, other on internal thermal mass. Can be used in places having extreme climatic conditions such as Ladakh.

![Fig. 4. Four-Vent Trombe Wall](image) ![Fig. 5. Four-Vent Trombe Wall](image)
d) **Special type trombe wall:** Such type of trombe walls are special either because of their construction or because of materials used. Materials may be concrete, water, stone, metal, sand etc. or in combination. Whereas installations can also include **solar thermal systems** to generate hot water.

Fig. 6. Metal Plate Trombe Wall  
Fig. 7. No Vent Trombe Wall  
Fig. 8. Projected Trombe Wall

i) **Water Trombe Wall:** Due to better performance of water as a thermal mass as compared to masonry, this type of wall uses water as the medium for storage and regulation of heat instead of regular masonry. Container of water are stacked to form a wall of thermal mass.

Fig. 9. Water Trombe Wall
ii) **Solar Transwall:** Transwall contains a transparent modular wall of water which also provides visual access to a building’s interior and is aesthetically pleasing. The members of this wall are placed in a sandwich pattern such that translucent absorbing plates are placed in between glazing and contains water.

![Fig. 10. Solar Transwall](image)

iii) **Solar hybrid wall:** Proposed by Spanish scholars it is a prototype Trombe wall hybrid in nature and is also known as ceramic evaporative cooling wall. The wall not only functions as a regular trombe wall during winter. However, it also provides cooling in summer. The wall requires cladding of inner surface of walls with a special type of ceramic and to avoid heat gain in summers it requires a layer of external thermal insulation.

![Fig. 11. Trombe wall - the ceramic evaporative](image)

iv) **Trombe wall with phase-change material:** These Trombe walls are a new typology which uses materials such as phase eutectic salts which have properties of phase-changing. This material addresses the problem of structural load. These phase-change materials have high thermal storage capacity in a lesser quantity and are also light in weight as compared to regular building materials.
v) Composite Trombe wall: The composite Trombe wall, which is also known as the Trombe–Michel wall consists of several different layers. These layers includes an insulating panel, a ventilated cavity of air, a wall of thermal mass, a closed cavity and a semi-transparent cover (see Fig. 12). These walls have overcome two major drawbacks of conventional trombe walls that are: (1) Heat loss during non sunny winter days and (2) Undesired heat in internal spaces in hot weather.
vi) **Fluidized Trombe wall:** In such type of trombe wall the cavity is filled with a high heat retaining, low-density fluid. This type of wall uses mechanical means such as fans to transfer the gained heat into the room. Fluidised particles are stopped to enter room by usage of two filets located at the bottom and top of air channel. A study conducted by a group of Turkish scholars stated that these walls are more efficient as compared to regular trombe walls because of the heat transfer fluid.

2. **Half height trombe wall:** It is a miss belief that these walls should be of full height, reduction in height simply means reducing the radiation capturing area and increasing the area for direct heat gain and natural light. These walls are a relatively simple and effective solution that can greatly compliments the quality of adjacent spaces to them. Commonly constructed around 4-6 inches (100-150 mm) from the inner surface of the window and the gap is sufficient enough for curtains to reduce heat loss and gain solar radiation for its proper functioning.
Advantages:

1. Trombe walls are effective in mild to extreme cold conditions.
2. With innovation technique these can even be used to cool the spaces.
3. They stop sun drenching and reduces glare in internal spaces.
4. They are ideal for private spaces such as bedrooms, living rooms etc.
5. Though can be during flexible times they are most suitable for night time heating.
6. These walls provide heating without utilizing usable space.
7. Works on the principle of radiation which is more effective than other means.
8. Low or no maintenance due to fixed system.
9. Easy to incorporate into building as part of internal or external wall.
10. Reduces load on heating appliances leading to energy efficiency and economically feasible.

Disadvantages:

1. Trombe walls can lead to increase in cost of construction to extra load on structure.
2. If insulation is not done properly can act as a heat sink at night.
3. Manual operation of vents and covering at night can be real hassle on a daily basis.
4. They reduce day lighting and access to views in the exterior.

Conclusions:

1. Integration of phase changing material seems promising with the trombe wall technique, can be studied for future purposes.
2. There are possibilities of usage of trombe wall in hot climate due to the advancement in material technology.

3. A new typology can be developed keeping the existing typologies as base work for further development.

References


