

## Research Article

### The Adjustment of Building Warmth by using the TROMBE WALL as a Good Pattern in Dry and Hot Regions (Case Study: Yazd City, Iran)

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**Abstract:** The purpose of this study is the survey of tools and resources that needed to assist building by passive solar heating approach and manage the energy and get massive production for this system. The consistency of the building with structure is one of the fame architectures. The creation of perfect condition in the space of building is the reason of using different stuff with different attribute in the building. Thanks to development of knowledge and producing the new stuff making the new condition is regular way. But in many cases using the new stuff beside the source of influxes have some defects, that can symbol to naught a accordance with different continent sophisticated that, make a problems in the nature system and producing the building rubbish. Also we know the fossil's energy running out of in the entire world, this problem lonely necessity to using renewable energies in all of industries among building industries and derivation constant architecture or green architecture from that. With sustainable development subject, there are a wide studies had been searching about energy in the building and using the natural ingredient. One way to manage the energy in the building is to know about attribute of stuff which comes from the natural. In the Iran's traditional architecture, using the brick show the high level of thinking and seeing the Iranian's architecture in using the harmonic stuff. The brick sorption the heat as a capacitor during the day and back this heat to the environment in the cold nights of the desert to prepare the comfort for people who living there. Thanks to the improving of knowledge and coming new stuff and the speed of building construction using the bricks beside the modern architecture is impossible. But we can use the other ingredient which existent in the environment to manage the energy in the buildings sustainably.

**Keywords:** Capacitor, heat detent, passive solar heating, Trombe wall

## INTRODUCTION

Should first be noted that the present study performed by investigating a lot of traditional patterns in hot and arid climates of Iran (like Yazd city) in 2011, also we investigate the properties and characteristics of traditional brick walls compared with Trombe wall and try to replace the new alternative with higher efficiency. This requires research on Trombe walls and qualitative investigation operation that this study presents it.

Sustainability through sustainable development perspective is called the ability of the ecosystem or the current operating system that can continue to operate in the unknown future without falling due to the shortage of key sources (Soflaei, 2004).

In this world, Architects in line with other scientists are seeking new solutions to meet the human's life. Although the strength and weakness points of world have a direct impact on the environment, these factors will be a critical tasks in regard the architects. The main root of the environment

and sustainable architecture related to 19th century (Mousavi, 2004).

John Ruskin, William Morris and Richard Letaby are considered as the vanguard of sustainable architecture. All of These pioneers have used the term of nature and nowadays the only word that can replace with this term is the term "Sustainable Architecture ". Application of sustainability concepts in architecture explains the new subject that we called it sustainable architecture, ecological architecture, green architecture and eco architecture and all of these factors have refer the same implications on sustainable architecture (Soflaei, 2004) (Fig. 1).

The word "sustain", derived from "sustainer" and the Latin root of the word "sus" means bottom up and "tinere" means keep and has been sed in the English language in 1290. This verb mixed with some concepts such as support and sustains and also selected from sustainability adjective. Term sustainability in mind is that this discussion can continue in the future (Givoni, 1976).

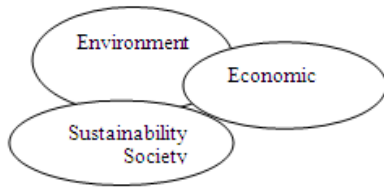


Fig.1: Main effective factors related to sustainability development

Sustainability in architecture is the same way that architecture can be accessed in the near future. This type of architecture is to associate the feeling of humans to nature. Many reasons need to be changed that human vision for how to use energy resources and due to this matter building construction is very important idea and principles of green architecture. Green architecture has many successful, including the dissemination of new construction techniques and selling appropriate materials with think of green architecture. Green architecture is based on four general principles (Mehri, 2009):

- Protecting from water and wind energy and other natural resources
- Provide environmental health
- Growing the economic in the country
- Provide a high quality of life for citizens

Nowadays we are in advanced technology, but with the convenience that this technology creates in the favorable atmosphere there are also some disadvantages. Countries that have natural endowment of energy, they are not completely in control of technology (Technical Document No. 22, September 1977, Prepared by the National Capital Development Commission in Australia). In our country, which has a variety of climates, we can use natural energy so that the role technology used in air conditioning, heating and cooling is much less. Solar energy is a basic technique to capture the energy. It can be divided into passive and active energy systems.

- **Passive system:** In this system building functions itself as a combination of absorption, storage and distribution.
- **Active system:** This system is attractive and use for storage the distributed systems (Technical Document No. 75, November 1971, Prepared by the National Capital Development Commission in Australia).

We note passive systems such as direct absorption system and Trombe wall. Direct absorption buildings are designed to absorb the direct sunlight into the room directly and led to the capture of large surfaces. In other words, living spaces lies adjacent to the glass surface; therefore it depends on the temperature changes from each of these levels throughout the day and night.

In Trombe wall system, a thermal mass is located between the glass and the living space. In this case the heat absorbed should warm the thermal mass during the day and this thermal mass can protect living space against the cold glass during the night. A thermal storage wall (Trombe wall) is composed a wall and a glass on its outer surface. The massive mass of wall works in order to store solar energy and generally it is created from solid construction materials (Trombe wall) or from water containers (water wall).

We cannot ignore the role of stuff in architecture. Building created form and shell that this shell come from stuff, so that this useful materials should have influence on people visually and mentally; including color, texture and the kind of stuff (Pirouzan, 2006). In direct absorption system, using the materials is evident in the blue wall.

Due to the importance of sustainable development issues in the current era and the necessity of using the new technique in using inexhaustible or renewable energy and raising awareness of people from the finite nature of fossil fuels and the high costs of using them, is the necessity of this study and gradually the necessity of using such methods is obvious to everyone.

The background to this research: This issue along with other issues related to the heating and cooling of buildings is presented in the Mr. Kasmaei's book (Kasmaei, 2003), "The Adjusting of General Condition".

Further inquiry showed so many questions about this topic and it is the purpose of this study to answer these questions. Due to the nature of the subject and the research followed Trombe wall system, This study seek to review and analyzing this kind of walls and wants to answer this question; whether the natural materials that are available in the environment can easily be used for heating and cooling buildings?

This study is a kind of analytical-descriptive research and we used the Library and attributive methods for collecting data.

Using renewable energy in buildings and architecture synchronization with climate can help us save energy and also to prevent environmental pollution.

So that human has physiological and psychological well-being in architectural space. And beside this; if the architecture consistent with the environment and culture and follow traditions of Iran's architecture, it will sustainable architecture and retain its beauty and efficiency. And applying the principles of sustainability and environmental synchronization architecture we can moreover create a comfortable space and comfort for life, prevent contamination of the environment.

Other benefits of sustainable design in buildings can be pointed out in the following:

- Increase the durability and life of the building
- Save energy and stuff and optimizing them
- Protection of natural resources and constructions

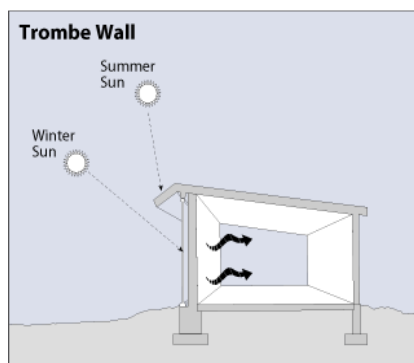


Fig. 2: Tromb wall in summer and winter

- Increase the comfort and satisfaction of the consumer from building
- No damage or interfere with the environment (nature) by using new energy in various sectors
- Creating environments and spaces that continue safety, health and physical well-being, mental health and productivity of its occupants.

**Trombe wall:** Trombe wall is a kind of thermal storage wall that is composed of stuffs with high thermal capacity. These systems generally have their own side of the glass with dark colors to absorb sunlight. Color is one of the affective factors for storage the thermal energy and light. Painting the internal and external surfaces of the building by taking the coefficients of thermal absorption and excretion of colors and recognition of neutral colors can be a cause of saving energy. (Light absorption coefficient in colors: black 100%-dark green and dark gray 70%-light green and light gray 40%-and a variety of white between 12 to 20% ) (Rouhizadeh, 2008).

So even in directly absorption systems the more we used dark colors the higher performance be achieved.

In this system, heat is conducted slowly through the thick wall. When the building's thickness is great, the temperature swings in the living room is less and the delay in transferring of heat through the wall would be long. Wall thickness can be optimized so that the maximum heating effect delayed as predictable as the maximum amount of heat is needed at night. (E.g. a 12-inch masonry wall can delay solar noon heat just before bed time). Trombe wall is a perfect element to complete the direct absorption system. Because delay in transferring of heat from the wall will cause, less heat waste through the windows. Consequently this steady stream of solar heat gets into space (Fig. 2).

**The vents of air Termosiroccolasion:** One of the benefits of regular Trombe wall is thermal stability. Of course its disadvantage is that it needs a long time to warm up in the morning and also after night without sunlight. We can add open doors on the top and also in the bottom of masonry wall to increase the internal temperatures of Trombe wall system in the middle of

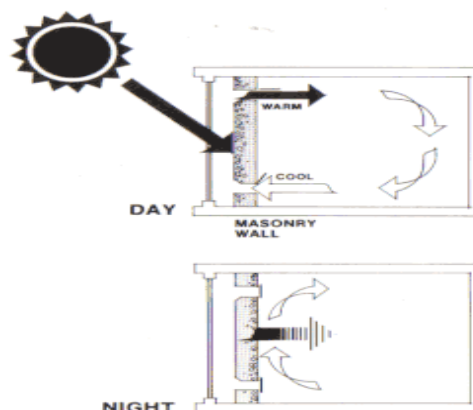


Fig. 3: Tromb wall working in day and night

the morning and the annual heating function (SSF). This allows the warm air between the glass and the absorber wall go up through natural movements and steepen into the room and cool air of inside room is lowered into the hole, take its place. It helps room warms up rapidly (by moving through the vents) that after a while the heat transfer by conduction in the wall replace with it and store the heat for use in the early evening on the wall. During the night, the air-absorbing surface of wall temperature and its surrounding air layer falls to below the ambient air temperature. It makes that with denser cold air in the glass space invert the direction of warm air and accumulates the cold air at the bottom of the room and flowing through the bottom hole into the room. Warmest air near the ceiling in the room is drawn into the upper hole and replace with cold air. Unfortunately this reverse Termosiroccolasion is very efficient cooling process that rid of all the heat and morning heating performance. The annual performance of a porous Trombe wall is worse than the performance of similar sealed system, unless a means is provided to prevent reverse Termosiroccolasion at night. We can use some air flow blocking methods of the lower and upper vents to prevent reverse Termosiroccolasion. Using vents that have manually performance is not recommended, because it is inappropriate and unreliable. Also not only the residents aren't present in time for opening and closing the pores, but without a visible marker such as smoke, it is almost impossible to determine the direction of air flow and proper position for these vents. The most practical and most useful way to control the pores is a lightweight screen that lies on the top pore of Trombe wall on the side the room and hinge to the upward. To avoid flushing ambient air in the summer, the vents should be closed and the wall should be shadowing by a projection. Although pores (with appropriate adjustments Circle), can slightly improve the performance of the annual heating, however, they have too much cost and help to the building's heating in summer. Many designers



Fig. 4: Tromb wall

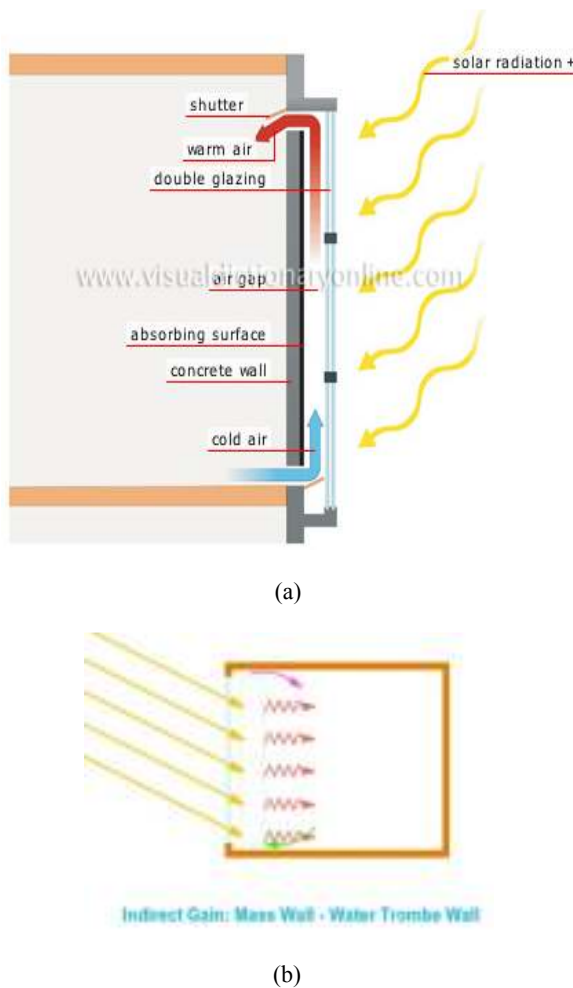


Fig. 5: Heat transfer at the tromb wall

overcome Trombe wall's problems by merging the vents of Trombe wall (for the heating at night) and direct absorption level (for operation of heating during the day). These two systems are usually placed in the building to strength it in the day hours. Direct absorption system is appropriate for daily spaces (living and dining areas) and Trombe wall is appropriate for evening space and night (bed space) (Fig. 3 and 4).

**Using direct absorption instead of pores:** The main advantage of Trombe wall pores can be quickly heating the room in the morning. We can merge directly absorbed system and sealed Trombe walls to obtain this advantage. As we mentioned, non-porous Trombe wall transferred heat to the space more than direct absorption through the windows. When non-porous Trombe wall combines with direct absorption system, it can eliminate some of the Termosiroccolasion problems. In this case, the set of Circle which are often unattractive removed and accumulated dust on the absorbable surface get less. Adding suitable direct absorption glass, prepare skylight and vision and provide a variety of beautiful in the uniform mass of masonry. Generally using a combination of direct absorption system with non-porous Trombe wall is recommended instead of porous Trombe walls (Fig. 5).

**Selective surfaces:** In all Trombe walls, especially in non-porous walls, a constant transfer from the wall to the glass is one of the major sources of heat rejection. We can use a selective surface to reduce the constant transfer from the wall to the glass. The black metal plates are a selective surface optically, because their black color absorb high coefficient of solar spectrum. Of course this metal plate with low-emission power prevents the reflectivity of spectrum from the infrared. Selective plate surface devise in occupied Palestine by "Harry Tibor" for use in solar water heaters. Today, these surfaces are marketed with adhesive coating and sensitive to pressure on the back of them. This surface increases performance of the system. A selective surface as a metal plate in terms of increasing the solar save coefficient is as a night insulator for a porous Trombe wall. Due to more thermal propulsion that yields from siroccolasion moving, there is less attention to the more performance of porous Trombe walls.

**Trombe walls advantages:**

- This type of wall works well in comparison with other static systems.
- These walls lay the thermal mass between living spaces and glass and sun. Therefore they create a natural buffer between residents and a solar absorber surface temperature changes.
- These walls move the heat slowly through thermal storage (as directed) Therefore temperatures have been adjusted and delayed. This factor allows solar heat to release in the building reliably.
- In this system, masonry wall separated the air of room from the glass. Thus, the use of night insulation in annual heating performance and comfort system at night is less important than the direct absorption system.

**Trombe wall disadvantages:** The performance of non-porous Trombe wall is too low for heating the area in the morning. Adding vents can warm the building during the early morning as much as heat release in the afternoon.

We should embed controlling systems for porous walls to prevent reverse Termosiroccolasion at night.

Porous walls enhance accumulating dust on interior surfaces of the glass and absorbing surfaces. The space between the glass and the wall is so thin that there is no access for repair. Therefore we should remove the glass for cleaning and re-painting the absorber surface (one of the suggested solutions in this chapter is the use of sliding doors.)

### CONCLUSION

The indiscriminate use of energy in buildings, especially residential buildings and due to population growth, the lack of energy crisis is predictable in the future. The recent performance of the developed countries with the aim of reducing the use of fossil energy in construction demonstrates an understanding of these countries from relevant crisis that have adopted the principles of rational orientation. The Iranian architecture, with its history of thousands of years has gained valuable experiences in harmony with nature. Unfortunately in the past decades, a deep rift is created in the continuity of this harmony. Nowadays the new scientific discoveries express new patterns in the construction style, we need to know to analyze and describe one of the methods in this category and have a small contribution to sustainable architecture. We explained Trombe wall that is one of the new methods in harmony architecture with the climate. We hope to use these methods in our building industry to prevent further contamination of the environment. And also we

can achieve new methods thanks to new research on sustainable architecture in harmony with the climate and efficient using of fossil energy.

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