



## Ecotech: An Old Style in Iran's Architecture

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**Abstract.** In this paper, analyzing the elements that have had multiple functions in traditional buildings of Iran has been considered. And, windward tower as a main feature of our architecture among the other elements in the architecture of ancient Iran has been selected, since; at the time it had advanced structure in order to improve natural ventilation in buildings. And then, the materials used in the ancient monuments such as bricks and cob which also have unique features are discussed. It is followed by investigating the theoretical and stylistic features that is called echo technology in contemporary architecture in west. Finally, the extent of similarity between ancient architecture in Iran and eco-style and that the use of natural ventilation or mechanical systems in buildings singly is not a practical way to achieve an appropriate form of energy and cost saving and natural systems should be combined with mechanical systems are realized in respect.

**Keywords:** Sustainable architecture, Ecotech, windward towers, buildings' material, thermal comfort

### INTRODUCTION

Most of the cities of Iran are formed by ancient monuments being extremely vulnerable to destruction due to changes in the last century. Studies show that so far no studies have been done on these buildings and there is no comprehensive understanding of them, while the function of them is based on human needs and the related environment, they might be useful in reaching a suitable building model. Now some architects consider architecture as the intermediary between humans and the environment, and by using natural materials, referring to the native method and its characteristics, create their own modern architecture.

They try to adapt their buildings to contemporary needs and bond them to the native architecture, as well. In the past, various elements were used in order to maximize the use of environmental area around buildings, so, after a review of various elements used in traditional buildings of Iran in order to create thermal comfort in different part of buildings, the formation of these elements in today modern buildings is discussed.

### METHODOLOGY

The research method is a combination of library studies and field study.

### Research questions

How were the buildings constructed in Iran?

What methods were followed and what is its orientation today?

To what extent, elements used in the construction of buildings of Iran, have the key role in the function of building?

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### **Definition of sustainability**

It is a kind of design planning to respond to current needs without damaging the resources of future generations. In sustainable design, economic and social sustainability depending on energy consumption as well as environmental approval of buildings and cities must be considered. (Sajjadi ghaem maghami, Pourdeihimi, Zarghami, 2010, 76). In general, the sustainable architecture can be interpreted to "create a stable man-made environment".

### **Sustainable environment**

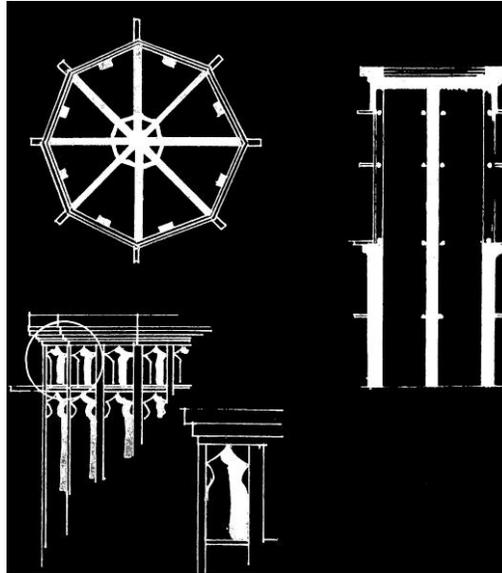
The basic requirement for achieving environmental sustainability is dynamic balance between the various environmental systems. In scientific point of view, simultaneous achievement to sustainability of 1) Ecological system, 2) the socio – cultural system, 3) an economic system is crucial.

Sustainability in architecture cannot be considered as a style or a specific orientation just belongs to the present time, because ethical attitude and approach are emerged that have got importance and validity according to its time and situation. (Sayad, Madahi, 2011, 16). Thermal comfort causing both physical and mental pollution. So, the perfect indoor climate conditions should be established by designers. (Battle McCarthy Consulting Engineers, 2002, 21).

### **Malikov 3, an essential part of the fabrics of the buildings of hot and dry or hot and humid area of Iran**

Finding details about background of windward tower (modified Malikov), is very difficult. Because there were the tallest structures of buildings and in each building the first signs of damage might be seen in the roof and especially windward tower. The simplest example of the windward tower has been found among the Indians of Peru Mvchikay. They had their homes ventilated by using windward tower. Windward tower by guiding the wind stream and using the natural, clean energy has had an important role in adjustment of temperature and reaching an appropriate temperature in residential places.

Windward towers of the old towns in these areas (hot and dry or hot and humid) look like vertical channels. And they are considered as the tallest places of the town after the mosques. One of the difficulties of archaeologists is finding an evidence to prove that the windward tower back to Iran before emerging of the Islam. The first historical document about Iranian windward is backed to the fourth millennium before BC. What is important is that the windward towers, the most innovative elements of traditional Iranian architecture, are destroyed gradually. They are durable because of their construction's techniques. Strength of windward is related to the maintenance of them and the way they have been built. (Mahmudi, 2009, 23- 17).



**Figure 1.** The sketch of the windward tower of Dolatabad garden in Yazd (Source: Pirnia, Introduction to Islamic Architecture, 2006).

### **Types of windward tower**

Regarding different perspectives in this field, scholars have offered different categories that are going to be discussed. 1) Purely functional windward towers; 2) Function-symbolic windward towers.

The first type is more common in homes in Yazd and countries around it. The second type can be seen in some houses in Yazd and cities around it. And it represents the importance of owner of the house in addition to the specific functions of the windward tower. In this case the dimension of windward tower is more than a three-door room.

Ali asghar Shariat Zadeh has classified windward towers based on local names and the names given to windward by their architectures. So, there are 3 types of windward towers in this classification: 1) Ardekani windward tower, 2) Kermani windward tower 3) Yazdi windward tower.

### **Ardekani windward tower**

This windward tower can be seen in the area of Ardekan. And the wind blow from Isfahan is its source of energy. They are blocked against winds blow from the West and the East and South. The construction of this type of windward tower somewhat simpler than other types and they are economical. Thus it is possible to build a windward tower for each room.

### **Kermani windward tower**

This type of windward tower is humble and simple and belongs to houses of Lower-middle level families. It can be built by all constructors because it is easy to be made. And they are mostly made of bricks and clay. This type of windward tower is also known as twin towers because they have got two-way direction. This type of windward towers is built toward direction in which famous winds are flowing. They are more practical and more accurate than the windward towers of Ardakani. Because the air pressure in one direction causes rapid depletion of hot and polluted air from the other side.

### **Yazdi windward tower**

This kind of windward towers are larger than the other. And they have got four sides. So, in some places they are called a four-way or four-side towers. The building is architecturally sophisticated and more difficult than other types of windward towers to be built and as well as that they are usually taller than the other types. This kind of windward tower is for the rich and they are sometimes seen in the houses of middle-class people of rural and urban area.

Windward towers can be divided into three categories regarding the form of their roof: 1) windward towers with flat roof; 2) windward towers with sloping roof, 3) Windward towers with curved roof (ibid, 30- 25).

### **Materials, texture and color of the windward towers**

The materials of the buildings are selected according to the climate that they are built in. The windward towers of Yazd are made of cob and clay. Clay can transmit thermal energy fast. Because the earth is non-compact and mild and clay is made of water and earth and after evaporation of its water, some holes are emerged in it. So, heat and cold are prevented from getting into molecules of clay, soil and brick.

Windward towers are usually made of adobe, brick, clay, plaster and especial wood which are called "shourouneh". This kind of wood is very strength. It is also resistant to termite attack.

The surface of the tower is covered by cob and its bright color reflects the sun's rays. Cob includes straws which make the surface of tower rough and it causes more reflection and less absorption of solar energy. Despite the fact that there is no need to store heat in hot and humid climates, using brick and clay materials are clearly seen. The reason likely is that these kinds of materials are abundant in this area ecologically.

### **Structures and instructions on how to build windward towers**

The windward towers of buildings, because of their responsibility to catch wind, are taller than the building itself. And holes as an important part of them, in order to catch the wind blows, also reduce its resistance against lateral forces. So, they should be made of extremely strength elements being strong against other forces. It has been seen in Yazd that bundles of wood are laid horizontally within the bricks to increase their resistance against lateral forces (wind- earthquake).

The bundles fasten different materials together and they are left at the end of wooden beams in order to be used for further repairs or constructing of higher parts of windward tower. The other structures used to increase stability and resistance of towers are Major and minor walls. In windward towers of south part of Iran, bundles of wood can be seen being resistance against moisture, rot and termites. These kind of wood which is come from India called "Chandel". Later another type of wood had four-side curved was used as well.

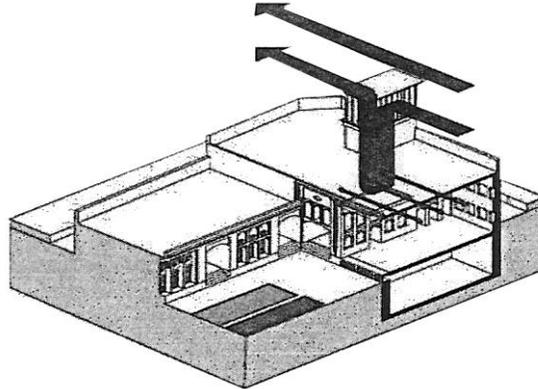
### **Windward towers' function**

Windward towers are a key part of the Iranians' architecture houses that improving thermal comfort is their responsibility. "Windward tower is used for cooling and ventilation of rooms on the ground floor or basement in summer." In other word windward towers can be considered as a traditional structure for making a building cool naturally. There are two ways to create a natural cooling system, 1) movement of air; 2) cooling by using evaporation system.

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In a general classification, function of windward tower, causing movement of air, can be separated into two ways: 1) directs air towards building (when the wind is blowing); 2) directs air towards out of building (when the wind is not blowing).

In hot and dry areas, in addition to the problem of heat, dry air and low humidity are among the factors that threaten the thermal comfort. Therefore, in many cases windward towers make the place cold by evaporation. So, their function looks like water cooler. This is not a case that is seen in hot and humid area of Iran.



**Figure 2.** Function of windward towers.

There were 4 different ways to keep water under the windward tower: 1) placing jugs of water under the windward tower; 2) constructing a pool in the middle of the room which was under the windward tower; 3) Connecting the windward tower to a living room with a horizontal wet channel, 4) Connecting the windward tower to groundwater through a vertical channel.

The proper function of any process or equipment with the objective of preparing comfortable situation for human beings requires providing appropriate temperature and humidity. Effective items which are practical to achieve these objectives can be categorized as follows:

- The temperature of air outlet;
- Transfer of sensible heat ;
- Transfer of hidden heat;
- The effect of air mass flow rate;
- Effect of wind speed;
- The effect of geometry and cross-section of the windward tower;
- The effect of thickness and geometry of the wet area;
- The effect of decreasing of the wet bubble;
- Effect of alcove;
- The height of the windward tower

One of the most important factors is weather the wall of the building is blocked or not (is there any possibility for opening the windows?)

Residents of a building with air conditioning system, experience a constant temperature, while if the window is mobile, people can have more freedom to customize. Understanding the behavior of wind pressure and wind on a building for architects and designers, who want to use their existing wind energy, is inevitable. If the building is located in the path of air flow, pressure differentiation happens naturally (i.e., air pressure increases as the molecules are compressed, and it decreases when they are opened). Pressure differentiation around the building can be used as

an important factor in natural ventilation. Windward tower are located in places with positive pressure and leeward are placed in negative pressure's area. The pressure differentiation between entrances and exits spaces provides the power to flow of air inside buildings. Natural ventilation occurs as a result of pressure differentiation that exists around the building and the wind's effect and the phenomenon of the "chimney effect".

Natural ventilation is based on three phenomena: 1) speed of the wind; 2) direction of the wind; 3) temperature differentiation.

When the wind is around a building or enter from a side and exit from the other side of the building ventilate the building naturally. Windward and leeward are able to expel air from the building to provide a condition for creating a natural flow of air. Windward spaces can gather outside air and leave it in the interior part the building. The combination of Windward and leeward spaces (like windward towers) can ventilate naturally. It is a wrong theory that using of mechanical systems disrupts the homogeneity of the building. It is impossible to ventilate a building naturally for several reasons. In these cases the natural systems can be incorporated with mechanical ventilation systems or air conditioning systems.

In this case, energy and cost will be saved significantly. If it is impossible to provide comfort for a building by natural ventilation system, combination of methods can be used. There are some main points which should be considered from the early stages of the project to the final design in order to reach successful ventilation of buildings. (In this case, the analysis of financial issues and the cost of design and implementation are key factors). The main points are as follows:

- The location and climatic constraints;
- The form and structure of the building;
- Interact with another feature of the building;
- Flexibility;
- Adequacy of costs;
- Requirements List;

### **The technology used in traditional materials**

One of the most important materials in Iran is cob which is highly resistance against heat and sound. Cob has got a pleasant and relaxing color and it comes in different types. In addition to the surface of the walls, cob is used in roof's insulation. In the central region of Iran, buildings are mostly lined with "cob" and make them more beautiful and decorated. In this case it is called "arzeh". This type of coating is smooth and flowing, trowel well and its colour is beautiful. Arzeh, because of the color and its material, decrease the sun's heat, especially in desert regions. This coating not only has perfect application in dry areas but also it is practical in the north of Iran like "Savadkoo" and surrounding villages. In rainy areas (north of Iran), the buildings are lined with special paint every 8 years, in order to prevent cob from being washed by rain. The color doesn't change the natural colour of cob. The color is a combination of "Anzrut" that is a chocolate color myrrh plus Louie.

Moreover, straw which is used in "cob" prevent it from being cracked. So, bricks with straw in their substances are more durable. In Fahraj mosque of Yazd instead of straw (which is rare and valuable in there) thistle have been used. This kind of thistle is abundant in the desert, crushed by hand, and used instead of straw.

### Special features of adobe in buildings

Proper bricks include clay and water is moulded after kneading properly.

- Brick is made of mineral soft clay with ground stone and water.
- Proper clay is made of straw and ground stone. Straw make all ingredients stick to each other and ground stone increases its tolerance. So, bricks stand toughly against pressure of building.
- If the earth, which comes from ruined houses, is appropriate, highly tolerant bricks can be made of its ground stone which are small or rough.
- Brick is made of fatty ground clay mixed with ash. There is usually little fat content in the ash. It makes water intake impossible. The color of this brick is grey.
- Goat hair is added to the mixture of clay, and the product would be resistance against crack mostly or almost completely.
- Soft mineral clay is combined with knitted camel's wool in order to provide brick.
- The rough layer around the rice is sometimes mixed with clay. In this case, brick is very resistance against being cracked.
- Muck of waste matter from animals is added to clay. so, it makes the brick more resistance against moisture and stick the ingredients toughly;
- Roots of some plants and herbs are mixed with clay in order to make brick;
- Fibers of palm tree are mixed with clay and highly resistant brick is made which is called "sazo dar";

In some cases, resistant brick is made by mixing crushed "kloush", which are stalks of rice, and earth. Due to expansion and contraction of the mentioned bricks against the heat and cold and natural factors, some are resistant and some are unstable. And they are selected according to the weather and climate of the location of building and its size. However, it is necessary to study the formation of the elements were used in traditional buildings of Iran but in a modern way, which are used in the modern world. That is called "Ecotechnology" on the West architecture. And it should be noted that Ecotechnology style is an old style of architecture in Iran.

### Ecotech architecture, technology integration, and human environment

How and to what extent usage of high technology in harmony with the natural environment hasn't been similar or not going to be similar in all types of buildings, in some important monuments of architecture and urbanism, sometimes latest technical innovations are used. It seems that using this kind of methods is impossible for developing countries. But the experiences of European countries in some areas, especially in the case of some small buildings such as residential units would be very helpful. Some architecture in order to establish connection and coordination between human and natural environment try to use natural material and indigenous methods. And try to find out about the characterization of traditional materials. Old valuable methods can be carried on in modern times by using indigenous architecture, which is the result of the acceptance of criteria of popular architecture. (Sayad, Mdahi, 1390, 49).

### Principles of Ecotechnology Architecture

In this style building is considered as a small part of the surrounding nature. It should act as a part of the ecosystem and life's cycle.

Ecotechnology architecture with the objective of environment focuses on the following: 1) reducing waste of energy in the environment; 2) reduce in production of materials with adverse influences on human health; 3) using the recycled materials, 4) elimination of toxins of materials.

As it was already mentioned, the principle in this method is based on the belief that building is a small part of the surrounding nature. Undoubtedly, desirable quality will not be provided without regard to the nature, appropriate lighted spaces and proper ventilation. In addition, since the stability and durability of the building is considered as an important factor, high quality construction and use of durable material should also be considered. Such a situation would be provided by using efficient management and use of the latest technology. The most important goals of Ecotechnology architecture are high quality standard achievement, safety and welfare of human to provide their health. In addition, it must not be overlooked that taking advantage of the ancient's experiences in improving the quality of architecture will help to achieve sustainable design.

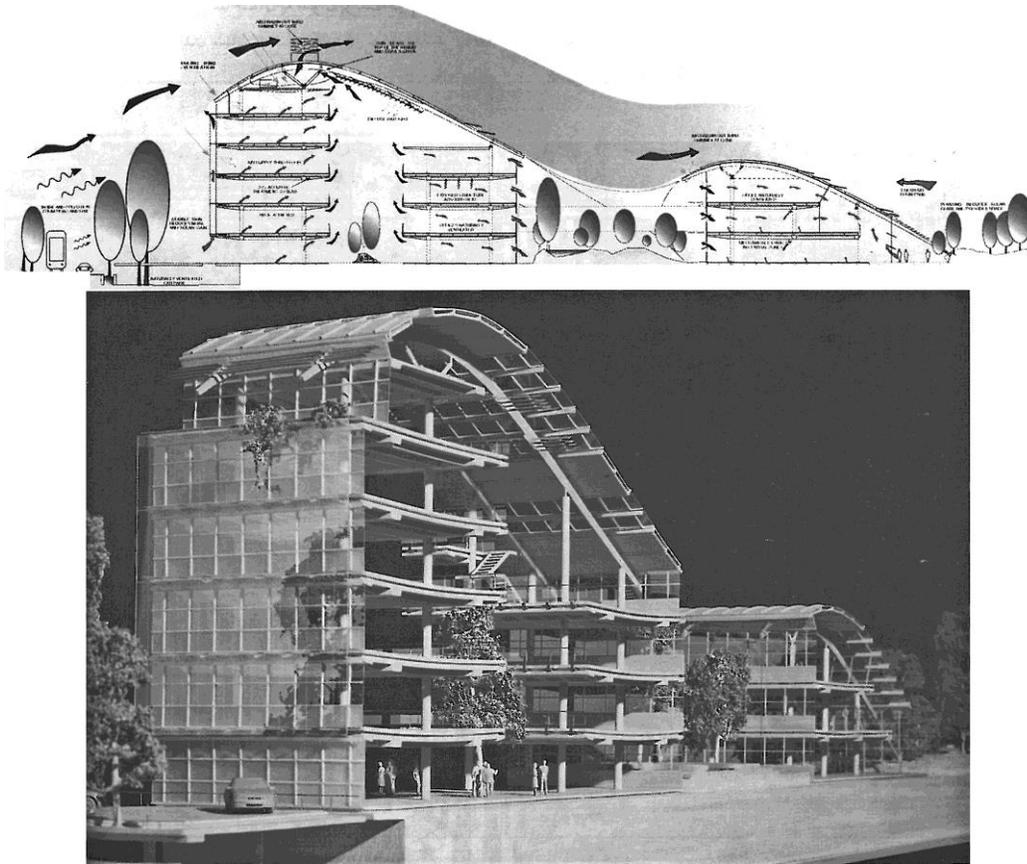
### **Characteristics of buildings built in the style of Ecotechnology**

Looking at what has been done in the field of architecture can be realized that design of building has changed over time, From blocking outside area in order to protect interior spaces to the use of nature and natural energy in construction process. For example, reusing deep eaves and Shoji valves, made of special glass, in Japan can be mentioned. Both are the traditional Japanese architectural styles that are congruent with the climate. Obviously, traditional architecture styles can't be used for people used to live in towers or believe in rational relationship with environment. Ventilation, lighting and mechanical systems are wide technologies benefited from both residents and architects. Natural ventilation allowing air flow from the ceiling, ventilation through the night refinement and air blowing under the floor, lighting control, etc., are all new achievements and innovative forms used them in some buildings caused getting benefit from energy and natural resources, such as heat, sun, wind, geothermal energy and rainwater. Meanwhile, various mechanical methods in order to save energy and produce new systems that minimize adverse impacts to the environment have been used. Designing of green buildings is an appropriate replacement with offices having ventilation system and using loads of energy and it is a serious struggle for air pollution and high energy consumption.

### **Background of Ecotechnology**

Changes in attitude and insight of architectures of "high-Tec" have happened since the mid-80s. And Tec architects believing in positivism think that the problem is not technology but the solution is in the proper use of technology and today, it is seen in their work that by using technology, focusing on getting benefit from natural agents like sun, wind, under-ground water and plants in order to environment adjustment. In the new architecture called Ecotechnology, technology is not known versus nature, But in parallel, natural environment provide opportunities to make human's life more comfort. There is a picture of building in 8-scale, beside beautiful picture of building in the recent work of the architects of this style, shown the use of climatic factors with equipment such as chimneys, reflective mirrors, smart crust, greenhouses, glass stairs and air conditioner. The building in scale is drawn concerning sun angle and speed and direction of the wind at different seasons (Qobadian, 2003, 122).

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**Figure 3.** Proper direction of the wind and sun angle as two important factors in the project (Source: Qobadian, principles and concepts in contemporary architecture of West, 2003).

### Ecotechnology Architecture

Ecotechnology architects consider the crust of the buildings as a second skin. By the first skin meant the skin of the human body. Norman Foster and Renzo Piano's work, a second skin, like the first skin has been designed intelligently. As human skin shows some reflection against cold, heat, humidity and air turbulences, crust of some buildings built by these two architects have proper reflections against environmental factors in different seasons. Things such as the sun, shade, current weather and heat loss during days and nights and during warm and cold season are computerised by using double glass, shutters and removable thermal insulation. These kinds of the buildings, adjusting itself to different environmental conditions, are known as a chameleon by Richard Rogers. Rogers writes about building in the future: "To meet expectations of the residents of the building and the most efficient use of energy, buildings in the future will be related to their surrounding climate dynamically.... in architecture, mechanical systems will be replaced by hidden micro- electrons and Biotechnology.... Buildings, cities and its inhabitants are placed as a moveable integral organic system, designed precisely. Instead of beams, columns and panels and other structural elements, a continuous and interconnected shell will be replaced. These moving robots will have many characteristics in common with living organisms by using electronic systems and biotechnology.

### Ecotechnology and its relationship with nature

The processes of creating natural forms have been developed in the centuries to reach acceptable solutions against external factors (climate, access to food, shelter, etc.). Since God has created

natural environments and they are all apparent symbols of him, they are more immortal and more comprehensive than everything that man creates. Result of the using natural forms in architecture is achieving excellent design that effectiveness of structure, functional needs and aesthetic factors are all combined in it. And constructions should meet the requirements of the laws of nature and respect to nature (Madahi, 2011, 55).

### **Role of materials in external surface of sustainable architecture**

#### **Sustainable building**

Reducing damage on the environment and natural resources is the objective of sustainable building design, which include the following rules: 1) Reduce consumption of non-renewable resources; 2) the development of the natural environment, 3) eliminate or reduce the use of toxic or harmful material to the environment in architecture. So, a sustainable building is the building with less inconsistency and incompatibility with the surrounding natural environment and in general, with region and the world. So the rational use of natural resources and ecological principles and construction management help to conserve natural resources and reduce energy consumption (Energy conservation) and environmental quality improvement. The overall goal of sustainable buildings Include: utilization of energy resources, prevent air pollution and conformity with environmental.

#### **Stable facade**

Three principles of sustainable features of facade of the buildings are strength, beauty and usefulness. Sustainable facade design has been introduced with the aim of honoring the three principles:

- 1) **Strength and Resistance:** designing structures with the least damage facing to earthquakes, wind and other natural and unnatural disasters.
- 2) **Stability:** Stable Materials is another feature discussed in Sustainable Design. (durability and application of materials must be in a way that reused in other buildings after demolishing the building and do not remain as construction wastes);
- 3) **Beauty:** unless facade designs can heal the psyche of consumers and meet their expectations in compatibility with their taste, won't be sustainable in their thoughts. . Therefore, the principle of sustainable design seeks to provide psychological comfort of humans. So, it can be done by connecting people with nature and also a closer relationship between human beings.

Therefore, sustainable design is a flexible design which can be effective against various conditions and in long time by taking advantage of the flexibility and adaptability, become useful and practical for different uses (ibid, 122)

#### **Materials used in sustainable facades**

**Metal:** Metals are used in facades in several ways. It is feasible by using three following methods,

Using of metal rolls, using of bent metal sheets and using of hollow connections. A wide variety of materials have been used recently as facades or second shell or dry joints. "Zinc and lead" are used in dry facades more than other metals. Key factors in using metals are ease of implementation, texture and various views.

**Glass:** protects the interior and exterior spaces against environmental factors let the light in as well (the authors).

**Concrete:** including materials that are not recycled in the nature.

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Masonry: using masonry materials such as brick, stone, concrete, etc., this has a long history in Iran.

Plastic: Plastic, resin base polymer, with the ability to use as the main facade or to the second shell.

Wood: Woods that have been implemented as a bearing wall are also applicable in the facade system (ibid, 127-123).

### CONCLUSION

After a review of studies on the use of technology and the most efficient use of clean energy in designs can state that elements, used in traditional buildings, are part of the structure of buildings and have climatic (energy conservation) - environmental and cultural functions as well. Unfortunately, today, they are not used in modern designs or just used symbolically in architectural designs. If these elements are applied in designs along with technology (sustainable technology) in order to minimize harm to the environment (As the use of heating and cooling systems to assist natural ventilation in building) in addition to the fact that this design is completely in contrast with buildings region regarding its construct and climatic, environmental and cultural functions, clean energy will be tied as an integral element of the design principles, and become more popular gradually.

It should be noted, the theory that says green buildings are just ventilated naturally or using mechanical systems disrupts homogeneous structure is completely wrong. For various reasons, complete natural ventilation is not adequate. So, in order to save energy and costs, natural systems should be combined with mechanical systems.

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