

Research Article

**INVESTIGATING THE STATIC HEATING AND COOLING SYSTEMS
TO COMPLETE THE BASIC CONCEPTS OF ARCHITECTURAL
COMPATIBILITY WITH CLIMATE BY USING A STATIC APPROACH
IN CASPIAN HUMID AND TEMPERATE CLIMATE**

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ABSTRACT

At first, this study has briefly introduced the different types of energy sources and renewable energy utilization methods (static, dynamic and hybrid) in architecture. Considering that the static systems are intertwined with architecture components and also due to their efficiency in terms of energy are considered as the main guidelines in this research. In another view on static method investigation, can be pointed to the vernacular architecture of different areas. So, the concept of architectural compatibility with the climate with a static approach is investigated in the humid and temperate area. Finally, types of the static heating and cooling systems for completing the guidelines of compatibility with the climate by referring to its efficient types in the desired area are discussed as the result of study. The library methodology is employed in this study by using written and electronic sources as well as the field method which is done by using photography.

Keywords: *Compatibility with the Climate, the Caspian Temperate and Humid Climate, Static Heating, Static Cooling, Architecture with a Static Approach, the Basic Concepts of Compatibility with the Climate*

INTRODUCTION

Abundant resources and limited technology are the architectural features of before the decade of the 1800's. At this time, the external wall of the building was used as the main intermediary between indoor and outdoor conditions. The Industrial Revolution changed all these conditions, because through the inventions made in this period, designers found a tool to get rid of the limitations that had affected the form. This event with many attractions had led to a fundamental direction shift in the architecture. The development of economical and high strength structural frames and steel members caused building to carry its burden only through columns and reduced the outer walls' role in the wind and rain prevention. In this case, the thickness of the walls for reducing the burden on the building is minimized and openings are formed to the greatest possible extent. The advantage of greater access to the daylight surrounding the buildings' wall was accompanied by defects such as the increased exposure to the sunlight, heat loss in the winter and sun heat absorption in the summer. Thus, thermal quality of the buildings was destroyed and was replaced by mechanical heating and cooling systems. The impact of these changes was primarily evident in big buildings through justifiable costs of engineering, tools and equipment. But later due to the abandon production, many of these advancements were also applied in smaller and residential buildings. However, it can be said that the price of these progresses led to the architectural emancipation from the bondage of climate and site and consequently increased energy utilization. When energy was cheap and abundant, little attention paid to the indulgence in construction sector. The oil embargo of 1973 created a severe shock to aware experts. The economic effects of rising energy costs realized whatever the environmental concerns could not do it alone. Public awareness of the current status of energy and economic consequences caused by architecture increased regardless of the environment and energy conservation in buildings became a part of effort to expand the use of renewable energies (Moore, 1993). Iran is one of the countries that have valuable experiences about the use of renewable natural energies by static method and its long history of settlement and magnificent civilization has created a valuable heritage of useful experiences that despite the extent of desert areas has provided the residential

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possibility for people for many years. By looking at the old cities and villages of many areas of Iran, the employment of clever ways by Iranian people to improve their living conditions can be realized. The use of these experiences in today's world which depends on the technology and industry more than ever, is precious treasure; because it gives this possibility for human to remove most of its energy needs by static method and without any dependence to the modern technology advancement especially in the construction of living spaces and to properly benefit from the natural renewable energies which are eternal and without environmental consequences (Tabbaz and Jalilian, 2008).

The purpose of this article is to answer the following questions:

- What are the utilization methods of renewable energies in the architecture?
- What are the basic concepts of the architectural compatibility with climate with a static approach?
- What are the rules and guidelines of the architectural compatibility with climate and with a static approach in the Caspian's humid and temperate climate?
- What are the Static-efficient heating and cooling systems' types to complete basic concepts of the compatibility with climate in the Caspian's humid and temperate climate?

Investigating the Energy Resources

Various divisions are presented for different types of energy sources. In one of the most general classifications, the types of the energy resources are in two groups of nonrenewable energies (finite) and renewable energy (inexhaustible, clean or new) (Fayaz, 2003).

Nonrenewable energies

Nonrenewable energies' sources include fossil energies such as oil, gas and its derivatives, coal and nuclear power. Now almost all countries are dependent on nonrenewable energy sources. The unchecked consumption of this type of energy sources especially fossil fuel in the twentieth century has created many problems for today's human that has led in the present century, the consideration of the consequences of the fossil fuels utilization and the benefits of utilizing renewable energies to be in the priority of the policy of the most countries of the world.

Renewable Energies

Renewable energies sources include solar energy, wind energy, geothermal energy, hydroelectric energy, sea wave energy, energy derived from temperature differences in ocean water, biomass, etc. that among these energy sources hydroelectric energy is already used more than other types in the countries. Due to the problems mentioned above, nowadays, most countries are seeking to take advantage of these energy sources in different branches of science.

Methods to Take Advantage of Renewable Energies in Architecture

Among the types of renewable energy sources, some of them, such as solar, wind, geothermal energy in the architectural compatibility with the environment and climate are more used, or at least has been like this so far. The methods of taking advantage of renewable energy sources (solar, wind and geothermal) in the architecture can be studied in three groups of static methods (inactive), dynamic (active) and hybrid (mixed) (European Commission Directorate, 1995).

Static or Inactive Systems

In static systems, the utilization of renewable energies in architecture is taken place after converting the desired energy into the usable energy to provide comfort conditions in building and related outdoor space (as the main aim of architect in architectural designing), controlling the obtained energy flow by natural methods (radiation, conduction or displacement) and without using any secondary energies.

Dynamic Systems (Active)

In dynamic systems, after converting the desired energy into the usable energy in order to provide comfort in the architectural space, the obtained energy flow was controlled and transferred to the intended spaces through secondary energies (usually electrical) abnormally. While static system has close compatibility with the architecture of the building and even can be considered as a part of architectural elements, but in a dynamic system, solar system designing does not need to be coordinated with the building designing or to be affected by it. Various components of a dynamic system (savers, distributed systems, controllers and collectors) can be placed almost anywhere away and then they can be linked

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together through a pipe or duct and without the direct impact on the buildings designing method and in a way that act well. Among the dynamic systems can be pointed to the variety of collector (flat collector, centralized collector, etc.), solar cells, heat pumps, and so on. Considering that the use of dynamic systems is not considered in this study, so, there is no need to provide more information about them.

Hybrid systems (mixed or hybrid)

Hybrid system uses both static and dynamic methods to provide solar heating or cooling and other renewable energies.

Investigating the Architectural Compatibility with the Climate, By Using a Static Approach in Caspian Temperate and Humid Climate

The main problem in using static methods in architecture refers to the consideration of "basic concepts in architectural harmony with the climate, with static approach" and considering these concepts in architectural designing. Examples of the application of these concepts can be found in the samples of vernacular and traditional architecture in different regions. In this section, after presenting the basic concepts in architectural harmony with the climate, with static approach, the rules and guidelines of compatibility with the climate, with temperate and humid climate in the Caspian area are provided by using the techniques employed in vernacular architecture that can be coordinated with the needs and constraints of today's life.

Basic concepts in architectural harmony with the climate, with static approach

Basic concepts in architectural harmony with the climate, with static approach include the following issues that its criteria in each climate are different from other climate.

- Building orientation
- How building is established on the earth
- The shape and form of buildings
- The relationship between the filled with blank spaces
- The features of open, semi-open, closed spaces
- The features of walls

In order to identify its criteria in the context of design to use in the architectural design, due to the placement of designing context in the temperate and humid climate of Caspian, these concepts are studied in the vernacular architecture of this area.

Guidelines of architectural compatibility with climate in the temperate and humid region of Caspian (according to the techniques used in vernacular architecture)

The criteria and guidelines of architectural compatibility with the temperate and humid climate of Caspian are presented in the following with respect to the basic concepts of compatibility with the climate and through the application of scientific methods and according to the techniques applied in the vernacular architecture of region; it should be noted that many of these instructions are useful only to deal with the regional problems and needs and in order to use them, other effective designing factors should be considered and in the event of their non-compatibility with other designing requirements, a proper design that covers all designing needs should be employed by using appropriate solutions.

Direction of Building

The most suitable direction for establishing the main side of building in these areas, in conjunction with the sun radiation is a direction that receives the minimum heat in the warm periods and maximum heat in the cold periods and in relation to the wind, a direction is the best that gets the most benefit from the favorable winds, and to the extent possible to be protected in front of adverse winds. Studies show that the south side is the most appropriate in terms of solar and wind energy receiving and east side is appropriate in terms of solar energy receiving but because of receiving eastern winds which are often damp is not suitable. North side and directions close to it, in terms of the wind and solar energy receiving are very good at hot times and inappropriate at cold times. West side and directions close to it, in terms of wind and solar energy receiving are appropriate both in summer and winter. In general we can say that the most appropriate direction in this area for a building with an open side is south to southeast at 30 degrees deviation from south and for a building with two open sides is north-south. Also, the best side for the

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establishment of main space of the building is the south side up to 30 degrees deviation to the south-east (with the appropriate status at all times of the year) and a side facing to the north and close to it and sides facing to east and west and northwest, because of being inappropriate at all times of the year, are suitable to establish more appropriate service spaces (Tahbaz and Jaliliyan, 2008).

The high level of groundwater in coastal areas, wet soil of region and the importance of the establishment of turbulence necessitate the distance of the building from the ground. Moreover, the construction of spaces without walls, like a pilot in the ground floor of the building can contribute to the establishment of wind flow under the floor (Tahbaz and Jaliliyan, 2008).

Building's form and Shape

Due to the importance of air turbulence in this region which offers one layered building, it is better spaces to be placed in the form of linear next to each other, namely, building to be in the shape of narrow rectangular strips that are built around or in the middle of the empty space. With elevation of building on one hand less land is occupied and on the other hand, with enhancement of altitude the possibility of more favorable utilization of air flow is increased (Tahbaz and Jaliliyan, 2008).

The Relationship of Filled and Blank Spaces

Studies show that the existence of open space around the building is essential, but it is better to protect the west and northwest sides from cold winter winds. So, if there is a path around the earth, buildings can be placed at its end (Tahbaz and Jaliliyan, 2008).

Features of Open Spaces

Due to the fact that in this region the most amount of wind at the hot times blows from the northeast, north and northwest and in terms of solar radiation receiving the most suitable shape for open space is a rectangular that its long side facing south to southeast at 30 degrees deviation from south and the most appropriate shape for ground is a rectangular that its long side is placed in the north-south direction (Tahbaz and Jaliliyan, 2008).

Features of Open, Semi-open Spaces

In this region due to the appropriate climatic conditions, semi-open spaces (such as a porch, veranda, etc.) are important as a joint between closed and open spaces. The placement of the semi-open spaces near or around closed spaces are useful because these spaces provide the possibility to air flow along with the protection from sun radiation and rainfall (Tahbaz and Jaliliyan, 2008). In addition to the climate problems, favorable and significant atmosphere qualities that create such spaces such as **Telar** in residential architecture of Caspian temperate and humid climate, etc. can be used in today's architecture and in accordance with its requirements and constraints.

Features of Closed Spaces

The exposure of the long side of the closed spaces to the north and south leads to the reception of uniform light in the level of those spaces and provides more possibility to have opens and consequently more turbulence. Due to the high humidity of region, spaces should have high ceiling to provide a greater volume of air and to prevent the enhancement of temperature and humidity in closed areas (in the event that spaces can be used both in winter and summer, in winter, spaces should have short ceilings and should be protected from the wind) (Tahbaz and Jaliliyan, 2008).

Characteristics of Walls

Open Walls

In order to establish the turbulence, every closed space should have open walls for entrance and exit of air which including air valves in pressure area and valves for its exit in stretching area.

The most appropriate state is that these two valves to be placed on two opposite walls. In case of design constraint, two adjacent walls or a wall with provisions for creating pressure and suction can be applied. (For example, additional and eave walls can be used for air circulation in the space or the airflow can be created inside through the temperature difference caused by the height difference in one wall or in the case of windows insufficiency, roof ventilations or ventilations located on the upper part of wall can be used). In this case, the utilization of vertical channels such as windward, chimney and so on can be suitable for ventilation. In order to flow air well within the space air inlet should be greater than its output

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or provisions such as horizontal shutters, roof eaves and roof edge bump, etc. to be used for direction correction of air flow. Other problem refers to the protection of open and clear walls in warm seasons which should be exposed to the shadow on one side and on the other side to the air flow. Thus, openings in addition to multiplicity and being large should be with broad canopies and openings of western and northern fronts that are exposed to the cold winds in winter should be covered by a protective door. In this climate, the use of horizontal canopies is recommended for the windows facing south and south-east and vertical canopies especially in the west side to the northern side windows. The conducted calculations show that in this region the depth of canopy of windows facing to the south and southeast is about 0.4 to 0.5. Also, it is suggested that all horizontal canopies to be grille to expel the heat accumulated under it from pore on one side and on the other side to distribute air inside the room well (Tahbaz and Jaliliyan, 2008).

Closed Walls

In this region, due to the relative heat and cold and high humidity and the occurrence of the sultry phenomenon walls can have high or low thermal capacity along with thermal insulation for roofs, with the proviso that the establishment of air flow in the building to be provided through openings in the hot weather and prevents annoying winds penetration in to the building in the cold weather.

If materials with low thermal capacity to be used ceilings with $U = 0.85$ and walls with $U = 0.95$ are suitable and if high thermal capacity or condensers to be used ceilings with $U = 0.22$, $U =$ western wall with $U = 1.2$ and other walls with $U = 1.28$ are appropriate.

Providing shadow for the eastern, western and southern walls is essential in the hot weather that in these conditions the utilization of the dark color for the mentioned walls is permitted. The two sides of walls should be protected by moisture- resistant covers or the possibility of continuous turbulence and ventilation to be provided in the vicinity of them. Due to the heavy rain, the facades facing to the wind should be protected by impermeable materials or by other ways. Also, the top edge of the walls and windows should be shielded with protective cover and tube to direct rainwater (Tahbaz and Jaliliyan, 2008).

Investigating the Types of Static Heating and Cooling Systems in Order to Complete Basic Concepts of Architectural Harmony with the Climate with Static Approach

The types of static heating and cooling systems which are useful to complete the basic principles of harmony with climate are presented in the following. Referring to the fact that a group of the mentioned strategies which are used only in the micro-scale building (and with dominant residential applications) are too costly group and also with respect to the other existing flaws in the application of each of them, many of these options are removed and using them in architectural design is not reasonable.

Static Heating Systems

According to the central role of solar energy in supplying heating, types of the static heating systems focus on taking advantage of this energy source. Accordingly, types of the static solar heating systems can be divided to a variety of sunny windows, thermal storage wall, solar space, air handling coils and aqueous roof which use different methods for absorbing solar heat. These receiving methods include direct adsorption, indirect absorption and distinct adsorption and living space is directly heated by solar radiation in direct absorption system and in indirect absorption, an intermediary aggregator or storage is indirectly heated by solar radiation and in distinct absorption method the collection of obtained heat and radiation takes place outside the useful space of the building (European Commission Directorate, 1995). In each of the mentioned static heating systems one or more energy absorption and receiving method may be used. For example, the direct, indirect and distinct absorption methods may be used in different solar spaces with differences in their components or indirect and distinct absorption methods are used in air displacement cycle system.

Static Heating System - sunny Window

In this system, south-facing window or roof windows lead winter sunlight into the building space. In this system through direct solar absorption method a part of current heating requirements of building is met or

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is stored in the thermal mass to meet future heating needs. This system usually has the following components: (Moore, 1993)

- Extensive glass surfaces to lead winter sunlight inside
- Thermal mass inside the insulation layer to reduce temperature fluctuations
- calculated eaves at the top of southern glasses (or any other solution for shading on the windows in summer and at the same time directing low-angle rays of the winter sun into the building)
- A means to reduce heat excretion at night (nocturnal insulation)

Static Heating System - Thermal Storage Wall

In the thermal storage wall system, a thermal mass is placed between the glass and interior space. In this case, the heat absorbed during the day is transferred to all thermal mass and during the night, the thermal mass like a shield protects the living space against the direct exposure to the cold glass. A thermal storage wall consists of the following components (Moore, 1993).

A wall with high mass that its massive mass stores the solar energy and usually is constructed of the bold building materials (Tromb Wall) or dishes containing water (aqueous wall).

- Glass on the exterior level of the wall (in order to receive the solar heat during the day and to reduce heat excretion at night)

Static heating system - Solar space

Solar space is a kind of solar collector which is in the service of other construction functions. Other terms that are used for this type of static solar system are: "Solarium", "Atrium", and "greenhouse" or sun room. Solar space is a kind of static heating system that includes a wide glass area to receive solar radiation. Solar space can act in several cases; in the first case, the solar space is directly connected to the living space and is a part of it. In the second case, the thermal storage wall exists between the living space and solar space. In this case, the heat transfer may be done by conduction through a common masonry wall (solar space with indirect absorption) or in the form of natural movement through the openings (doors, windows or particular pores) in a common wall (solar space with distinct absorption) (Moore, 1993).

Static Heating System - Air Movement Cycle

This type of static heating system is consisted of a solar collector and a thermal storage mass (usually a stone platform) which is separated from the living spaces. In this system air is used for convection and air flow is transferred from solar collectors to the thermal storage hole and then to the living space and similarly, this cycle continues (Moore, 1993).

Static Cooling

Static cooling of a space corresponds to the static heating. While static heating mostly comes from the sun, in static cooling, numerous heat reducing and wide variety of atmospheric effects can be used to provide thermal comfort in hot times. Unlike the static heating which is widely welcomed for a while, static cooling has a much longer history in the theory and practice in the climate buildings; however, a few general rules of it have been widely used in modern buildings. One of the overall goals of the static cooling is to prevent flushing and sharp rise of temperature in the building which is created by sun in the first place. Therefore, static cooling is not solar and instead, is non-solar or anti-solar. Static heating and cooling can be common in many same rules because both of them highly depend on the heat flow with natural methods (conduction, radiation and displacement). Static cooling can be deduced as a series of research areas which focus on the main heat reductions and yet many cooling systems are involved with multiple heat reducing. In general, in investigating the types of cooling systems, these heat reductions can be divided to the cooling groups through ventilation, radiation, evaporation and mass effect that are briefly discussed below.

Static Cooling - ventilation

The function process of active cooling systems is done through ventilation in two steps:

- A) Evacuation of hot air from inside the building and replace it with cooler air of outside.
- B) Conducting moving air towards the skin of residents to make their body cool with a combination of displacement and evaporation.

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The following two strategies can be used to create ventilation in buildings: (Moore, 1993).

Ventilation through the Use of Existing Wind Flow

The placement mode of buildings, rooms, position of inlet and outlet openings in the rooms and also interior separators of spaces, etc. have major impact on the speed and direction of wind movement in the building. Effective strategies in ventilation refer to the use of existing wind power, the use of transverse ventilation systems, unilateral ventilation, the use of ventilator and ventilating, double glazing roof and so on that the practices affecting the project should be investigated due to the location and type of building.

Ventilation through Wind Flow Creation

The use of these strategies is appropriate in areas where there is no natural wind or somehow the position or shape of the building or its interior spaces combination makes impossible the use of natural wind. For example, it can be pointed to the ventilation through chimney effect which is created by the temperature difference caused by the height difference. The procedure is in this way that the exterior cool air is replaced with relative warm air that moves upward to escape from the upper openings. In order to increase the displacement flow by increasing the temperature difference in the system, this chimney effect can be strengthened by using sun to create a solar thermal chimney. This is done by using a collector for heating air after being pulled out from the building. Heated air by the sun moves upward to exit from upper output. The air flow increases in the building with the use of this effect and with increasing radiation intensity on the collector. From scientific point of view, when the air flow is needed more (i.e., when the sun is shining strongly) this action leads to the greatest amount of air flow (and consequently, the most cooling effect).

Static Cooling- radiation

Radiative cooling is a type of heat transfer from a warmer surface to surrounding cooler surface (or outer space). This type of heat transfer can be used to cool the building (in which the warm surface of building radiates heat to the sky) or cooling of the human (that the warm skin of body radiates heat to the surrounding cooler surfaces of the room, for example, cool walls in an underground building). The effective strategies in static cooling supply method can be referred to the central yard and enclosed patio as well as the aqueous roof systems (Moore, 1993).

Static Cooling - evaporation and Dehumidification

Evaporative cooling refers to the exchange of sensible heat of air with the latent heat of existing water droplets in the moist surfaces. This type of cooling can be used to cool the building (in this case, the wet surfaces are cooled through evaporation), to cool the air of building (which is done directly through evaporation or indirectly through contact with a surface that has already been cooled through evaporation) or to cool the residents (in this case, the sweat evaporation cools the skin surface). Static cooling by dehumidification method (namely, removing water vapor from the indoor air) is done by using three dilution methods through ventilation by surrounding dry air, distillation or drying (Moore, 1993).

Static Cooling- mass Effect

Cooling through mass effect refers to the utilization of thermal storage for heat absorption during the hottest time of a periodic cycle of temperature then releasing it when it is cooler. Buildings with high thermal mass usually use their thermal storage capacities in four ways to meet cooling (Moore, 1993).

- Reducing the daily temperature fluctuations inside building (where the utilization of conductive materials with high mass for walls and floors' surface is led to the creation of a type of uniform thermal effects which absorbs and releases heat gradually). Thus, the mean temperature remains unchanged and only the minimum and maximum temperatures that are located on both sides of the mean fluctuate)
- Delaying the daily minimum and maximum temperatures (which are useful to delay the temperature of daily maximum air and surfaces of building to the colder time).
- Nocturnal ventilation by flowing air in the building during the night (in this method, cool night air is drawn throughout the building to drain away the heat which is stored in the walls and massive floors during the day).
- Contact with soil to reach to the seasonal storage of heat (There are two main methods to use the method of contact with the soil in order to cool the building: direct contact in which the wall of the building is

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almost completely buried in the basement and indirect contact in which building is cooled with heat exchanger buried in the basement like air pipe or tunnels)

Compound System

Compound system is a system in which two or more static solar heating systems are used in a building. The utilization of this system allows coinciding the distinct functional properties of each system to the needs of the various areas of the building and consequently leads to the performance improvement of these systems.

Investigating the Types of Static Efficient Heating and Cooling Systems in Order to Complete the Concepts of Harmony with the Caspian Temperate and Humid Climate

By referring to the basic concepts in architectural harmony with the climate with static approach as well as investigating the types of static cooling and heating systems to complete these concepts and due to the features of Caspian temperate and humid climate (including the high moisture of the air, soil and the importance of the establishment of the turbulence and natural flow of air, low air temperature fluctuations during the day and night, different seasons, etc.), among the systems introduced in the previous section, static heating systems of solar window and solar space are efficient in the climate and efficient cooling systems in this climate are systems that uses transverse ventilation (the use of existing wind flow) and ventilation with chimney effect (the creation of air flow).

CONCLUSION

This study by introducing the basic concepts of architectural harmony with the climate with the static approach, discussed about the guidelines of architectural harmony with the temperate and humid climate in the Caspian region, according to the techniques used in vernacular architecture. After considering some of the most common types of static heating systems (including a sunny window, thermal storage wall, solar space and air movement cycle) and types of static cooling systems (by methods of ventilation, radiation, evaporation and dehumidification and mass effect) it is concluded that the static heating methods of sunny window and solar space and static cooling method by using ventilation are efficient methods to complete the basic concepts of harmony with the temperate and humid climate in the Caspian region due to the weather conditions and its specific climatic. It is important to note that it is tried to adjust the utilization of these methods in architecture with the needs and constraints of the contemporary life.

Indeed, identifying the principles governing these methods and adapting them to the current architecture conditions can contribute to optimizing the use of fossil fuels and improving environmental conditions of present century without incurring any additional cost.

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