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Sustainable House in Iran's Desert

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ABSTRACT

The buildings in the Iranian desert regions are constructed according to the specific climatic conditions and differ from those in other climates. Lofty walls, narrow and dry streets, highly elevated air traps, big water reservoirs and arched roofed chambers, are the outstanding features of desert towns in Iran. Hot summer and cold winter which are because of arid environment and also dusty storms, dry and hot and nasty winds have forced human to find a remedy. After thousands years and by gaining experience people has found solutions with diverse shapes for this important case. The desert buildings are equipped with air traps, arched roofed, water reservoirs with arched domes and ice stores for the preservation of ice. Today because of technology development, new techniques have replaced these native solutions. In this study we try to show theoretical topics about issues of stability, climate, green architecture, energy saves and naturalization of architecture in a modern framework and according to aesthetic criteria, which are rarely considered in given issues. Also subjects relating to the materials of buildings and the method of operation of the traditional cooling systems in the cities in the Iranian desert regions are described
KEYWORDS: Sustainable house, renewable energy, Iran's desert architecture.

1. INTRODUCTION

The concept of sustainable development that was commonly used in the world's scientific communities is termed as one of quality and tends to handle the qualities of life. Its aim is also to enhance the standards of living for the successors. A notion of sustainable development possesses deep contents in three ranges: 1) Environmental sustainability, 2) Economic sustainability, 3) Social sustainability [12].

In order to realize these aims of sustainable development, it is necessary to attach much importance to it if it is interacted to architecture. It is obvious that the ecological problems have made the architects find a remedy to prevent the threats of these problems from endangering man s future. The notion of a sustainable environment is to sustain the earth to the coming generations in its best form. According to this definition, the human practices can be sustained only when they would be carried out without any loss or dimination of natural resources or degraded environment. The aims behind sustainability of environment are the minimum consumption of energy sources; use of recycled materials; entirely recycled material wasted; protection and supply of energy and recycling it without creating pollutions.

Given the points mentioned above, a sustainable building that has the least adverse effect on the natural structure and environment over its life cycle and as long as it is locally and internationally located and well-established.

A number of principles should be observed and obeyed while we plan a building in a sustainable way: 1- recognition of location: a sustainable planning is contingent upon a location that can be identified because if we show sensitivity to local nuanced issues, we can occupy it without destroying it. This identification or recognition contributes significantly and can occupy to the development of architecture up to sustainability both given its performance features and given climatic and weather considerations. 2- The relationship between architecture and nature: this relationship can be followed by the recovered environmental life and an encouragement to revert to this mode of living. 3- Gaining good knowledge of environmental effects: their negative affects can be minimized by drawing upon technology and architectural strategies [7].

The consistency and harmonization of a building with a climate constitute is an important principle of a sustainable architecture. One more thing observable in this mode of architecture is that the use of fossilized fuel reserves has been minimized by virtue of appropriate designing of building and the requirements are so parsed that no damage would be laid on the resources belonging to the coming generations. It may be said that the newly-initiated strategies for supplying emerging to the building are likely the variously important parameters that help achieve the aims to establish a sustainable development [12].In this paper first we will review and discuss all local ecological feature and designing principles in our target environment where is hot and dry climate in Iran's desert

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residential places. Then we will purpose our design for a modern house by applying numbers of local designing principles to achieve a sustainable house based on renewable energy sources. The designing processes are done using 3Ds-Max and VERAY software which common in architectures design.

2. Research background

Those researches conducted in this regard are most of theoretical background and have not any result as an evaluable and constructible architectural structure. This kind of behavior with Iranian traditional architecture is seen for the first time. Design software played an important role in modeling and offering climatic features of the constructions. The book under title of "An introduction to Islamic architecture of Iran" written by Mohammad Karim Pirnia and published by Industry and Science University (Tehran) can be referred to as one of the most important researches in this regard. In this book, Iran architectural buildings have been classified into different historical and architectural styles and eras and features of each architectural style have been studied [10]. The book of "Climatic study of Iran traditional buildings" is another research activity considering traditional architecture of Iran focuses mainly on climatic features and particulars of architecture and its stable patterns and studies different ways of architectural matching with geographical conditions in different climates of Iran[6]. Wind catchers have been evaluated as a symbol of stable architecture in Iranian traditional architecture at hot and dry climate. The subject has been widely studied in the book of "Wind catcher: a symbol of Iranian architecture" where structure, function, and kinds of wind catchers and their role in cooling the buildings and identifying the architectural fabric. In any of the researches, architectural building has been introduced based on results obtained from the studies which can match requirements and patterns of Iran modern life. [9].

The present research mainly aims at evaluating climatic and architectural structure of the buildings especially that of the wind catchers in Iran deserts and designing a building based on the obtained results and principles. The building can be introduced in the contemporary architecture through reviving wind catchers as one of the architectural elements lost its function in the contemporary architecture and a modern building from Iran stable architecture as a pattern of a stable architecture.

3. MATERIALS AND METHODS

The development of 'simplified' simulation tools for architectural designers has received a lot of attention from the research community in the past. We used 3ds Max 2010 and AutoCAD 2010 softwares to modelling ideas and simulation of climatic situation of building.

4. Simulation modelling at the Architectural design

Simulation modelling in the architecture industry allows contractors to create structures in completely unique shapes and sizes that have never before been tested. Computer simulation can refer to a computer program that simulates an abstract model so that it can be studied and analyzed. It can also refer to a 3D computer graphics model made to represent a three-dimensional object through the use of specialized software. Computer modelling is the process of creating an abstract model to simulate the behaviour and response of a wide range of systems and prototypes. This technology is used in the physical sciences, medicine, and architecture as an aide to the design process.

Building simulation tools have become an integral part of the ensemble of computer applications for the design, engineering and (to some extent) operation of buildings. The primary objective of their use is to conduct a performance analysis that informs for instance a pending design decision, a dimension parameter choice or a budget allocation for maintenance. How e,ectively this is done, is as much dependent on the quality of the tools and technical skills of the consultant as it is on other factors. Among these other factors, the management and enforcement of the causality between certain design considerations and a requested analysis are crucial. [1]

The tools embedded in these environments focus on data integration and simulation interoperability but above all on rapid and timely invocation of the most adequate simulation function (rather than simulation tool) in a given design context.

With the help of a proper modelling tool, the design team de5nes what experts will be consulted for what input and what decision moments will drive the engineering design process. The challenge is to represent a particular design decision as a set of tasks and events and associate the appropriate analysis requests with them. The development of the models is a joint upfront team responsibility. This has the immediate bene5t that all domain experts are involved in the early 'project modelling' stage and thus have a chance to control their own 'destiny' in the later execution of the project. These observations have led to the formulation of design analysis integration (DAI) initiative with four-layered workbench architecture, shown in Fig. 1. [1]

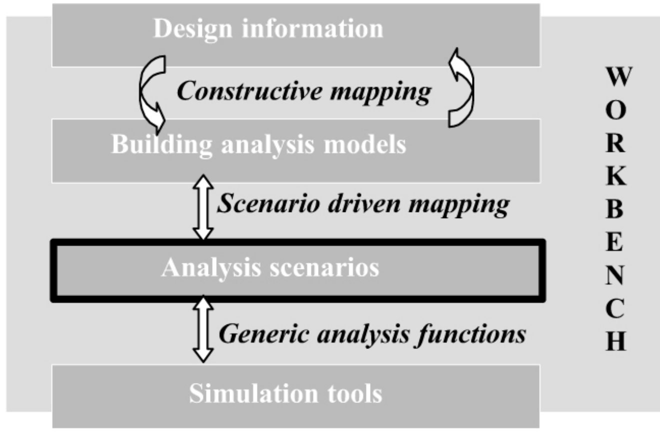

Fig.1. Architecture of the design analysis integration (DAI) initiative.

5. Climatic designing

A climatic designing is an approach to the ways and means by which we would be able to take any necessary measures to achieve sustainable development and environment sustainability aims [11]. In a climatic designing process, first and foremost the type of local or regional climate, atmospheric conditions and local weather where building are typically taken in to account; than the bad condition of unfavorable local climate, introduced in this paper a climatic indicator, are identified and finally a consideration is taken in to account how to provide strategies to moderate them so that a good comfort would be provided in designing spaces. Meanwhile, the main aim of climatic designing is to adopt the best approach to designing for the erosion of needs for heat and cooling of a building by substituting natural energies instead of fossilized and electrical energies. This designing process dates back to native architecture of different regions in the world including Iran. They, however, fell in to oblivion with the advent of modern architecture. Therefore, in the exercises of climatic designing the consideration of ways in which the old visions of climatic designing can prove useful. Nowadays, this type of designing has made progress so far that warm water and light in the building can be supplied without using fossilized energies. The use of resources and renewable energies technology is one of key principles in sustainable development. There are three main reasons for this allegation: 1. these new sources affect the environment much less than other energy sources. 2. These sources are renewable and are not depleted like fossilized fuels. 3. The energy required for small communities would be supplied in a cost effective way [6].

6. Strategies to reduce the effects placed by heat

This climate when the weather is hot, the level of humidity and air temperature rise to some extent that it would be impossible to cool the air by using evaporated frigidity ascended from the surfaces of water and plant. Thus, some other means should take in to account.

6.1. Creation of shade

The first strategy to develop shade is to create projections and having a recessing system in the plan of exterior walls. In more than one story build, if upper stories are more projected than the ground floor, it will both create a shade on the lower story view, and avoid positioning under drops of rain. In preparing or devising a plan, also, if both eaves and retreat taken in to account, some parts of a building will cast shadows on other parts in some periods of a day and thus satisfy our needs. Since the building must be safe from not only the immediate radiation of sun but also the reflected rays of it, one strategy to follow here is that a measure should be taken to encircle the open space of the yard with high walls so that a good shadow Casting would be provided there. Meanwhile, a possibility would be provided to plan and construct the yard deeper that we can plan and construct the intended building.

6.2. Decreasing the contact surface of external walls to avoid sunrays.

In hot climate, if there are much heightened spaces, they become hot a little later and thus comfort heat would be supplied in this way. In winter, however, the increase height of rooms causes them to become hot in a more lagged way. It, therefore, a consideration should be taken to build a more heightened spaces in architectural designs and develop a suspended ceiling that can be condensed and extend like an accordion, the problem can be solved without fail. In summer when the significantly high rooms supply better the frigidity requirements, the suspended ceiling can be removed and in winter to reinstall it to warm the space during a less period of time. Meanwhile the design of this suspended ceiling and the details used and obeyed in its fitting can also contribute to the beauty of spaces.

7. Strategies for lowering the undesirable effects of heat on man‘s comfort

Like shadow and shad provision, ventilation is one of the most important factors for the preventing of unwanted energy in summer. Ventilation not only reduced the thermal energy effect but also decrease its undesirable effect by evaporating the dampness of building. From psychological point of view, air current can directly and immediately influence our sense of cold even in temperatures not more than 34c. The more extended speed of wind contributes to the rate increase of continuous perspiration and therefore the undesirable sense of heat and continuous perspiration begin to recede [7].

7.1. Walled ventilation in a building

7.1.1. Facade ventilation

Use of two-walled layer: In the event an external wall is made laminated (two-ply) and the 10 centimeters wall of facade or frontal is made within a radius of 10 centimeters of the main wall, we can develop a string crevice all over the frontal within a minimum of 30 centimeters of the ceiling. Then, it will be made possible for the wind current to flow out of the bottom of the wall in to the trough of the two layers of wall and finally flows out of upper gap. Air current, if a remains on, considerably contributes to the evaporation of dampness. Besides, sunrays do not radiate directly on the main walls and prevent the temperature from rising. A canopy is also developed to avoid raindrops influence in to the pares of the walls. In addition, it is recommended to fix screen on these openers to prevent entering of unwanted bodied, animals and insects (Fig.2).

7.1.2. Floor and ceiling

- If the building is placed or located on a pilot, the air current will flow from under it (the pilot) which facilitates to create comfort. In the meantime, in areas A where ground water has a higher level, localizing the structure on the pilot minimizes the absorption of moistures from the floor. (Fig.3) - Developing a grid shelter helps create an air current to flow on the roof because if we have solid wall for the parapet wall, no air current would be allowed to flow on the roof [10]. (Fig.4)

7.2. ventilation by taking advantage of thermal run-off

One more option to apply a natural ventilation system in modern building is to take advantage of thermal run-off. A thermal run-off is based on a varied vertical pressure (vertical pressure difference) which is developed in a vertical canal: if the sun s heat or other thermal sources warm air of the lower part of canal in the terminating section of canal and in the most bottom surface, then the vertical pressure difference is created by the heated air lower canal and a current also begin to flow towards the upper side of canal [3].

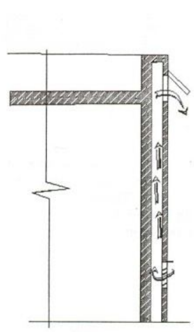

Fig.2. A schematic use of two-walled layer for ventilation.

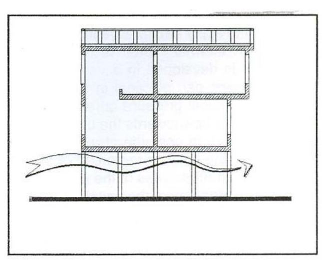

Fig.3. A schematic of floor ventilation.

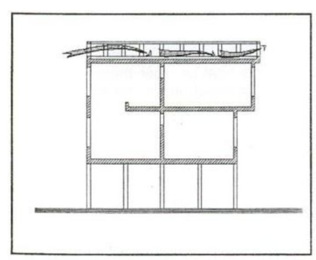

Fig.4. A schematic ceiling ventilation.

A canal can be set up in one side of a building to create a thermal heating in a such a way as from the spaces of the building there can open a compartment like a cooler part to this canal. If there may opener in other sides of the spaces to allow the wind to blow in to the spaces through them, the in blown wind enters the canal through the ports and then is driven out (conducted out) together with canal air current by means of canal thermal run-off. The thermal run-off developed in the canal leads to a situation where the air inside the rooms is suctioned to the canal direction through the compartment (Fig.5). The more the height of canal is in proportion to its length and width, the better the thermal run-off takes places because according to “Bernoli Effect”, through the narrower section the air flows, the more speed it flows. [8].

7.3. Using stair box as a suctioning canal and air blower

- If the making of stairs is not materialized with masonries and through would still remain between both steps and if the slabs of the steps are made as porous, we can heighten the sharp roof (range) and make the desirable wind or breeze from in to the building by developing openers on the range, that is to use the same approach by which an air-trap used in hot and humid regions creates natural ventilation by utilizing appropriately the wind. This can also be used in modern building. For residential flats the stair box of which is not directly connected to main spaces and the gates of which are impediments to the entry of wind within the flats, we can let the natural airflow in to the building by developing some openers over the entrances of apartments. - as for trade and office and cultural building in which the various spaces can be partitioned only by one partition, all parts can be so designed as air current could flow up in all parts of under- the- ceiling spaces. Thus, we can position the stairs in the center of building as already mentioned and we can make an overhead trap door above it unit vertical ventilation develops. The most important governing rule on building vertical ventilation is the varied air pressure in lower and upper parts of the building and a concurrent flow of heat towards the upper part [7]. The air current that flows in to the building through the opening windows around it move throughout the construction and flows out of the upper part of the central space. If the force of natural current of air is inappropriate of there appears an unwanted audio problem or that of safety after the windows open, one can use simultaneously both artificial and natural currents. In this situation, the use of fixed or mobile blowers can increase the speed of internal air in addition, alluvium exchange provides good comfort.

7.4. Ventilation reveled by Shovadan

In regions where there is a hot climate and the level of ground water is not high such as Dezfol region in Iran, one can be reveled by what exists in the traditional architecture of this city to create natural coldness. Shovadan consists of rooms that are built about 6-7 maters below the surface of yard. The temperatures of these rooms are equal to the average temperatures over a yard. In this way is about 22c all over the year [5]. Today designing can benefit both from rooms with function of storage within 6-7 meter deep in the ground and direct the wind in to the Shovadan by constructing a duct against the dominant wind. Meanwhile, this duct can be to steps or stair type that provides the way to gain access to Shovadan with the difference that it is not made of any masonry. One must provide a vertical duct against the duct directing the dominant wind in order to be conducted from Shovadan to the space that is designed to be used. This duct, like that of cooler, can have an opener in rooms and conduct the air in Shovadan rooms. In general, ventilation whit this system is done in such a way that the air conducted in to the Shovadan loses its temperature by cooling with the walls and cold air of Shovadan and then flows through the second duct to the residential spaces. The force of the wind behind the entered wind causes an amount of air inside the Shovadan to exit out through the canal [9]. (Fig.6)

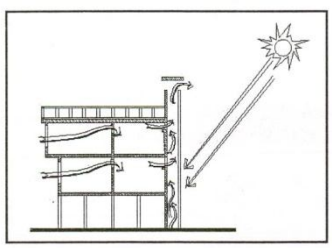

Fig.5. A schematic of ventilation by taking advantage of thermal run-off system.

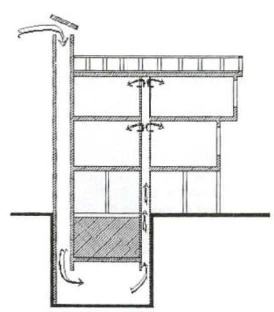

Fig.6. A schematic of ventilation in Shovadan.

8. Designing the sustainable house

Our design is based on the following limitations:

Ecological features: high sun radiation, high latitude, low humidity, low raining, cold winter, very hot summer, high fluctuation of temperature during night and day, low plant coverage, dusty weather. **Common house features of the area:** Building volume: extended cuboids, Building form: extended rectangle (plan), Building roof: Dom-shaped, Air-conditioning: increasing height of room’s to accelerate outflow of warm air through openings located at top of the dome, Great opening toward central yard-Yard has paved ford and flower bed pit, High and narrow wind wards, Equipped with basement, cistern and cellar to cool the building , Face of the building is coated with shining, light-colored materials, thatch, Thick walls, Materials with high thermal mass.

Urban texture features: Buildings are connected together, compressed urban texture: narrow passages with high walls having elements to porch which function as canopy and used as buttress considering statics. High walls of houses which mostly located at eastern –western direction, Wind wards are located at southern direction. Having secondary yards termed as Narenjestan. Porch is located along vertical or northern axes, Houses are somehow rotated toward west or western south in order to take more light, heat contact level , Houses are inner directed, Buildings are located toward south eastern south. The whole designing process is clearly illustrated in (Fig.7).All steps from first sketches and final results are shown. Details are shown in following figures.

Fig.7. Designing process.

The northern part of house is shown in Fig. 7 and all features of the other parts of house are described in details. Also the balcony of house where is really important in our designing is shown and specification are described. In Fig. 8 we summarize the main plan of the designed house all parts of the house are shown and identified. Building coordination with slope and its position at the heart of earth is shown in the Fig.10. Also the new facilities for building cooling and ventilation and the specific green roof are shown and other climate specifications of building are described in details.

Fig.11 illustrates sun rotation, reasons and causes to have air flow under the building. The position of bright and shadow around the building are identified. In designing of wind catcher, many inactive designs were suggested and researched and then registered in a final design. An inactive vaporization loop has been provided at the base of tower and exactly in the perimeter of water ditch which embodies traditional concept of desert in desert. Key advantage which is provided by this system is the creation of natural air ventilation and lower temperature around internal building in comparison with outside air which under normal conditions needs the reduction of temperature that necessitates further and certain pressure in energy consumption of building. Air which is cooled by passing on water, enter into collection by openings or ventilation towers provided that ventilation towers are in an area protected against dust and above water level and in shadow. Function of wind catcher is so that they bring into flowing air of outside and water basins which are installed into them make air light and cool and direct it towards inside of home (Fig.12).Hence updating these native solutions and using of them can decrease fuel consumption largely and solve most of environmental problems and prevent polluted and poisonous air enter into home, so also helps to promotion of environment quality. The effect of ceiling slop on the ventilation and interior design of the house is shown in Fig.13.

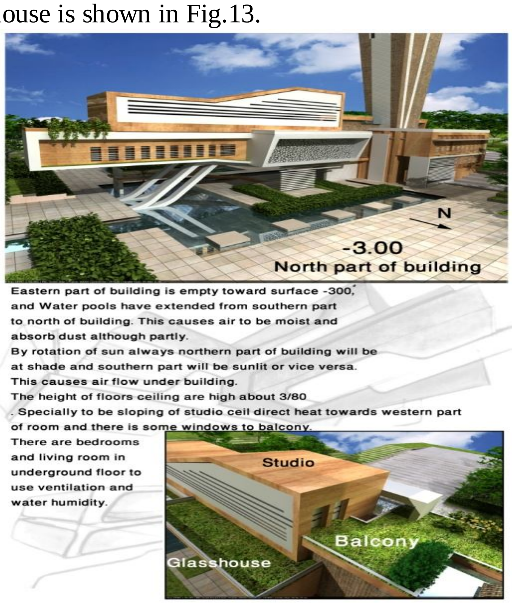

Fig.8. Description of different parts of house.

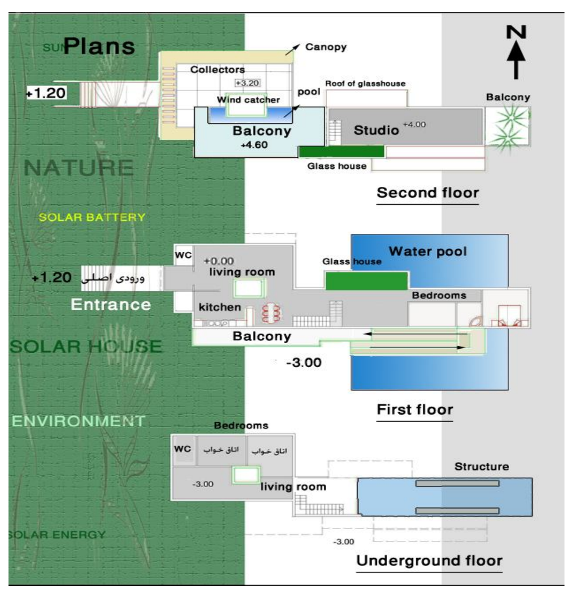

Fig.9. The plan of the house.

Fig.10. Climate specification of building.

Fig.11. sun rotation and air flow under the building.

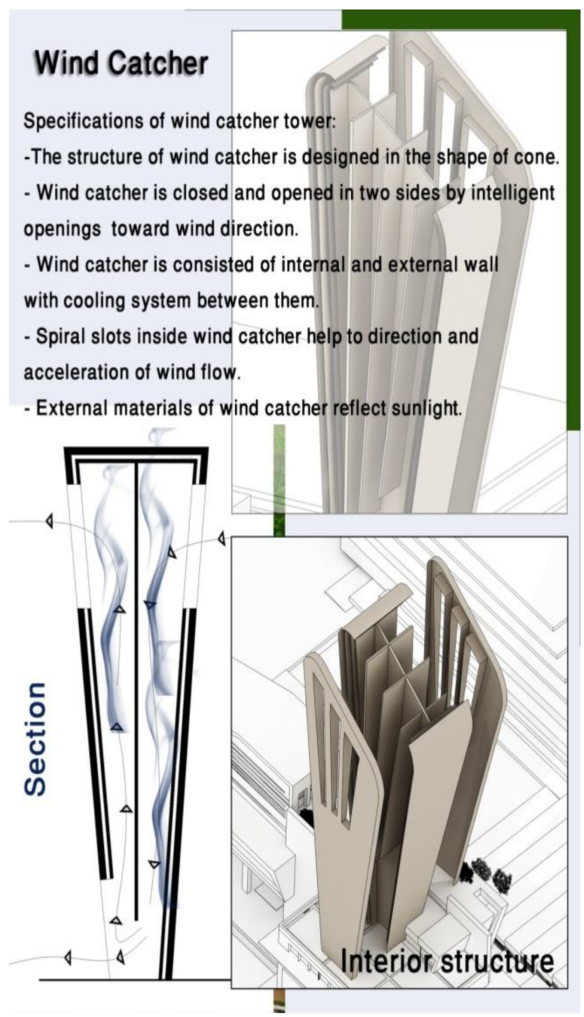

Fig.12. Wind Catcher.

Fig.13.The effect of ceiling slop on ventilation.

9. Conclusion

The provision of optimum cold and heat conditions for the residential building of hot areas was founded on ecological linking architectural approaches and effective COA's (courses of action) to abate climatic disagreeability and hardships constituted the bases of native constructions. Man's access to technology and its unleashed entry in to Iran and developing in to oblivion. This paper introduces some COA's for the design to allow them to respond to environmental problems as before because these problems not only threaten man's comfort but also would use no other energies than those found in nature. We way have architecture as concordant to hot climate by obeying these pieces of advice and keeping in line with sustainable development and sustainable architecture and by appending minimum quantity of energy and destroying in a least way the environment.

According to evaluations of the present article, recognizing desert features and economical, social, cultural, and environmental schemes applied in desert traditional architecture as well as time requirements of the current era, following principles may be helpful to obtain desert stable architecture:

- Maximum use of restorable constructional materials and those that is native to desert.
- Minimum use of those constructional materials with non-restorable energy focus including steel, brick, aluminium, vinyl, and insulator.
- Energy optimization and maximum use of different forms of restorable energies especially solar energy in desert.
- Capturing surplus energy of construction and its saving in underground and even lower than it.
- Designing and constructing with long lifespan [7].
- Strength and resistance of construction against environmental events.
- Independency from electricity power which is dangerous for life and buildings.
- Flexibility and capability of construction to promote and add future technology [6].
- Lack of connection between the construction and gas or electrical network protectors.
- Minimum requirement to maintain and repair.
- Considering reuse and recycle during building the construction.
- Maintaining the construction and its facilitating for the residents [3].
- Producing some parts of the building at the site while controlling its quality and economical scale, if possible.
- More easy and inexpensive nature of the environmentally stable construction in comparison with current common buildings in order to increase demand [9].
- Forming the spaces based on cultural-social features and behavioural patterns of the desert population in order to stabilize human relations.
- Topology of the buildings to access public transportation, bicycle routes, and pedestrians access to human services.

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