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THE DESERT CITY
AS AN ANCIENT LIVING EXAMPLE OF ECO-CITY
Case study¹: Yazd

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ABSTRACT

The theme of this article is the green dimension of urban and architecture design in Yazd as an oasis in the middle of deserts in the centre of Iran where people were able to adapt to very hard climate condition through millenniums. Studying the residential tissues in this area shows that the architectural characteristics of the ancient and traditional parts of habitation complex - before been modernized- are according to the new paradigms of eco-architecture, sustainability and ecological city theories at a time when the global environment appears increasingly fragile.

Native architecture in the desert is the consequence of experience-based knowledge acquired through trial and error over time and often handed down through the generations in a long process of construction, the local climate representation, materials, sensibilities, and style of life. Traditions of vernacular architecture have many lessons for seeking sustainable forms. There is much to commend the common-sense approach to energy conservation and environmental protection practiced, however unknowingly, by many builders in the past. The aims of this study are to give an overview of Iranian vernacular architecture in the perspective of sustainability.

Keywords: sustainable architecture, vernacular architecture, city, desert, Yazd

A Timeless Way Of Sustainable Building

Sustainability in any urban development is non-damaging to the environment and which contributes to the city's ability to sustain its social and economic structures.

According to an accepted definition of sustainable development that is taken from the Brunt land report², the objectives for an agenda of urban design in a regime of sustainable development would emphasize conservation of both the natural and built environments. Principals of sustainable urban design would place priority on the adaptation and re-use of existing building, infrastructure and roads, together with the re-use of recycled building materials and component. Where new development is necessary, the pattern of such development and its structures should minimize the use of energy consumed in travel between essential activities and also in the operation of the buildings. Sustainable development places a premium on the conservation of natural resources, wildlife and habitat protection. It also assumes high degrees of self-sufficiency at all levels of settlement structure.

We do not have to search far for ideas for sustainable building: they are all pervasive in our lost constructional traditions. The solutions to present environmental problems are probably not to be found in the traditions of "great architecture". It is more likely that they will be

1 This study is according to an investigation conducted by the author in 2003 about the principals, criterias and indicators of sustainability in deserts. In that investigation ten green principales and indicators were presented as the signs of sustainable architecture in such regions

2 Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development ,1987)

associated with the everyday buildings that have always formed the greater part of towns and cities.” It is the vernacular or ‘a Timeless Way of Building’ to which the urbanist must turn for inspiration and guidance³.”

The aim of the next chapters is to discover the lessons that can be learned from the timeless ways of building that can be found in the native traditions of the vernacular.

The urban structure of Yazd

Yazd province is located in the central part of Iran, The neighbouring deserts⁴¹, as well as a scanty rainfall give the province a dry climate. There is a variety of climates in this province with altitudes of 850m to 4,055m (Shirkooch, whose summit is snow-covered all the year around). The average annual rainfall is 60mm. The temperature variation is so high in winter and summer, even at day and night, between +45 to - 20°C, with the average being 11.9 up to 20.7°C. Most of the Yazd province is covered with deserts.

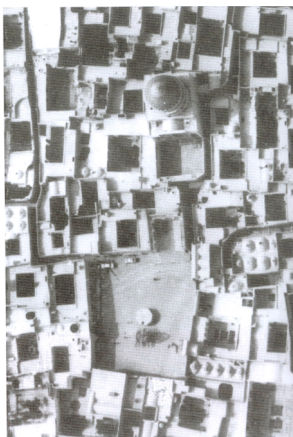
The city has a 3000 year long history, dating back to the time of the Median empire, an ancient settler of Iran. In the course of history due to its distance from important capitals and its harsh natural surrounding, Yazd remained immune to major troops' movements and destruction from wars, therefore it kept many of its traditions, city forms and architecture until recent times



F.1:
Skyline of the city made of clay and mud brick has been dominated by the domes and wind catchers. The structure of this compact city is open to the favourable winds that are drawn into the heart of city to ventilate the basements and deep courtyards.
(Source of photo : Herdeg, Klaus.1990)

There are common structural and physical features in the layout of cities in most of the desert cities. The complicated and interrelated factors that have been shaped historic architecture and urban form in desert regions are mostly affected by climatic characteristics.

The urban form of traditional city of Yazd is the highly centralized or inward looking. Certainly, the orientation and relation to the environment has been of high importance in the planning of city. The particular climatic problems caused the people of the hot, arid zone to find solutions through their settlements architecture. The high radiation and temperature in the summer, diurnal variation of temperature, seasonal variations from dry, hot summer to cold, dry winter, low humidity, limited water supplies and the dusty winds are the most important factors in forming the urban structure of Yazd.



F.2:
The concentrate urban form reduces penetration the dusty wind as far as influence of hot radiation on the surface.
(Source of photo: Urban construction in arid and hot zones, 2002)



F.3:
The narrowness of the semi-covered passageways and high walls along two sides of allays make shade in summer afternoons and protect the complex against the dusty desert winds.

³ Alexandre, 1970

⁴ Kavir-e-Loot, Kavir-e Namak and Dasht-e Kavir

Visually, the unity of the city fabric is reinforced by the use of clay and mud brick as a main building material, which is found locally, reduce the heat absorption and also reflect the sunlight. This city with the domes and vaults of mud and baked brick, has been formed by the different levels: street, court, balcony, roof. The roof turns into to be a surface, as active as any on the ground. The tenuous relationship of levels animates the fabric of the city just as the roofscape animates the horizon with its domes, balustrades, wind towers, and steps.

In this “compact city”, high-density urban structures of mixed land use are thought to promote walking and cycling as the main modes of movement for short. While on an urban scale, the street appears as if carved out of a mass, in reality the wall defining it is a thin membrane at the building scale.

Concentrated urban texture diminishes penetration of dusty wind into complex as far as heat influence on the building surfaces. Covered passageways and narrow alleys with long walls in clay make the shade and thermal comfort conditions in the hot summers. In addition, their direction is in a way to avoid hot summer sun rays and stormy winds. The organic network of ways (passage, alley, cul-de-sac) has been made according to ground slope and the underground water canals⁵.

The skyline has been dominated by fantastic mud brick towers, giving the city an incredible urban aesthetic. These wind towers serve three fundamental functions: to ventilate basements, to provide convective cooling and to cool the interior mass of the house. “ These wind towers are rectangular with openings facing to catch favourable wind , slightest movement of air and direct it downward into underground spaces. This model had become a part of the identity of this city in coping with natural forces for many centuries, now has been abandoned in modern architecture.

For reaching to get into an individual house, a hierarchy of the public amenities, semi public neighbour to a private space has been considered.

The form of developed part of Yazd has changed entirely. In the new city set out in the form of a grid, the streets and alleys are not similar to the past with the protection role that provides the shadow for passenger in hot summer.

The residential building design in Yazd

The form of the residential building is also inward looking centralized by a deep courtyard. The built spaces around this court have been designed to maximise its passive potential to warm the house in winter when sun angles have the maximum penetration into the winter room.



F.5: the two different courtyards that have made microclimates in the centre of traditional houses (source: Herder, Klaus 1990)

F.4: The plan of a typical traditional house composed of tree courtyards(private, ,Guest's and men's, small orange garden and men's reception) shows how the living spaces have been organized and oriented around the courtyards. (Source of plan: Urban construction in arid and hot zones, 2002)

⁵ In the past, for obtaining water from underground sources Qanats were dug, but now deep wells have replaced them. Qanat is an ingenious ancient method of irrigation system, by which underground mountain water is tapped and the water channelled down through a series of tunnels to the ground level. In the water, when there is less need for water, it is stored in reservoirs to be used in the summer

The plan of the house is geometrical and nearly symmetrical. The major rooms are facing southwest and southeast, the optimum orientation for this kind of climate. For effective solar gain window openings are in walls with an orientation within 15-45 degrees west of south with a southern orientation being the optimum position. The best state of buildings is taking the least heat in summer as much as holding the heat in winter. The courtyard where consist the plants and trees compatible to desert environment and a water pool, makes a microclimate for having the comfort conditions in this hot region.

By the wind catcher, the air is conducted into the interior spaces and on water surface at the centre of the courtyards and the plants gets enough coolness in the afternoon.

Not only do the wind catchers act as the principal elements for using the clean energy, also the spaces arrangement helps to maximize using this renewable energy.

Using the materials like clay and mud brick with the low thermal capacity and the thick walls are a current solution for insulating the building against the temperature variations.

The architects have used the massive form of the building, with rubble filled spaces in walls and roofs, hypercausts, made of partially filled cavities, and shade walls and roofs to not only ensure that the sun never fell on, for instance, a thinner part of the roof, or inside rooms in summer with angled walls, but also they used the curve of the domes and vaults to minimise solar gain into the room below and speed up heat loss from the room through ventilated cupolas.

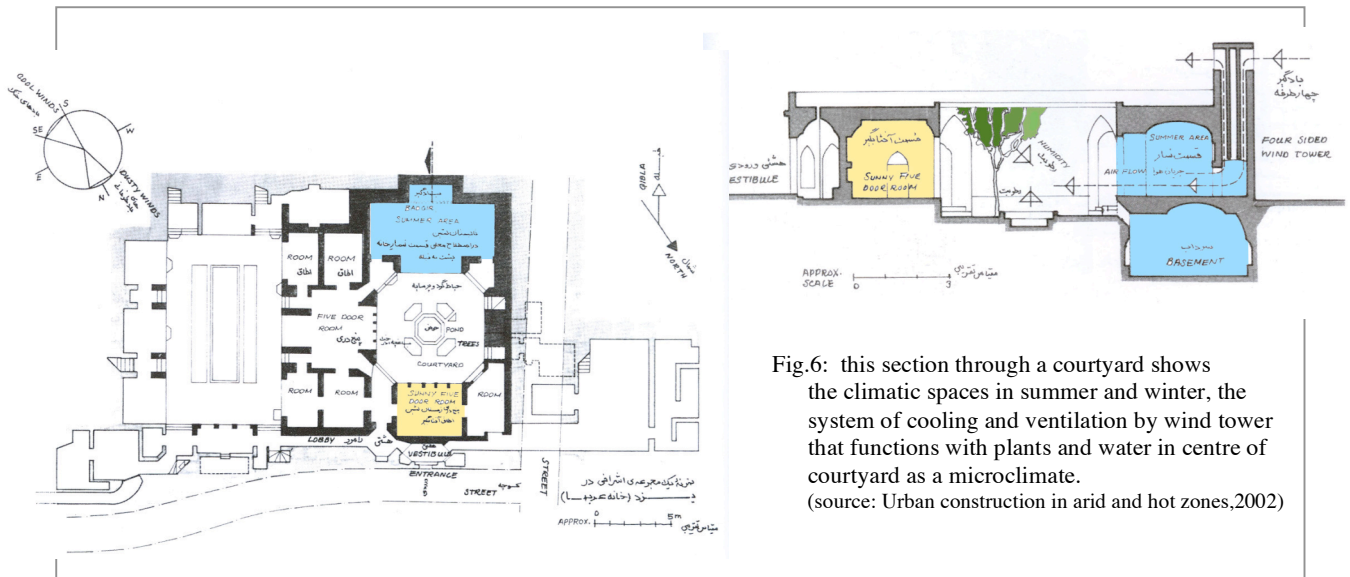


Fig.6: this section through a courtyard shows the climatic spaces in summer and winter, the system of cooling and ventilation by wind tower that functions with plants and water in centre of courtyard as a microclimate. (source: Urban construction in arid and hot zones,2002)

The habitants according to the space functions and their climatic conditions in the different seasons choose how spend their time: in the canicular hot and dry summer's days, almost the Underground spaces and the space in the shadow (north-east, south-east), are being used for running away from this heat. These underground spaces have the more low temperature rather than the up spaces. In the winter's days, the living rooms face south toward the low winter sun; provide the conditions for the reduction in need of fossil energy.

On the other hand, at the cool summer's nights of the desert, the habitats could spend their time on the roofs and under the clean sky full of the stars without any need of the air-conditioner.

In modern parts of actual Yazd, the style of houses has changed; the buildings are often air-conditioned. However, some old people have conserved their habitudes for sleeping on the roof in the summer nights and spending the hot summer day in the undergrounds but in the different form rather than fabric houses.

The principles of sustainable architecture gleaned from vernacular architecture

In the urban scale, the model of this compact city of Yazd is according to principles of the sustainable urban design. “Certainly the compact city and “ densification” of development can achieve reductions in the use of fossil fuels for transport and town heating, reduction too in the use of land and in the cost of urban infrastructure. The organic model for the city is most in tune with the concept of sustainable development when, in particular, it takes on the attributes on nature’s ecosystem.”⁶

According to the Urban task force⁷, the sustainable city –or more accurately speaking, a city that approximates to a sustainable form-is a compact and flexible structure in which the parts are connected to each other and to the whole, with a clearly articulated public space.

At the smaller scale, there are a number of design principles of buildings which is going to be studied and analyzed, here, resulting from this vernacular architecture.

-Compatibility With Regional Context

The vernacular tradition has much to teach in the art of relating the building to its site. This common-sense approach to the location of a building on its site and the organisation of the building elements to mitigate the averse effects of a hot summer has valuable lessons for the greening of building design. In this case study, buildings formed with local climate and the environment, the living rooms in the southern parts and bedrooms with the main windows maximising the benefit of any sun for the cold winter. The summer spaces In the northern face and wind catcher show the solutions for compatibility with the climate and local conditions.

It is important to insulate buildings to the highest standards; to reduce the amount of external wall surface; to orientate the building towards the sun; to organize the interior of the buildings compatible to the sun movement and wind direction. Further energy savings can be made by designing the building to work well within the conditions set by the local climate.

-Using The Local Materials

The second principle gleaned from this study is using of local regional building materials for construction work where possible; it is preferable to use materials requiring low inputs of non-renewable energy in fabrication, transportation to the site and in the construction process itself. Those materials, which are labour-intensive rather than energy-intensive in their extraction, dressing and erection being more environmentally friendly and equitable in terms of the distribution of resources, are more acceptable for purposes of sustainability.

The used materials such as clay and mud in this region require only man’s efforts to make a structure from them. Most people on this planet live in building made from earth. Building from earth does least damage to the environment: It is close to the building site and so does not involve transport energy costs. Until the later stages of the industrial revolution in the nineteen-century, settlements were constructed largely from building materials obtained close to the site. Moreover, when no longer required, the building decomposes naturally and without pollution, return to the earth from where it comes before.

Nevertheless, it can stimulate the imagination as an analogy for sustainable development. The sod or earth roof has a long history reflecting the value of soil and turf as shelter from heat, cold and rain. The earth roof still has great potential in future urban centres of developed world where it forms valuable open space in dense developments; it can improve air quality, modify microclimate, retain rainwater and provide the base for urban agriculture;

⁶ Moughtin, Cliff, 2006

⁷ Urban task force, Towards an urban renaissance,1999

-Reduction The Environmental Damage

The third principle is to mitigate the effects of any environmental damage and to avoid those materials that cause environmental damage. Today, all new buildings cause environmental damage, no matter how carefully they are designed. Much of the atmospheric pollution is caused by the burning of fossil fuels in the creation of energy to support city life. This energy is used in the building of city structures (energy capital); during the lifetime of the structure; and in the transportation of people and goods between and within cities (energy revenue) It is considered that two types of energy used in the building: energy used to construct the building and energy used to service, operate and maintain the building.

The pollution causing environmental damage can be attributed directly to the building process. "For example, 50 per cent of the world's fossil fuel is directly related to the serving and use of building materials, to transport them to the site, and in their erection as part of the building."

The building design that is compatible with climate in relation to the sun for absorbing the maximum of heating in winter as well as shade in the summers and providing coolness and natural ventilation by the wind catchers and making the spaces in the fond of earth, has made the conditions to use the clean energies and to reduce the fossil energy consummation and consequently the environmental damage.

Moreover, Using the local materials, no wasting the materials by reusing them, reducing the transport between the site and the resource, making the restoration possibility of building help to reduce the environmental pollutions.

-Re-Using and Re-cycling

The forth principle is to the priority given to the conservation and re-use of buildings, infrastructure and materials and also design buildings for flexibility so that a mix of uses can be accommodated under the same roof and so that floor plans are "robust", in the sense that they can be adapted for different uses during the lifetime of the building. A building, which can be used for many different purposes and is easily adapted to serve many different activities during its lifetime, has a flexibility that reduces the need for demolition and rebuilding to serve changing needs

Re-use and recycling of building materials and components in the construction of new building and infrastructure was the main tradition of this regional building. Nowadays, the flexibility of ancient buildings has allowed them to be re-used with the different functions such as school, office, restaurant, and hotel in the traditional tissues.

-The Life Styles

The last subject, which also needs more consideration, is the different ways and styles of living for using the maximum of environment potentially. It seems that the culture particularities according to people's view to the world and their environment characteristics, which help to adapt and respect the nature laws. The most important requirement for life in desert is to have personal particularities in compatibility with natural environment as much as which of social. We can find them clearly in the people everyday life in this region. The first is having the working mentality for to defeat the hard conditions and transforming the environmental limits into possibility. The second is to be sufficient to what the nature gives him though little. The third is thinking ahead, a characteristic imposed by limits of hard nature for earning one's living that ensure him and future generation without fright of future. These three characters help the person for sustain the life at least in the good conditions. The attempt that must continue the generation by generation. This manner helps the people to know better their needs and environmental potentials. Citizen participation in development and the political structures, which sustain it, is clearly an essential requirement of local and regional government in a sustainable world.

Conclusion

In spite of harsh climatic conditions, urban spaces and architecture in the arid and hot region that have been dealt with in this paper identify a continuous, evolution throughout ages. The architecture explicit integration of elements into whole complex of the city in ideal perfection and harmony with the environment.

In an overview, the compact form of city, wind towers, orientation of buildings to sun and wind, arrangement of the summer and winter spaces, using local materials and clean energies as the environmental potentials, the narrow and covered passageways, the underground spaces, deep courtyards, thick walls, using the water and plants, reusing the materials are some considerable solutions in urban and architectural design of this region for having the green city even in the actual theme.

It is useful for us to learn from history in the awareness that settlements, at best, are manifestations of human creativity. From their very origins people have planned their settlements and there is much that we can learn from the ideas and design concepts, skills and even rules that have been adopted throughout history with the conscience.

The principles of sustainable architecture gleaned from vernacular architecture of Yazd showed that old cities can be manifestations of a culture of sustainability, passing on the baton of urban stewardship from generation to generation in a friendship relation with the nature. Future cities can learn a great deal from this model, even if we cannot simply import traditional practices into the 21st century unchanged. Such examples like Yazd show that there are limits to the growth of cities, in the past, as well as today.

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