

SUSTAINABLE FEATURES OF THE VERNACULAR ARCHITECTURE:

A Case Study of Climatic Controls in the Hot-Arid regions of the Middle Eastern
and North African Regions.

1- The Ksours and Kasbahs of Morocco

2- Arabic Courtyard houses

3- The Windcatchers of the Iranian City of Yazd

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Wednesday, December 12, 2007

Vernacular architecture around the world is impressively rich with ingenious techniques early dwellers used to protect themselves from the diverse weather conditions they were subject to. Great examples of well-thought vernacular architecture are located in the Middle-eastern region and north Africa where a hot and arid climate zone prevails. This climate condition is probably a good example of extreme weather conditions and studying the architectural techniques that allows the creation of independent microclimates in these regions is worth exploring.

Some of these traditional techniques are being slowly rediscovered today and slowly applied to modern forms of architecture. However, sustainable features in general and passive climate control in particular, even though newly rediscovered, are starting to limit the architectural expression of the buildings.

This case study explores the use of passive heating and cooling in Kasbahs, courtyard houses and traditional Iranian houses in the city of Yazd. These studies unearth impressive techniques and further studies of vernacular architecture would be inspiration to the modern sustainable movement.



Southern Moroccan Ksours and Kasbahs and Arabic Courtyard houses

Kasbahs are fortified dwellings built out of adobe mainly located in the hot-arid regions of North Africa. The climate in these regions is harsh, with an average daily maximum of 104°F and reaches 109°F in the summer. Minimum temperatures reach 44°F in Cold months such as January. Humidity varies from 10% in the hot months to 50% in other months.



Photograph of a Kasbah.

Typically, These Kasbahs have small size windows and are built usually high and very close to each other. The town that counts several of these dwellings is called a *kasr* (*pl. ksours*), a type of fortified village. These Kasbahs are a skillful adaptation to the harsh climate in the hot-arid region. Indeed, the primary purpose of these constructions was to protect the inhabitants and the animals from the extreme sunny days of the summer.

Through studying this type of architecture, it is clear that every single feature of these dwellings is well thought in order to contribute to the creation of a microclimate within the town: the layout of the Kasbahs, their height, their orientation, the use of materials in addition to the inner migration within the dwelling All play a major role in the temperature regulation inside.

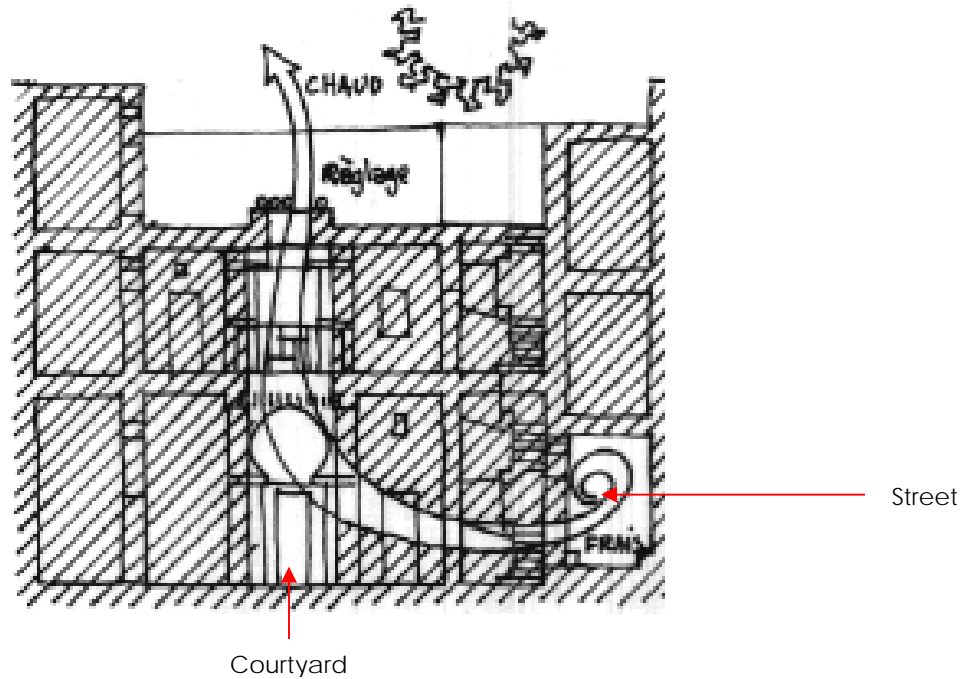
It is important to note that The plan of a Kasbah is introverted, with a major atrium on the inside, typically referred too as a courtyard. These courtyards, discussed in depth later on, play a major role in the climatic control of these houses.

The urban factor:

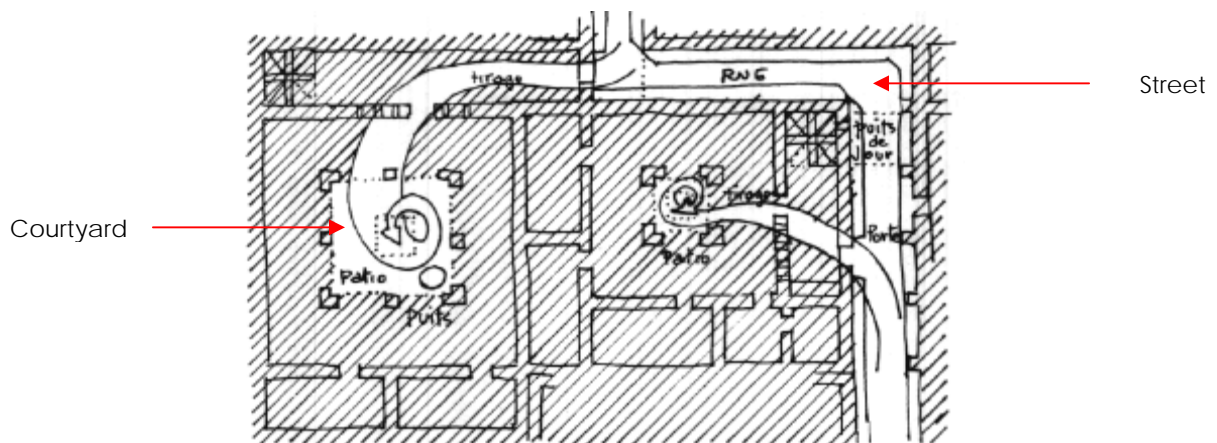
The streets and alleys inside the ksours have attributes that make them contribute to the ecological regulation in the ksours. Indeed, the streets are narrow and never rectilinear with parallel sides. This helps reduce luminosity and therefore the streets stay shaded most of the day. Their sinusoidal form helps break the flow of wind through the city as the sand carrying winds are naturally undesirable. If these winds infiltrated the Kasr, they would easily disperse the cool air that accumulated during the night time.

An important factor to keep in mind is the fact that all the dwellings share as many as three exterior walls, which helps avoid exposed facades to the heat. Each Kasbah has a lower surface to volume ratio which is very efficient thermally. Since most of the walls are shared, the only exposed surface becomes the roof. In certain instances, the proximity of these dwellings to each other create

covered streets below that play a major role in the passive cooling of the house. Certainly, the cool air that is stored in these shaded areas is drawn by convection towards the courtyards and then, high up towards the exterior of the house. This helps the house stay cool during the day.

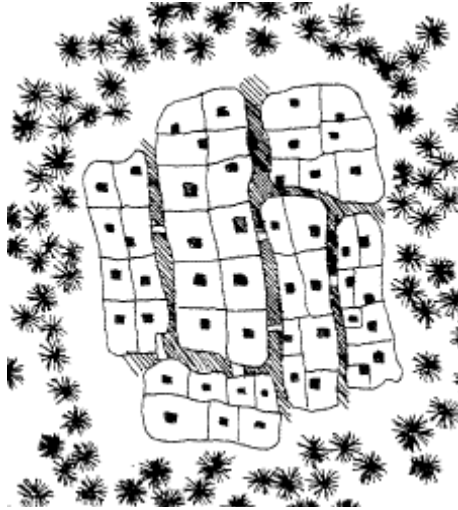


Section showing ventilation through convection
Illustration obtained from Hensen's Article



Plan showing ventilation through convection
Illustration obtained from Hensen's Article

In extreme cases, certain villages become monolithic structures that contain several buildings under one roof.



Sketch showing a plan of courtyard houses forming a monolithic structure.

Illustration obtained from Ibrahim's Article

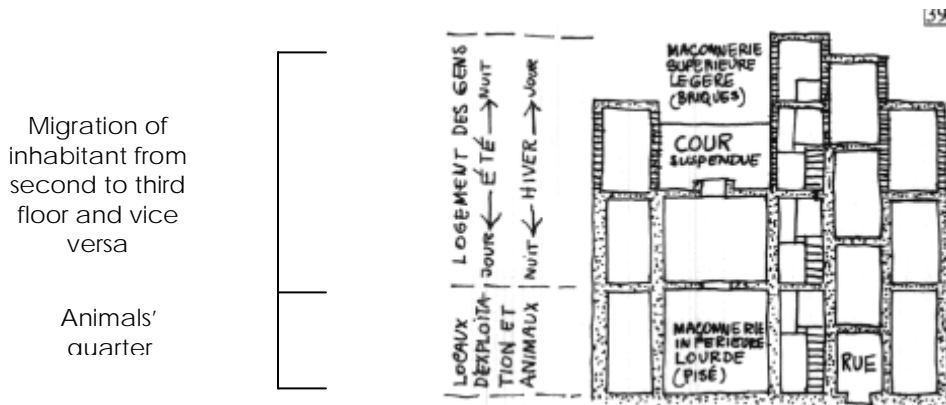
The thermal mass:

The walls of the dwellings can be as thick as 3 feet. They are meant to serve as extensive thermal masses, which creates cave-like temperatures inside the house (temperatures in cave are constant). The diurnal temperature range could be 68F (20C), which leads to a temperature difference of 41F to 59 F (5 to 15 C) between the exterior and the interior of the house.

The thermal masses store the coolness at night and slowly dissipate it during the day.

The exterior facades have almost no fenestrations in order to prevent the interior from sandstorms and also from direct heat gain. In addition, the wall surfaces are rough and thick, which helps absorb the harsh sun heat.

The inhabitants' interior Migration:



Section Through a typical house.
Illustration obtained from Hensen's Article

A very interesting concept is the migration of the inhabitants inside the house. Indeed, during the summer, the family inhabits mainly the lower portion of the Kasbah during the day and the upper portion during the night, and vice versa in the cold months.

North African Courtyards Houses

An important feature of the architecture of the previously discussed Kasbahs is the use of courtyards. However, courtyards have been used in several other dwelling types and in many different climatic regions.

Courtyards are a successful feature that plays several roles. Certainly, introverting the house provides privacy of the residents from the exterior realm. They also give a special spatial significance to the interior of the house in addition to providing

a small garden inside the house. Most important of all, these courtyards regulate the climate inside the house.

The first climatic advantage of these courtyards is the fact that they allow daylight into the house. This daylight penetrates all the rooms, since they are all arranged around this atrium.

The second climatic advantage is the ventilation and passive cooling. The orientation of the rooms towards the patio creates good cross ventilation during the warm weather. During the night time, the courtyard loses heat by irradiation, and the coolness of the floor, walls and furniture lasts until late afternoon. The Sun itself does not penetrate the courtyard until it is noon when the sun is high in the sky. This actually has its own advantages. As the cool air dissipates from the floor and adjacent rooms, convection current is created and therefore adds to the comfort within the house.

In the Kasbahs, the amount of sunlight accessing the atrium can be controlled using wooden shutters.

In addition, in order to ensure a steady flow of air by convection, the concept of *takhtabush* was introduced especially in North African countries like Egypt. The *takhtabush* is a type of loggia. It is a covered outdoor sitting area at ground level that separates the courtyard from the back garden. This disposition creates another case of ventilation by convection. Since the back garden is typically less shaded than the courtyard, hot air rises from the floor and draws the cool air out from the courtyard through the *takhtabush*. This creates a cool draft between the two spaces.



Photograph of a takhtabush

In addition to the takhtabush, North African and Middle Eastern houses make extensive use of shading devices and privacy screen, which also help regulate the climate inside the house. The *mashrabiya* for instance is a widely used wooden lattice screen composed of very small wooden balusters round in section. The name mashrabiya is derived from the word “drink” in Arabic. The mashrabiya was originally a “drinking place” where jars of water were placed to be cooled by the evaporation effect when air moves through the space.



Example of a Mashrabiya

The mashrabiya has many different functions among which: controlling the passage of light, controlling air flow, reducing the temperature of the air current, increasing the humidity of the air current and assuring a great amount of privacy.

According to architect Hassan Fathy, the south sunlight entering a room has two components: the direct high-intensity sunlight and the lower intensity reflected glare. The mashrabiya's interstices both intercept the direct solar radiation and soften the uncomfortable glare. In addition, considering that the mashrabiya is made of out wood, it helps regulate the humidity inside the space. It is known that wood absorbs, retains and releases water. When air passes through the interstices of the porous wooden mashrabiya it vaporizes some of the moisture gathered in the wood and carries it towards the interior.

Other widely used screening devices are the claustra. The *claustrum* is a multitude of small vents made out of plaster. These allow a uniform distribution of air flow, provide security and have a good aesthetic value. They are typically used on the higher section of the wall in order to allow the dissipation of hot air.

Dwellings in the Iranian city of Windcatchers: Yazd

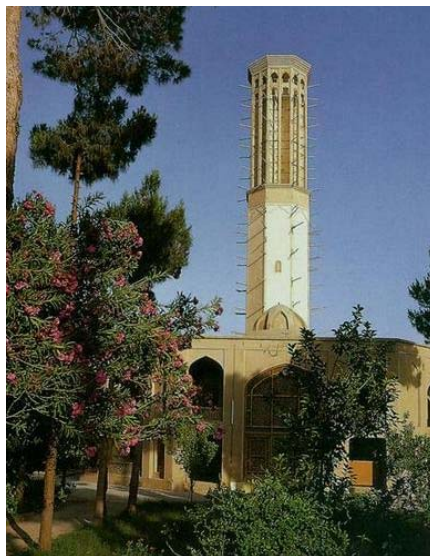
Yazd is an ancient city in the middle of the Iranian desert. It is known for its silk industry and, from an architectural point of view, it is famous for its craftsman builders who are able to create domes and vaults of mud and baked brick with projected diameter as long as 19 feet.

The climate in Yazd is also hot and dry and the architecture of the traditional dwellings responds quite successfully to this kind of weather.

Similarly to the previous example, the house is also arranged around a courtyard. There is sometimes a distinction between the rooms occupied in the summer and the ones occupied in the winter. The summer rooms face north away from the sun and in the winter they face south and have glass doors that allow the low winter sun to penetrate.

The materials of which the houses were traditionally built were mud brick, baked brick, and some white lime plastered walls and baked floor tiles. The materials serve as great insulators and at the same time allow the absorbing and storing of heat and coolness.

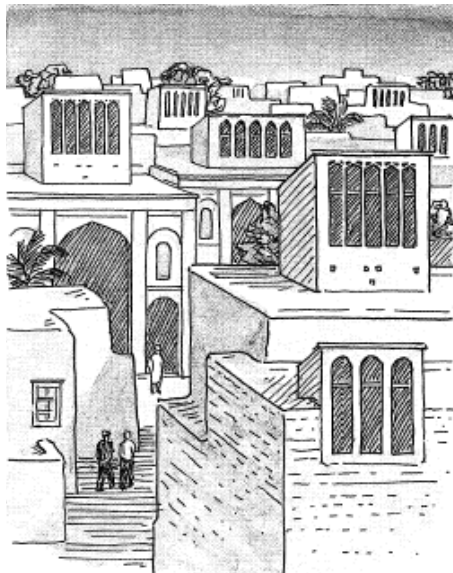
Similar passive cooling and heating techniques are used in these dwellings as described previously. However, one important feature that the traditional Iranian houses of Yazd is the use of wind towers, called *Badgir* in the Arabian Gulf. These towers catch the passing winds and channel them down to the ground and basement living spaces.



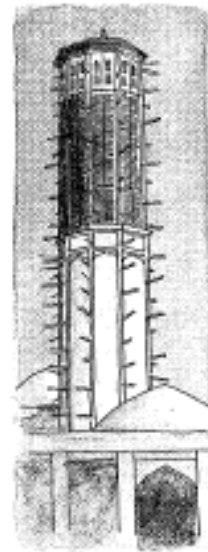
Photograph of a typical Iranian wind towers

These wind towers serve to cool the inhabitants on summer mornings and evenings when the air is cooler than room air. In addition, they provide an effective ventilation to refresh the air and remove unwanted smells from cooking especially in the basements.

The direction of these wind towers is of course important. Some of them are directional and face one direction only, the one from where the wind is blowing (show image of directional wind towers) and others are omnidirectional (face several directions) because of the different direction where the wind might be blowing. When there is no breeze, these towers still serve as a means to good ventilation.



Directional wind towers
Illustration from Johnson's Article



Omnidirectional wind towers
Illustration from Johnson's Article

In addition to fulfilling these primary purposes, the towers are also built as thermal masses that cool off at night and allow hot air to automatically rise.

To be more effective, the effect of these towers is often combined with the concept of cooling through evaporation. The air channeled through the wind tower is directed towards the typical courtyard that would contain either a pool or a fountain. The evaporated water adds a comfortable freshness to the air.

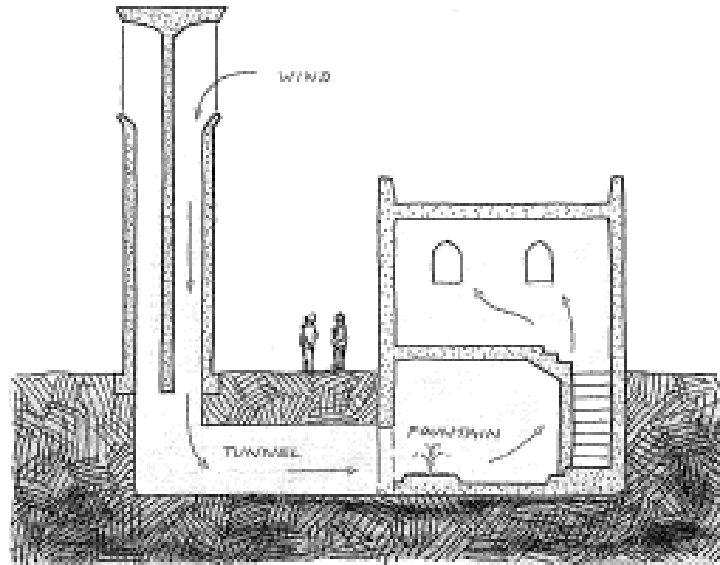


Diagram showing the wind tower effect and cooling through evaporation
Illustration from Johnson's Article

In the winter however, these wind towers are closed off from the rest of the house in order to stop hot air from dissipating from the interior of the house.

It is also worth mentioning another passive cooling technique that is often used in these Iranian houses. The use of domes in square rooms and barrel vault roof structures over rectangular rooms also play a role in the passive cooling of the interior. The barrel vault roofing is used usually in regions where winds blow in one direction. In this case, heat loss by convection across the roof is maximized. When domes are used, small air vents are introduced in order to draw air out of

the dome. This is explained by the aerodynamics resulting from the curved shape of the roof (Clark, p202). Indeed, the velocity outside the roof increases which results in a lower pressure inside the dome. The air is then naturally drawn to the outside of the dome.



Sketch showing domes in a village near Tehran, Iran
Illustration from Ibrahim's Article

As a conclusion, the weather-oriented structures previously described are full of lessons that could inspire the designers interested in passive climate controls. Even though the previous examples are set in an extreme climatic zone, some techniques could be successfully implemented in temperate environment. Additional studies of vernacular dwellings could surrender ideas of aesthetically pleasing structures that are very efficient in terms of energy use.

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