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A RESEARCH ON HISTORICAL AND CULTURAL BUILDINGS IN IRANIAN VERNACULAR ARCHITECTURE

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A RESEARCH ON HISTORICAL AND CULTURAL BUILDINGS IN IRANIAN VERNACULAR ARCHITECTURE

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Abstract

The need for preserving historical constructions is not only a cultural requirement, but also an economical and developmental demand. In addition to their historical interest, cultural heritage buildings and landscapes are valuable because they contribute significantly to the economy by providing key attractions at a time when tourism and leisure are major industries. Herein, the great Iranian tradition is as yet little known in the West and there is much to be learnt both from it and the building techniques which are integral with it. Meanwhile, not only is the Iranian vernacular building tradition itself still alive, but there is much to be gained from the knowledge of a highly developed technology which makes such ingenious use of natural resources without the consumption of additional power.

This article is a study of the artisanship involved in the construction of the mud brick vernacular architecture of Iran, and the cultural aspects of a traditional architecture that incorporates an understanding of buildings that date back centuries. Expanding the existing knowledge of these earthen heritage properties, examining their behaviour in the local climate and explaining their current condition in order to express the need for the preservation of traditional artisanship as part of a sustainable conservation future are the other prominent concerns of this work. Among different Iranian Vernacular constructions, Ice-houses, cisterns, water-mills and wind-catchers are the subject of the main body of this article.

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1. Foreword

The traditional heritages of the Iranian regions are entirely constructed from sun-dried bricks and loam. Throughout the centuries, the population has developed very sophisticated building techniques, and created a unique architectural environment. As in other parts of the world, with the advent of modern materials such as cement, indigenous construction and conservation practices carried out by craftsmen are rendered intellectually invisible by a process similar to the drawing of a veil. The elimination of these practices equals the erosion of centuries of building and conservation culture. As this heritage is rapidly disappearing, as shown by these obsolete construction techniques, this documentary is an excellent archive for future generations (Mackintosh, 1997).

The contents rely heavily on three bases:

- 1) The information provided by the eldest and the most well known masons and master builders of the region during several interviews (some of the retired masons had up to 70 years of experience).
- 2) The consultancy of leading experts on earthen material constructions and Iranian vernacular architecture specialists from the University of Tarbiat Modares in Tehran.
- 3) Historical documents and travel accounts concerning the traditional buildings of the Iranian desert regions.

The work could be of use for those vernacular architecture specialists and conservators working in the American Southwest, Africa, Europe, Latin America and Middle East earthen archaeological sites. It has also international values especially for understanding the vernacular architecture of desert regions. Furthermore, it has a strong didactical vocation and, together with another documentary by Arthur Pope (Persian architecture, 1969) could be so instructive. For further information on the mud brick vernacular architecture of desert regions, see the comprehensive book by Iranian cultural research association, *The Iranian Atlas of Vernacular Architecture* (2007).

2. Introduction

Iranian vernacular architecture has developed over millennia in response to the Iranian plateau's arid climate, scarcity of acceptable building stone and wood, and extremes of temperature (Tavassoli, 2005). The ubiquitous building material is sun-dried brick and rammed earth. Building types include wind towers which exhaust warm air from buildings during the day; cisterns which are egg-shaped in section; ice houses with walls behind which water in shallow channels freezes at night; etc (Bourgeois & Pelos, 1983). Some years ago, a huge legacy of fascinating and often beautiful vernacular buildings survived on the Iranian Plateau. Many occurred chiefly in the villages, but others had their grander counterparts in the towns. Some are either unique to Iran or may be prototypes of buildings elsewhere. Few Iranians or visitors have had time or inclination to look at such buildings, partly because the huge number which survived has tended to make them commonplace, but also because Iran has such a wealth of architectural and artistic treasure which has demanded prior attention.

However, unless positive action is taken, most will have crumbled. Their rapid disappearance derives from a variety of good reasons. A redundant building, constructed of stone in a temperate climate, may survive many years as a ruin. (Kasmaie, 2006) But these Iranian buildings are chiefly built of unbaked mud-brick. Any mud-brick building quickly deteriorates without constant maintenance; this inevitably ceases once a building is no longer useful (Stronach, 1973). The fierce climate of the Plateau accelerates this process. Technological innovations of the first half of this century are the root cause of their redundancy.

Modern refrigeration, new sources of power and the internal combustion engine have overtaken such buildings as ice-houses, mills and caravanserais. Landlord's houses and buildings such as hunting lodges have been neglected, both on account of absenteeism and also of land-reform (Hyde, 2000).

Readers may notice that the literary sources noted in this article are confined in range. Few travellers, either today or in the past, have been sufficiently interested to record vernacular buildings. Those that have (notably John Fryer in the seventeenth century, C. J. Wills in the nineteenth and Hans E. Wulff in the twentieth) have shown a general interest in both Persian buildings and customs which is rare.

The notes which follow are the result of researches from 2003 till 2009. During this time examples of the following types of buildings were noted, some briefly. They are listed here in the hope (justified by experience) that others, may have information to contribute (which would be much appreciated): ice-houses, cisterns, water mills, wind-catchers, windmills, animal mills, houses, hunting-lodges, agricultural buildings, pigeon towers and caravanserais. The first three, Ice-houses, cisterns and water-mills, are the subject of the main body of this article. Notes on wind-catchers are also included.

Study of these buildings, motivates some instructive skills and cultural values in which the Iranians excel:

- 1) First, the design and execution of domes and vaults in mud-brick, which result in beautiful buildings, often constructed for mundane purposes.
- 2) Secondly, the Persian imagination and ingenuity, which is unrivalled in making the best use of water in a hostile desert environment. In this the Iranian contribution to the world's technology is probably unique.
- 3) Iranian traditional building techniques show an ingenious use of natural resources without the consumption of additional power.
- 4) Employing local materials in construction and repair work has many advantages as the original materials are close to the site.

Meanwhile, these buildings contribute significantly to the economy by providing key attractions for tourism industry; and elimination of such traditional techniques equals the erosion of centuries of construction culture.

3. Additional information

As in all traditional vernacular buildings dating proves to be difficult, the considered buildings to which a period is even ascribed, are all thought to have been built before the reign of Shah Abbas (1587-1629); and the extent of decay of these buildings is estimated to be more than 60 percent in most cases. However, wind catchers and cisterns have fewer damages as they are not fully redundant in desert regions yet.

4. Water-mills

Before water became a prime-mover, power traditionally relied upon man and animals. Stone querns may still be used on a small scale domestically, and perhaps a camel mill survives deep in some bazaar. The majority of water-mills are now powered by oil-driven machinery, hardly surprising in a country where water is in places more precious than oil. Two types of water-mill survive in Iran: the Vitruvian mill, the type common throughout the western world with its water-wheel set vertically on a horizontal axis; and the little-known Greek mill with its water-wheel set horizontally-the fore-runner of the turbine. When this survey began, it was wrongly assumed that the Vitruvian mill would be more common than the Greek mill on the Iranian Plateau. However, the reverse seems to be true. Indeed, we can only report two Vitruvian mills, both near Isfahan (at Lahijan and near Pir Bakran). Each has an exceptionally attractive site, the mill forming a small island in the mill-stream. Each was worked by two water-wheels, one on each side. The reasons for both the preference for the Greek mill and the lack of evidence of its existence became apparent as work proceeded.

Greek mills were first recorded during the first century B.C. in Thessalonica (whence their name) and in the Pontus, and it is probable that they came into fairly wide use in the Eastern Mediterranean and Near Eastern countries from this time. By the fourth century A.D. they had spread to Ireland and China, (Singer, 1957) but who is to say that they were not invented spontaneously in different parts of the world? The Greek mill, with its direct transference of power from a horizontally set water-wheel to a millstone fixed above it on the same axle, is only an extension of the idea of the rotary quern, using water power instead of man power. An abundance of slaves made such development superfluous, and it was not until a labor shortage made the old system unworkable that the water-powered Greek mill, rotating its millstone once for each turn of the wheel, came into use. However, such mills could only temporarily satisfy the increased demand and the Vitruvian mill was invented. The simplest Vitruvian mill, with its vertically-set water wheel, turned its millstone five times for each revolution of the wheel. The persistence of the Greek mill seems to depend on a relatively small supply of grain to be milled by a small water supply, there being no real efficiency in the construction of the far more complicated machinery of the Vitruvian mill, unless there was sufficient grain to be ground (no Greek mill has been reported in the valleys of the Nile or Euphrates). It has also been suggested that in Europe the Greek mill was to some extent ousted by the introduction of the feudal system, in which the lord of the manor owned one central mill, to which the peasants brought their corn instead of milling it individually. This may partly account for its survival in the Shetland Islands, where the mills of this type were in use until the mid-twentieth century and where, under Norse rule and subsequently, the feudal system never operated (Beazley, 1963).

It is perhaps hardly surprising that the Persians with their long tradition of efficient use of water favor the Greek mill which is powered by a small quantity of water directed at high velocity to turn the horizontal water-wheel (Weaver & Pinder, 1963) (Figure 1). First, the water from the leet pours in a torrent down the vertical "chimney" (a drop varying from 3. 20 to 7. 40 m. in those measured). Near the bottom of the chimney it rushes down a wooden tube of narrow bore which ends in a nozzle; this further constricts the jet which is directed to the water-wheel itself. The wheel is housed in a small space right under the heart of the mill. It is half-filled with rushing water if the mill is working, and is usually difficult to reach without a long, wet crawl in the dark. Therefore, few water wheels were actually examined. That at Band-e-Amir (Figures 2, 3) is a shallow cone-shape, like an inverted coolie hat, made up of timber blades set in a big timber axle (diameter 28 cm.). The jet of water is directed into the top. That at Doshmanziari is remarkably like those seen in the Shetland Isles; the blades or paddles are set in a massive hub, and these are struck tangentially by the stream of water.

Figure 1. **Sketch showing machinery of mills at Band-e-Amir; the floor of the grinding room has been cut away to show the water-wheel**

Source: By Author.

Figure 2. **Greek mills, Band-e-Amir: the water wheel**

Source: Weaver & Pinder, 1963.

Figure 3. **Greek mills, Band-e Amir: mill leets and chimneys (Weaver & Pinder, 1963).**

Source: Weaver & Pinder, 1963.

The vertical axle passes up through a fixed millstone set in the floor of the grinding room above the wheel-house to turn the upper millstone which it supports. The iron tip of the axle rests on a timber sole-tree which acts as a lever whose precise position can be varied by the fine adjustment of the lightening rod; thus the closeness of the millstones and the fineness of the flour can be controlled.

Millstones vary remarkably little in diameter. Those measured were 93, 96 and 103 cm. (in Shetland they varied from 68-91 cm.). The grain in Iran is fed from a plastered bin (or a separate store) integral with the building, not from a hopper as is common elsewhere. In both cases, however, the wheel itself is used to cause vibration in order to ensure a flow of grain. In Iran a vertical stick, sprung in tension against the hole in the upper stone, vibrates the chute from the corn bin (taking the place of the clapper where a hopper supplies the grain). It is difficult to convey adequately the sculptural quality of the inside of an Iranian grinding room, particularly when it is cut into the rock face. The fine shapes of the plastered bins and other containers, the wheel housing which curves round the millstone, the curve of the roof, whether vaulted or rock cut, and the walls, themselves often also curved, are whitened with a fine coating of flour dust. This covers everything in a working mill (including the millers) except for the spinning focal point of the hard grey millstone and the dry yellow corn streaming into it. (Figure 4).

Figure 4. The mill wheel directly over the water wheel

Source: Weaver & Pinder, 1963.

When first investigating the Greek mill in Iran, it seemed that such mills were rare, but in 1975 it became apparent that there may have been many more on the Plateau than was suspected. The necessity to get a sufficient fall of water in a relatively hot area means that some mills—perhaps many—are underground. Perhaps the only sign of their existence on the surface may be a ventilator, and the jube which is in fact a mill leet, which runs at ground level and then drops in the "chimney" down which the water pours in a torrent to the underground water-wheel. There is, for instance, a disused mill immediately outside the Zoroastrian cemetery at Yazd, of which few visitors can be aware. After turning the water-wheel, the water runs into a qanat system (Wulf, 1966). This may have given rise to the idea that some mills are positioned in qanats. This seems unlikely, since the all-important drop to the wheel would entail very deep excavation with the mill, say, 4.m. below the qanat. Whenever possible, the mill is constructed on a hillside to make the most of the natural fall. Then at least half the mill can be cut out of the ground like a cave and it can be conveniently reached from the lower level.

There is considerable variety in the grouping of the mills, since this depends on the quantity of grain to be ground and on the water supply. By far the most spectacular are the groups of mills below great irrigation dams. The dam of Band-e-Amir in Fars was built in c. 960 A.D., possibly on Achaemenian foundations (Cultural research association, 2007). The mills were surveyed in 1983 when some dozen were seen, but it is told that there had been thirty working in recent times (Figures 5, 6).

Figure 5. Lay out plan of mills at Band-e-Amir

Source: By Author.

Figure 6. Plan and section of a typical mill at Band-e-Amir

Source: By Author.

Note: The upper mill-stone rests on the axle. The iron tip of the axle rests on the sole plate; thus by slight adjustment of the position of the sole plate the precise clearance between the two mill-stones can be controlled. A jet of water is directed by the wooden pipe into the water wheel. The peg driven into it prevents the water forcing out the lining which restricts its bore and thus increases the velocity of the water.

The prime function of this great dam was to provide a reservoir for irrigation of the Marv-e Dasht (the plain to the east of Persepolis), but presumably it was also used to provide power for water-mills from an early date. The mills are grouped in three clusters fed by leets. In plan, they look rather like some botanical diagram. Three main leets are led off from the side of the dam. From these a leet is taken for each mill, each controlled by its own sluice gate. The gate is simply constructed and operated; it is like a wooden, two-handled flat shovel and is positioned by a cross slab on the leet.

Walls were of rubble masonry except for the wheel and mill houses which were partly cut out of the rock. The flat roofs were of timber and mud, since the presence of water meant that trees flourish. In other places where timber was scarce, the roofs were of brick vaulting and walls often of unbaked brick.

Another important group of mills which survives is that below the huge Sasanian dam at Shushtar which was illustrated by Madame J. Dieulafoy (some of these were working till 1971). (Dieulafoy, 1887) (Figure 7). However, most groups of mills are on a much more modest scale. Above Estebanat (south-east of Shiraz) there is a series of six stone-built flour mills just above the town fed by a rushing mountain stream. It is told that there were mills in the town which produced "oil for the face". North of Qutabad (near Jahrom), were the remains of another series but these were built along a jube. The caravanserai at Aliabad, outside Pusht-e-dam (in the Dasht-e-Lut), had its own underground mill (and hammam [bath]). The single mills were the biggest. Of these, that at Ferouseh, seventeen kilometers south of Abdeh, has one of the most attractive settings. It is still working by water power, and this in itself may be considered to be a curiosity by the local inhabitants. Such mills also exist at a petrol station in Abdeh (a promising place-name for anyone in search of a water-mill). The mill is in a high walled enclosure, like that of a garden, on the outskirts of a village beside a poplar wood. The only visible building in the enclosure is a watch tower which could be reached from the underground mill. Only the domed roof of the mill, crowned by a ventilator, and the noise of the grinding, betrayed its existence. It was fed by a good jube with the usual arrangement of sluices. Other parts of the enclosure were walled off, partly as a garden and partly for animals.

Figure 7. Remains of Sasanian mills at Shushtar

Source: Mirdanesh, 2007.

The mills described so far have been recorded as part of a survey covering a wide area. A much more detailed account is given below of a grain mill in Fars, at Deh No, Doshmanziari. The mill was built c. 1940 by a group of men who pooled their funds (Cultural research association, 2007). It is now used less than when built, because an oil-powered mill has since been constructed in the village itself. The water-mill is some distance from the village, where it can be powered by the river and is less convenient. Payment is made in kind to the miller.

(Lambton, 1953). A donkey-load of wheat is about 20 mans and of this the miller takes one man (6 1/2-7 kilos). The miller, who lives in a house in an orchard nearby, is a Sayyid; all the Sayyids living in the village take the proceeds from the mill for the twelve days after the New Year, as a customary right. In 1948 the revenue of a mill might be set aside to defray the expenses of a mosque, and this may still hold true.

5. Ice-houses

Ice houses were buildings used to store ice throughout the year, prior to the invention of the refrigerator. The most common designs involved underground chambers, usually man-made, which were built close to natural sources of winter ice such as freshwater lakes. During the winter, ice and snow would be taken into the ice house and packed with insulation, often straw or sawdust. It would remain frozen for many months, often until the following winter, and could be used as a source of ice during summer months. This could be used simply to cool drinks, or allow ice-cream and sorbet desserts to be prepared. The common use by the Persians of ice and snow for cooling drinks and food was reported by John Fryer in the late seventeenth century: "They mightily covet cool things to the Palate. Wherefore they mix snow, or dissolve ice in their Water, Wine or Sherbets," (Fryer, 1963) he wrote (and of Isfahan) "... the Poor, have they but a Penny in the World, the one half will go for Bread, and dried Grapes, and the other for Snow and Tobacco ..." Outside Shiraz he saw that ice was stored in "Repositories" which he tantalizingly describes only as "fine buildings" but it seems likely that they were similar to the huge domed structures still to be seen in parts of Iran. Only a few survive, most as disintegrating ruins, although they were in common use only a few years ago. By Fryer's time the practice of storing ice was probably already long established, possibly having been introduced by the Mongols. Ice-houses in China were known as early as the eighth century B.C.; they were probably small thatched buildings, like their successors there.

In Britain, ice was not then considered to be a common necessity and was certainly not for the poor, but the ice-house was to become a feature of the great eighteenth-century estate, as it was in France. However, the English ice-house is as a bantam's egg to an eagle's when compared with those of the Iranian Plateau. There the great demand led to buildings of monumental scale and size. Figure 8 shows the Stourhead ice-house, (Locke, 1975) one of the larger English examples, drawn to the same scale as a typical Iranian ice-house at Yazd (Yazd the Gem of the Desert, 1997). However, the principles governing the design of each are the same: the ice has to be insulated and kept dry. The differing climates made insulation a far greater problem in Iran, and drainage of prime importance in damp, temperate Britain.

Figure 8. Ice house at Yazd: plan and section

Source: By the author.

Obtaining the ice was another matter. Iran is not only largely desert, but fresh water is rare and even in winter, when the temperature falls to freezing at night, the mid-day sun is hot. Huge quantities of ice would be needed to fill these vast, domed wells. Some was brought as blocks of snow from the mountains, but the ingenious Persians, ever inventive in their masterly adaptation of desert conditions, had an imaginative and simple answer. Alongside each ice-house is a long shallow channel, about 100 x 10m. and 40-50 cm. deep, which is entirely shaded by a great wall, longer than the pool and as much as 12 m. high; the wall is constructed of rammed earth and mud-bricks made from the earth which was excavated to form the channel. The channel is lined with tiles to make it watertight. C. J. Wills (1891) gives a clear description of ice-making in the latter part of the nineteenth century: "The delicious AB-I-ROOKHI (stream of Rookhnabad) is diverted from its course on the first cold night. A few inches of still clear water is collected in the pond, by morning it is frozen, at night the water is collected in the pond, by morning it is frozen, at night the water is again admitted and another inch or two of ice is made (Tavassoli, 2005). When three to six inches thick the ice is broken and collected for storage in a deep well on the spot; and so day by day the process goes on during the short winter, until the warehouses are full. Should the supplies from these be exhausted by a very large demand, ice, or rather blocks of snow, are brought from the mountains; but as these are some distance, and snow melts faster than ice, the weights being equal, the price rises" (Wills, 1891). The ones who remember the work in icehouses say that on clear frosty nights water would be diverted from a stream to the ice pool. The ice formed was usually skimmed off in

layers of about one inch. It was packed hard down, each layer insulated by straw (and presumably rammed as in Britain). Then the door was sealed and the ice kept until it was needed in summer. The man in charge of the ice-house would probably be responsible for the cistern in the village and might also look after the mosque. Villagers would be asked to contribute towards his wage and the repairs of the ice-house.

The low cost of the ice and the way it was used was also explained by Wills. "The great thing in such a place is the cheapness of ice, for about 15s in dear years and 5s. in cheap ones, ice can be obtained all through the warm weather, and in fact is used from May to October, as no one would think of drinking anything uncooled. A huge block is thrown down each morning by the ice seller-it is supposed to weigh 14 lbs." The ice-house is best understood from the illustration (Figure.9).

Fig 9. Remains of an Ice-house near Kashan

Source: Ghobadian, 2001.

Barely half-a-dozen have been seen, although hundreds must have been in use even sixty years ago, particularly in the vicinity of rich cities on the edge of the desert, like Yazd, and on caravan routes. Those measured ranged from 9 to 14 m. in internal diameter. The overall internal height of that at Yazd is c. 19 m. The disused ice-houses had often been used as rubbish dumps so it was not possible to investigate the method of drainage (if any). One or two had boldly decorated walls, the bricks near the top being laid in open checkered patterns and the tops crenellated. Most spectacular perhaps was the pair of ice-houses found on the outskirts of Sirjan; the ice-walls which linked them curved to give extra shade, giving a plan form like some huge winged creature (Tavassoli, 2004).

Although a mass of nineteenth century literature is available on English ice-house construction, notably in garden encyclopedias such as Loudon's, or in books like Pap worth's Rural Residences, almost nothing seems to have been written on examples outside Europe. The

notable exception is the redoubtable Mrs. Fanny Parkes, whose *Wanderings of a Pilgrim in Search of the Picturesque* gives a vivid account of life in India in the second quarter of the nineteenth century. She describes the ice-pits of Allahabad: "My husband has the management of the ice concern this year. It is now in full work, the weather bitterly cold, and we are making ice by evaporation every night." At first glance, the principle might be thought to be similar to the Iranian method, the word "evaporation" perhaps having crept in unnecessarily. But such assumptions are shown to be wide of the mark by the unexpected statement of this careful author: "The highest temperature at which ice was made in 1846 at Cawnpore was 230 of Fahrenheit or 110 above freezing point" (Parkers, 1852). Her drawing shows that the ice was not made in the channel as in Iran. Instead, the channel or pit, which was a cubit deep, was filled with dry straw; on it were placed small bowls which were filled from pitchers and the ice was made in these. Presumably the bowls were porous; evaporation would lower the temperature of the water and the dry straw would insulate the bowls from the heat radiated from the ground-on a still clear night the temperature of the water could be several degrees lower than that of the air immediately above the surrounding ground. Even so, this explains nothing fully, and it would be interesting if any reader could provide a complete answer. Mrs. Parkes reported that her husband's work went on until February 19th, by which time over 107 tons of ice had been made. It was stored in small thatched buildings similar to those used in China.

This single Indian example makes one wonder whether there is not more to be learnt about Persian techniques than might at first be imagined. Although modern methods of refrigeration have made the ice-house obsolete in Persia, there are still people who can remember its use.

6. Water storage

Water storage is a traditional reservoir of drinking water in Persian antiquity. In Persian phrase literally translated as "water reserve". Persian prowess in the skill of water collection and storage is based on long experience. Indeed, the qanat system was recorded during the reign of Darius I, (Wulf, 1966) and qanats now in use in the south of the Sahara are known as "Persian work". The qanat, or underground water channel, through which water is carried by gravity from a water-bearing stratum at a higher level (usually near the base of mountains) to a village or oasis on the Plateau, has been recorded by many travellers, (Smith, 1953) so will only be mentioned briefly here. A qanat is beautifully simple in its basic conception, but the skill of those who plan and construct these ingenious tunnels is hard to exaggerate. Certainly an understanding of the system, both its potential and its limitations, is essential to the appreciation of settlement on the Plateau. It accounts for flourishing settlements many miles from any source of water, and for the collapse of the same towns and villages if the life-giving qanat has been cut either by a natural disaster or the hostility of an enemy (Herbert, 1928). The fascination of the qanat has led more recent travellers to ignore other less spectacular systems of water collection, such as that of the conservation of sheet wash in the desert: the trapping of the flood water following the rare but heavy rainstorms which occasionally occur in areas of otherwise arid plateau.

Indeed, no traveller would choose to be on the road following such weather, so it is hardly surprising that only one reference has been found. This again comes from that indomitable seventeenth century recorder John Fryer: "... the other [method of obtaining water] is immediately from the Heavens, reserved in cisterns built by the charity of well-disposed

persons; out of which the Poor, the Covetous, and Slaves, Flocks and Herds too, are often supplied, when a plentiful Rain has made them overflow. It was only after careful examination of the ground that isolated structures (Figures 10a, 10b and 10c) which we thought to be desert shelters were recognized to be cisterns-this function having first been dismissed since there seemed to be no source of water supply.

Figures 10a and 10b. **Desert cisterns fed by sheet wash**

Note: A and B near Muhammadiyyeh

Source: By the author.

Figure 10 C. Desert cistern near Chamale

1. Earth banks, c.1m. high.	6. Maintenance step
2. Central hole, 30 cm. dia.	7. pise.
3. External mud plaster finish.	8. Mud brick course
4. Mud brick dome	9. Stone base
5. Intel channel	10. Waterproof plaster lining

Source: By the author.

Low banks of earth and stone (often less than a meter high) contain the water, which is guided by an almost imperceptible fall in the ground towards the cistern. The water flows in through a hole at ground level and is taken out as needed by a bucket through a small door. The cistern is protected from the sun by a dome or vault depending on its shape. Before the internal combustion engine put the caravan and mule out of business, such cisterns seem to have been common along some of the caravan routes (Mirdanesh, 2007). Now they are increasingly rare. But a few villages and small towns may still rely partially on this system. For instance, there are six large cisterns, two of which seem to be new, outside the desert town of Khor; it seems that these were constructed to collect sheet wash. Numerous smaller ones, mostly derelict, were seen along the road Nain-Chupanmar-Khor. The occurrence of numerous cisterns in varying states of repair also mystified Fryer "... These Cisterns or Storehouses for Rain are dug out of the Ground deep into the Earth ... which being once finished, like their caravan seraws have no Endowment to maintain them, either to keep them clean, or from falling to Decay: ... on which account it is, that about their great Cities so many of all sorts are found, newly built, superannuated, defiled (which they esteem so, if either Man or Beast have dropped in and been drowned), unfrequented, and full of Nastiness; so pervicaciously Vainglorious, that they will have the Repute of an entire Founder, or none." Clearly, the problems of endowment and maintenance are neither new nor local, but the capital cost of building by traditional methods is comparatively economic in Iran. However, any qanat system is clearly preferable to such a haphazard means of water collection as that from sheet-wash so it is hardly surprising that those cisterns fed by qanats are usually bigger and better constructed. One excellent example seen in 1981 had only recently been built. Like others in the province of Yazd it is cooled by two

wind-catchers or wind-towers, and this functional architectural composition is unexpectedly satisfactory. (Yazd the Gem of the Desert, 1997)

The design (Figure 11) seems typical of a fairly wide area: a deep, circular well, about five meters in diameter, is protected from evaporation and dust by a dome. The simple form of the egg-shaped dome contrasts nicely with the vertical towers which rise above the crown of the dome in order to catch the wind. A vaulted porch is often constructed to shade the upper part of the underground flight of steps which leads down to the well. The covering of the surface of the cistern is the most difficult part of the construction because to cover openings of 15 to 16 m width needs a lot of experience, but this is done by resorting to bends and the elliptical arches which prevent the expelling force.

Figure 11. A cistern with five wind-catchers in Kish Island

Source: Mirdanesh, 2007.

7. Wind-catchers

A wind-catcher (badgir) is a traditional Persian architectural device used for many centuries to create natural ventilation in buildings (Tavassoli, 2005). It is a ventilating shaft which projects above the roof of a building and provides it with air-conditioning of a most effective kind. Wind-catchers are among the most spectacular and best-known elements of Iranian architecture, yet it is surprising how little information is available about their design (Ghobadian, 2001). A wealth of local knowledge must exist, but presumably this is chiefly empirical. Little work seems to have been done in the comparison of wind-catchers which cool different types of building, or between those of different regions. Nor does any scientific analysis with the use of wind tunnels seem to have been made. Yet the little we have so far achieved suggests that the subject is far more complex than it might appear to be at first sight and that considerable variations exist. The fact that the two wind-catchers of the cistern shown in Figure 12, which appear to be similar to one another, have quite different internal plans at ventilator level (Figure 13) is an indication of such complexity.

Figure 12. A new cistern with two wind-catchers, near Yazd.

Source: Yazd the Gem of the Desert, 1997.

Figure 13. A cistern cooled by wind-catchers, Muhammadiyyeh. Roof plan and detailed plans of wind-catchers at ventilator level

Source: By the author.

Nothing is known of the design at lower level since this cistern, like others, was inaccessible. Similarly, a low, plain looking tower examined in a ruined house revealed an extraordinarily intricate interior with a variety of partitions in its short height. This leads us to wonder what a thorough examination of other towers, particularly those attached to cisterns, might reveal (Aghdabiglo, 2001). Most of the wind-towers seen have been in the province of Yazd, but they are used over a wide area, including that bordering the Persian Gulf where Fryer observed them (Yazd the Gem of the Desert, 1997). The tower is usually used to cool houses by creating a system of air-conditioning in one of the main rooms. This may be in the cellar (the zir-e-zamin), a common practice in Yazd, or at ground floor level (Chupenah). An example of a zir-e-zamin was unexpectedly found on the first floor of a ruined landlord's house in a desert oasis near Faraj. Towers vary greatly, but the ventilator at the top, which may be around two metres high, is usually divided on the module of a mud-brick (20 cm.) by thin mud-brick partitions. It may be further baffled with divisions formed of mud on a framework of light timbers (Mirdanesh, 2007). In the case of a cistern which, since it is otherwise sealed, must have a minimum of two towers, a current of air flows down one tower and out of the other, cooling the water by evaporation as it passes over it (Ghobadian, 2001). It is at this point that fact gives way to speculation since it has not yet been possible to examine the towers thoroughly, the cisterns being inaccessible since they contained water. First, how is the difference in air pressure, which is necessary to cause a draught, created? It is usually assumed that the wind is "blown down" the shaft. Fryer, who seems to have seen badgirs on houses but not on cisterns (which is to be expected, since the cisterns he described were filled by rain wash), gives the following description: "... and from their [house] Tops have many Breathing-places to receive the Wind, which are so fixed, that whatever Breezes stir, they shall suck them in, and transmit them to all the Rooms of the House, as they list." It also seems possible that a hot desert wind blowing through and across the top of a wind-tower may suck air out (by a Venturi system). In the case of cisterns, it would also be interesting to know how much water is lost by evaporation and whether it condenses on the inner face of the dome in cold weather. In the house, the air is often passed over a pool of water which thus acts as a humidifier (Mahyari, 1985). The height of wind-towers gives cause for speculation. Are they always constructed to a strictly functional height, or does a neighborly rivalry prevail? In towns there is presumably a necessity to build clear of the shelter of a neighboring building-hence the fascinating sky-line in a wind towered town. Indeed, at times aesthetic considerations or even prestige may be governing factors in the design of towers (Mahmoudi & Mofidi, 2008).

It will be plain from these inadequate notes that there is much more to learn about the design of this widely-acclaimed feature of Iranian architecture.

8. Conclusion

Iran's traditional architecture is designed in proportion to its climatic conditions, and more than often, the unique fabled artistic background of Persia makes up for the seemingly lack of natural resources and beauty (Kasmaie, 2006). Traditional building techniques are particularly important because they are the result of centuries of development and practice. The recording of craftsmanship is extremely vital, not only because it provides empirical evidence of original practice, but also because it can be directly applied to practical conservation. Employing local materials in construction and repair work has many advantages, not least of which is the fact

that the sources for the original materials are close to the site. Also the workmanship necessary for using traditional materials such as mud requires more skill, sensitivity and grounding in traditional culture than what is required for modern materials.

The intermediate technology is now seen by many to be an essential ingredient of progress in the 21st century (Murakami, 2008). This great Iranian tradition is as yet little known in the West and there is much to be learnt both from it and the building techniques which are integral with it. It is the fate of vernacular buildings throughout the world to be neglected until they are nearly extinct. The Folk Museum and the Museum of Buildings are relatively new ideas in Europe, where they are thought of primarily in terms of conservation and education in history and the arts. In Iran their value could be even greater since these functions could be combined with those of an institute of intermediate technology. Not only is the building tradition itself still alive, but there is much to be gained from a knowledge of a highly developed technology which makes such ingenious use of natural resources without the consumption of additional power. The Persian ice-house with its great shade wall could hardly be described as small, but the technology it represents is certainly beautiful in its simplicity. Water collection and its storage in desert conditions and air-conditioning by means of wind-catchers are living skills which the Iranians might pass on to others (Mahmoudi & Mofidi, 2008).

However, unless positive action is taken, most Iranian Vernacular buildings will have crumbled. Thus, In the name of Iranian architectural heritage, it is hoped that any further decay of such historical constructions can be prevented by funding.

BIBLIOGRAPHY

AGHDABIGLO, Z. *Passive cooling system*. PhD thesis, Sydney University, 2001, pp: 76-79.

BEAZLEY, E. *Greek mills in Shetland*. In: *The architectural review*, CXXXIV, July, 1963, pp: 62-64.

BOURGEOIS J. and PELOS C. *Spectacular Vernacular: A New Appreciation of Traditional Desert Architecture*. New York, Peregrino Smith Books, 1983, pp: 67-71.

CULTURAL Research Association. *The Iranian Atlas of Vernacular Architecture*. Cultural Research Association, 2007, pp: 71, 93 and 114.

DIEULAFOY, J. *La perse, la chaldee et la susiane*, Paris, 1887, pp: 680.

FRYER, J. *A new account of the east Indies and Persia being nine years travels 1672-81* (Vol.3). Tehran, Cultural Research Association, 1963, pp: 149.

GHOBIADIAN, V. *Climatic Analysis of the Iranian Traditional Buildings*. Tehran, Tehran University Publications, 2001, pp: 308-337.

- HERBERT, T. *Travels in Persia, 1627-29*. London, Broadway Travelers Edition, 1928, 143 p.
- HYDE, R. *Climatic Responsive Design*. New York, E & FN SPON publications, 2000, pp: 97-112.
- KASMAIE, M. *Climate and Architecture*. Tehran, The Iranian Construction-Co, 2006, pp: 54-58.
- LAMBTON, A. *Landlord and Peasant in Persia*. London, Broadway travelers edition, 1953, pp: 143.
- LOCKE, G. "Icehouse". In: National trust newsletter, 24: 20, 1975.
- MACKINTOSH, T. *Yemen: Travels in Dictionary Land, John Murray*. London, 1997 [Accessed in September 2009]. Available in: <http://intarch.ac.uk/journal/issue20/reviews/fodde.html>
- MAHMOUDI, M. and MOFIDI, M. *Effect of Climate on physical Aspects of wind-catchers in Yazd and Bandar- Lenghe*. In: Conference on Fuel Conservation in Buildings (Tehran, February 17-18, 2008), Proceedings, pp: 239-251.
- MAHYARI, A. *Wind catchers*, PhD thesis, Sydney University, 1985, pp: 47-71.
- MIRDANESH, M. *Acquaintance with historical monuments*. Tehran, Madrese Co, 2007, pp: 173-92.
- MURAKAMI, S. *Environmental assessment of vernacular architecture*. Keio, Keio University Press, 2008, pp: 67.
- PARKERS, F. *Wanderings of a pilgrim in search of the picturesque* (Vol.1). London, Hutchinson & Ross Inc., 1852, pp: 78-83.
- SINGER, C. *A history of Technology* (Vol.2, Ch.17). In: "POWER" by Forbes, R. J. UK, Oxford University press, 1957, pp: 593-595.
- SMITH, A. *Blind white fish in Persia*. London, Island Press, 1953, pp: 92-95,156.
- STRONACH, D. B. *The first international colloquy on the conservation of mud brick monuments*. Yazd, ICOMOS, 1973, pp: 64-73.
- TAVASSOLI, M. *City planning in the hot and dry climate of Iran*. New York, G. Golanyed Co., 2004, pp: 102-109.
- TAVASSOLI, M. *Architecture of hot arid climate*. Tehran, Tehran University, 2005, 38 p.
- WEAVER, M. and PINDER, R. *Reconstruction of a mill at Band-e-Amir*. Tehran, Cultural Research Association, 1963, 78 p.

WULF, H. *The traditional crafts of Persia*. Cambridge, Mass Co., 1966, 246 p.

WILLS, C. *The land of the lion and the sun (Modern Persia), being experienced of life in Persia from 1866-81*. London, Broadway travelers edition, 1891, 241 p.

YAZD the Gem of the Desert. *A tourist information guidebook* (Vol. 1). Yazd, The society of Yazd Public Libraries, 1997, pp: 75-84.