INDIGENOUS IRANIAN ARCHITECTURE

CONTENTS:

INTRODUCTION

The development of indigenous Iranian architecture was predominantly, though not exclusively, the development of the use of mud-brick. For example, although most major sassanide buildings were in stone, yet the majority of Iranian buildings of excellence through history were executed in sun-dried mud-brick. Although today, in the north and west stone and timber are used, most indigenous buildings across Iran is still executed in sun-dried mud-brick. The use of mud-brick as a draining tool for aspiring master masons had got advantages inherent in the material; the fact that it was so cheap and easily obtainable encouraged experiment. Mud-brick building through its lines and form clearly demonstrates the major mechanical forces involved in the structure. The smallness of the unit of composition gives it great flexibility and elasticity. Thus ad-hoc adjustments can be made, even to modifying the basic brick unit, during the process of construction to respond to most structural or spatial demands that may arise.

After construction, any structural error will show up, often without the collapse of the whole building. Mud brick buildings with large cracks and distortions have stood up through the years, clearly demonstrating in the structure the particular reasons for them. Thus in the absense of mathematical techniques Iranian masons, schooled for centuries in mud-brick building, were responsible for many new and complex structural forms developed to a high level of perfection.*1. It can be argued that even today it is unsurpassed as an empirical method of building instruction, resulting in quick, easily apparent and reliable results and a built form practically and aesthetically in harmony with the Iranian environment. One simply was to juxtapose Iranian indigenous architecture, domestic or monumental, with 'modern' Iranian building for this point to be illustrated.

HISTORICAL BACKGROUND

Iran played a major role in the development and dissemination of mud-brick, vault and dome construction and styles such as the 'Apadana' and 'Aivan' and building elements such as the 'bad-gir'. The debate on what originated exactly where is somewhat academic for the present paper. *2. Here I will simply try to inject some historical perspective into the subject. It will suffice here, to simply to summarize

By the 4th millenium B.C. sun-dried mud-brick was beginning to replace pise using shuttering as the major building technique. Originally they were oval shaped mud-lumps *3 but by the end of the 4th millenium the flat-rectangular mud-brick formed in a wooden mould began to be generally used. Houses by this time had all the basic architectural features of doors, windows, recesses, butresses, rendered and painted walls. In general

*1. A U Pope & P Ackerman Eds. " A Survey of Persian Art" p. 901 - 2, also see footnote 3 p. 901.

*2. See Hans E Wolff 'Traditional Crafts of Persia'. Pope and Ackerman.'Survey of Persian Art'. R Girshman 'Iran'. K A C Cresswell 'A Short Account of Early Muslim Architecture' to follow the debate.

*3. R Girshman Iran p. 29.

WOOD CONSTRUCTION

Figs 158 - 159.

Houses predominantly of wood are found north of the Alburz mountains. In the low lands near the Caspian Sea the houses are raised approximately 600m.m. above ground on a system of alternating, heavy sleeper beams, blocks and boards on which the floor of the house lies. Verandah columns ring the house and support the horizontal purlins (kasin) on which a framework of steeply inclined rafters (salju) and bamboo (kartun) battens are supported. The rush thatching is carried on this framework. Bamboo and rushes grow in abundance along the many water ways in this area.

Further upland the raised floor is not necessary. The main frame is laid directly on the ground. The vertical stiles that form the room are nailed across with thin branch wood or bamboo stems and filled with a mixture of wet loam and straw (kah-gel).

In place of thatching, shingles (tahteh) or burnt tiles are also used. The tiles are either fastened with a nose at the back to attach them to the roof battens, or they are made into semi-tapered cones which are then slit into half resembling spanish tiles. Burnt tiles are made by the local potter using a fat clay.

Galvanised iron roofs are beginning to replace other roof types.

MAKING BRICKS *11.

Mud-Bricks: Earth for the mud-brick is taken from the excavations or from a pit nearby. A pick and spade are used for digging. If the earth is being dug from a deep pit a windlass may be necessary to haul it to the surface (See fig 163). The earth is soaked in plenty of water; straw and chaff are added and thoroughly mixed by treading with bare feet. It is then mixed again using a hoe.

The brick mould is simply an open wooden frame with a handle. The moulder scatters a thin layer of chaff on the ground. He puts the mould on to it and fills it with the mix, smoothening any surplus off with his hand. With a quick smooth motion he removes the mould and places it next to the formed brick to repeat the operation. In this way he can make 250 bricks an hour.

The bricks are left in the sun for three to five hours depending on the weather. They are then set on edge to dry for a day or two. They can be used immediately after for building. This work is only done during hot months of May to October.*12. A standard brick is 8" x 8" x 1½" - 200mm x 200mm x 38mm.

MAKING BURNT BRICKS

Brunt bricks were made by Babylonians in the 4th millenium B.C. *13, and in Iran kilns in Susa and Siyalk have been excavated dating from the 1st millenium B.C.*14. As bricks are normally used for facework the clay used has to be selected and staked and clean of impurities. The brickworks is situated near a suitable clay pit usually outside the settlement. There must also be a deposit of a gray sand nearby.

*11. The following information is substantially derived from Hans E Wulff 'Traditional Crafts of Persia' p.p. 110
*12. Compared to Egyptian method (or whose recommendation) Where shade and winter is preferred for a more even drying.
*13. R Girshman Iran p. 166
*14. C Singer 'A History of Technology'.

The clay with 1/5 of its colume of the grey sand, is soaked in a pit filled with water and left to slake for 24 hours. (The sand makes the clay lean and after firing becoming light-cream in colour, otherwise it would turn red).

After 24 hours the mass is thoroughly mixed with wooden shovels and then hoed. It is carried in buckets and poured into a gutter which leads to a neighbouring pit. There it is seperated from course materials through a sieve and the strained clay is allowed to settle. After the 1st day the surplus water is scooped off from the top. Four days later the clay is normally dry enough to be moulded.

The mould is a cast-iron box with two compartments to take the narrower standard size bricks. It has four projections at the base which is used for gripping, no handle. A handfull of the gray sand is first put into the mould and shook around so that it sticks to the wet surfaces. The clay is then put into the mould and levelled off either with a straight edge or wire. The mould is then turned over and emptied.

The brick is allowed to dry for a day, then turned on edge to dry for a further 3 to 4 days. It is then ready to be fired. A brick kiln *~~14~~, consists of a vaulted fireplace which goes 8½-5 m below the ground surface. One vault is full of holes and serves as a grate. Steps lead down to this fire-place. The ~~perceivable~~ past of the kiln is the surrounding room over the grate. It has one opening at the ground level and one above reached by a ramp. There is a smoke outlet at the top.

The first lot of bricks are stacked through the bottom opening and the re-mainder form the top. The bricks are stacked with spaces between them to allow the combustion gases to pass. The top layer is packed close and smeared with clay to corner the joints except for 1m^2 areas which allows smoke through. One of the openings are then closed up.

Fuel oil, *~~15~~, a by product of the regineries, is mixed with chaff and dry stalks of sugar-beet and shovelled into the fire hole. The bricks are fired for 72 hours. Then a large quantity of the fuel mix is shovelled in and the resulting sudden lack of air begins to reduce the heat. Fire hole and smoke outlet are now also covered up with clay and the kiln allowed to cool for 72 hours.

The bricks are then ready for building. Those nearest the grate are usually overfired and used for constructing water basins and cisterns, commom features in Iranian houses. The kiln just described has a capacity of 5 0,000 standard bricks 8" x 4" x 2"/200 x 100 x 50mm Khuzistan kilns have a capacity of 150,000 standard bricks.

Another type of kiln (see fig 176) consists only of the fireplace and grate. Limestone is stacked in the centre over the grate and the bricks around this, with spaces to allow the combustion gases to pass through and out in all directions. After 24 hours firing, the bricks are allowed to cool and except for the outer layer, they are then ready for building with the burnt lime is just enough to prepare the mortar for this batch of bricks*~~16~~.17

*~~14~~. Types and methods vary from province to province. Example here is from Hamadan.

*~~15~~. Previously desert shrubs (car, tarkha) (artemisia herbs alba) and wormwood was used. It has a long intense stem.(the shrub)

*~~16~~. Wulff considers this method inefficient. However if firing for 24 hours produces as good bricks as the previous method with 72 hours firing and burnt time for mortar, there is a case for it.

Because of the scarcity of timber, vaults and dome construction was developed in Asia. Flat roofs needed timber beams, branches and matting on which a layer of mud was placed. This method is still used when there is no scarcity of timber. Early vaults used wood centering ans shuttering. It was not until the discovery of gypsum mortar that the use of timber even in shuttering could be entirely dispensed with. Gypsum sets almost immediately on contact and there is no danger of slipping. *4. The first Iranian examples are found in the Barthian buildings of Ashur (1st cent. ad.). Earlier examples are the Ramesseum in Egypt, and in Babylonian Graves and canals through Sassanide and Islamic times, (Sassanide Dyn: 224 A.D. - 651 A.D: Islamic 651 A.D.)*5, this method reached high technical and architectural standards.

"Even today it can be said that there is hardly a room that a Persian builder cannot cover with a vault, from the most horrible peasant house to the covering if a cinema in Yazd where a single barrel vault of sun-dried mud-bricks spans a hall seating 600 people". *6.

In style, form and plan, the 'Apadana' and 'Aivan' are the most characteristic of Iranian indigenous architecture. The 'Apadana' is a large room in the centre of a building with a wide hall open on one side and having small rooms at each end (see figs. 1-4). Already developed in pre-Achamenian times (Achamenian dyn: 550 B.C. - 249 B.C.) it was widely used in Iran and later Iranian builders spread it through the Moslem world. The plan on the monumental scale as illustrated in Persepolis differs little from present day peasant houses in Azerbaijan and in the central province (compare figs 1-4). In detail the capitals on wooden columns in the Azerbaijan houses are stylised versions of the bull's head in Persepolis*7, which is doubtless a heritage from its antecedents - it developed from the customs of a nomadic people who were used to looking out into open space and blue skys.*8

CONTEMPORARY

Geographical Influence: Availability of Materials - Climate etc. and Building Types:

As it effects building types, Iran can be broadly divided into 2; the mountain ranges with their thick forests, snow and heavy rains (225" p.a. in the Caspian Provinces*9) and the desert interior. Within the mountain ranges another two sub-divisions can be identified. The Alburg mountains of the North (the Caspian Provinces) have rather more timber, rain and snow. The house constructions are predominantly timber, with sloping thatched, tiled or shingled roofs and wide overhangs. (See Fig). The Zagous mountains of the west have houses with stone or brick walls and with a flat thatched roof.(See fig). In the desert areas houses are made of mud-brick with vault and dome roofs. Though these divisions are broadly accurate there are of course many more types and differences. For example brick walled, flat thatched roofed houses are also found in the Alburg mountains.

Finally, although stone is generally available in Iran, brick, particularly mud-brick, is preferred. Stone was more often used where permanence was very important, in buildings such as fortresses, caravanserais, bridges etc. otherwise the vast majority of indigenous buildings of Iran were constructed in the cheaper more flexible and rapid, brick. *10. Today in mountainous regions stone and rubble villages, have been built for centuries while cut stone is widely used for foundations.

*4. Pope and Ackerman .
*5. " " p.p. 415.
*6. H E Wulff p. 105.
*7. H E Wulff p. 104.
*8. Pope and Ackerman pp. 429-430
*9. H E Wulff: The Trad. Crafts of Persia M.I.T. Press 1966 p.113
*10. Pope and Ackerman 'Survey of Persian Art' p. 900 - 901

BUILDING

There is no distinct professional differentation between the builder, mason and bricklayer. You are either an apprentice or a master builder with apprentices working for you. No drawings are prepared for the house - the owner and builder mark it out on site with powdered lime.

FOUNDATIONS

The foundation trenches are dug 18" deep/500mm approximately and slightly wider than the walls. The excavated earth is mixed with burnt lime and water to make a soft paste. A layer of this paste about 6"/150mm. deep lines the bottom of the trench course stone ballast with stones 150mm to 200mm in diameter is thrown in. A second layer of paste and then stones are placed. This is repeated till the trenches are full. Within 3 to 4 weeks the foundations have set and wall building can commence. In time the lime-mud-stone mixture becomes as hard as rock.

WALLS

Pise or Rammed Earth

Most perimeter walls, surrounding gardens etc. are made of this technique. Earth is moderately wetted and, with chaff, kneaded with bare feet into a plastic mass. The building line is marked with a string (risman). The builder then places this earth in lumps on to the properly set foundations and along the strine. If it is a low garden wall foundations may be no more than a layer of cut rock on the ground. The clay lumps are shaped freehand into a course 15"/400mm approximately *17. When a course is finished it is smoothed with a trowel and allowed to set, for usually 2 to 3 days by which time it should be hard enough to begin a second course until the wall is complete.

Yard walls are usually topped with a layer of burnt brick that corbels out 4"/100mm to protect the wall against rain. Garden or orchard walls are capped off with wooden sticks about 30"/250mm long x 2"/50mm thick. The sticks carry a layer of thorny brushwood or rushes weighed down with a course of a lime mixture which sets and becomes water resistant.

The walls narrow with height normally. An 8'/2.5mm high wall is 800mm at the base and 250mm at the top. Another method is to mix clay, rubble, straw and lime and firmly pack and harden it in 2 wooden mould making horizontal layers each 450 - 600 mm high. Still in use in Iraq, Iran and Turkey.

MUD BRICK

The courses are laid along a string which marks the building line. The bricks are laid in bond and the mud-straw mortar mix is the same as used for making the brick. The mortar is laid about ¾"/18mm thick, The mortar is spread with a steel trowel, and the level chicked with a plumb-line or straight edge containing a small pendulum, (sagul).

Outside walls are usually 600 - 950 mm thick. Inside walls can be single brick (yakajuri), bricks on edge (tigeh), or bricks squared to form box like holes (sandupi). The transition between a vault and a flatroof or top floor is also built hollow to lessen the weight and save bricks (see fig 168).

*17. i.e. Half an Isfalian cubit
1 cubit = 80c.m.

The walls are rendered (gel rus kasidan) with a mud-straw mix (kah-gel) enriched with lime (ahak) which makes it insoluable after setting.

BURNT BRICK WALLS

The mortar (sey-ahak, maseh, malet) for burnt brick walls is a mixture of hydrated lime and sand. For modern urban buildings, sand-lime-cement mortar is often used. A specially water proof mortar, often used for reserviors, is made by mixing sand, lime, cement and wood ashes (hakestari-hamniam) and either the hairy seeds of rushes or goats hair is added for internal bonding and to prevent cracking. *18. 19

Outside walls are seldom rendered but the joints ~~neatened~~ cleaned to give an attractive finish. More recently mud-brick structures with a bonded in veneer of burnt brick on the outside has been adopted.

STONE

Many buildings today are built on a stone base approximately 1m high. Thus the brick parts are high enough to be safe from the splashing of winter rains. Ashlar masonry is widely used in the province of Fars. It is laid without mortar. When it is set in mortar a special lime and clay mixture (dugub) is used for the joints (darg, darzesang). It is applied soft and the stones set easily with a very thin joint. In a few months it sets very hard.

FLOORING

The average house floor (kaf) is made from a hard setting mixture of lime and plaster, often mixed with stone, grit and red iron oxide for colouring. Wealthier houses have stone slabs, burnt bricks or glazed tiles for flooring.

ROOFS

There are basically three types of roofs.

1. Pitched Roofs: (See Wood Construction)

In the Caspian provinces with their heavy rainfall (225"p.a.) you find pitched roofs covered with either straw, (figs. 158-159) *19, shingles (tah, teh tet) or burnt tiles (sofal, sefal, tufal). Burnt tiles are made by the local potter (sefal gar) from a fat clay. They are flat and have a nose (dokmeh) at the back to attach them to the roof battens.

Others resemble spanish or roman tiles - i.e. slightly tapered cones slit in half. They are used widely in Mazanderan and Googan. Galvanised iron roofs (sir vaneh) are becoming increasingly common.

2. Flat Roofs: (Bam, post e bam, rubun)

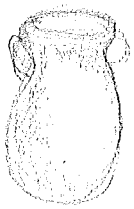
These typify the houses on the Iranian plateau and at the slopes of the Zagros mountains.

Ceiling joists (tir, sardar) are placed over the walls or over heavier beams (samal) supported by columns where there is an open porch. On this, either ceiling boards (sogaf - pus) or battens (pardu, dastak) are nailed and covered with braided reed mats (hasir). A mud straw lime mixture is laid over this in thin layers. Each layer is allowed to dry and then compacted with a rolling stone (gattaban) before the next layer is applied. In Fars and Isfahan the roof is approximately 250mm thick. In Azerbaijan it is 500 mm thick and a much greater proportion of straw is in the mix. During construction salt is strewn on the mats and mixed with the mud to keep insects, particularly white ants and borers, away.

The mix is laid on the roof in sections of approximately 3 m. wide. In between each section a rain channel is formed slightly depressed in the centre and deepening to the edge of the roof where it ends in a wooden spout. After each rain the roof has to be compacted otherwise it would develop cracks while drying, (a roller remains on the roof) and any straw has to be immediately shovelled as matting straw seeps in quicker than rain. Such roofs keep the rooms cool in summer and warm in winter.

VAULT AND DOME CONSTRUCTION

Vaulting: Introduction



In Europe vaulting was developed for a limited practical reason - the need for a light roof over a high enclosure that could be carried by walls pierced by many windows. The fundamental motives were religious and aesthetic and it's use was largely limited to buildings embodying just that. In Asia, scarcity of timber led to the development of vaulting to meet almost every conceivable spatial problem from peasant houses to mosques to palaces. Unfired mud-brick was used because it was far more flexible and adjustable than fired brick.

Two basic forms evolved; the barrel vault and the dome on squinches. The former roofed rectangular spaces and the latter roofed square spaces. A single vault or dome could normally span a limited area, but many combinations were developed, achieving large spans and roofing the most awkward spaces.

" A view over a Persian desert town, with thousands of vaults of all kinds, defying all regularity, gives the impression that there is nothing that cannot be done with a vault built of unfired bricks." *1.

Vault construction, as currently in practice in Iran and Iraq, i.e. without wood centering/shuttering became possible with the discovery of gypsum mortar. Gypsum mortar sets almost immediately on contact and there is no danger of slipping. The first Iranian examples of such vault construction is found in the Parthian buildings of Ashor (1st Cent. a.d.)*2. But earlier examples of such construction can be found in the Ramesseum Granaries (Egypt New Kingdom) and in Babylonian graves and canals.

1. Vault or Arch constructed with centering.

Centering did not die out immediately with the discovery of gypsum but was used in a modified form. A thin layer of stone and gypsum was laid over the scaffolding and when it set it formed the centering for the bulk of the stone and mortar which constituted the vault. Thus only a very light centering was required. It was erected on the sustaining walls after they had been built up to the imposts. The diameter of the vault was consequently greater than the breadth of the room.

2. Vaulting without centering using staging/mirror wall.

This type is used widely in Iran today. The courses are set vertically from the sustaining walls and leaning slightly against the staging/mirror wall. The thrusts are thus distributed between the vertical and horizontal axis, between the sustaining and mirror walls working together with the sticky gypsum mortar to minimise any possibilities of slipping. The vault described a large segment of a circle forming a parabolic (½ elliptical) curve.

*1. E Diez See Pope and Ackerman p. 918.

*2. Pope and Ackerman p. 415.