BUILDING IN DEVELOPMENT: THE POTENTIALS OF INDIGENOUS RESOURCE MOBILISATION

A collection of articles by:

THE DEVELOPMENT WORKSHOP
Farokh Afshar. Allan Cain. Mohd. Reza Daraie. John Norton.

Village Builders' Training Workshop - Yazd, Iran, 1977. Learning through discussion, practice and experimentation.

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F.Afshar, A. Cain, M.R.Daraie, J.Norton.

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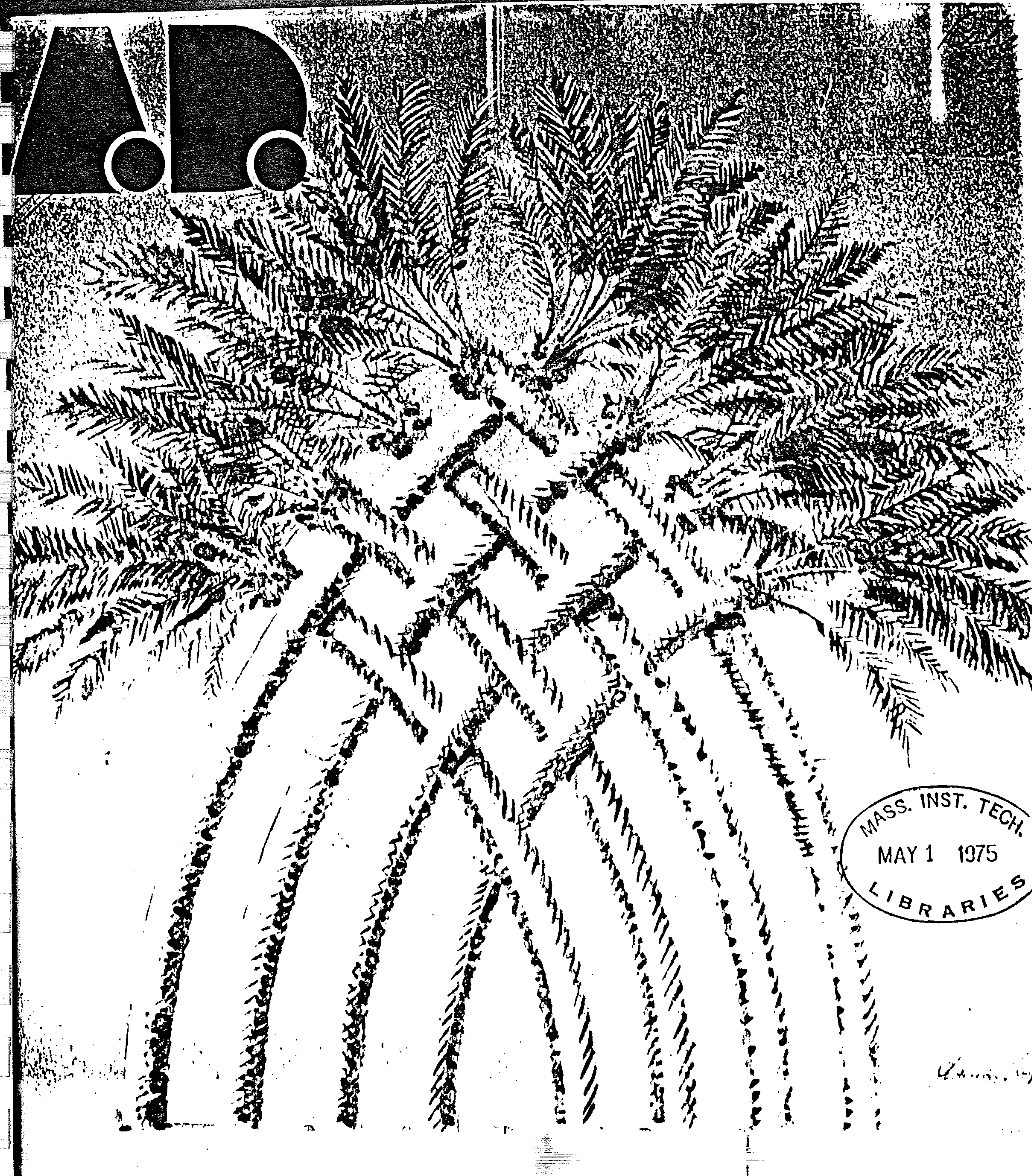
THE WORKSHOP

The Development Workshop is made up of a group of architects and researchers from a number of countries. They work collectively on the research and development of indigenous methods of planning and building. They have been involved in projects in Egypt, Sudan, Oman, India, Turkey, Iran, and various other countries. Research and development work is carried out into methods which remain in the hands of Third World communities.

Education is a primary motive. Workshops have been conducted with builders and young trainees in rural communities in order to develop upon existing skills and methods; and with university students to equip them to be of more use to the majorities in the Third World. Educational materials in the form of publications, exhibitions and films are being prepared.
The promotion of co-operative development of local building and small-scale industries is another aim of the Workshop.



INDIGENOUS HOUSING
Directory of Alternative Technology Part 2

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INDIGENOUS BUILDING and the Third World

In Third World countries, indigenous building processes could play a more central and functional role in building development than mere nostalgia. This would call for a deeper understanding of the indigenous built form – the traditional processes of construction, and the environmental and social functions which it performs.

With first-hand experience in Egypt, Oman, India, Iran and Sudan, ALLAN CAIN, FARROUKH AFSHAR and JOHN NORTON argue the feasibility of a policy of indigenous building for non-industrial countries in general. They present six case studies from the Arab country of Oman – specific elements of the built environment, such as wind-catchers and water supply. These studies are presented in boxes with grey borders.

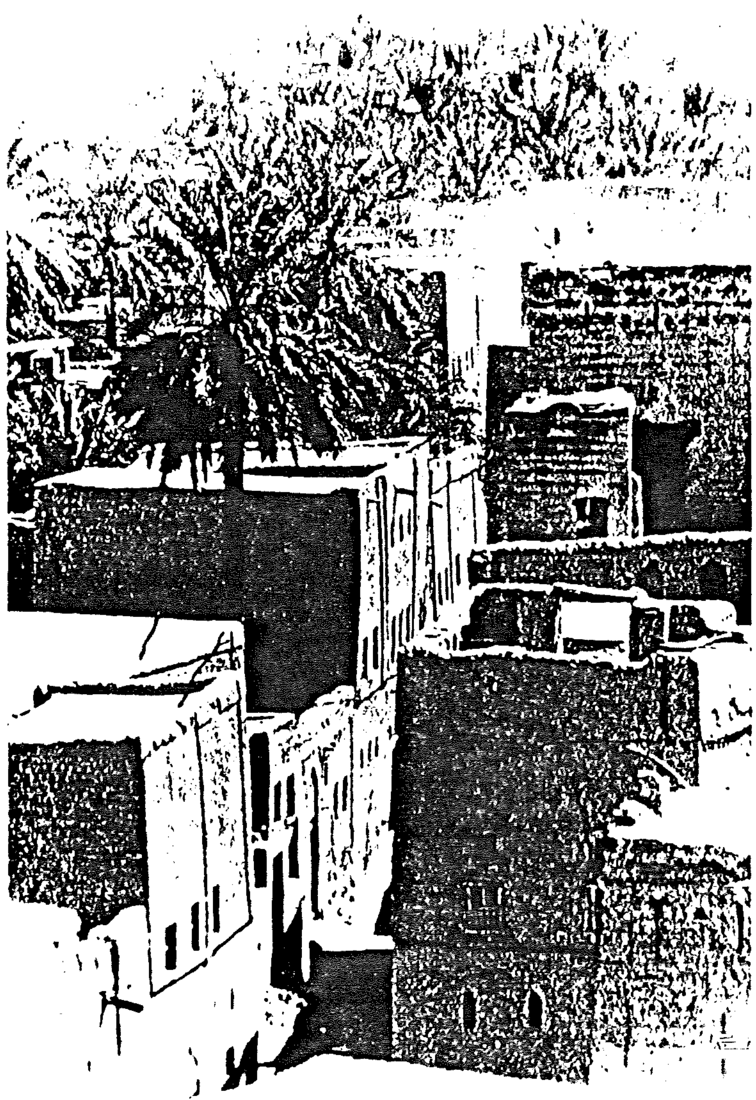
Indigenous systems

By 'indigenous systems' we mean those systems that are traditional to a country. A 'system' can be simply defined as a 'set of related parts', denoting 'organisation'. Many traditions, far from being backward or illogical as often supposed, do in fact have an underlying rationale or 'system' which is closely related or 'indigenous' to their particular region.

The potentials of indigenous systems have been neglected in most Third World countries. Instead they have been replaced by Western methods often inappropriate to local conditions and needs – physical, economic, social, cultural and aesthetic. The visible material success of the Western industrialized world has made it the obvious model for Third World countries. The very term 'developing countries' implies a correlative 'developed' world which would act as an ideal. Over the years, the values, objectives and methods of the West have been adopted by the other countries through a combination of imposition and emulation. The British model of parliamentary government has been implanted intact into countries with very different indigenous political organisations. Western medical methods have been unquestioningly applied, often to the complete neglect of long-practiced local methods of healing.

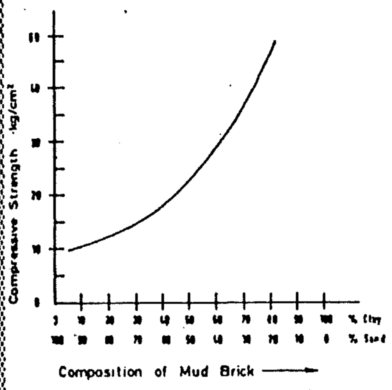
Today there is a growing awareness that such literal transference of methods rarely works. Nor is it adequate to start with basically Western objectives and methods and then modify them to local conditions: The Third World has very different social, cultural and economic bases (and in most cases, different physical environments as well).

Furthermore, in the global context of political economy the Third World is now in a very different position from that in which the Western World developed, when it had the rest of the world to draw its resources from. Yet today the Western world itself is beginning to have grave doubts about the validity of its own socio-economic models. Profligate consumption of energy and resources has precipitated the energy crisis and aggravated a major economic recession. Over-specialisation and institutionalisation have taken control out of the hands of the majority of the population and left them alienated. Moreover, at the time that the Western world was developing, it was concurrently shaping the socio-economic systems of the rest of the world, often to its own advantage and to the detriment of the country in which it was acting. Much of what is considered 'modern' today in a developing country was fathered by this shaping process and continues to work to the detriment of the country. However, amongst the many inappropriate imported models, those indigenous systems that were through neglect least affected by this shaping process may now paradoxically have the most to teach us. Many of the indigenous systems remain relevant to local needs, are based on low and

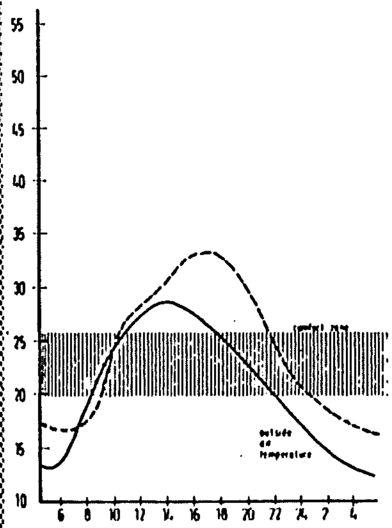


Allan Cain (Canadian, born 1949), Farroukh Afshar (Iranian, born 1947), John Norton (English, born 1949), studied together at the Architectural Association School of Architecture. Since 1971 they have been carrying out projects and research in Egypt, Oman, India, Iran and Sudan. In 1973 they were commissioned by the Government of Oman to carry out a study of traditional building in Oman. They are currently running a course at the AA on indigenous building methods in developing Countries and are working collectively as the Development Workshop. They hope to publish an extended version of their researches.

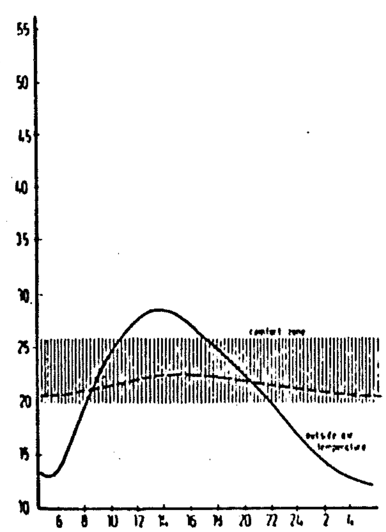
Sun-dried mudbrick
I. The material.



Strength of mud brick in relation to its proportional composition of clay and sand.



Prefab concrete room.
Interior air temperature — — —



Mud brick room.
Interior air temperature — — —

Soils, the basic ingredients of mud bricks, vary in their suitability for brick production. The inorganic part of soil can be graded as to its particle size, ranging from gravel, through sand and silt to the finest which is clay. Gravel must be removed from soils to be used for brick making, just as the organic matter such as humus must be excluded.

In those soils used for brick-making, the sand provides resistance to abrasion and water damage, and the clay provides the structural strength. By mixing various proportions of sand and clay, the brick can actually be engineered to suit a particular building or structural requirement.1

Because the strength of mud bricks is lower than that of some other load bearing materials such as concrete, mud walls are built thicker. But since the material is cheap and easy to obtain, the cost of construction still remains minimal.

Partly due to the thickness of mud walls and partly because of its low thermal conductivity, rooms built of mud are known to be much cooler in hot areas than those made of any other material. Mud walls and roofs effectively insulate room interiors from the external extremes of heat and cold. Tests were carried out by the authors on indigenous mud-brick buildings in Egypt and Oman and similar modern buildings in concrete in the locations. These tests illustrate a basic climatic response to the environment of indigenous buildings on the one hand and recently introduced built forms on the other.

Heat builds up on the exterior walls and roofs of concrete buildings due to solar radiation. Surface temperatures usually exceed even the air temperatures. Concrete walls, being relatively thin and having a low resistance to heat, conduct this heat quickly into the interior of the room; thus only an hour or so after the peak heat outside the air temperature inside is *in excess* of the outside air temperature. In the same way, if the nights are cold the temperature quickly drops inside concrete houses in the evening.

Mud walls during the day heat up to a lesser extent than concrete walls, since the light-coloured surfaces reflect more solar radiation than do concrete walls. The thick mud walls deter the flow of peaks of heat or cold experienced by the outer surfaces. Interior wall surfaces, as a result, tend to remain constant at a temperature which approximates the average of the range of the exterior wall temperatures. During daytime the interior air temperatures are therefore below those outside, and at night time the interior temperatures are above those outside.

Hence mud brick's capacity as a climatic regulator is advantageous in hot, dry areas which have a large temperature range between day and night.

Mud brick's greatest advantage is its cheapness and availability. The cost of brick is purely a product of the amount of labour put into its production. A team of three men can made 2000 or 3000 bricks a day using the traditional hand-frame mould. More mechanised forms of production though the standardisation of quality and brick size have rarely matched the traditional method in cheapness and quantity produced.

Mud brick's real shortcoming is its need for periodic maintenance. If exposed to weathering or rain, mud walls must be re-rendered every few years. Experiments have been done and new rendering materials produced which increase the walls' life span by many years. The bricks themselves may be stabilised using small quantities of cement or bitumen, in order to make the brick stronger and more resistant to damage.

Mud brick, either in its traditional form or upgraded and stabilised, remains a material of great potential for domestic as well as public building. With the price of non-traditional materials escalating and the materials themselves being in short supply in some developing countries, traditional building methods and materials may again prove increasingly important.

Even today mud or earth is probably the most widely used building material in developing countries. Recent figures from India show that about 60% of buildings in rural areas are in brick. Although it is primarily a rural material, the same figures show almost a quarter of urban building to be in mud. In many cities in Iran a very high level of urban architecture has been achieved using mud.

Mud building can be found in many forms ranging from rammed earth (pise), puddled earth & fine gravel (cob), through to mud brick (see *AD* 1/73). Similarly it is found in many geographical and climatic regions, from cob houses in Devon, England, through the adobe pueblos of the Hopi in America, to the impressive examples of mud brick building in the Middle East and North Africa.

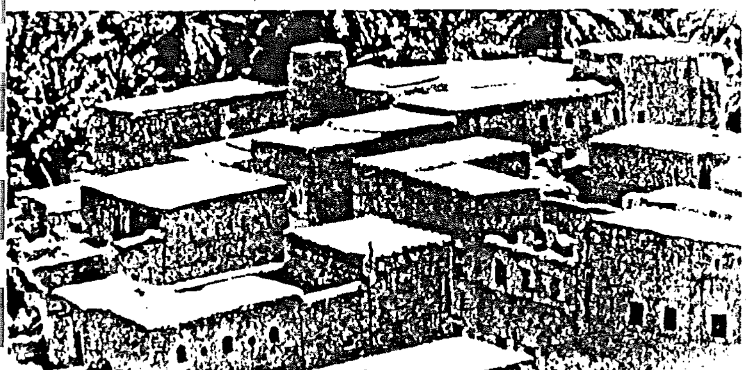
In official architecture mud brick has been replaced by new materials such as concrete. Along with most other indigenous building materials, mud brick has been dismissed on the grounds that it tends to produce environments which are physiologically unhealthy and structures which are unsafe. Before mud brick or any other material is discounted, its properties should be analysed and compared with properties known about other materials so as to discover its merits and demerits and applicability particularly since every material has its own value in its proper context.

Sun-dried mudbrick
II. Vault and dome roofing.

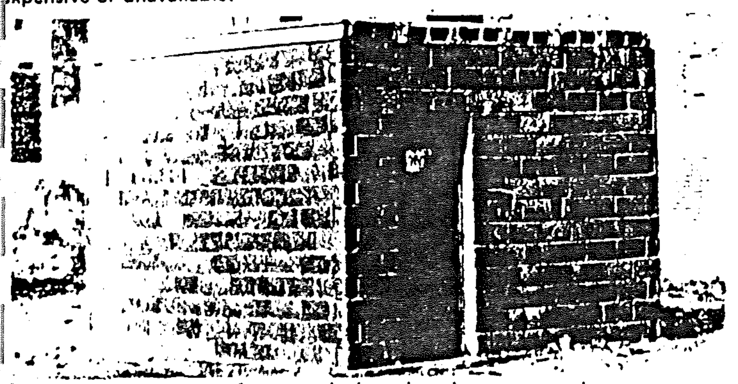
The building of walls has never presented a real problem to builders. On the other hand, roofing has always been demanding. One of the simplest solutions to roofing is the use of wooden beams to span between two walls. But with populations increasing and local timber resources being depleted, even this solution in many third world countries is not possible today. The use of steel and concrete in reinforced slabs is being suggested for roofing more and more. This type of roofing has been attempted in low-cost housing projects in many countries, but it has the effect of increasing the unit cost well beyond the resources of the majority of the people, besides causing a balance of payments strain on those countries which have to import the steel and cement. Furthermore the corregated-iron roof, which is adopted as a cheaper though second-best imported solution, is notorious for turning the inside of houses into ovens whenever the sun shines.

Centuries before the advent of materials such as concrete, steel bars, and corregated tin, countries like Egypt and Persia experienced some of the problems of population increase and lack of materials for flat-span type roofs. They were forced to look to the materials at hand, and came up with a solution that was economical, simple, and climatically ideal. The vault and the dome, made of the same materials as the walls, mud-brick, became the standard roofing system in both rural and urban areas alike.

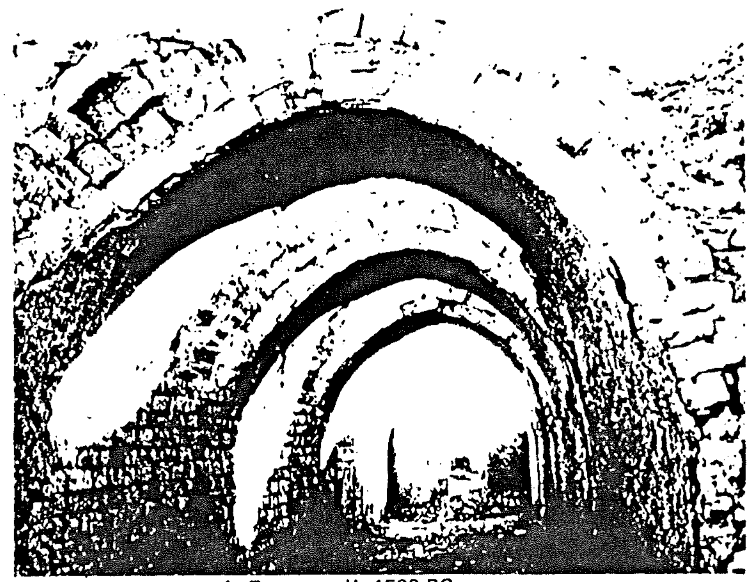
One of the earliest examples of this form of construction is seen in Egypt near Luxor in the New Kingdom, Granary of Rameses II, built almost 3500



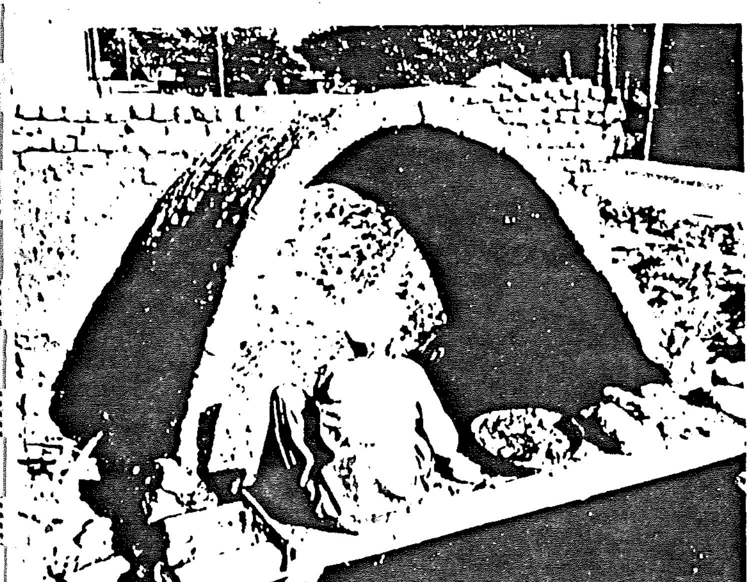
Construction of the traditional flat roof becomes a problem when timber is expensive or unavailable.



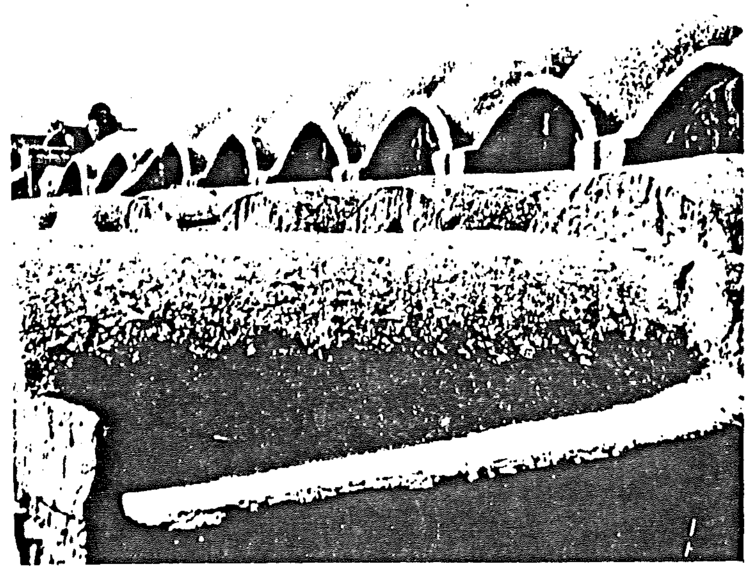
Reinforced concrete roofs are a solution, though very expensive.



Egyptian: granary of Rameses II, 1500 BC.



Vault and dome construction can provide inexpensive roofing.



Iranian: vault and dome.

rs ago of only mud brick and
standing today. The method construction common in ronic times survived ough the centuries in the mestic architecture of the bians, who lived along the per Nile south of Aswan.

Similarly in Iran the history vault and dome building in d brick goes back centuries. more recent times its use has n neglected to domestic lding. The fluid lines of the hitecture of rural Iran are erent in the mud brick terial itself. The fact that the d brick itself was so cheap easily obtainable encouraged masons to experiment. The s and forms clearly demonte the major mechanical ces in the structure. The conuctional unit, the brick, being all, and the fact that it can be ily cut and trimmed allows at flexibility so that adjustnts can easily be made during process of construction. It mains an excellent material om which to learn the structral principals of building.

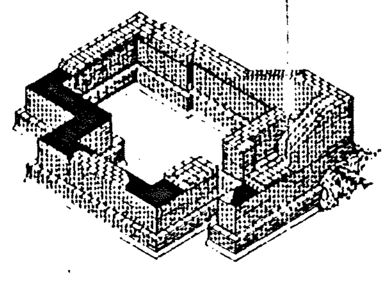
Mud brick has strength only compression, it is brittle and ill not stand up to forces of nding or tension. For this ason the forms of the vault d the dome, for which it is oted, have evolved. A crossction through the vault mmonly built by Nubian asons in Egypt shows a form ry close to an inverted tenary. The catenary is the rm that a chain or string will ke when allowed to hang eely, suspended between two oints, is in pure tension; an verted catenary experiences nly compressive forces with no nding or tension. A vault hape approximating this is ideal or mud brick roofing. Unlike other forms of masonry, such as tone or red brick, the mudrick vault and dome resemble shell structures' in their strucural analysis. Because the mortar used is mud and is the ame material from which bricks re made, when bricks bond ogether their surfaces dissolve nd then fuse together on rying.

Hassan Fathy saw the advantage in mud brick vaults and domes in the late 40's when he built his Gourna village. The potentials for mass housing using locally available resources are apparent and deserve serious consideration.

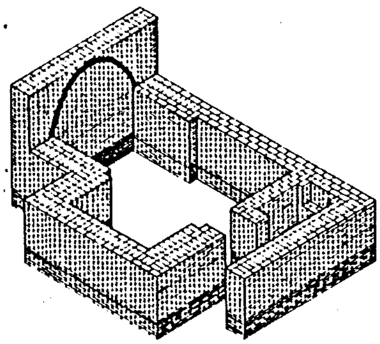
System for building mud brick vaults and domes without centering or shuttering

Traditionally the immediate problem experienced by European builders is that while vaults and domes are self supporting structural forms when completed, they have needed support and centering while under construction. This usually involves first building an identical vault in wood over which the masonry vault rests, until complete and dried. In countries where timber is short, this type of vaulting is hardly advantageous. A system for building vaults and domes, without this framework, or shuttering, evolved in countries like Egypt and Iran.

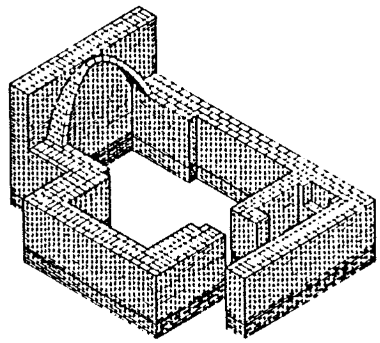
Illustrated here is a house built recently, in Egypt, by a group including the authors, which shows the principals of one of the methods of mud brick building without centering or shuttering.



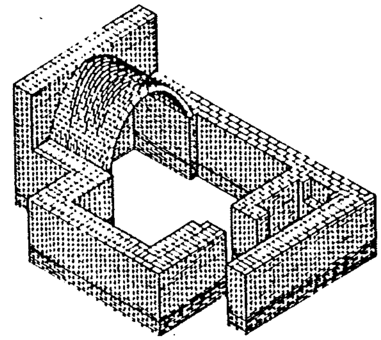
Foundations



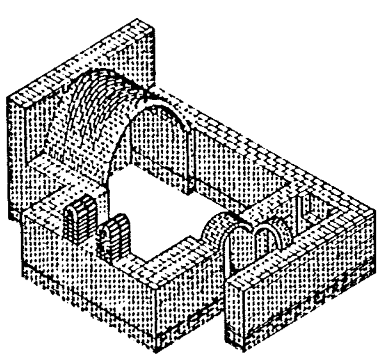
Walls built up to the level of the spring points of the vaults. End wall built up for vault to lean on. Inverted catenary form traced on end wall.



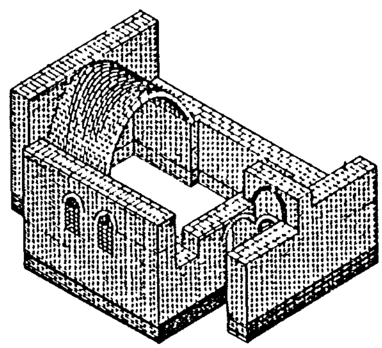
Vault building with courses leaning towards end wall so that no form work or shuttering is needed.



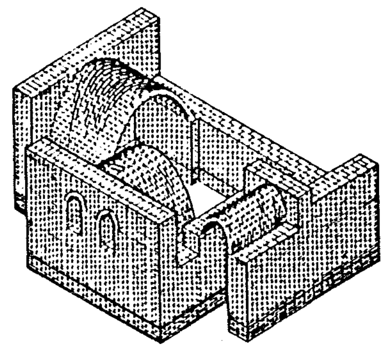
Vault completed.



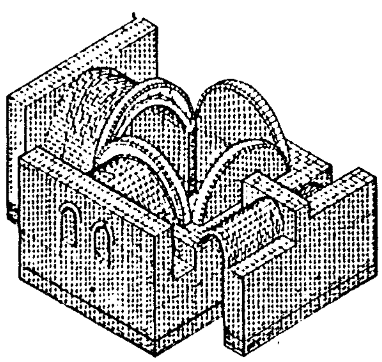
Window openings built up with dry brick — no mortar.



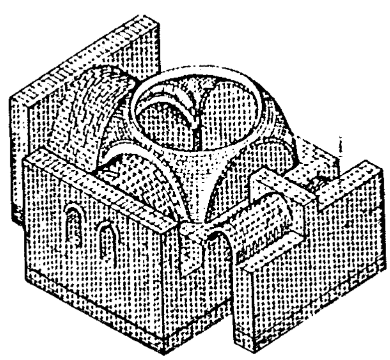
Walls built up. Arches built over dry brick in windows.



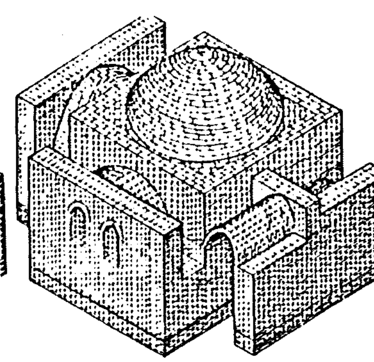
Small vault built in same way as large ones. Loose bricks removed from window openings.



Circular arches built over vaults to form a base for the dome.



Pendentives completed, forming continuous course from which dome can be completed.



Brick courses of dome incline increasingly until dome is finished.

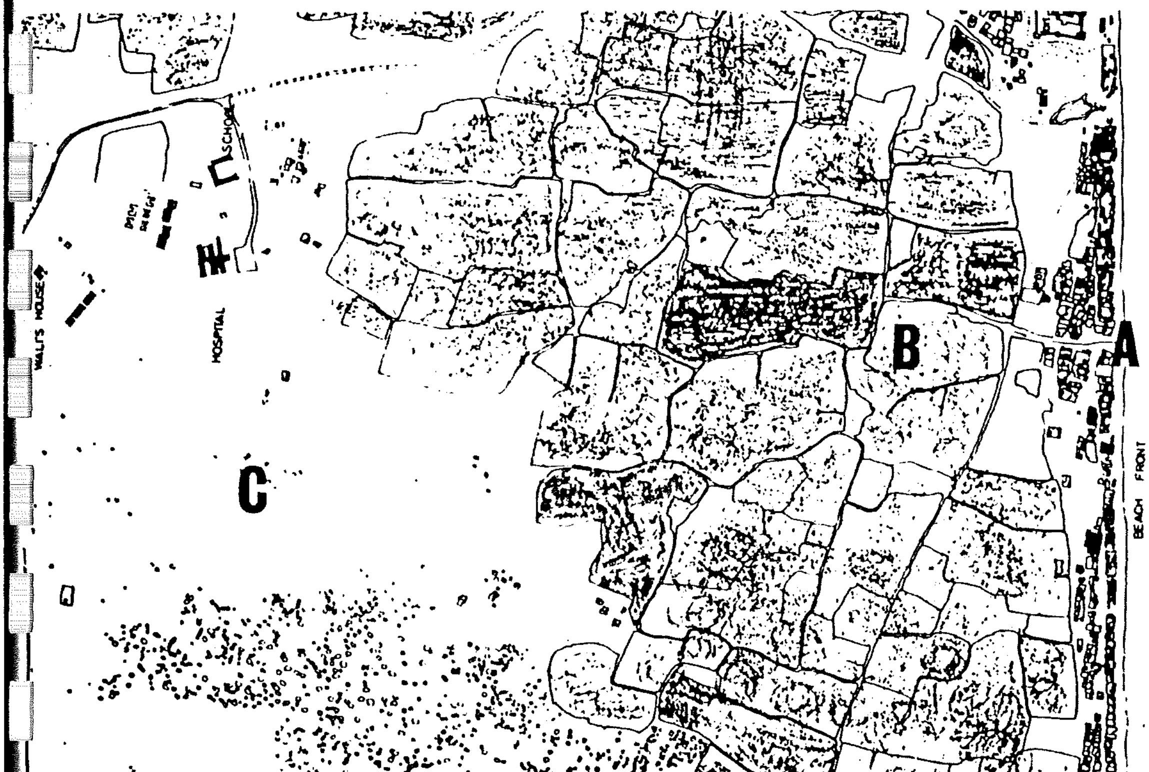
Climate and micro-climate.

When planning or designing in a country where one finds a severe climate one must consider the effect of that environment on the ways of living and ways of building of the inhabitants. For hundreds of years the inhabitants of any particular area have been building up a collective knowledge and way of dealing with their local conditions. This knowledge and experience is there for anyone to share and learn from, standing in the local architecture and living patterns of each particular region. The problem presented is how to extract the principals of design, inherent in the vernacular building and apply them to modern design and the projects of rural and urban development in this country.

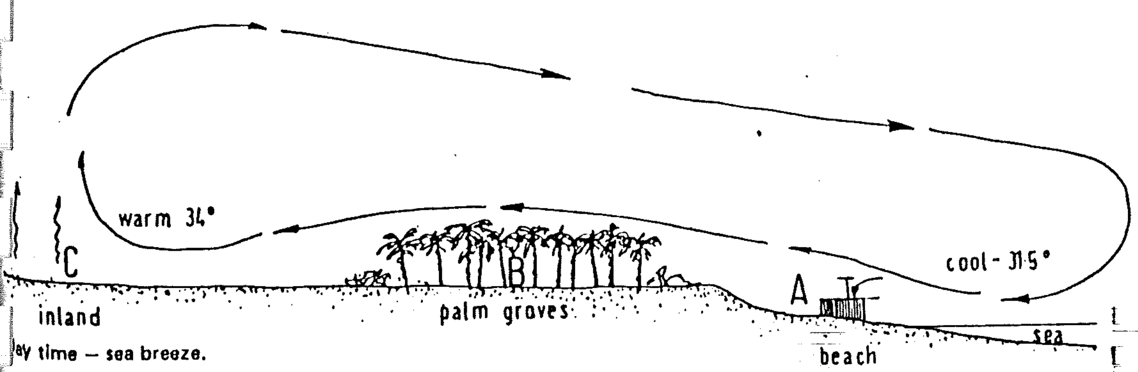
The advantages of employing this knowledge in modern building are apparent. The added expense in air conditioning could be avoided or at least drastically reduced if some thought was given at the design stage to sight orientation, the consideration of the sun path and wind direction. The glare from large expanses of badly designed window openings can be avoided by studying openings of local traditional design. When comparing imported building materials with those used locally one is likely to find that in terms of heat transfer and thermal comfort the local materials are superior, and when one compares the material costs, the local materials will likely prove the most economic. In any contemporary design if the structural performance of a local material meets the standards required in the design and is superior climatically there is no question but that it should be employed.

By a thorough analysis of the behaviour of certain traditionally used building materials and ways of building, we hope to find ways of improving on their use and of course develop ways of improving services and standards in new buildings using these materials, thus evolving a modern architecture truly in harmony with the climate, the local environment, the changing ways of life embodied in improved standards of living.

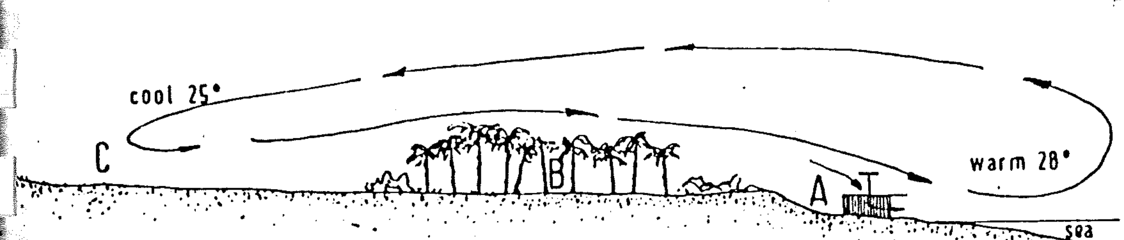
Meteorological data can be obtained from permanent weather stations; and statistics for temperature, relative humidity and precipitation for general



Plan of Sohar area showing test sites.



Day time — sea breeze.



Night time — land breeze.

s can be obtained from such es as the Meteorological ce, HMSO, London. But and erstanding of the micro ate which affects individual lements and buildings can y rarely be obtained from h published material.

Proximity to physical ures such as bodies of water, s or mountains or other built ms, or the quantities and ds of vegetation, or the ilude, all have their effects on difying the macro-climate or climate said to generally ect the region. In fact when lerological observations are de every attempt is made to late the testing apparatus m micro climatic localized luences.

Mountains or hills have the ect of physically altering wind tterns by simple deflection or channelling of winds down lleys. Changes in altitude rrespond to temperature anges. The stratification of yers of air of different tem- ratures over a daily cycle duce local winds in the slopes d valleys.

The presence of a moist aded environment in vegetated eas means that the micro imate within and around the een area is quite different from at outside.

The spacing between build- gs within the settlement fects wind flow within the ttlement and the shading of reets, just as does the organiza- on of the spaces within the ouse. Open spaces can be ganized in such a way as to duce air movement when there no wind. Materials used in the onstruction of buildings affect heir internal thermal environ- ment.

Particular features within uildings such as wind catchers (badgir) and cleverly designed openings, as well as orientation on a site, all affect the micro climates within and around buildings.

Because the micro climate which affects the built environ- ment is due to particular conditions which vary from place to place they can only be understood through field testing, observation and local experi- ence.

As an illustration of this, it is known that bodies of water affect the temperature of areas nearby, because water heats up and cools at a rate much slower than land. The difference in temperatures of the air over land and water cause pressure differences which in turn induce localized winds. This is known as the onshore/offshore or land-sea breeze effect.

Tests were carried out by the authors to evaluate the influence of the onshore and offshore winds on the minor climate of a settlement (Sohar) on the Persian Gulf Coast.

Four stations were chosen – offshore in shallow water, on the beach, in the planted belt and in the semi desert island. 1,2.

A series of climatic tests were made in each area every two hours over 24 hours.

When this information is graphed one can see clearly the daily pattern in the micro-climate of each area.

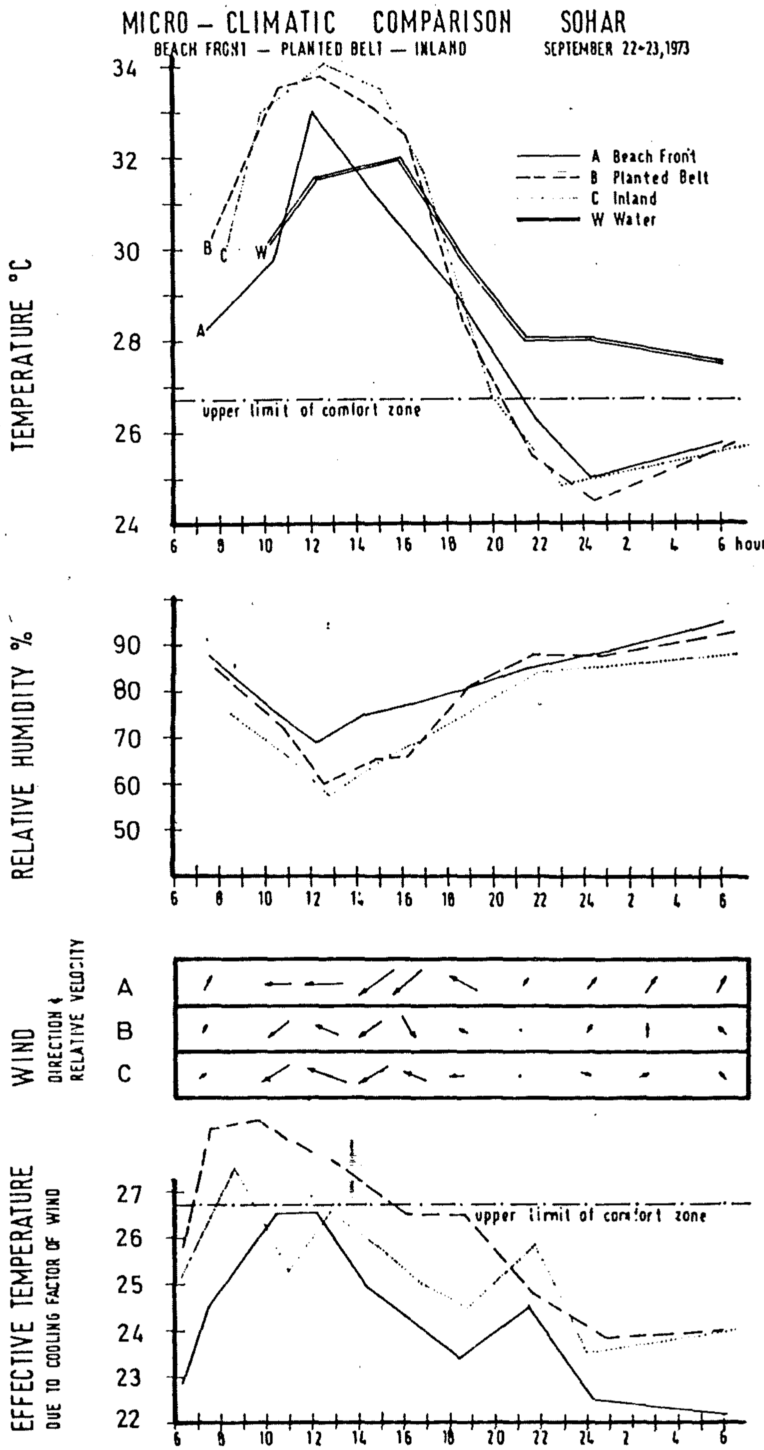
The temperature of the water is clearly more stable than the land temperatures, fluctuating only about 4°C between day and night while the land tempera- tures fluctuate as much as 9°C. It should also be noted that the peak in water temperature lags several hours behind the peaks in air temperatures. The same is true for the coolest tempera- tures.

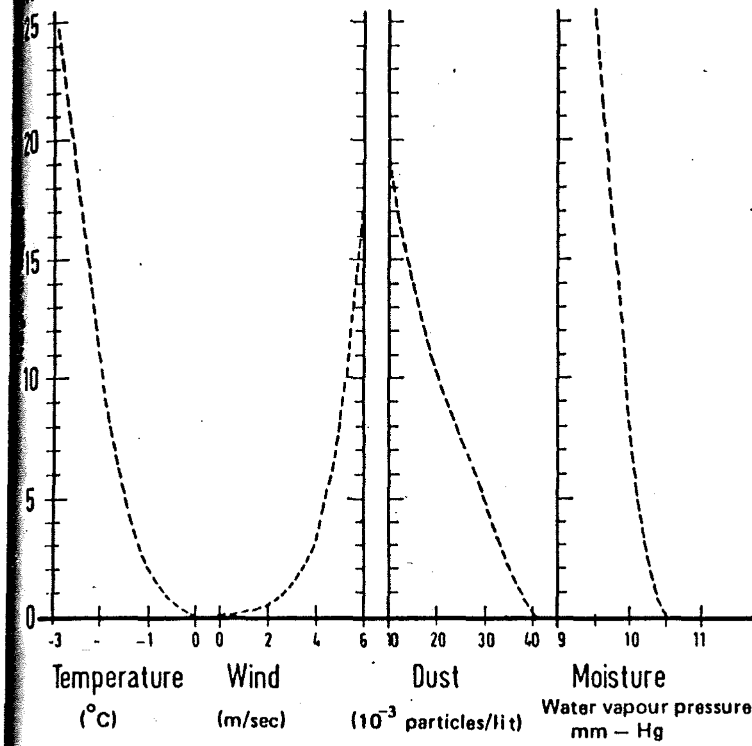
It can be seen that during the daylight hours when the air temperature is higher than the water temperature, there tends to be an onshore breeze; but at the time that the air temperature falls below the sea temperature the offshore land breeze influence begins to take over. The prevailing wind in this season aids the daytime onshore sea breeze.

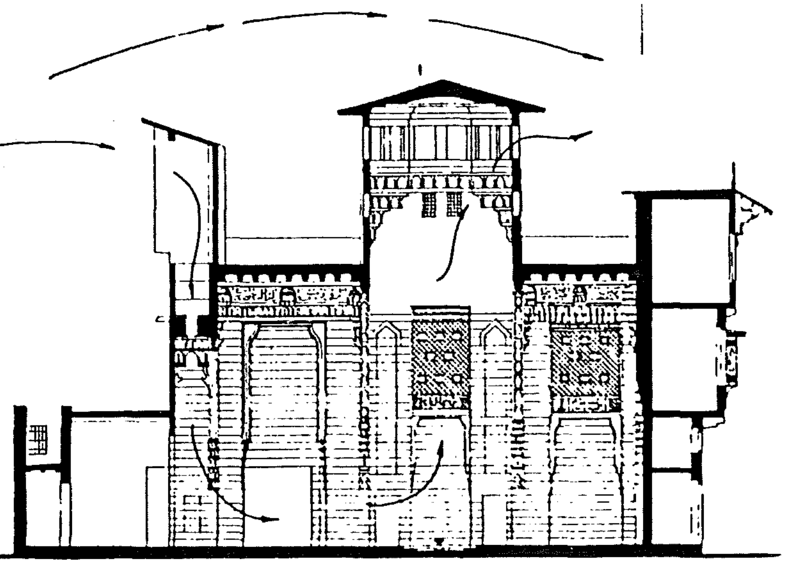
The temperatures on the beach (station A) are moderated due to the proximity to the sea. During the daytime while there is a sea breeze the temperatures on the beach are one or two degrees lower than at the interior. stations, but at night while the land breeze is predominant the temperatures of the three land stations are much the same. The relative humidity is about 10% higher on the beach during the day than at the two stations further inland though they are much the same at night.

The beach micro-climatic area would seem to be more comfort- able than the other areas since it has a somehwat lower daytime temperature, but the fact that it also has a higher relative humidity tends to keep the condition above the comfort level.

Air movement thus becomes the most important factor in attaining comfort conditions. With air so heavily laden with water vapour it quickly becomes saturated, and little evaporative cooling on the skin's surface can take place unless air next to the skin is continually replaced by air movement. Air movement due to the onshore/offshore effect is quite strong during the daytime especially on the beach, where the breeze off the sea is unobstructed. The wind's velocity is reduced through the planting belt, but is still a factor in cooling. The effective temperature or the apparent temperature felt on the skin's surface after evaporative cooling aided by the air movement, is within the comfort zone on the beach front. For some hours of the day in the other two inland areas the effective temperatures still exceed the comfort limits.



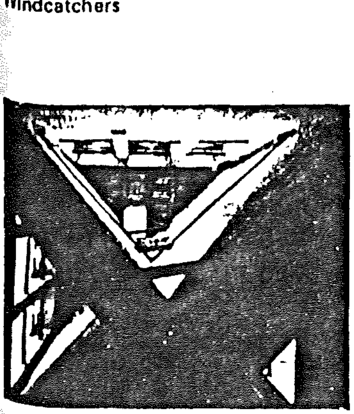




Uni-directional windcatcher. Ka Mohib al Din, Old Cairo.

Wind catchers.

Windcatchers



Looking up the shaft of a multi-directional windcatcher.

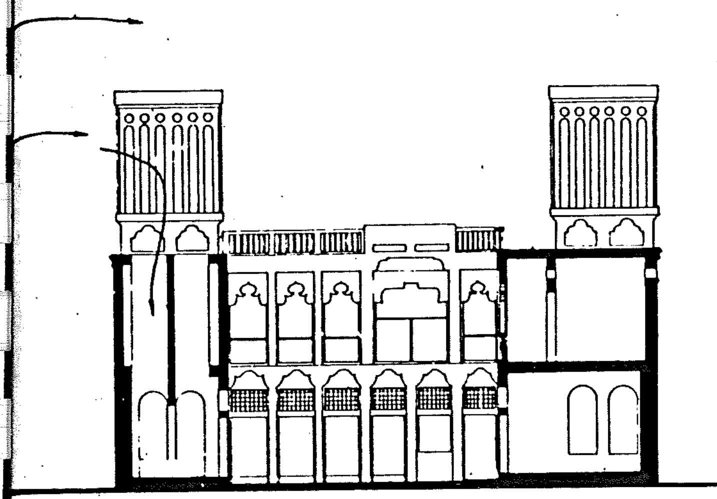
The wind catcher or wind tower as an element in the traditional house form can be found in settlements ranging from the Sind region in Pakistan, through Iran and Arabia to Egypt and North Africa. Its design form varies from region to region according to climatic conditions. In general, their use proves advantageous in hot regions where air movement can provide some degree of cooling, just as air passing over the skin's surface helps the body to lose heat through evaporation.

As shown graphically, the wind catcher, in having its intake as high above ground as possible, obtains air which is cooler and cleaner. This is even more important in dense urban areas where breezes are inhibited at ground level and the air is hot and dusty. The wind tower must be high enough above the roofs to catch an unobstructed high level air stream. It is usually oriented so as to catch favourable breezes. For example, the Egyptian wind catcher (Malkaf) has a scoop-like form and those studied in the old quarter of Cairo usually faced north to intercept the breeze off the Nile from the Mediterranean. The catch is one-directional, since winds blowing from other directions are from the desert and are hot and dusty.

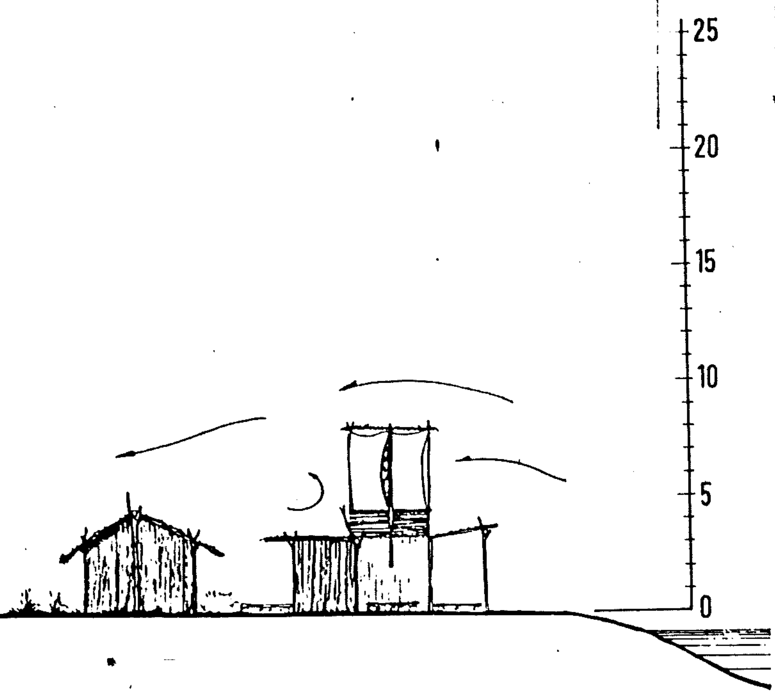
It became apparent in Cairo after making tests on the wind tower throughout a daily cycle, that its function is not dependent purely on the wind's ability to force its way into the house. In fact, during the heat of the day, a breeze will tend not to enter the house, even if the catcher is open, because the air inside the house is already cooler than outside, the temperature inside being kept down by the massive loadbearing walls which retain much of the previous night's coolness. The cooler interior air is dense and has a higher pressure than the hot, lighter, exterior air. The walls keep the inside temperature constant at about the daily average; so that in the afternoon or evening, when the outside air does fall below that average, the exterior air's temperature and pressure relative to that of the interior has reversed and air flows freely into the house. Thus the wind catcher only functions when it is needed, and only encourages cooler air into the interior. The whole house functions to control the micro-climate within, and responds to the climate in different ways at various times throughout the day.

The design of the wind catcher itself is not the only consideration. The air outlet is just as important. While wind blowing from a single direction exerts a positive pressure on the front face of the building, it also creates a suction on roof and leeward wall. If exhaust openings are located in these areas, air will be sucked or drawn through the building. The section of the Cairo house illustrates how a raised section of the roof is employed as an air exhaust. Its roof is of light construction and heats up rapidly, thus heating the air underneath it. This warm air rises and escapes, leaving a low pressure area behind, which induces more air movement upward and outward.

Thus this one example in Old Cairo teaches us that the wind catcher design depended upon not only a consideration for the prevailing wind, but also upon



Multi-directional wind catcher. Courtyard town house, Dubai.



Cloth multi-directional wind catcher. Beach house, Batina coast, Oman.

the micro-climate within the building, influenced by the heat capacity of the building materials, as well as a concern for the effective escape of the exhaust air.

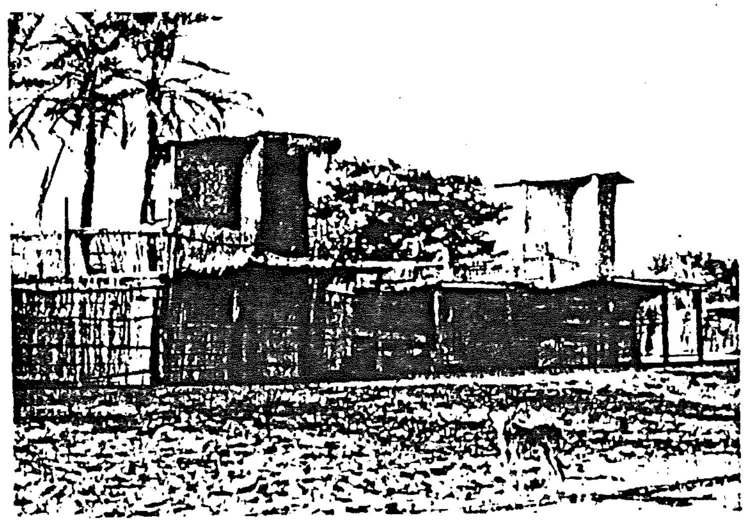
In Iraq, an ingenious solution to the problem of variable wind direction is the incorporation of a sail or fin-like projection into a pivot-mounted scoop, to keep it facing the wind at all times.

A simpler and more common solution to shifting winds is the multi-directional wind catcher ('badgir' in Persian) found in the Arab Gulf region and Iran. In urban areas, these towers are elaborately sculpted and decorated. A horizontal section through one of them would show an X configuration. Winds from any direction are thus admitted into the house. This kind of tower is found usually on the coast where land-sea breezes are in effect. During the day the wind catcher admits cool air off the sea, while at night breezes blow off the land. In cooler seasons, when air movement is not needed, traps are shut and the wind catchers' openings covered.

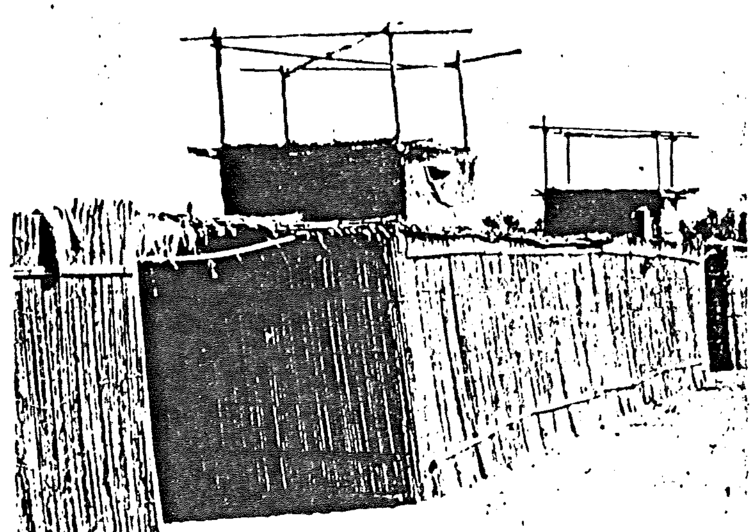
In rural areas, on the Batina Coast of Oman, cloth sails like wind catchers are used which have a similar X configuration to those of the Arab Gulf. These in some ways are more directly responsive to the climate as they are demountable and can be taken down and stored in the winter.

Some wind catchers are able to cool the air before it enters the building. Air is often drawn through a cool basement chamber, or across a bed of planting, before entering the living quarters. Evaporative cooling can be incorporated into the wind catcher in the form of porous water-filled jars, or mats of wet grasses. Hassan Fathy, in the design of a wind catcher for a school in his Gourna Village, used beds of wet charcoal for the air to pass over before entering rooms, and claims to have measured a drop of 10°C in air temperature.

With the costs of mechanical air conditioning remaining prohibitively high, the use of the wind catcher could prove advantageous today in many regions.

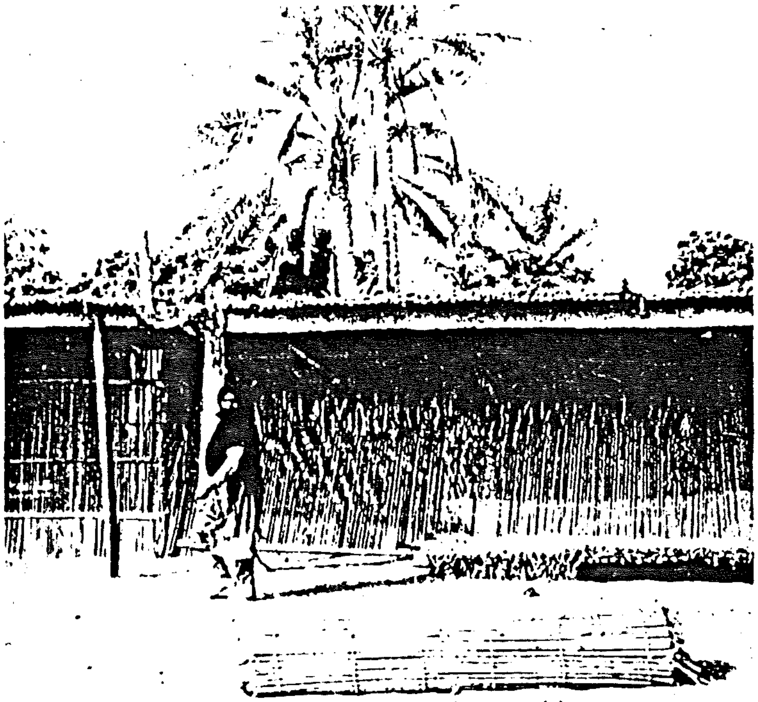


Cloth wind catcher

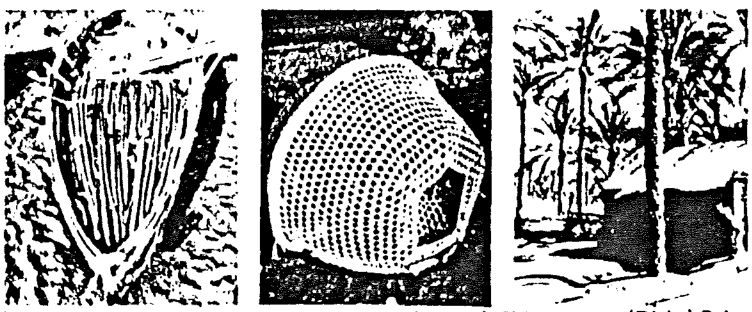


Cloth wind catcher

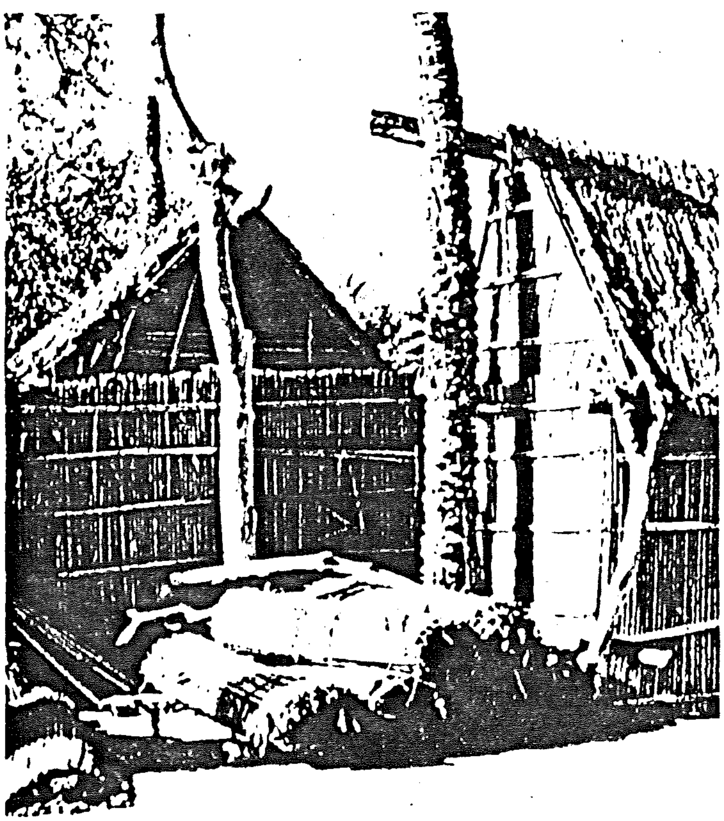
Palm frond stems as a building material.



The palm tree provides a readily available building material.



(Left) Boat made from palm frond stems. (Centre) Fish trap. (Right) Palm frond stem house in relation to material source.



Houses built completely out of palm stems, with rolled-up panels for extra use when needed.

Palm trees occur in varying forms and densities throughout the hot regions of the world, and represent for the community a valuable commodity, being used for providing food (dates/coconut), mat-making, boat building, fish traps, and, of particular relevance here, house building materials.

The palm tree trunks are often used for construction of the basic framework of a house, or as roof beams. But the palm frond stems are also an important building material, particularly in hot humid regions (mostly Coastal areas), where the combination of high temperature and humidity make air movement vital in achieving comfortable conditions.

The palm frond stems are used non-structurally, in panel/curtain-wall form, as light-weight screens which allow a free passage of air through them, whilst providing shade from the direct rays of the sun. As a material the stems are thus used efficiently to respond to the climate. Panels are also used as window screens, for privacy and control of light.

The frond stems cheapness as a material and ready availability make it, for many people, the only building material they can use. The poorest people use successive layers of panels for insulation against winter cold.

The stems can be used in a number of ways, even in some cases simply as a base for plastering. Construction is essentially very simple. A timber framework of vertical posts and beams is erected, tied together with string, (or with leaves in some countries). Houses are flat roofed or pitched. Pre-assembled panels are tied onto the framework to form the wall fabric, or, where the stem is not strong enough to support itself in pre-assembled panel, individu palm-frond stems are placed in lattice framework.

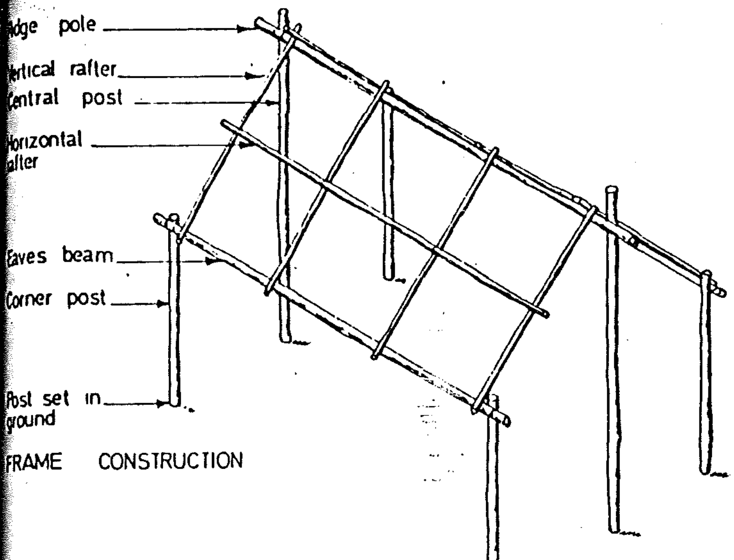
The panel types used va according to room use, ar allow the owner/builder to hav a degree of control in respon to climatic changes.

By far the greatest drawba to the use of palm fond stems the short life span of t material. Timber or palm fro stems have to be replaced eve 3 to 5 years. The princip reason for this rapid deterio tion is termite attack. T termite eats away the inside the materials, leaving a th film of bark to protect it fro the open air and rays of the su Eventually the strength of t material is lost and it collaps

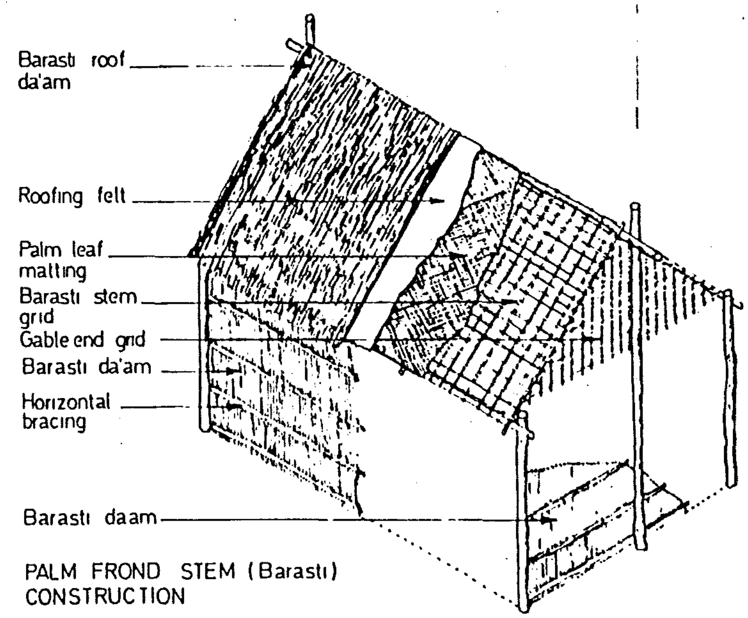
By using anti-termite shiel (the insects are unable to nego ate properly-designed inorgan overhangs) and by isolating t palm frond stems, and oth organic materials, from t ground, the life span can increased up to 15 or 20 year

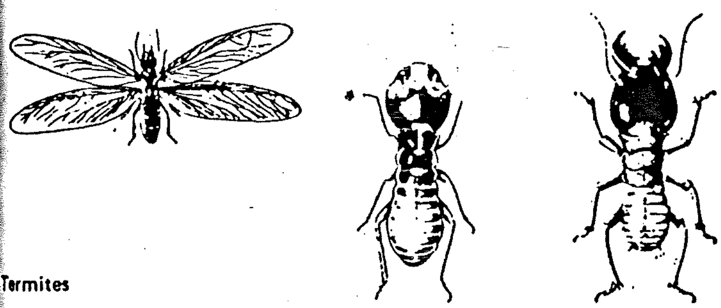
Fire is also a problem, espe ally in cooking areas. Palm fro stems burn easily, but the dang can be reduced by using no combustible materials in fire ri areas. Fire retardent paints an mud plaster both to varyi degrees protect the palm fron stem from fire. Althou mud plaster is the most efficie protection, it contradicts t palm frond stem's values f ventilation and light control.

Various tests have be carried out on the palm fro stems to evaluate its physic properties, leading to findi ways of improving its use an potential. There could, f instance, be value in using it reinforcement in simp elements such as lintols.

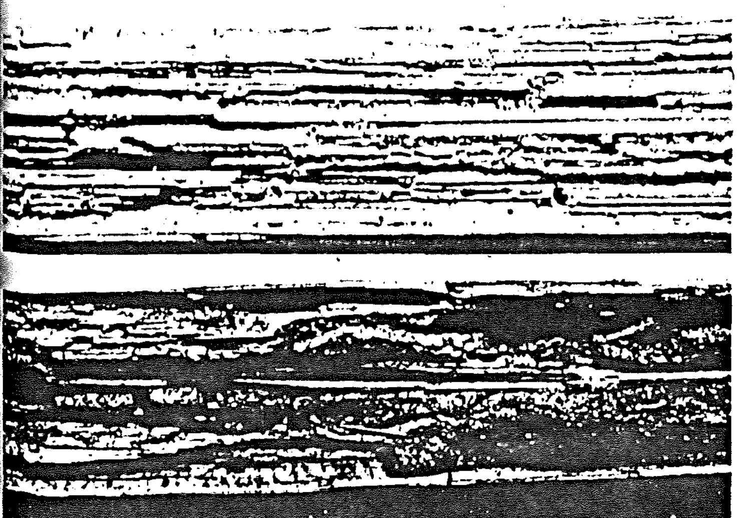


House construction

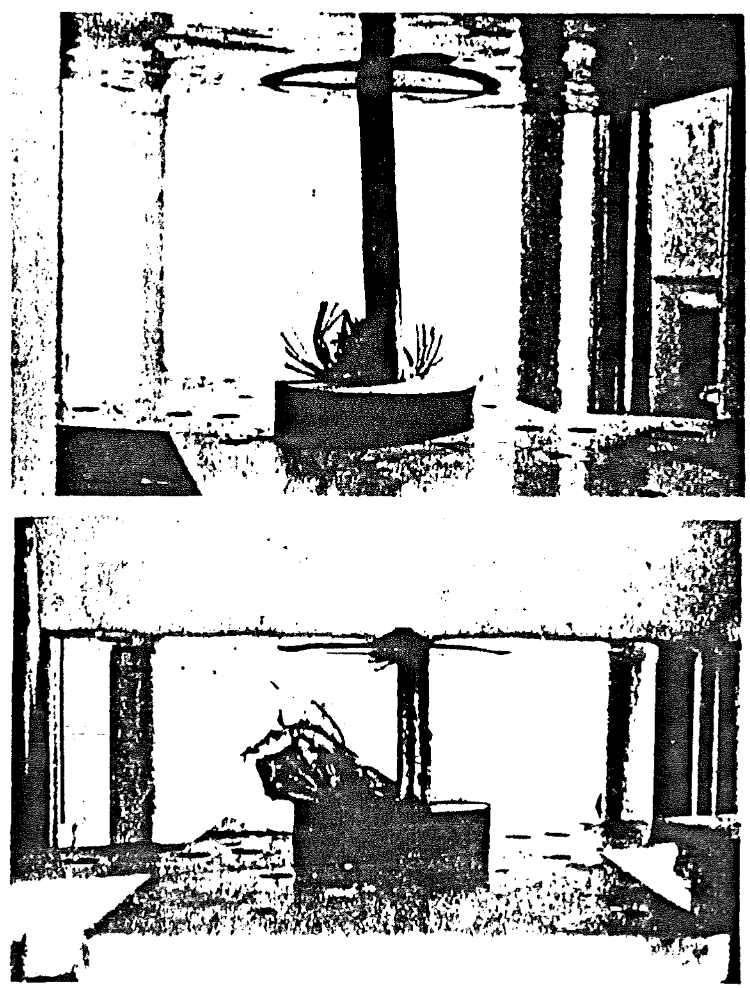




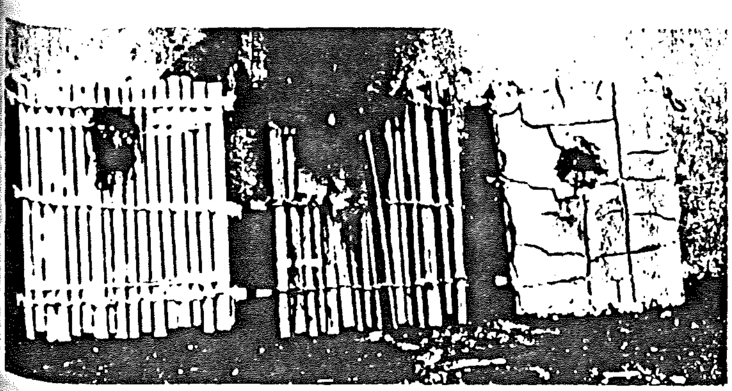
Termites



alm frond stems. Stem when attacked by dry wood termites (top) r by subterranean termites (bottom).



Wet palm frond stem under initial loading (top) and compressed to half its length (bottom) showing shredded fibre.



alm frond stems as a building material. Being tested for fire.

Openings

In general the functions of a window are firstly to permit light to penetrate the interior of a building in such quantity and distribution that a satisfactory interior illumination results, and secondly to provide a view of the exterior. However, in the case of hot countries in general, ventilation and the control of glare that results from the brightness of the exterior light, together with the provision of privacy, are all equally important considerations in designing the window opening.

These requirements in a hot country are commonly met by the use of screen walls which provide a latticed baffle to the exterior. The screen functions by making use of the contrast between brightness and darkness. In conditions where the intensity and brightness of the sun are great, the surface that the suns light falls upon will frequently become unpleasent to look at, a condition known as discomfort glare; where to look at a bright exterior particularly from a subdued interior causes psychological and physical discomfort. Under those conditions, with a large window opening presenting an unobstructed view, there would be such contrast that it would be a strain to look out of it. Screens made up in a lattice form provide a baffle between the interior and the exterior, so the brightness outside is broken up by the areas presented by the lattice in silhouette, which provides an area of darkness and compensates for extreme conditions in the direct open sunlight, achieving a comfortable average.

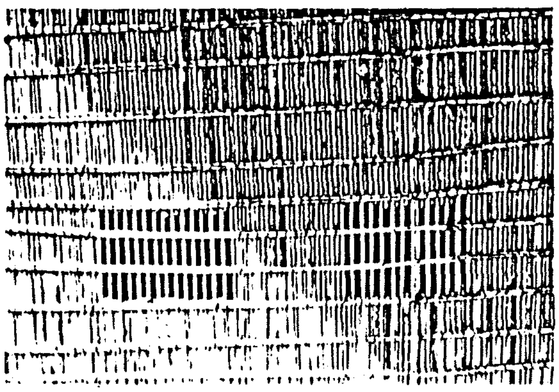
At the other end of the scale when the exterior is not very bright the contrast will be reduced and the eye is increasingly able to focus upon objects beyond the screen, ignoring, on account of the diminished contrast, the visual banner it previously afforded. It can be seen that at times when exterior conditions are visually unpleasant, the screen protects the eye from them, but with comfortable exterior light, it effectively disapperas.

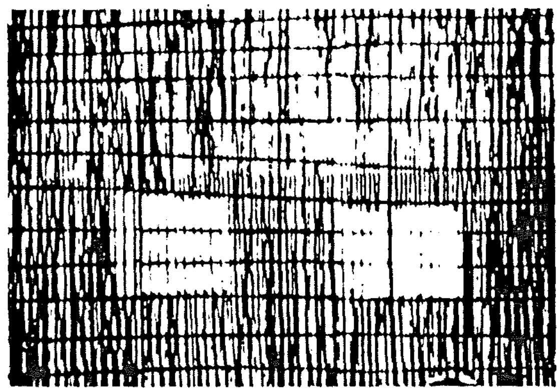
As well as the visual qualities for those inside looking out, the occupants will be in complete visual privacy, by merit of the fact that when looking towards the screen from the outside, the solid areas will be bright and in contrast the gaps in between will be dark, prohibiting a view of the interior.

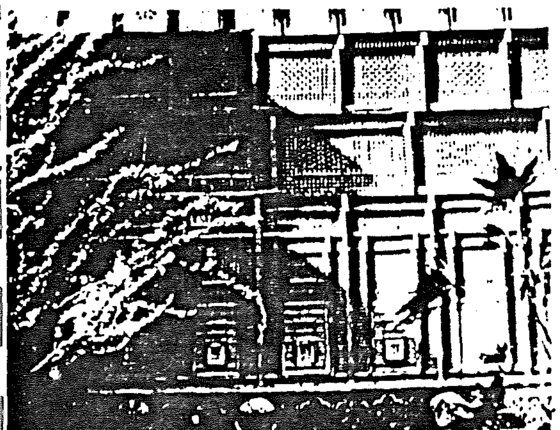
It is not sufficient to simply balance light areas with dark areas, since too sharp a contrast between the two will also cause discomfort. The transition between light and dark must be softened so that the eye can move gradually from one to the other without violent changes. This is achieved by the use – natural or manmade – of materials with a circular section, so that light fades off with the curve. These screens also allow a fairly unrestricted passage of air through them.

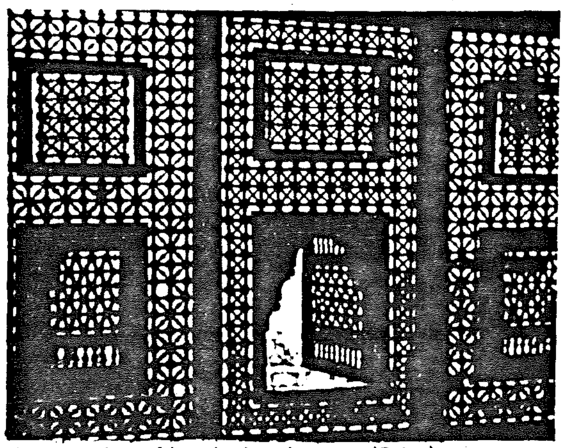
Palm frond stems achieve this effect simply and naturally, the stems being tied together, with their leaves removed, which results in alternating strips of solid and void. The high humidity in many areas where palm frond stems are used, has the effect that the sky is as bright as the ground, and the stem screen provides an equal baffle at all levels. Areas of greater opening can be made where the view is onto a darker object, and therefore not unpleasant to look at.

The craft made mushrabeya of Egypt functions in the same way, but in relation to the hot dry climate, the sky is darker and consequently a pleasant area to look at, whilst the ground is too bright. The response to this is that the screens are very dense at the bottom, but get more open at the top, allowing a view


Exterior view of palm frond stem screen. The interior appears to be totally dark. (Oman).


Interior view of palm frond stem screen, which filters external brightness. (Oman).


Exterior view of 'mushrabeya' screen. (Cairo).


Interior view of 'mushrabeya' screen. (Cairo).


Palm frond stem screen detail. A smooth transition between light and dark areas is achieved by curved section of the material.


Detail of 'mushrabeya' screen.

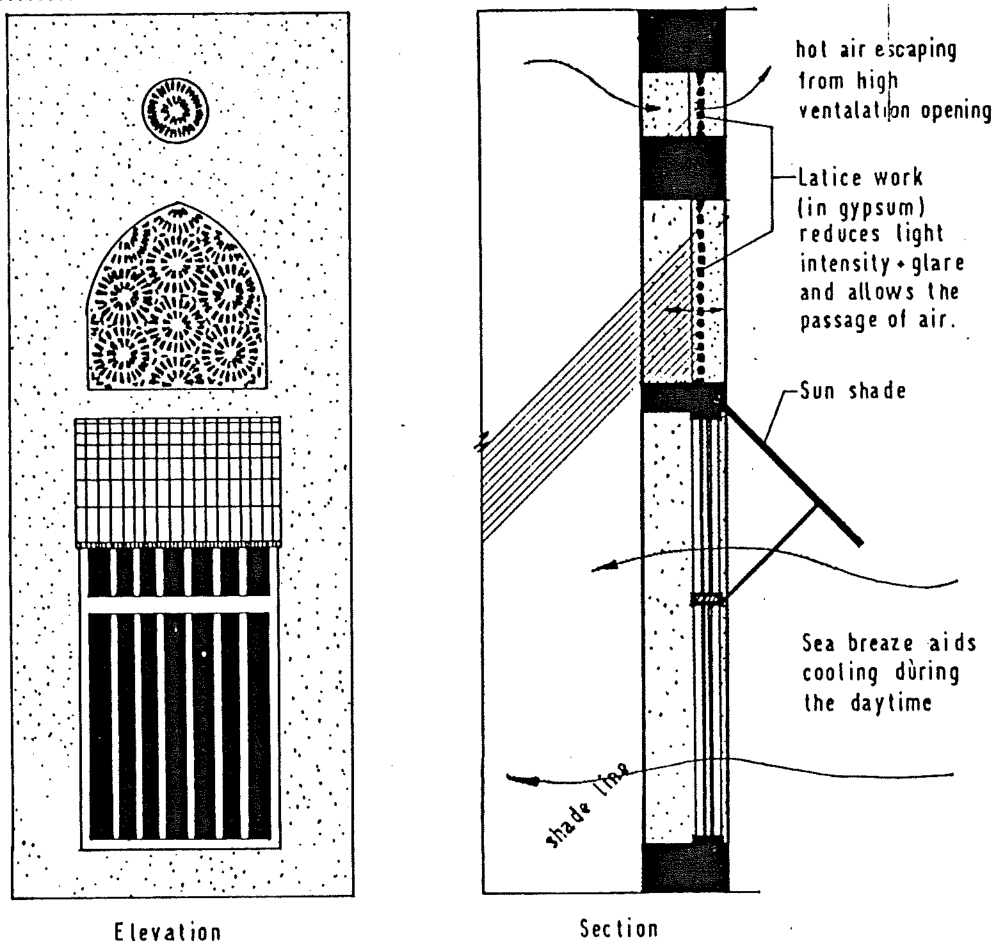
of the sections of the exterior which are comfortable. The mushrabeya is made up of tiny pieces of lathed wood, pieced together to form an intricate screen. Both types of screen are well suited to the climate they are in.

A development of the window as a ventilating screen (whilst still letting in light) is the multi-level openings, in this case as found in Muscat Oman. The function of these windows is not clearly seen without an understanding of the climatic performance of the whole house. Where the walls of the house are sufficiently thick and have a good thermal capacity, the temperatures of the walls internal surfaces remain relatively constant throughout the day.

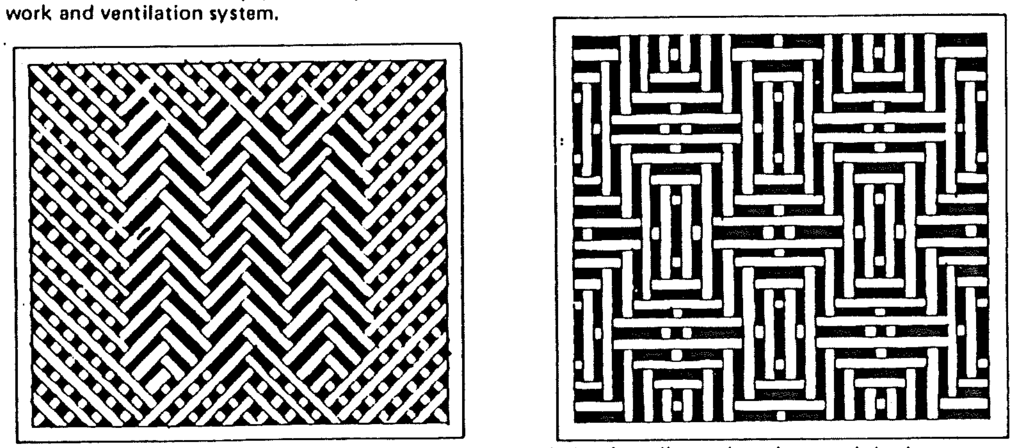
The outdoor temperature fluctuates throughout the day and for some times it will exceed wall temperatures, and others it will be lower. In the hot season it is therefore advantageous to isolate the dwellings interior from outside air temperatures when the wall temperatures are below air temperature by closing the window shutters. When wall temperatures exceed air temperatures window shutters are opened to equalise indoor and outdoor air temperatures. On the other hand, during the hot season when the air is humid, air movement must be encouraged to aid the bodys cooling system. Windows must be designed so as to allow the passage of air into the building when it is advantageous, but to exclude solar radiation which would raise the indoor temperature. Shading devices such as the wooden 'awning' type are also used.

As with the two types of screen already described, the multi-level opening also incorporates lattice screens, usually at the top of the opening to shield the brightness of the sky. Small openings near the ceiling also allow the rising warm air to escape out of the room.

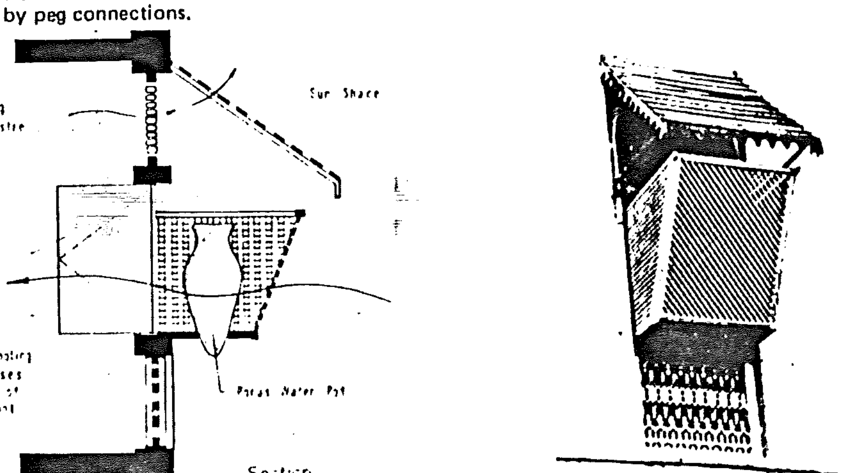
Some windows also incorporate an elaborate cooling system, where a porous water jar is placed in the opening so that air entering the room passes over it. Water seeps through the surface of the jar, and in the process of evaporation causes the jar and its contents to be cooled. This cool area consequently reduces the tempera ure of the air that passes over it.



Window details from Najwani house, Mutrah bay front. Multi-level openings, showing function of lattice work and ventilation system.

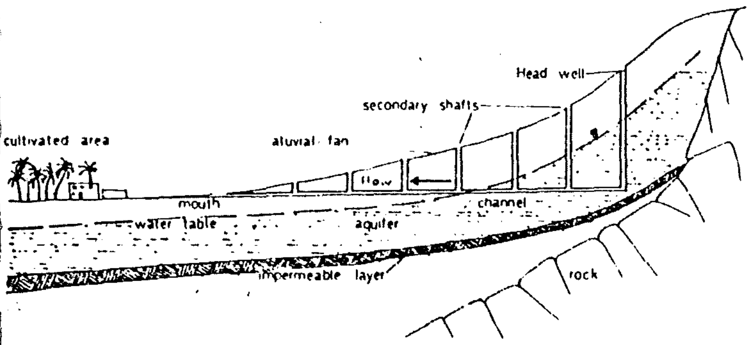


Lattice windows from houses in Muscat town centre. Made of small wooden pieces each having a square section, fixed by peg connections.

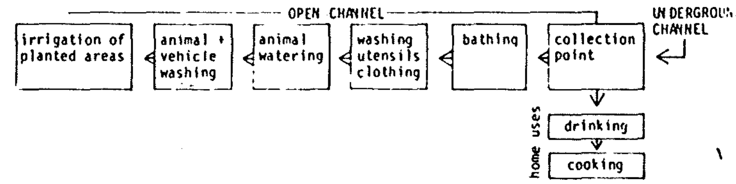


Bait Mughub, Muscat. Window detail incorporating evaporative cooling system

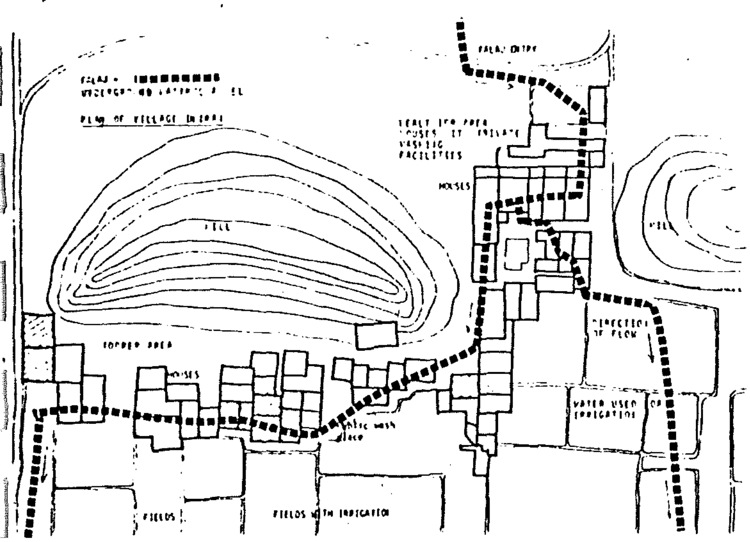
Water supply



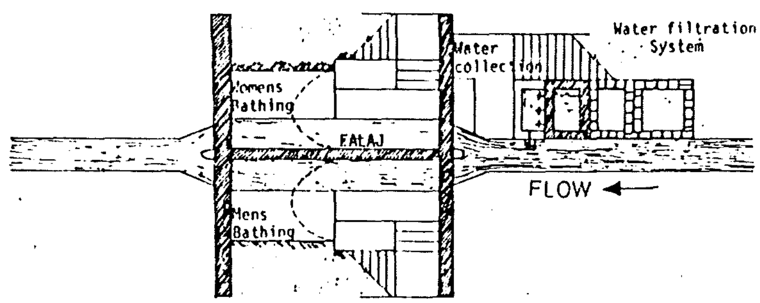
Falaj — water supply system



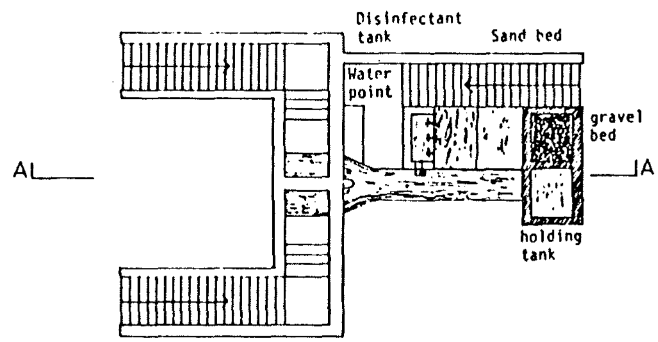
Falaj water distribution.



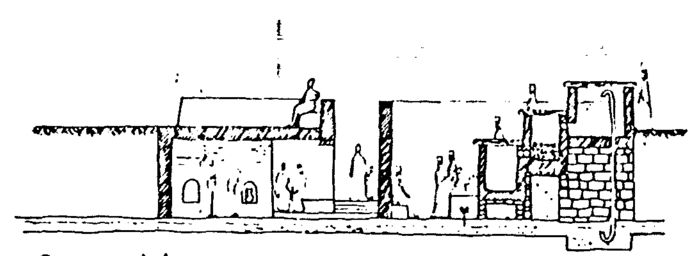
Plan of Iranian village with hierarchical use of water channel system



Falaj Level Plan



Ground Level Plan



Falaj Section A A

Falaj — water purification and bathing area improvements.

Falaj. Note that drinking water is supplied in jars to protect people from contaminated water.

Domestic bathing area.

ilability of water is a prime ermining factor for settle- nt since agriculture and nans require sufficient pplies of fresh water. In areas ere average annual rainfall is ularly less than 100mm, ter must be obtained from ow the surface of the ground.

One method of obtaining ter has been developed in ious Middle Eastern ntries, the Falaj (Oman), Qanat (Iran). The system olves the tapping of the ilter or water table in high und or hillsides, and bringing water down through man- de underground channels to cultivated areas in the valleys d plains. Vertical shafts are to allow access to the nnel, used in the original avation and for maintenance the horizontal channel. By ng a horizontal channel, the ter is easily brought to the as of settlement and agricul- e. The underground channels noted for their reliability.

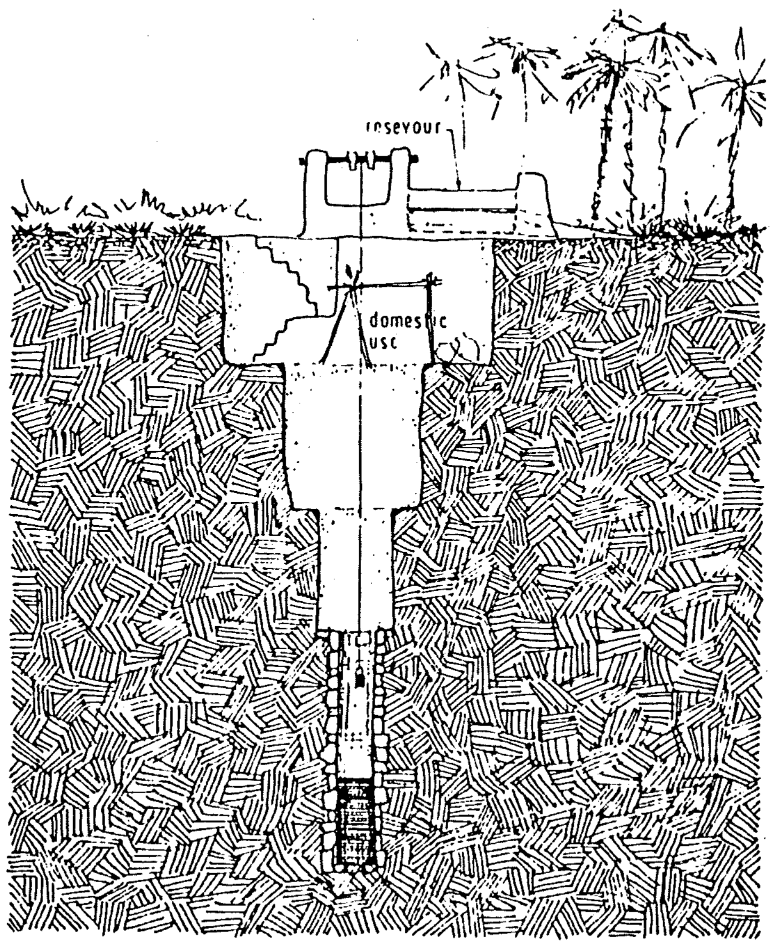
The actual distribution of laj water is organised in such a y as to minimise the chance contamination. A definite ear utilization is held to, as e water flows through the tlement, ensuring clean water drinking before con- mination by washing and imals.

It can be seen that drinking ter is always taken from the alaj' at the point that it erges from the ground. ater is often collected from s point and deposited in pots rther down channel, for blic drinking,. Some houses richer families (in the best sitions) have private wash eas built over the channel, t washing for the poorer embers of the community is one in public wash houses. ater is also distributed to ivate plots of land in return a proportionate tax, the oney from this being used for ch things as educating the ildren. Improvements in the erarchy of water use and the sign of facilities, is often ecessary, and an outline ggestion is shown here. Sand lters and disinfectant tanks can e introduced for purification, nd the organised sequence of e (such as the design of public thing facilities) can be refined n conjunction with education in alth and hygiene.

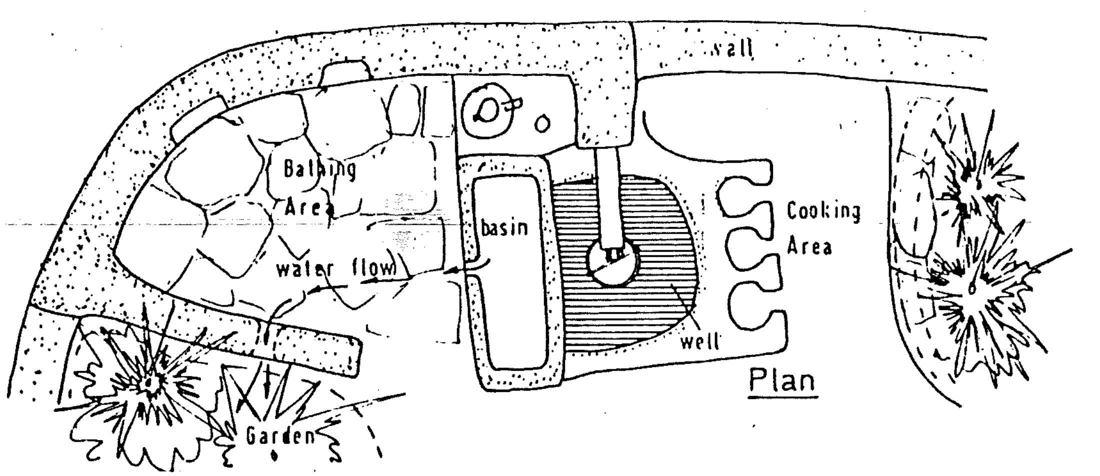
In town centres it is not always possible to have direct access to a water source, so drinking water is sometimes distributed by tanker. Water is also obtained from wells, but because the water table is usually at great depth, a great deal of energy is expended in raising the water (by hand or animal power). To facilitate this and initial excavation, wells are often built in a series of steps of decreasing diameter for people to descend the shaft.

Domestic indoor washing areas should be designed in such a way as to conserve water. Indigenous examples demonstrate the concern to cut down wastage. The example here shows an integrated drinking, cooking, bathing and washing area. The water runoff from washing is used to irrigate a fruit tree.

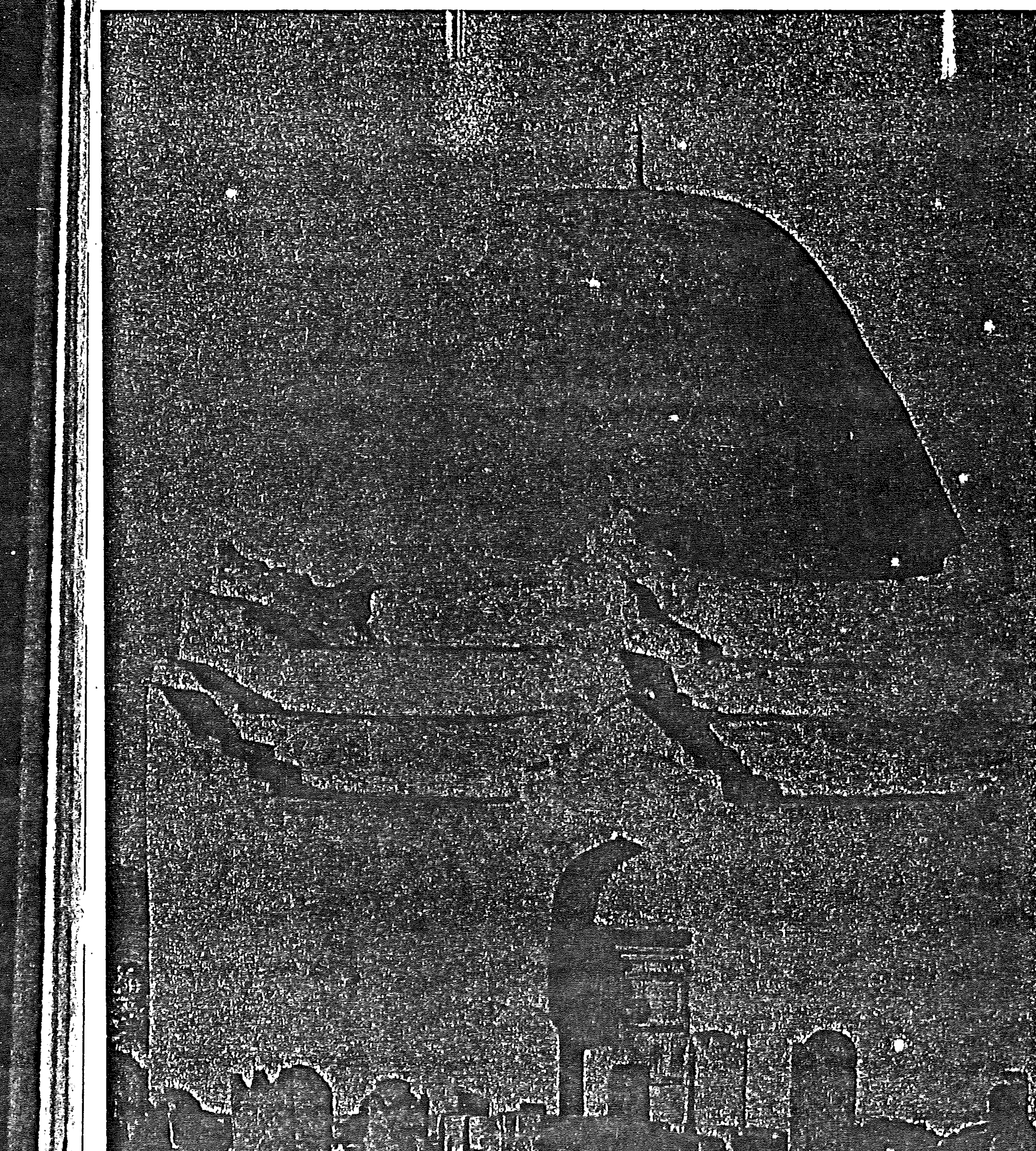
This example illustrates how washing areas and water use in general can be designed to harmonise with traditional customs, and yet be acceptable in health terms and inexpensive and simple to construct for the average house owner.

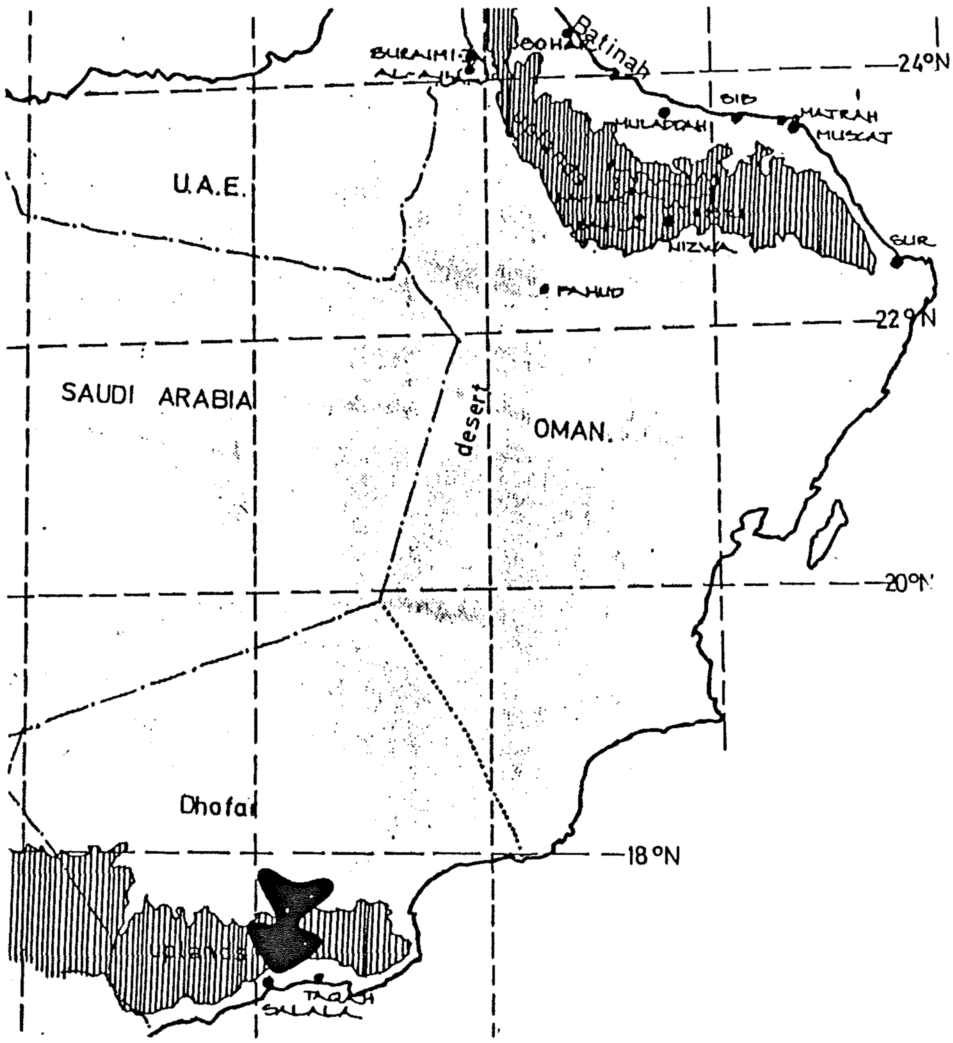


Stepped well.



Washing area for Nizwa summer house.





SALALA

INDIGENOUS BUILDING AND RAPID URBANISATION:

A CASE STUDY OF SALALA IN SOUTHERN OMAN

Authors:
Allan Cain, Farroukh Afshar, John Norton.

The authors are co-ordinating the Development Workshop in the AA. They have undertaken work in Oman and Egypt as well as other developing countries. The Development Workshop at the AA concerns itself with Indigenous building methods as they relate to developing countries.

Left: Mosque in Salala

The purpose of this case study is to look at a traditional settlement and analyse the influences, both environmental and socio-economic, which produce its characteristic built environment. The patterns are seen through its settlement and the forms into which the houses have evolved. The question is asked whether these forms are valid today when such traditional centres are experiencing economic changes and rapid urbanization. Salala, a traditional trading town in Oman, has experienced recent rapid change along with the rest of the Arabian Peninsula, but more particularly has a refugee problem as a result of the guerrilla war in Dhofar.

Salala is the capital of Dhofar, a province of Oman, on the Indian Ocean coast of the Arabian Peninsula. Ruins of a city dating back to pre-Islamic times have been found in the neighbourhood of Salala. History has shown the present town to have been an important port of call on the dhow routes connecting Zanzibar and the African coast to Muscat, the Gulf, Iran and India. Salala was also a centre for the export of gum arabic - frankincense - for which the Dhofar hills were once famous.

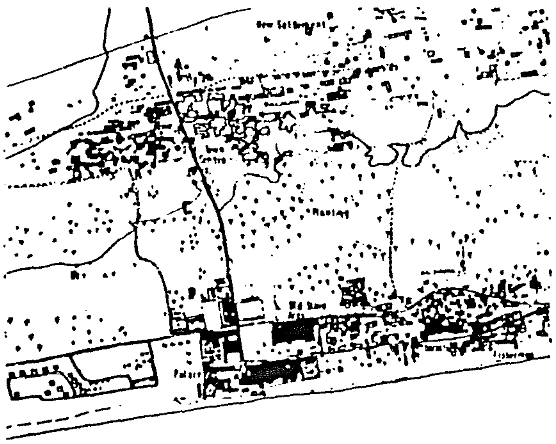
Although there are similarities between the Dhofar coast and the rest of Arabia, its terrain and climate are unlike most of the arid Peninsula. While Dhofar is far removed from the main path of the Indian Ocean monsoon it still feels its influence; the coastal hills, with a limited rainfall, are green with vegetation for parts of the year, and the towns on the coastal plain experience a heavy mist in summer.

In the past the population was divided between these two regions - the coastal plain and the hills. The coastal inhabitants were sedentary, and divided themselves into groups ranging from administrators, such as the local Governor (and at times the Sultan who has a palace in Salala), through merchants, to farmers, fishermen, and finally the slaves who had been brought from Africa at the height of Oman's era of power in the Indian Ocean. The hill people (Jebbelese) on the other hand were mostly herdsmen, subsisting on their cattle and any trade which grew out of selling cattle and gum arabic. Because of their basic poverty and reliance on a single economy little specialization developed in the hills.

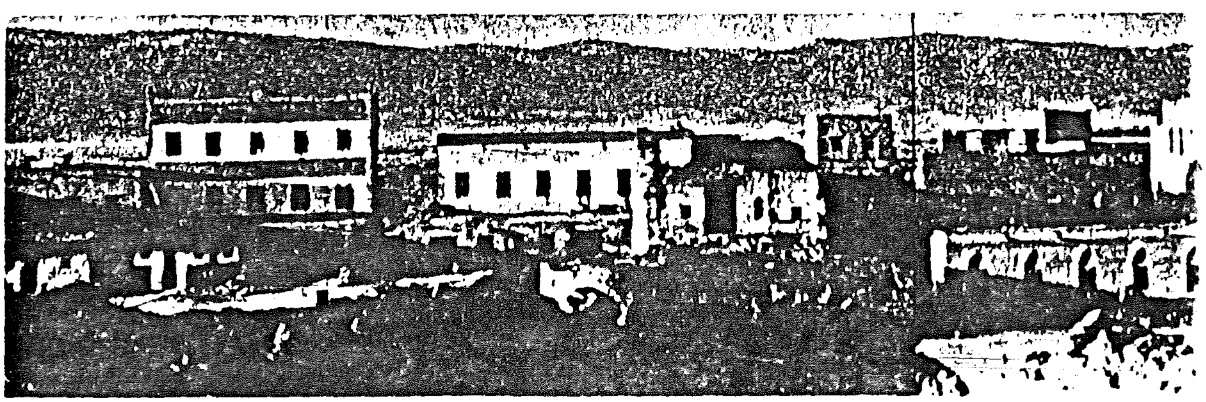
The economy of both the coastal townspeople and the hillsmen relied to a large extent upon trade between the two groups. Because of the seasonal rainfall pattern the hills were only green for part of the year, so that cattle grazing was impossible for the remaining time. During the dry period the herdsmen were dependent upon the merchants on the coast for buying dried fish for fodder.

Off the Dhofar coast there are excellent fishing grounds, where the main catch is sardines. Many of the inhabitants of the coastal areas were involved in seasonal fishing and agriculture. In the towns, some of the merchants, owning larger boats, engaged in fishing on a greater scale. The main catch was taken during the winter, and the sardines were then spread on the beach to decompose and dry. For months the distinctive odour of rotting sardines hung over Salala. Afterwards oil was collected and exported to the Gulf; and the dried residue was either used as agricultural fertiliser or sold by the merchants to the hillsmen as fodder to tide them over the last few months of dry weather before the summer rains. The merchants and townspeople would in return have a continual supply of meat to supplement their basic fish diet. The merchants also exported the gum arabic, gathered by the Jebbelese, to India.

Settlement on the coast followed basic economic patterns. Fishermen lived on the beach so that their boats could be hauled up in front of their houses. Behind the beach lay the palm planted belt where



Above left: Settlement patterns Salala. *Above right:* Coconut palm stems are important as a building material near the beach. *Below:* Townscape of old centre.



A framework of hardwood sticks or palm stems is the supporting structure for the walls. Leafy palm fronds become the screening material.

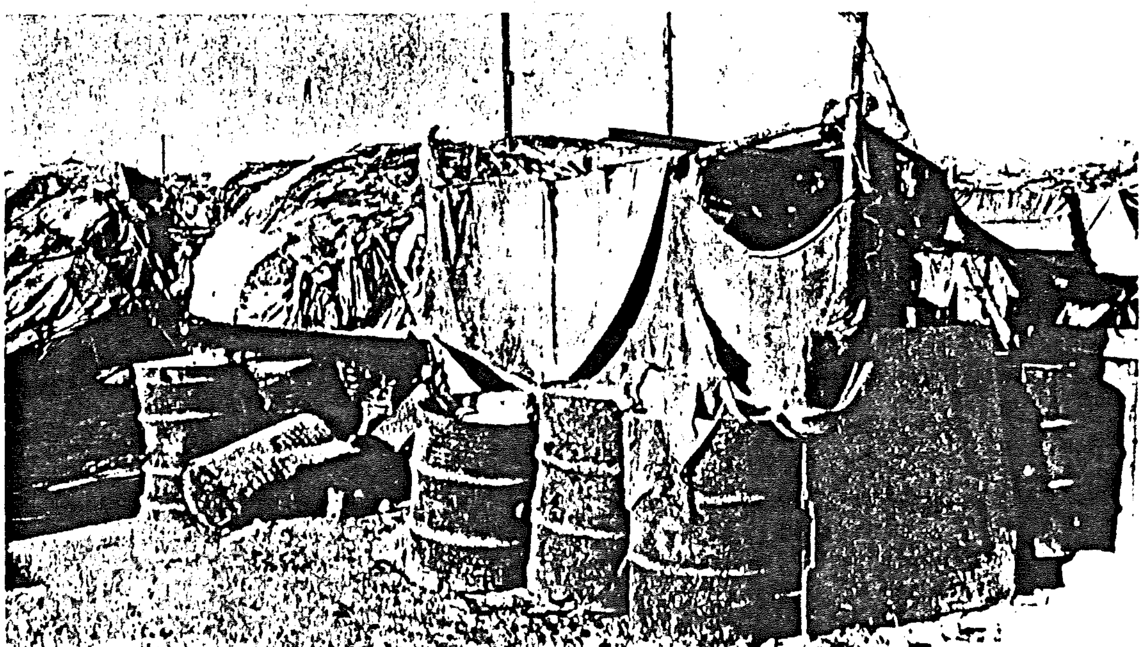
most of the agriculture was carried out. The Sultan's palace, surrounded by the huts of his household slaves, the Suq (market) and administrative buildings, such as the customs house, were also grouped near the beach. Further inland the merchants lived in the town centre of Salala. Within the town itself the settlement pattern followed not only economic, but tribal lines; tribes grouped into areas each presided over by the local leader or Sheik. The tribal distinctions within the town of Salala itself often mirrored the tribes of the hills, but members were involved in trading rather than herding.

The settlement pattern of the coastal plain also responded directly to the particular micro-climate of the coast. The daytime onshore and night time offshore wind system found in most areas near large bodies of water is felt in Salala. Winds of any kind are welcome in the hot humid season. Air movement is essential to aid the body's evaporative cooling mechanism. Houses have been built and the settlement organised in such a way as to take these factors into consideration. Near the beach and in the nearby palm planted belt, peasants and fishermen have built their houses of palm stems. Screen walls are constructed of this material and allow air movement through, while maintaining a high degree of visual privacy. The loose matting also softens the light and reduces the glare from the exterior. Further inland the merchants demand a more substantial house but still experience the heat and humidity of the beach dwellers. Here limestone is the basic building material. Its thermal capacity, though regulating the heat, is really only an advantage in the somewhat cooler winters. Here the micro-climate has been controlled through the layout of the settlement and the design of spaces between and within the houses. Because it is essential to encourage air movement, houses are situated in a way not only to accept the maximum breeze but also so as not to block air movement to neighbouring houses. Ideally each inhabitant would chose to build his house where there are no obstructions between it and the southern sea breeze exposure, so that air could reach the front of his house with maximum velocity. Any obstruction of the wind produces a 'wind shadow' behind it where velocity is reduced. Town houses in Salala were sited with this in mind, and each house is built beyond the wind shadow of the neighbouring house. Included in the plan of most town houses in Salala is a large front yard, which ensures that building is not carried out immediately upwind of the house. There were no formal roads in Salala's town centre as the wide spacing provided ample room for movement.

Not only the settlement but the house has evolved along climatic lines. The traditional courtyard house found in most tropical regions has been adapted to Salala's particular climate. The Salala town house makes use of the inward looking courtyard's cool air well to trap night time air, as well as presenting an open faced south wall pierced by many openings to accept the cooling sea breeze.

The evolution of the courtyard house also reflected the patriarchal social and economic structure of the family. The head of the extended family was, as well, the director of the family business. The rest of the family were economically tied to him and lived under the same roof. Thus as the extended family grew, so did the house. The existing town houses reflect the accumulated growth of many generations.

Hence, within the indigenous settlement of Salala one can see how its form and process of growth over many years has been in response to environmental factors such as climate as well as social and economic influences. This is true for most indigenous settlements which have grown largely without a predetermined master plan.



Refugees have become squatters in the old Town Centre of Salala.

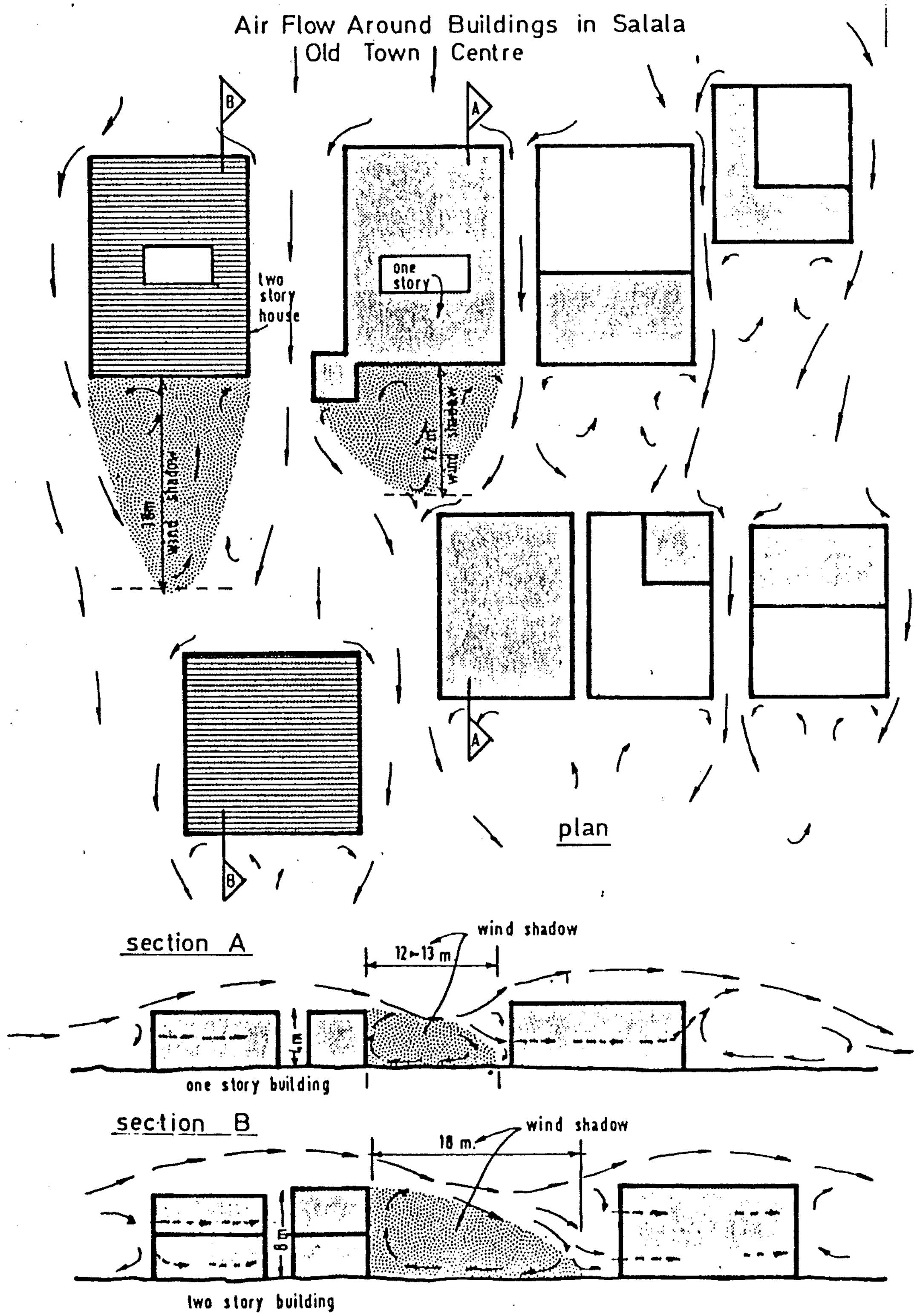
But today with the concentration on growth within urban areas the economy of these traditional centres has changed. Rapid urbanisation has been accompanied by huge population increases with its related environmental and health problems. The investment in non-traditional industries has been detrimental to these old centres and the rural areas. The depopulation of some rural villages has gone hand in hand with overpopulation and overtaxation of resources in the old town centres. These centres have rapidly turned into slums, providing cheap accommodation for those looking for employment in the new industries which have grown up around or outside the old quarters. Salala today is an example of some these changes, though seen on a much smaller scale than in Cairo or Delhi.

The discovery of oil in Arabia is basic to the economic change. Young men left Dhofar for Saudi Arabia and the Gulf to find employment in the oil fields and now return, after a few years, with their wages. Permanent emigration is not the rule, and migrant workers usually send money home periodically, or save up their earnings towards an investment in a house or a small business, which, on returning, will allow them to remain in their native town. The other factor which has strongly influenced Salala is the guerrilla war, which began in the hills in the mid 1960's and continues today. Salala finds itself cut off from its hinterland, and consequently the traditional trade relationship between the townspeople and the herdsmen in the hills has died. Many of the irrigation canals which once watered large vegetable gardens and palm groves are blocked and agriculture is in decline.

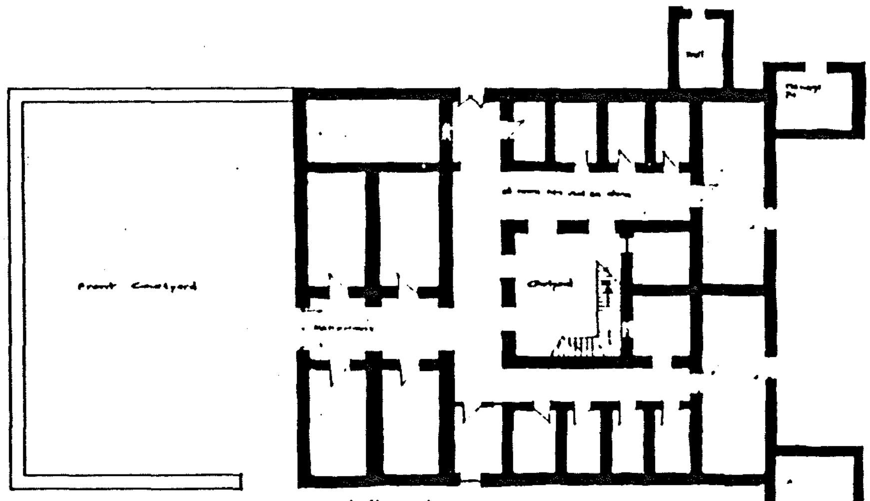
With grazing land in the hills burned and the hillspeople's economy destroyed, large numbers have moved down to Salala in hope of staying with kinsmen there. Overcrowding in the old town centre is the result. Refugees from each tribe from the hills try to settle in their corresponding tribal area in the town. The existing settlement pattern, depending on openess for ventilation and climatic comfort, can not accommodate an increased building density. Squatter settlements have established themselves in the open spaces, with all the associated problems of sanitation and hygiene. Bedrock only a few centimetres below the surface makes sewage saturation of the soil an added problem.

The destruction of the traditional economy has also affected the merchant families of Salala. The economy no longer rests in the hands of the heads of families. Most of the money is with the young workers who have returned from the oil fields. This shift in economy is also felt on the social level, with the change in the structure of the extended family. Now it is common for a young man to build his own house rather than live in that of his father. Several young brothers may pool their resources and labour to begin building a home. It is usual for one of these young men, on returning to Salala, to secure a small plot of land either privately or from the municipal government and begin building immediately. This group differs from the squatters because they have rights to the land on which they are building, and more importantly they have money to invest in building. Not only are workers from the Gulf oil fields in this group of owner builders but also those who are fortunate enough to have jobs with foreign contractors, in the local administration, or on the British air base.

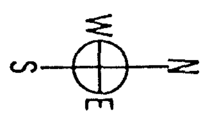
Problems of high density and those relating to health and hygiene are apparent.

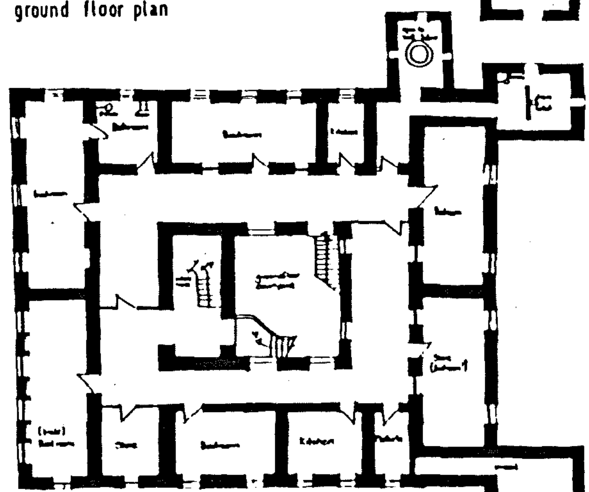


Tests were carried out using portable meteorological equipment, in order to establish the relationship between air movement and the siting of houses. (Arrows indicate air movement).



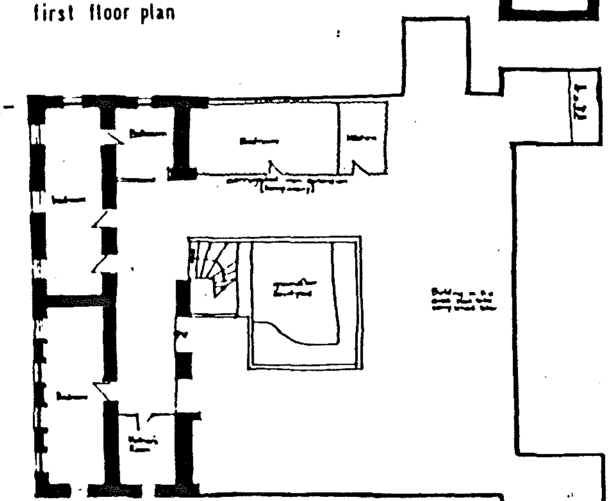
ground floor plan





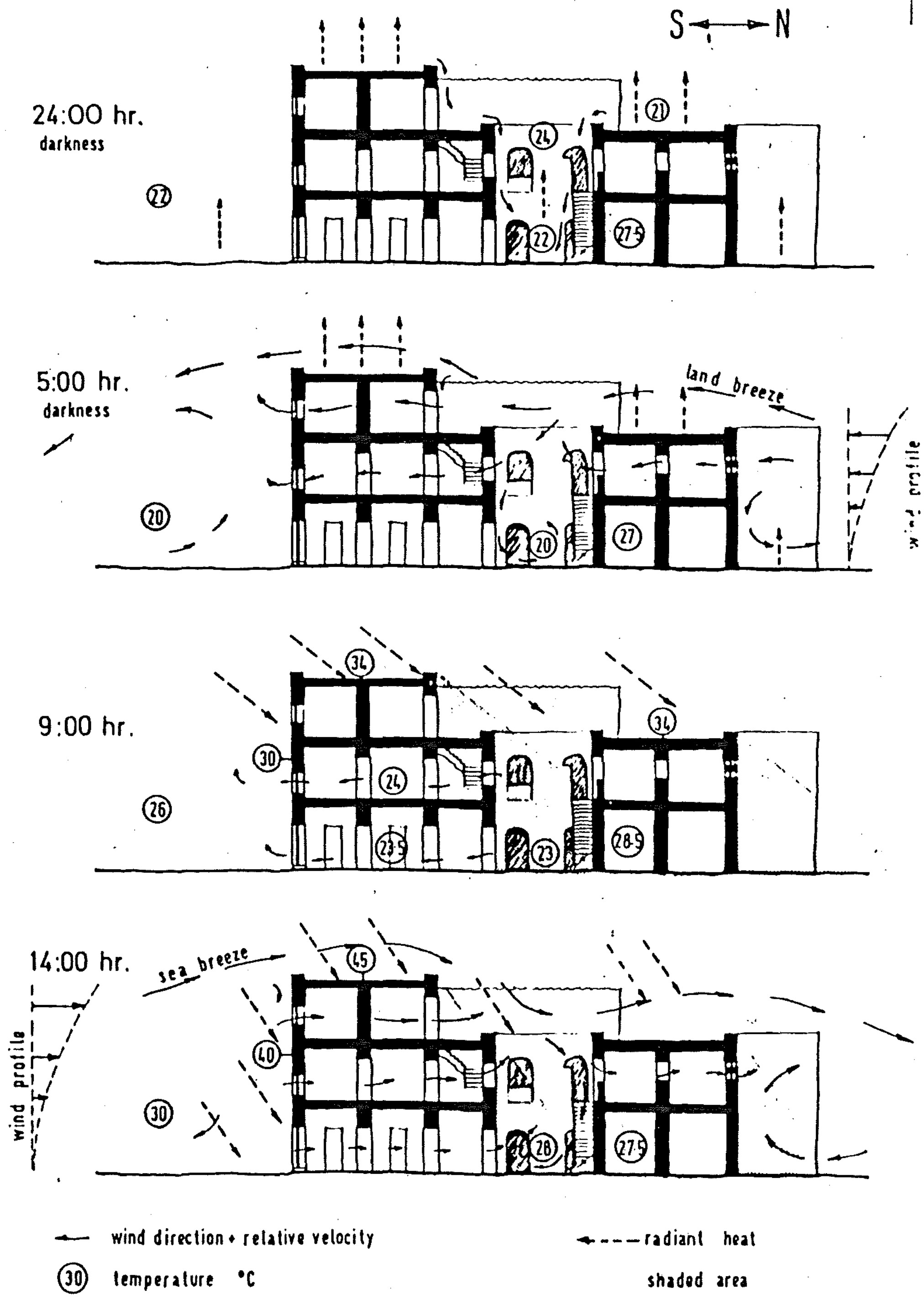
first floor plan

Courtyard house in Salala old town centre. 60-80 years old. Limestone construction. Extensions still underway. Inhabited by extended-family of several brothers.



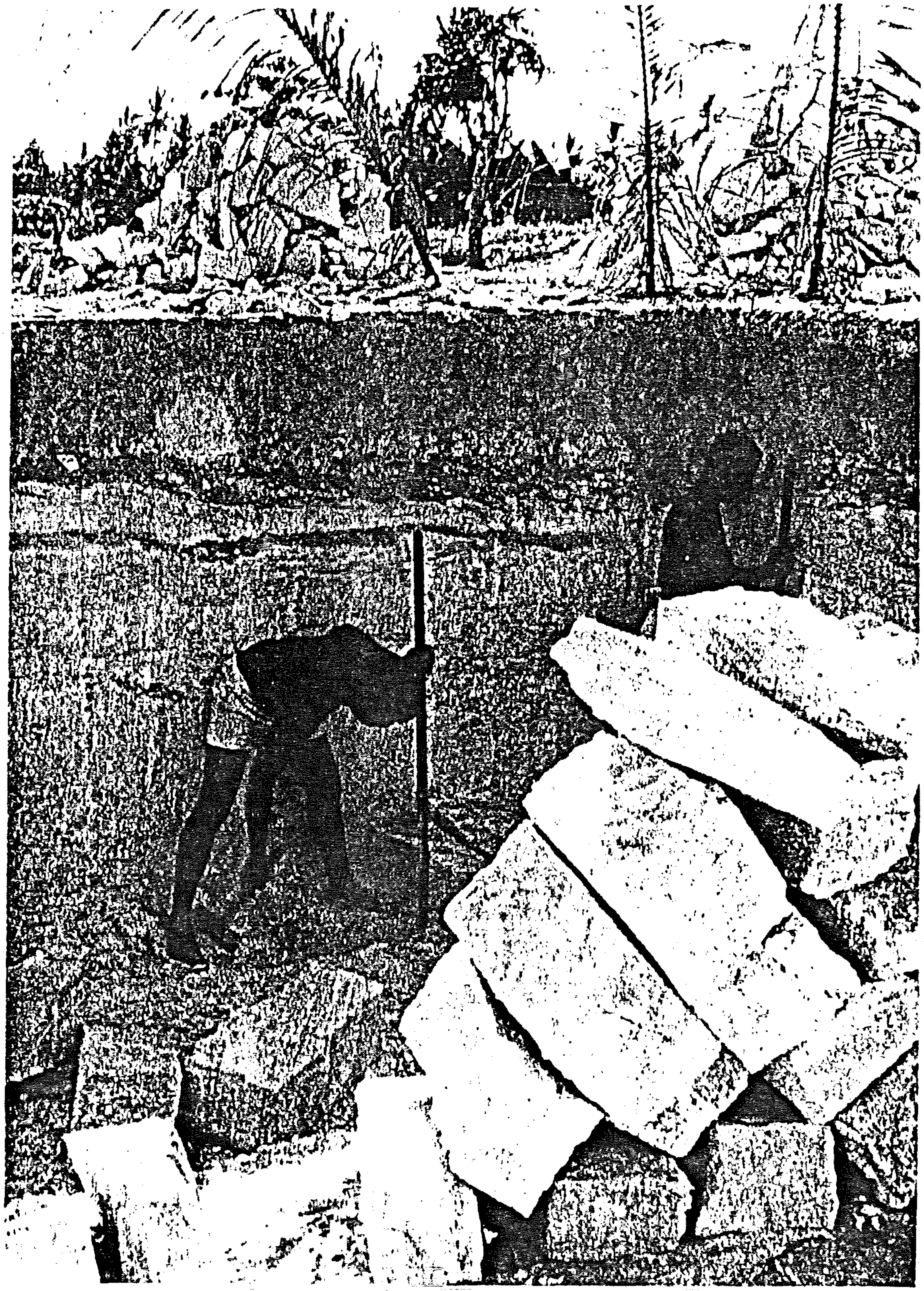
second floor plan

between air

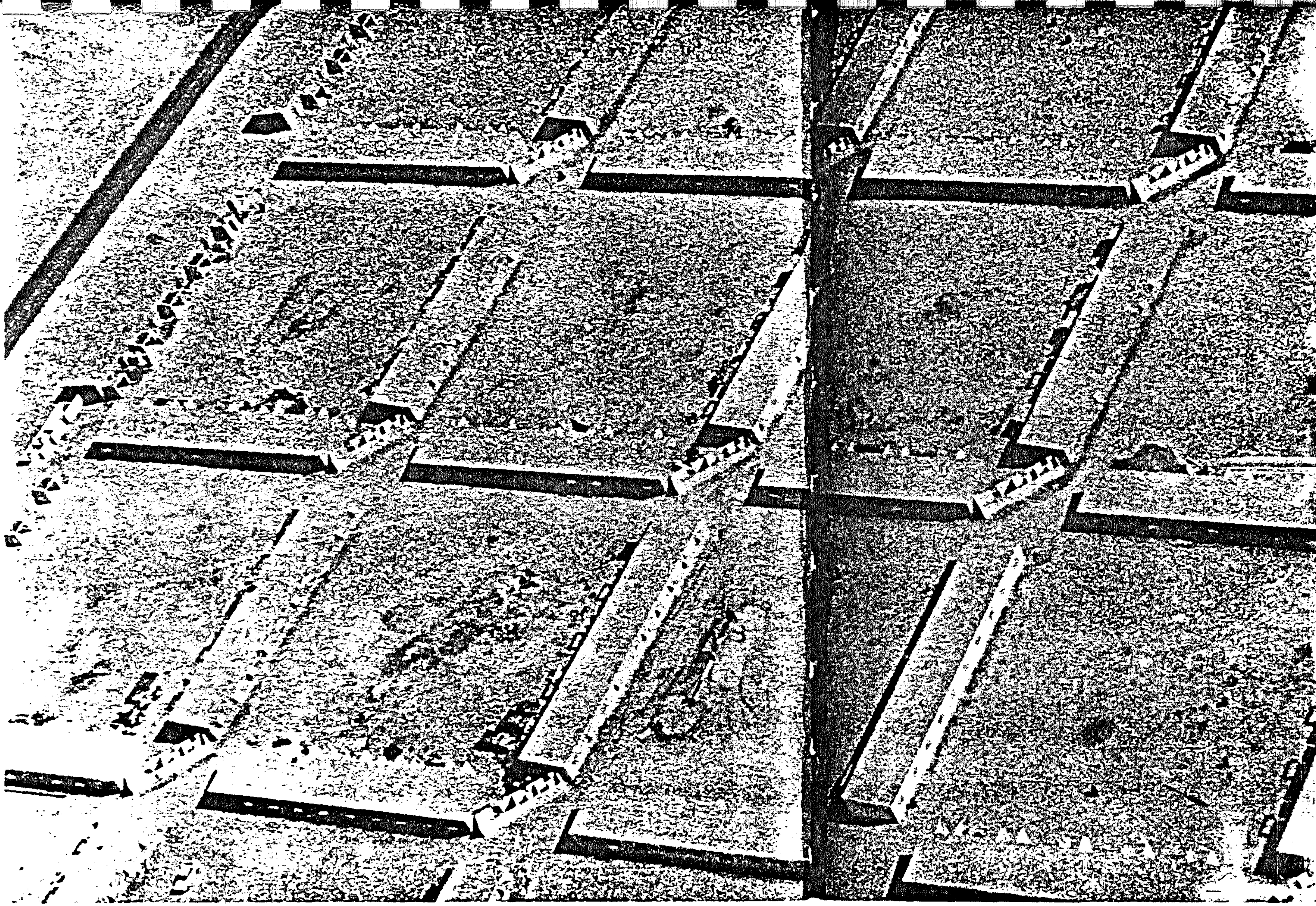


Climatic Response of Salala Courtyard House · Oct. 28, '73

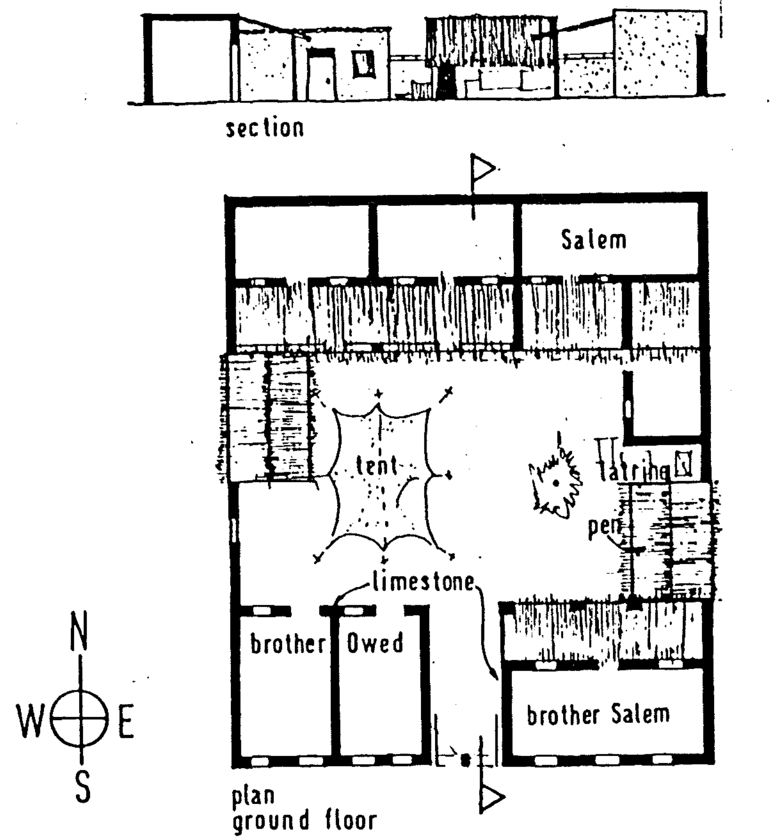
The courtyard house, typical to hot regions has evolved in a different way due to Salala's particular micro-climate. Its response to the climate is seen over the span of a typical day.



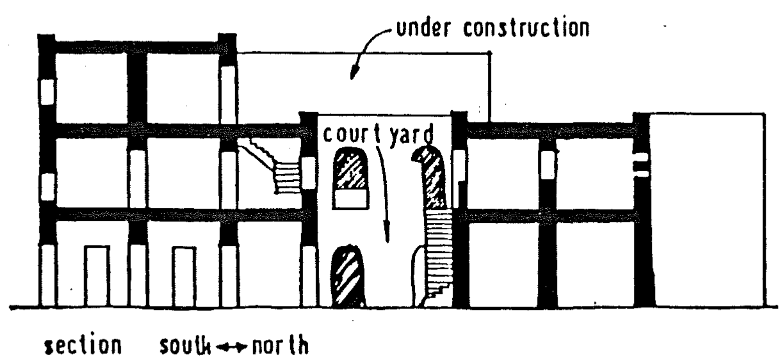
Quarry pit.



The official solution to the refugee problem has been the construction of a limited number of barracks like units.

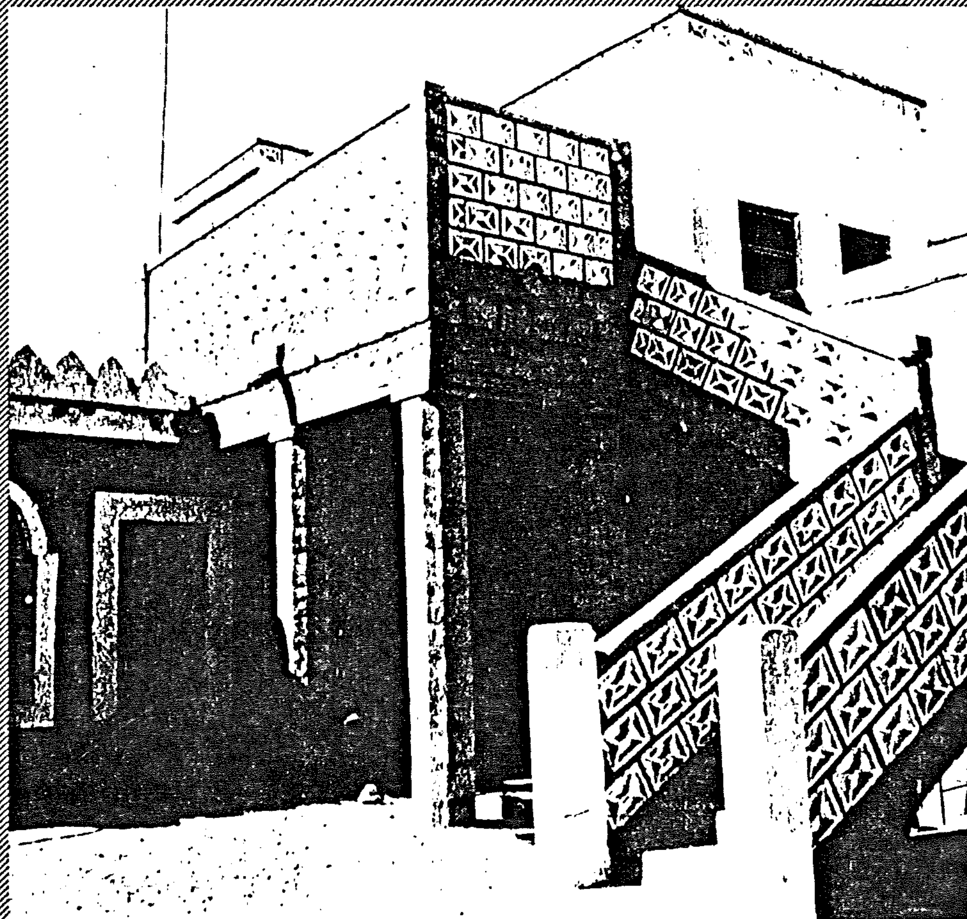


Three story limestone house
in old town centre of Salala.
60 to 80 years old. Extensions underway.



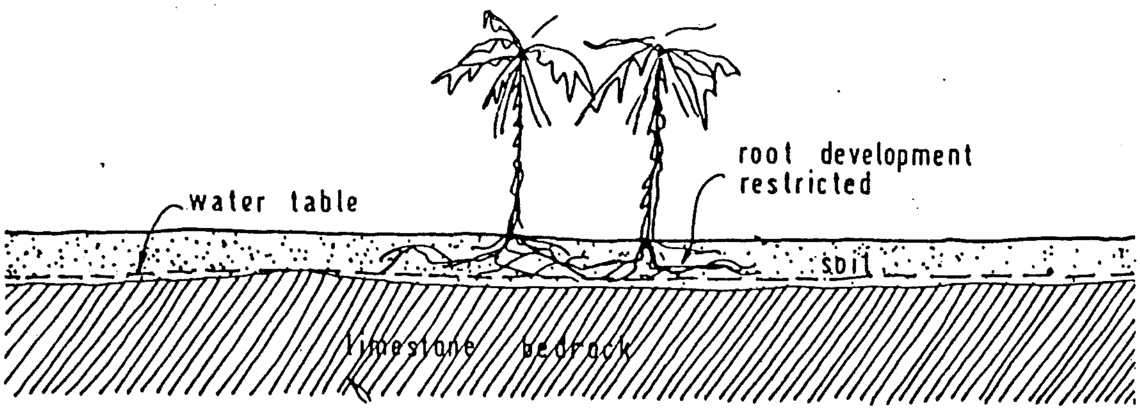
In time the new houses show signs of evolving into a form similar to the traditional courtyard house.

New building in Salala illustrates the process of the evolution of the traditional courtyard house.

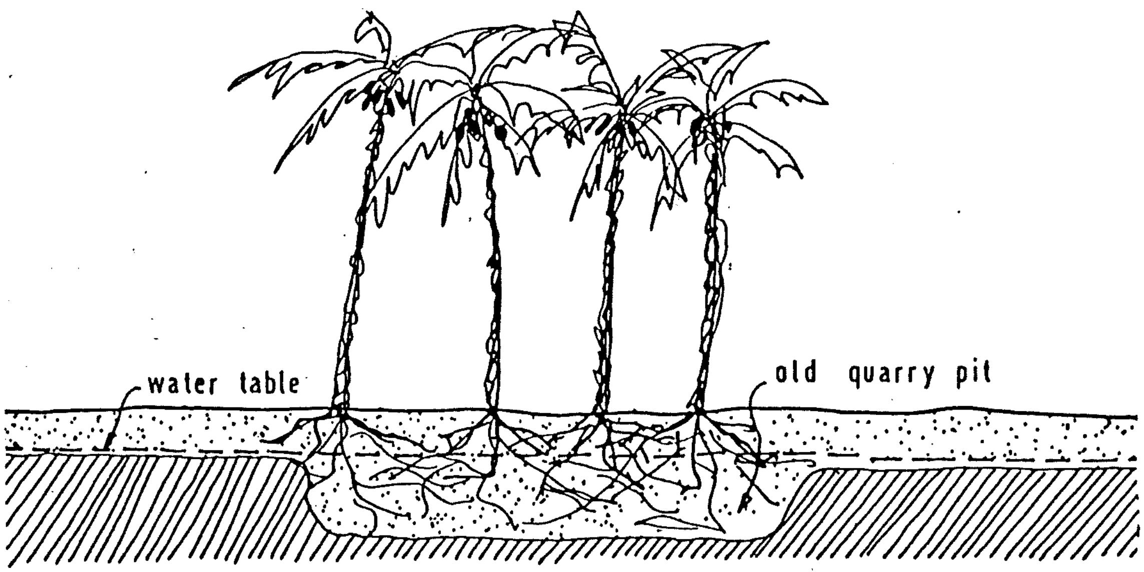


New building in Salala illustrates the process of the evolution of the traditional courtyard house.

The manual method of quarrying limestone is with pike, hammer and chisel.

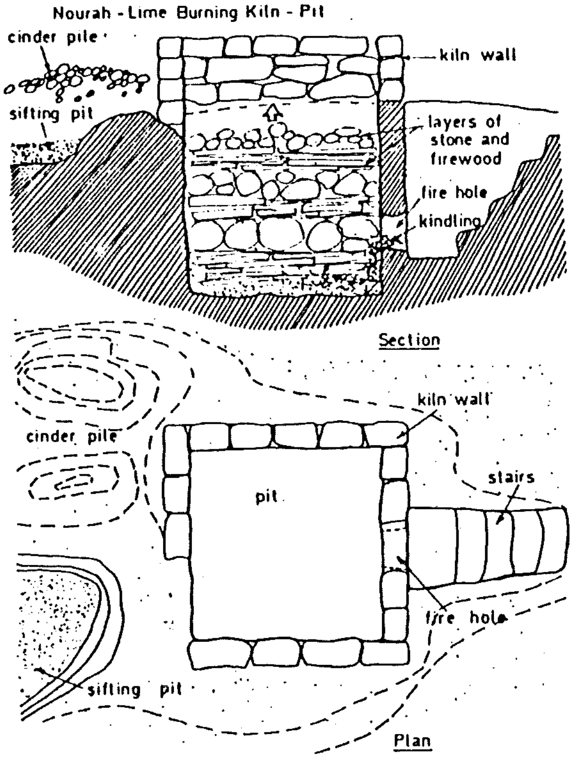


The restricted root development of a limestone bedrock condition.

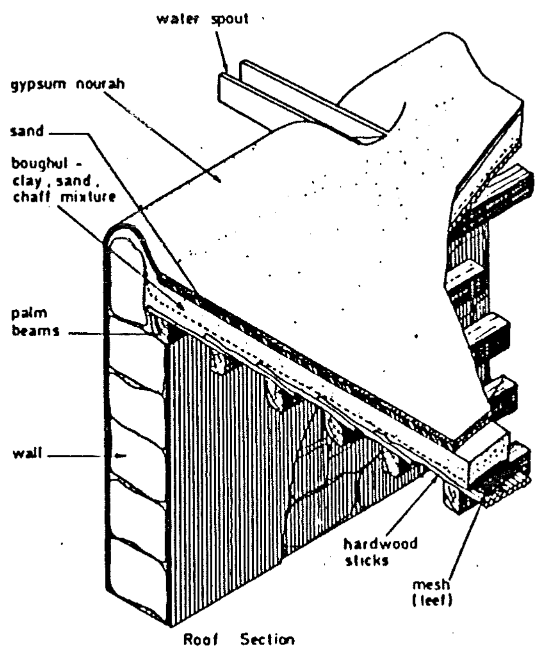


The improvements provided by planting on old quarry sites.

Officially built refugee housing.



Traditional Nourah-Lime Burning Kiln-Pit in the Sálala area.



Most houses made of wood obtained from the hills, for roofing.With this source cut off, new roofing solutions have to be looked for.

An owner builder with little money to begin with, will start only by building a palm stem wall around his plot and a simple room with the same material. A formal entrance way, made of limestone block, and situated on the south face of the perimeter wall, is always built during this first stage. As soon as financial resources permit the owner will extend his house, within the walled plot, by building one or two substantial rooms, usually of limestone block. These new buildings are developing into a form very similar to the courtyard house; indigenous to the Salala area. Ground floor rooms are being built with load bearing materials very consciously so that they would support future growth above, in the same manner as did their fathers' houses.

With the sudden influx of people into Salala, there is a tremendous increase in the demand for building materials. The most common indigenous building material is limestone. The soil is very shallow on the coastal plain and limestone is the bedrock. Limestone comes from the compacting over centuries of marine material such as coral. More recent deposits are found near the coast and the older harder material is found inland. The war has limited the limestone quarrying to the coast. Limestone is an excellent building material for use in Salala where houses are continually growing and the materials re-used. Hard limestone blocks are used over and over again. Limestone is traditionally quarried by hand, using a hammer, wedges and a pike. This is very hard work and is carried out under the hot sun. Quarry pits are usually places where ten or more men work together, but each as an individual and selling only the blocks that he cuts himself to local builders or individuals who are building their own houses.

The demand for building materials has put great pressure on the traditional quarrying system. The price of limestone blocks has gone up ten fold in the past four years. One year ago limestone blocks were being sold for as much as 30 Rials, or £33 per 100, while concrete blocks, which have recently been introduced, were selling for 22 Rials, or about £25 per 100. Since then concrete, which has to be imported, has tripled in price, making it out of the reach of the owner builder. Thus with the increase in prices and the problems of supplying the materials, house building becomes slower.

Suggestions have been made on upgrading limestone production through mechanisation. An Italian limestone cutting machine was bought and given to one of the foreign contracting companies to run. The machine was being operated by its crew of eight at well below the manufacturer's stated production rate of two to three thousand blocks per day. The process was constantly being hampered by mechanical breakdowns and dull blades, as the Salala limestone was unlike the Italian stone for which the cutter was designed. The block output per man using the mechanical method in fact compared unfavourably with the traditional system, where a man could produce more than 30 blocks per day.

Upgrading of the production of building materials is essential in Salala. Investment in the development

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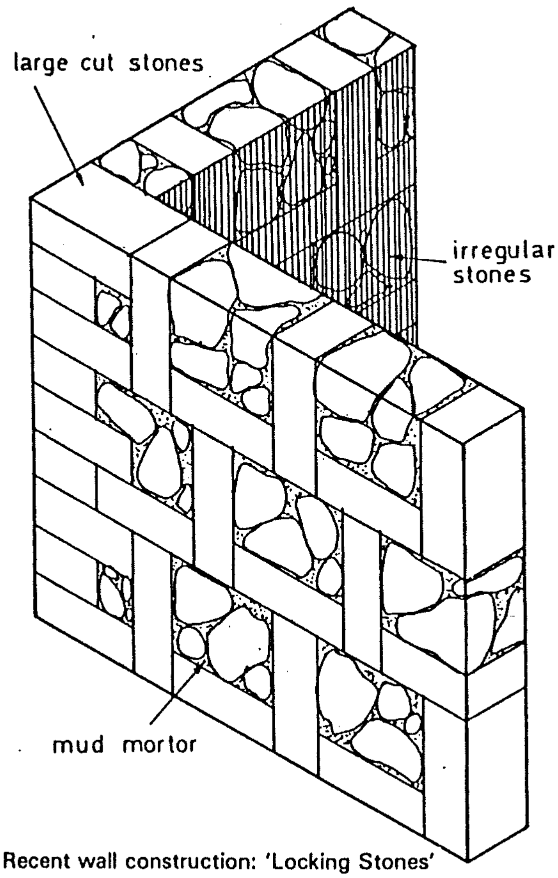
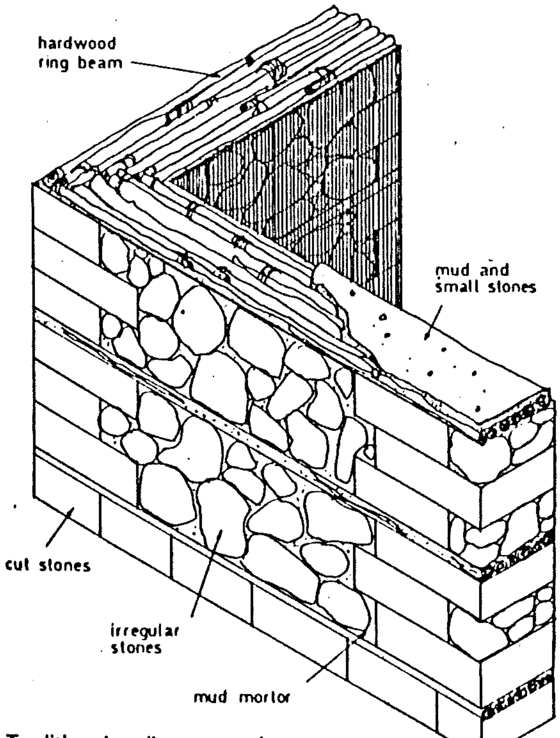


Recent wall construction: 'Locking Stones'



Traditional wall construction.

of the indigenous building systems on which the majority of the people depend may provide an answer. If interest has been shown in the improvement of methods within the traditional quarrying system chances of success may have been better. The men who now work together on the quarry site, but as individuals, if organised into a co-operative, could operate a cutting machine effectively. Their knowledge of the best cutting sites and the qualities of the local stone would be an advantage. Mechanisation, if only creating a dependance on imported parts and personnel, is questionable. The acquisition of mechanical skills by the local people should accompany the mechanisation of such industries as limestone cutting.

The war and accompanying economic problems has affected other aspects of the indigenous building industry. Access to the hills, where one obtained hard limestones for the production of burnt lime, and more importantly timber for reinforcing, lintels, and roof construction, is now very difficult. Consequently traditional building, which relied on a supply of these materials, has had to adapt itself to new solutions or become dependant upon the importation of building components or materials from abroad. Limestone structural walls were, for example, dependant on the use of hardwood lateral reinforcing between alternate courses of block. This allowed for the use of irregular infill stones between the blocks, thus greatly decreasing the need for cut stone and making the walls cheaper. Since this hardwood from the hills is no longer available, walls have to be built using more precisely trimmed limestone blocks in an interlocking way, thus increasing overall cost. On the other hand, pressures are such that imported timber, plywood and concrete are now being used for roofing.

The growing dependance on imported building materials and components means that money invested by the local people in building and housing is leaving the community. Although there was a tremendous amount of building begun with the influx of refugees and workers from the Gulf, this has now all but stopped with money running out, having been spent on imported materials. The same money spent on indigenous materials and methods would still be circulating in the community, producing employment and generating more building.

In conclusion, it can be seen that economic change in Salala has produced a basic change in the social structure, but the indigenous courtyard house remains the dominant form. Environmental factors such as the climate and physical terrain remain as important today as they did in the past. Whilst an artificial micro-climate can be created using expensive mechanical means, the traditional built response remains both effective and a source of valuable information from which to design and organise new settlement.

With new pressures on the building industry the way materials are used has changed, and at times new materials have replaced old. When this has led to the reliance on imported materials and mechanical systems, the corresponding shift in investment away from the local building industry has further weakened the indigenous economy of Salala.●

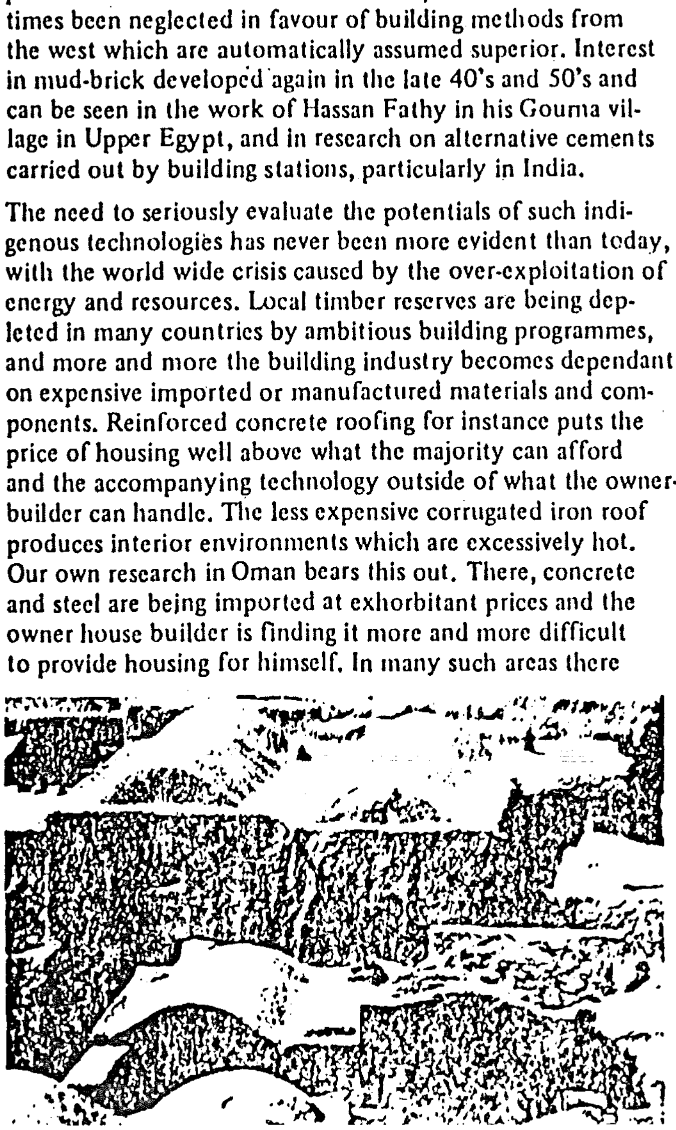
Indigenous Building Methods — Mud Brick Vault and Dome Building

by Allan Cain, Farroukh Afshar, John Norton, The Development Workshop

The authors Allan Cain (Canadian), Farroukh Afshar (Iranian), and John Norton (English) work collectively as The Development Workshop. Since 1972 they have carried out projects and research on indigenous building methods in Egypt, Oman, India, Iran and Sudan. In 1973 they were commissioned by the Government of Oman to carry out a study of traditional building in Oman. They are currently running a course on indigenous building methods at the Architectural Association.

The mud-brick vault and dome system evolved centuries ago in countries like Egypt and Iran. Their invention came about largely out of necessity in hot-dry semi-arid regions where roof spanning materials such as timber and reeds became more and more scarce as populations grew. Although mud-brick building reached an extremely sophisticated level, in public and domestic architecture alike, it has in more recent times been neglected in favour of building methods from the west which are automatically assumed superior. Interest in mud-brick developed again in the late 40's and 50's and can be seen in the work of Hassan Fathy in his Gouma village in Upper Egypt, and in research on alternative cements carried out by building stations, particularly in India.

The need to seriously evaluate the potentials of such indigenous technologies has never been more evident than today, with the world wide crisis caused by the over-exploitation of energy and resources. Local timber reserves are being depleted in many countries by ambitious building programmes, and more and more the building industry becomes dependant on expensive imported or manufactured materials and components. Reinforced concrete roofing for instance puts the price of housing well above what the majority can afford and the accompanying technology outside of what the owner-builder can handle. The less expensive corrugated iron roof produces interior environments which are excessively hot. Our own research in Oman bears this out. There, concrete and steel are being imported at exhorbitant prices and the owner house builder is finding it more and more difficult to provide housing for himself. In many such areas there



As locally available timber becomes scarce, the traditional flat roof becomes more difficult to build.

exists local mud brick building industries. Walls were built of mud brick and in the past the roof structure was usually timber. There exists a potential for the up grading of the traditional mud brick building industry in the introduction of vault and dome roof technology.

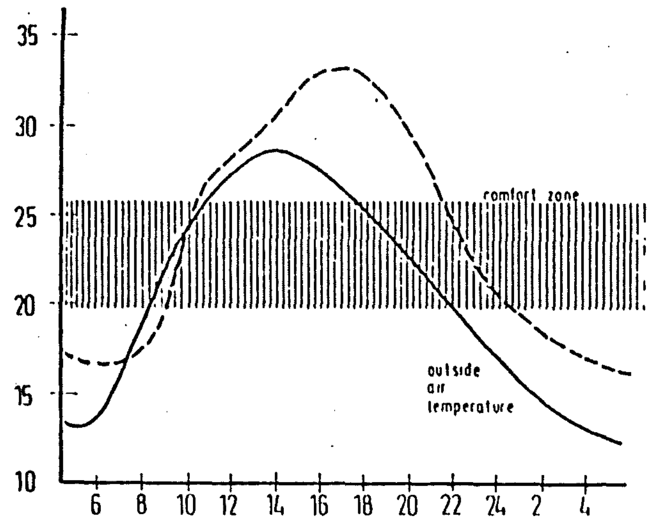
Structural Performance

Sun dried mud brick has been used most commonly for load bearing structures. The brick itself has strength in compression but not in bending or tension. The vault and the dome are responses to this. The traditional vault follows a geometry similar to an inverted catenary. The catenary is the pure tension curve that a chain or rope takes when it is allowed to hang free, suspended by its ends. Thus an inverted catenary shaped vault of mud brick is always in compression and is one of the most efficient forms possible.

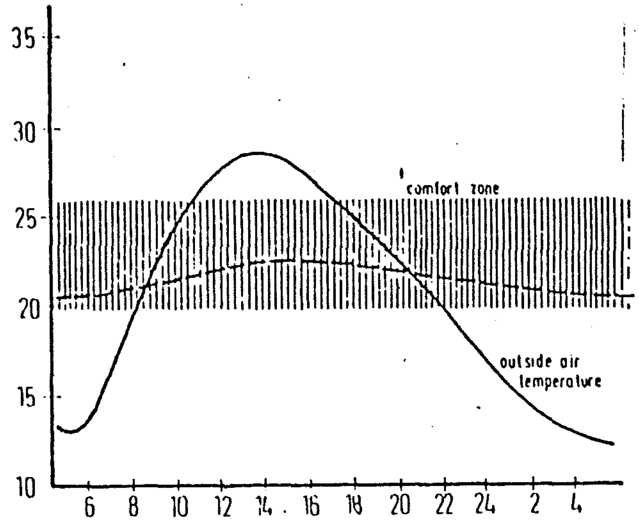
Vaulting in the European tradition involves the laying of the masonry over a wooden supporting formwork which is later removed when the vault is dry. The particular adhesiveness between mud brick and mud mortar combined with the indigenous method of building vaults and domes makes supporting framework unnecessary at any stage of the construction. Vaults are built so that courses of brick are sloped and lean into the end wall which supports the vault while it is being built. Vaults that we built could be stood on immediately after after being constructed. Domes are usually semi-circular, the geometry and the slope and placement of the bricks being determined by a string with one end anchored at the centre of the circle, and the other end tracing out the arc of the dome. The dome, like the vault, is built without any supporting formwork.

Climatic Performance

When looking at the climatic performance of buildings made of mud brick and those made of concrete the advantages of the former are obvious (see charts). Mud-brick's high



Prefabricated concrete room interior air temperature --



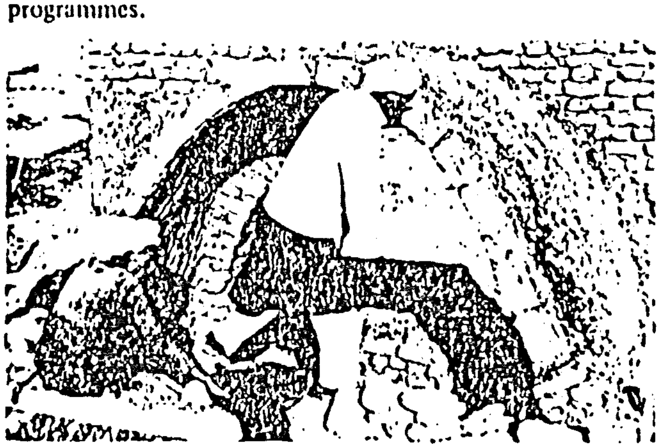
Mud brick room interior air temperature ---

from extremes of heat and cold. Similar structures of concrete tend to heat up excessively due to solar radiation and will require extra expensive mechanical air conditioning to achieve comfortable conditions within.

Vehicle for Training Skilled Builders

Mud-brick through history has shown itself to be an excellent tool for exploring and learning about structural principals of building. Because the material can take only compressive forces the built forms reflect the structure directly; there are no hidden stresses. The very cheapness encourages experiment and the small size of the unit, the brick, allows for adjustments during building. Pope, in his Survey of Persian Architecture 1939, says: "Trained in the instructive school of raw and fired brick the masons of Persia . . . mastered many fundamental forms which were soon carried to a high degree of perfection. The construction of huge but relatively thin shelled domes . . . and the construction of vaults a hundred feet in width are all proof of a command of constructional forms that modern mathematics could scarcely have bettered."

While training in Egypt in vault and dome construction we experienced how instructive this building medium is. Today when there is a need for the training of skilled builders in Developing Countries the instructive potentials of mud-brick building should be utilized in practical educational programmes.



Because of the adhesiveness between mud brick and mud mortar Domes and vaults can be built without any supporting framework.

Economic Potential and a Decentralised Building Industry

It goes without saying that mud's universal availability and cheapness when compared to any other material are great advantages today when prices of most other materials are rocketing and shortages are being felt. Mud-brick remains unaffected by the international market system which gives inflated prices to other materials.

The material's wide availability makes it possible for a building industry incorporating mud-brick technology to operate in a decentralised, self-reliant way, as there is no need to import materials from outside. Local masons could be trained to form a core of skilled builders or a building co-operative to deal with the more complicated problems of building, such as roofing or large public building. Investment in local materials and expertise means that money spent on building remains in the local area rather than passing to a city based contractor, or being lost abroad.

Conclusions

Mud-brick vault and dome technology has been presented as a case study of an indigenous building method which has potential for development. This is not to say that advanced and intermediate technologies do not have an important role to play in developing countries, but indigenous technologies have been the most neglected. Much pressing work has to be done. The trend in many countries, even where a strong vault and dome roofing tradition exists, is to put all the investment for new building into western capital-intensive methods. As a result highly skilled traditional masons find no market for their trade. New apprentices are not being trained. Before such skills are lost they must be reassessed and developed. The shortcomings of such indigenous materials and methods must be analysed and improvements suggested in the light of modern research. For example, improvements can be made in the mud-brick's strength properties and more importantly in its resistance to water damage, abrasion, and to insects. These improvements must be fed directly back into the indigenous industries.

Finally, the feasability for the use of vault and dome roofing should be explored in other developing countries where the environmental and economic conditions are appropriate and modern roofing techniques are proving too expensive.

Traditional Cooling Systems in the Third World

by
Allan Cain,
Farroukh Afshar,
John Norton
&
Mohammad-Reza Daraie

Today more than ever the technology of the industrialised world is being exported intact to the developing world. Western industries depend on marketing their wares to the Third World in order to buoy up their own countries' failing economies. For example, in Britain now 50 per cent of the building industry is dependent on foreign contacts.[1] The West's technological development was founded on the cheap raw materials and energies taken from the colonial world. Developing countries today do not have a world of resources to freely exploit and a few are now beginning, out of necessity, to look towards a more self-reliant road to development.

Agricultural technology in the United States now demands 5 calories of energy input to produce 1 calorie of food; on the other hand, in China 1 calorie input of energy produces 20 calories of food – 100 times less.[2]

There exist in the Third World a wealth of indigenous technologies which have largely been ignored, if not actually suppressed, during the era of rapid growth in the industrialised world. However large numbers of people in the rural areas and old quarters of cities and towns in the Third World rely entirely upon indigenous technologies. These technologies are almost always identified as signs of underdevelopment because they are most often employed by the poorer classes of society. Those who have never had access to large amounts of expensive energy have invented technologies which are efficient in use of local materials.

Millions of pounds are spent on the research and development of 'Advanced Technologies' – advancing them further and further away from any relevance to the majorities of the world. We believe that we must research and develop those "simpler" and not unadvanced technologies which the majority of the people in the Third World use and live within. Such a scientific reassessment of the indigenous in Third World countries could form the basis of a real development.

This article deals particularly with the indigenous technologies of cooling, using largely natural sources of energy and techniques which have been developed by people locally.

Maziara Cooling Jars

The Maziara is a traditional water cooling and purification system used in rural areas of Upper Egypt. The evaporative cooling properties of large porous ceramic water storage pots are employed. Similar methods have been used in different parts of the world to keep liquids and perishable food cool.

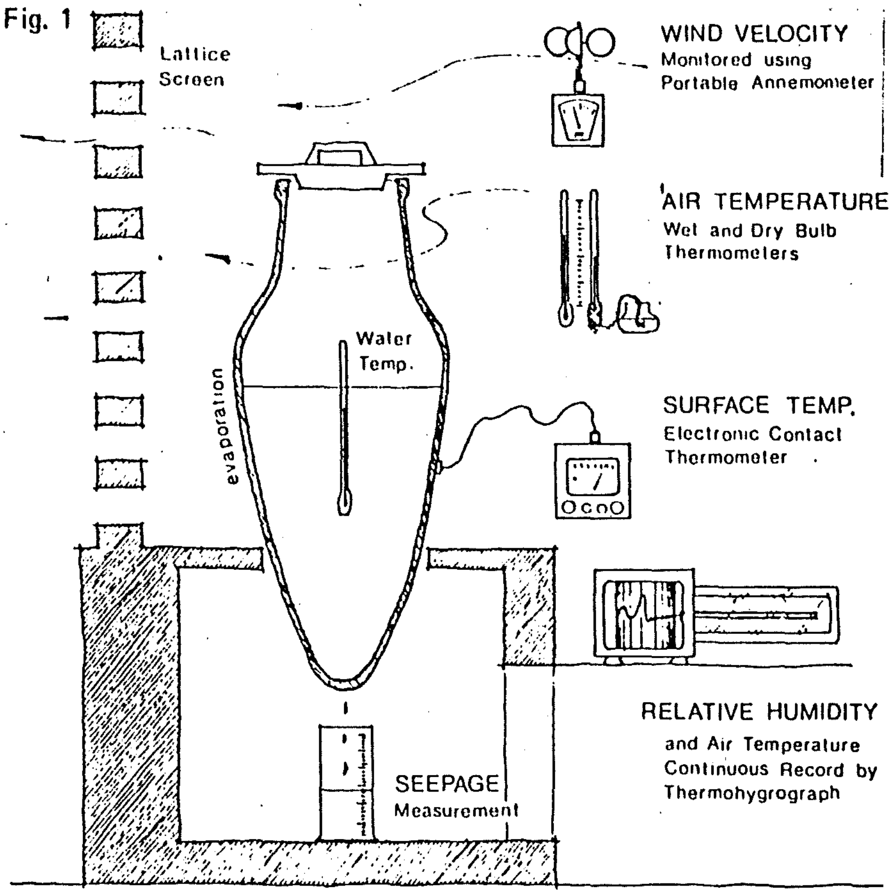
The supply of safe drinking water is a primary factor in the maintenance of public health in developing countries. Consideration must be given not only to the water source and its quality but also to the distribution and storage systems. In an Egyptian village area studied by the authors,[3] there was no modern system of piped water to individual homes. Water was available from wells or from the Nile River and its canals. Nile water and water from irrigation channels is unfit for drinking and often carries dangerous pathogens such as 'bilharzia larvae'. Shallow wells are also often polluted and clean water is only guaranteed from deep wells. Women collect water from these sources in the early morning and then carry water jars (bellas) on their heads back to their homes. Once home the water is stored in the Maziara. These large, unglazed ceramic jars hold the day's supply of water for drinking and domestic use.

The porous nature of the unglazed ceramic means that water seeps through the jar's wall, maintaining a wet outside surface. Some of the water evaporates and the rest drips down the sides of the jar and is sometimes collected. Drinking water is usually scooped out of the pot with a dipper, though it was discovered that water collected at the base after it had been filtered through the pot is much cleaner. The water in the Maziara is kept cool all day by the action of evaporation from the jar's outer surface. Evaporation, i.e. the change of water from a liquid to a vapour, absorbs a considerable amount of heat energy (580 calories of energy for every cc. of water evaporated.) Heat is therefore continually drawn out of the water in the storage jars. The dry Egyptian climate means that the outside air can absorb a great deal of water vapour, and in turn a considerable amount of evaporative cooling can take place. The Maziara is usually situated so that evaporative cooling.

An experiment was set up using portable meteorological testing equipment in order to evaluate the cooling action of the Maziara (Fig. 1) Water samples were taken at various stages in the system, to be measured later in the laboratory for purity.

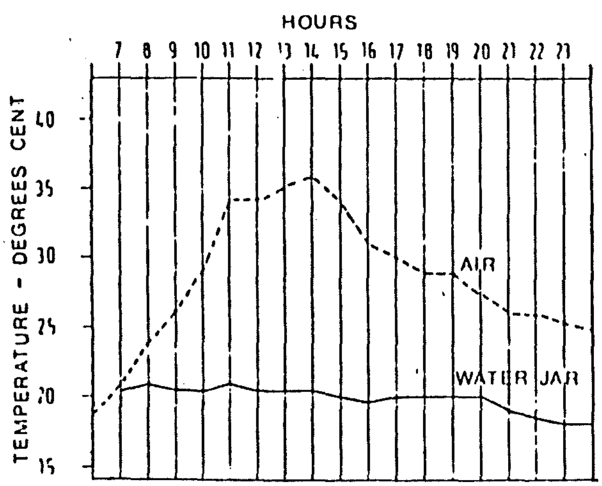
Results of the climatic tests showed that even though the outside air temperature ranged from 19°C. to 36°C. over the day, the temperature of the Maziara water remained relatively constant at 20°C. Since one feels comfortable in Egypt only between the narrow range of 21°C. to 26°C. the water feels refreshingly cool all day. The constant Maziara temperature (Fig. 2) may seem surprising with such a large air temperature range, i.e. 17°C. This can be explained by the fact that as the day progresses and the air temperature rises, the relative humidity (the amount of water vapour in the air) decreases (Fig. 3). As the air becomes drier more water evaporates from the water jar's surface and the cooling rate increases (Fig. 4).

Fig. 1



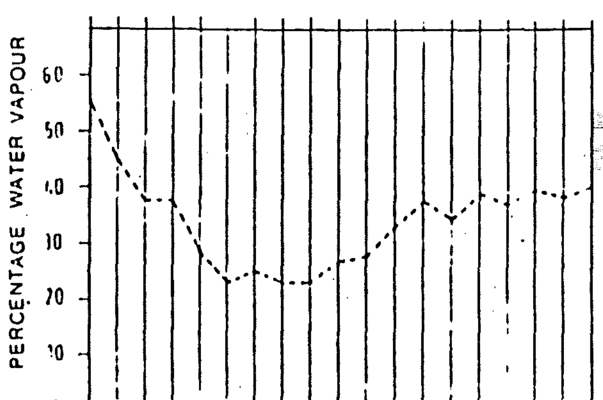
MAZIARA WATER JAR TESTING METHOD

Fig. 2



COMPARATIVE TEMPERATURES
OUTSIDE AIR VS WATER JAR

Fig. 3



RELATIVE HUMIDITY OF AIR

The Maziara though mechanically simple proves to be a very sophisticated system; its temperature self-regulation is a response to local climatic changes.

Over a 16 hour test period a single jar produced 1700 k. cal. of cooling. At the hottest time of the day the jar's cooling rate was 165 k. cal./hr. or about 192 watts (Fig. 5).

In order to test the Maziara's water purification action a series of laboratory tests were made on water samples. Into the Maziara was placed water collected from the nearby Nile River. Samples were taken from the river source and from the effluent runoff after water had been allowed to filter through the Maziara system. Other samples were taken from inside the jar. Samples were tested in the Government laboratories in the Luxor hospital and it was found that the filtered outflow water was pure to the Government's drinking water standards, even though the original Nile water that was put into the jar was contaminated.

Pollutants can either be suspended in the water or chemicals dissolved in the water. The filtering action of

Fig. 4

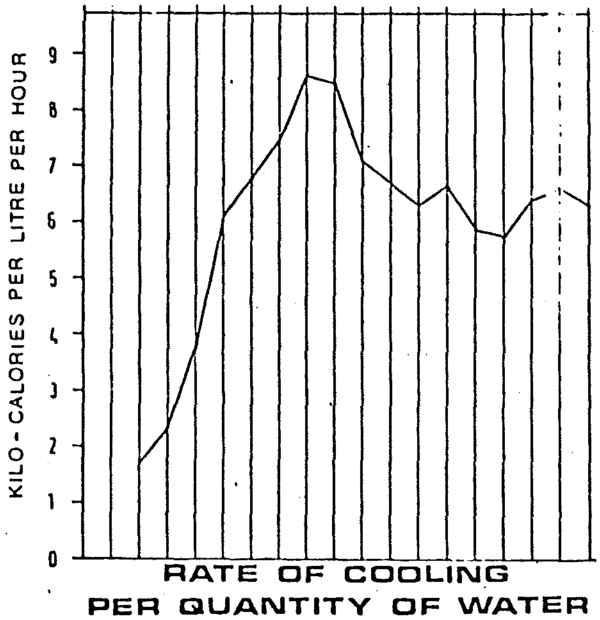
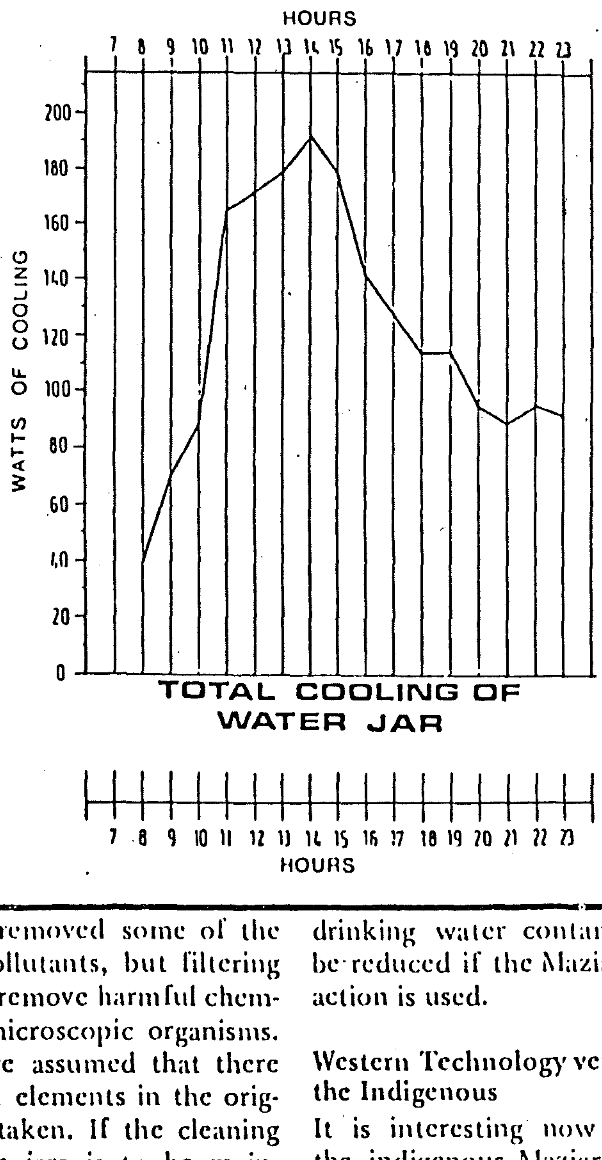


Fig. 5



the Maziara removed some of the suspended pollutants, but filtering alone cannot remove harmful chemicals or all microscopic organisms. It is therefore assumed that there were no such elements in the original samples taken. If the cleaning action of the jars is to be maintained they would have to be rinsed periodically and sterilised with boiling water.

The result of the purification tests illustrates that chances of drinking water contamination can be reduced if the Maziara's filtering action is used.

Western Technology versus the Indigenous

It is interesting now to compare the indigenous Maziara cooling jar method to its Western counterpart, the mechanical cooler.

Technological sophistication is usually measured in terms of the number of transistors or moving

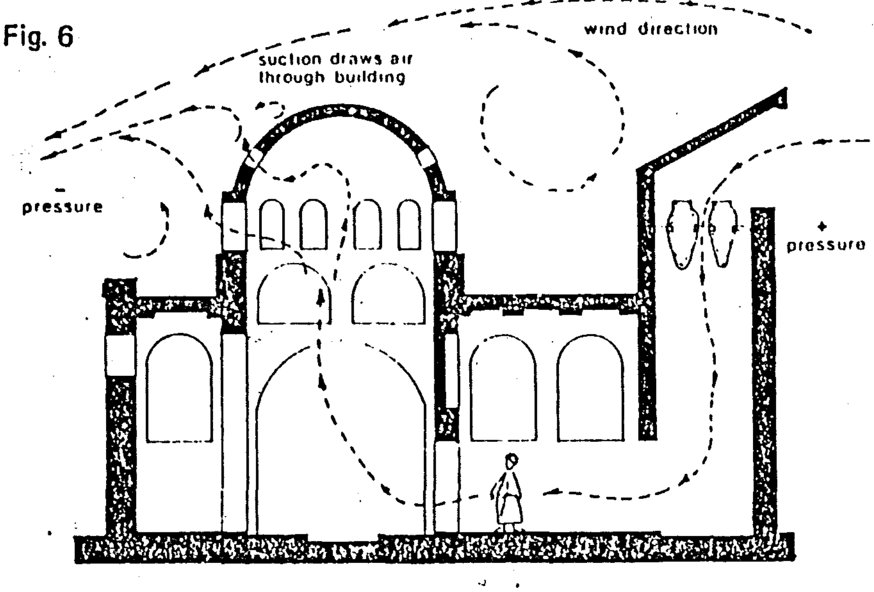
air conditioner could be called a piece of advanced equipment. If we evaluate sophistication in terms of efficiency we find the opposite. An air conditioner producing 12,000 BTU's of cooling will in turn consume 2400 watts of electrical energy.[4] This means that an equivalent of about 70 per cent of the total cooling output is required in electrical energy to run the unit. The Maziara cooling jar method, on the other hand, requires no other energy than that required to fill the jar with water in the morning. It is, as well, totally self regulatory and responsive to climatic changes without the aid of a complicated thermostat. The inefficiency of these mechanical systems is compounded and in global terms: "200 million Americans use more electricity for air conditioning than 800 million Chinese use for everything."[5]

The hazards of modern air conditioning systems are rarely advertised in the glossy brochures distributed by companies' dealers in the Third World. Mild shock sometimes occurs at the entry of an excessively cooled building, if the temperature differences between inside and outside are too great. Mechanical air conditioners often produce pools of very dense cold air in the lower parts of rooms. Such stratification of temperature over long periods affects blood circulation, respiration and other bodily functions particularly in children and old people.[6] Indigenous cooling systems by the very fact that they are usually naturally regulated, avoid these dangers.

Most of the vast rural areas of the Third World do not have access to electricity in order to power a mechanical unit, and must therefore rely on some other non-energy consuming method. The average per capital income of people in many countries, if accumulated over several years, would hardly be enough to purchase the cheapest mechanical air conditioner. On the other hand, a large unglazed jar suitable for cooling, costs less than a pound, and can be made in a village kiln, and could if developed form the basis of a small industry.

Comparative experiments are currently being planned by the authors

Fig. 6



WIND-CATCHER WITH COOLING JARS

Air is cooled as it passes over evaporative cooling jars

in Iran, in the use of water jars for air cooling within buildings as against mechanical cooling. In theoretical terms, five or six water jars, each producing up to 200 watts of cooling, would be equivalent to a small window-mounted mechanical cooling unit of 1000 to 1200 watts.

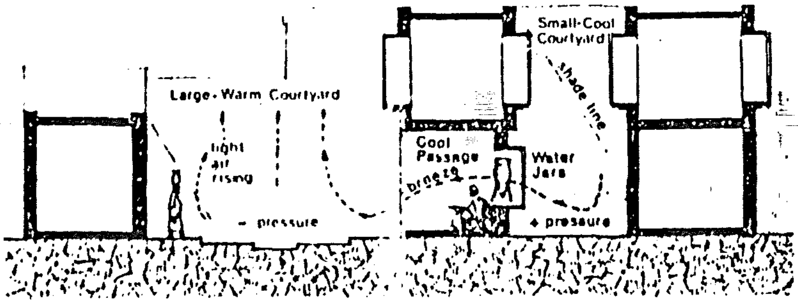
Development of Local Technologies

A wide variety of cooling solutions based on the principles illustrated above have been developed indigenously in Third World countries, and there is still much scope for their improvement and wider use. Porous water jugs and even simple dampened reed matting have been used in conjunction with wind catching towers, which funnel air down into rooms of houses after it has been conditioned by evaporatively cooled surfaces (Fig. 6). Professor Hassan Fathy, in a design for a wind catcher for a school in Upper Egypt, used beds of wet charcoal for air to pass over before entering rooms, and he reports a drop of 10°C. in air temperature.[7] In Iran, wind shafts often lead to basement water cisterns. Both the air and water is cooled by the effects of evaporation. The water being stored underground retains its coolness, and the air after being cooled is directed up into the rooms of the house. (More information on the wind catcher as an air cooling device can be found in *Architectural Design Magazine*, April 1975, pp 217-218, by the authors.)

The courtyard of the Middle Eastern or Mediterranean house has long been known for its cooling properties.[8] The court acts as a well to trap cool night-time air and retain it throughout most of the day. An interesting adaptation of the typical case is the two courtyard house. One court is small and deep and therefore generally shaded and cool; the other is wide and open to the heating of the sun's radiation. Air in the small courtyard, being cool and dense, has a higher pressure than the warm air of the large and therefore rises. If an opening or passageway connecting the two courtyards is well positioned, there will be air movement induced by convection from the cool courtyard through the passage to the warm courtyard. The air's velocity is controlled by the size and nature of the passageway as well as the temperature and pressure differences between the two courtyards. Water cooling storage jars if placed in this passage will add to the cooling effect of the breeze (Fig. 7). In houses where this feature is employed, the inhabitants spend the hottest hours of the summer days in this cooled space between the courtyards.

In Muscat Oman, water jars have been mounted in specially designed window openings, not only for the provision of cooled water but to reduce the temperatures of the air passing over them and entering the room (Fig. 8). Similarly in India simple coarse woven mats over window openings when wetted cool the air passing over them into the room. Such matting usually needs rewetting by hand every 20 minutes. A recent development in India based on research into the indigenous method is an air conditioning unit (Fig. 9) using matting of khus-khus grass, which is widely available in Northern India and gives off a pleasant aroma when wet, in conjunction with a water reservoir and a small mechanical fan. The water reservoir maintains a controlled drip which is just enough to keep the matting wet. A low voltage fan, which could even be battery powered, is the only energy consuming part of the unit.[9] A development upon this could use a roof-mounted wind trap to provide air

Fig. 7



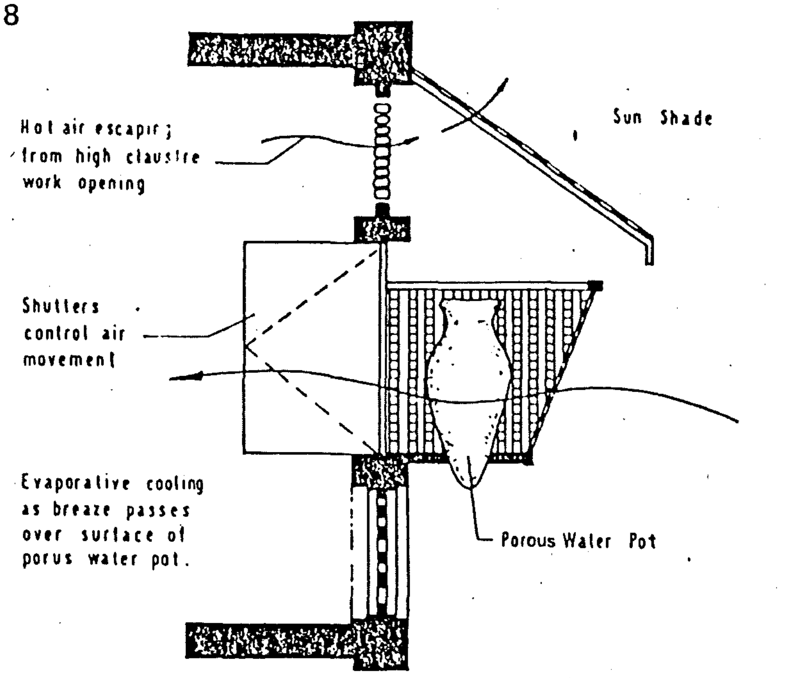
TWO COURTYARD HOUSE -- AIR MOVEMENT INDUCED

Convection system between courtyards. B[illegible]e is drawn across cooling jars movement and the fan as only a back-up system.

Perhaps more important than air cooling is the cooling and storage of perishable foods. A large percentage of the total food produced in Third World Countries rots and is lost before it is eaten because of the lack of any cooling storage facilities. Again in India evaporative coolers have been used indigenously which could help alleviate this problem. A domestic cooler was developed using a porous outer water jar and a glazed inner jar as a dry compartment to hold the food (fig.10). The space between the two jars acts as a reservoir for water, which keeps the exterior porous jar wet. Evaporation of water from the surface of the outer jar keeps the whole system, including food stored within it, cool.

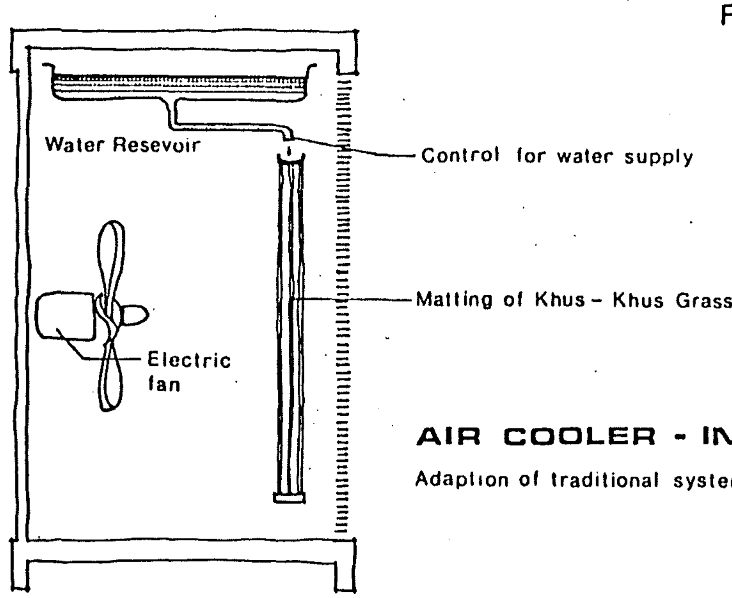
This article has dealt with some of the technological innovations that have grown out of an indigenous scientific approach to a basic problem – cooling – in many Third World countries. It should be seen as one example out of many such neglected systems which could be developed upon. Technologies adopted, as well as the approach taken to the improvement of indigenous methods of solving problems have a strong impact upon the direction of the road any society chooses towards development.

Fig. 8



WINDOW MOUNTED COOLING UNIT - MUSCAT

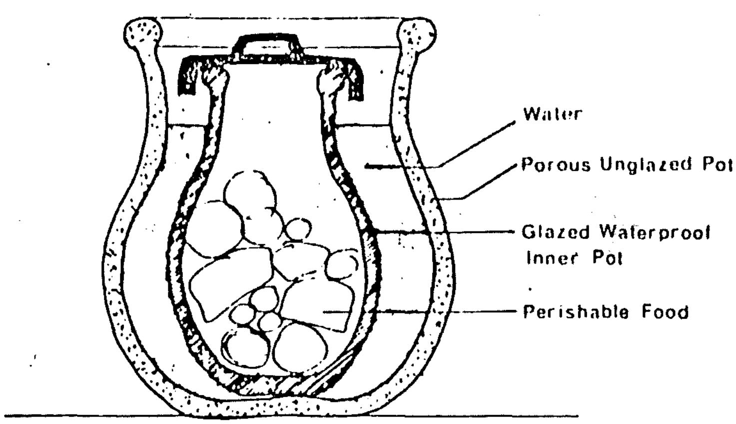
Fig. 9



AIR COOLER - INDIA

Adaption of traditional system

Fig. 10



FOOD STORAGE COOLING UNIT - INDIA

Evaporative cooling from moist exterior surface

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Note:
All photos, drawings and charts by the Development Workshop.

BRICK

Members of the Development Workshop, (see: 'Indigenous building and the Third World', *AD* 4/75), are currently working on a hamam – public bath house – in the Niazabad Village, as part of a project for the Selseleh Integrated Development Project in Lorestan, Iran.

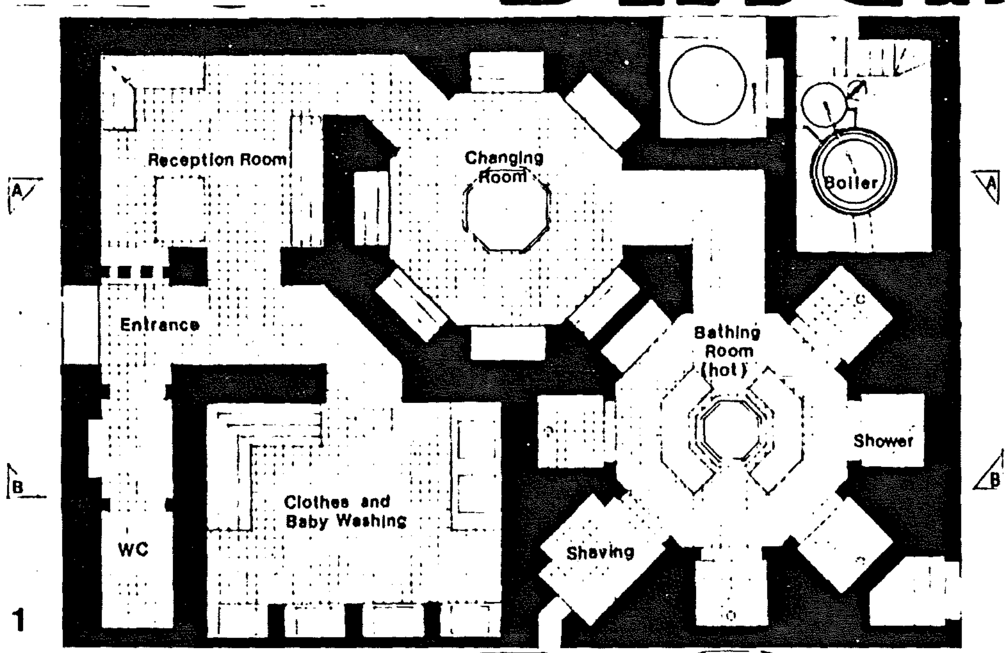
The hamam, as a social and health institution, has long played an important role in villages and towns in Iran. People came together in the hamam to bathe, massage, shave, and chat at leisure, men and women using the hamam on different days. The barber, often the closest thing the village had to a doctor, commonly operated from the hamam, providing not only shaves and haircuts, but also circumcisions.

A hamam has always been built either out of stone or fired brick, since it is too damp to use dried mud-brick. It is usually built into the ground, with the vault, dome roofs, chimney and entrance articulated above ground. Placing the bath underground contains the heat better, and also carries the weight of the vault and dome more easily. The village water channel is diverted, and flows by gravity down through the heating chamber, (which burns brush and wood fuel), and into the baths. The smoke runs in ducts under the bath floor to heat the rooms above, before being emitted through the chimney. A hamam has a minimum of two rooms: the first is a changing room, where people sit on raised slabs in niches around the walls, facing each other. The second is the large bath room, which has similar raised seating slabs around the walls, a communal hot bath pool, and a warm rinsing pool. People soak in the hot bath. On the raised slabs they rub themselves and each other down, and rinse themselves, drawing water in pitchers from the rinsing pool. The open plan arrangement with people facing each other is very important for the hamam's social function. The rooms get progressively hotter as one moves to the steamy interior bath room itself. Connecting entrances are bent for insulation and privacy reasons.

Development Project programme

In the Selseleh district there had been many hamams functioning in the past, but for a variety of reasons most of these have fallen into disuse. The recent government-built hamams with shower cubicles are largely not functioning because their heating system or oil deliveries have not been maintained. The Development Project's programme is to renovate and revitalise existing hamams, to train local people in their maintenance, and to set up a local fuel distribution system – as well as build new bath houses, of which the Niazabad hamam

1



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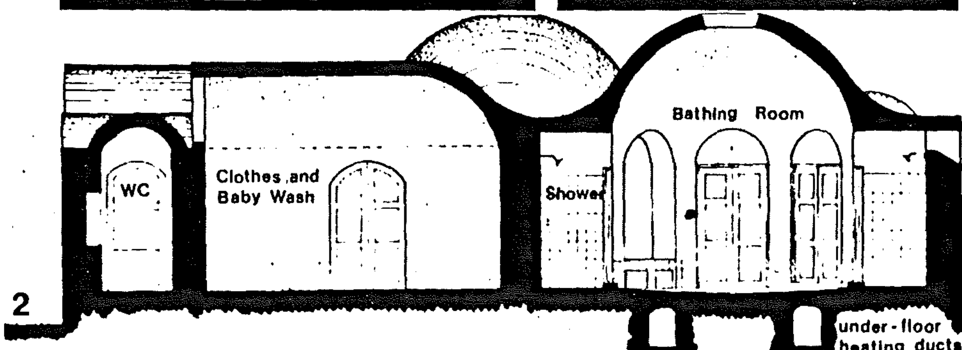

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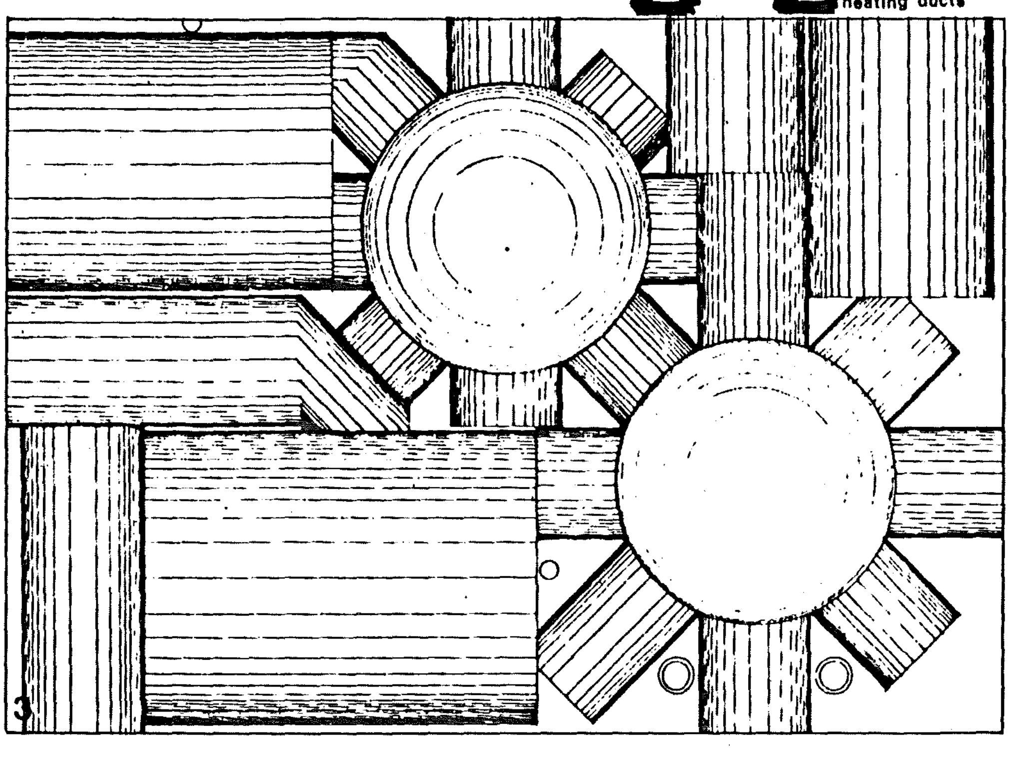
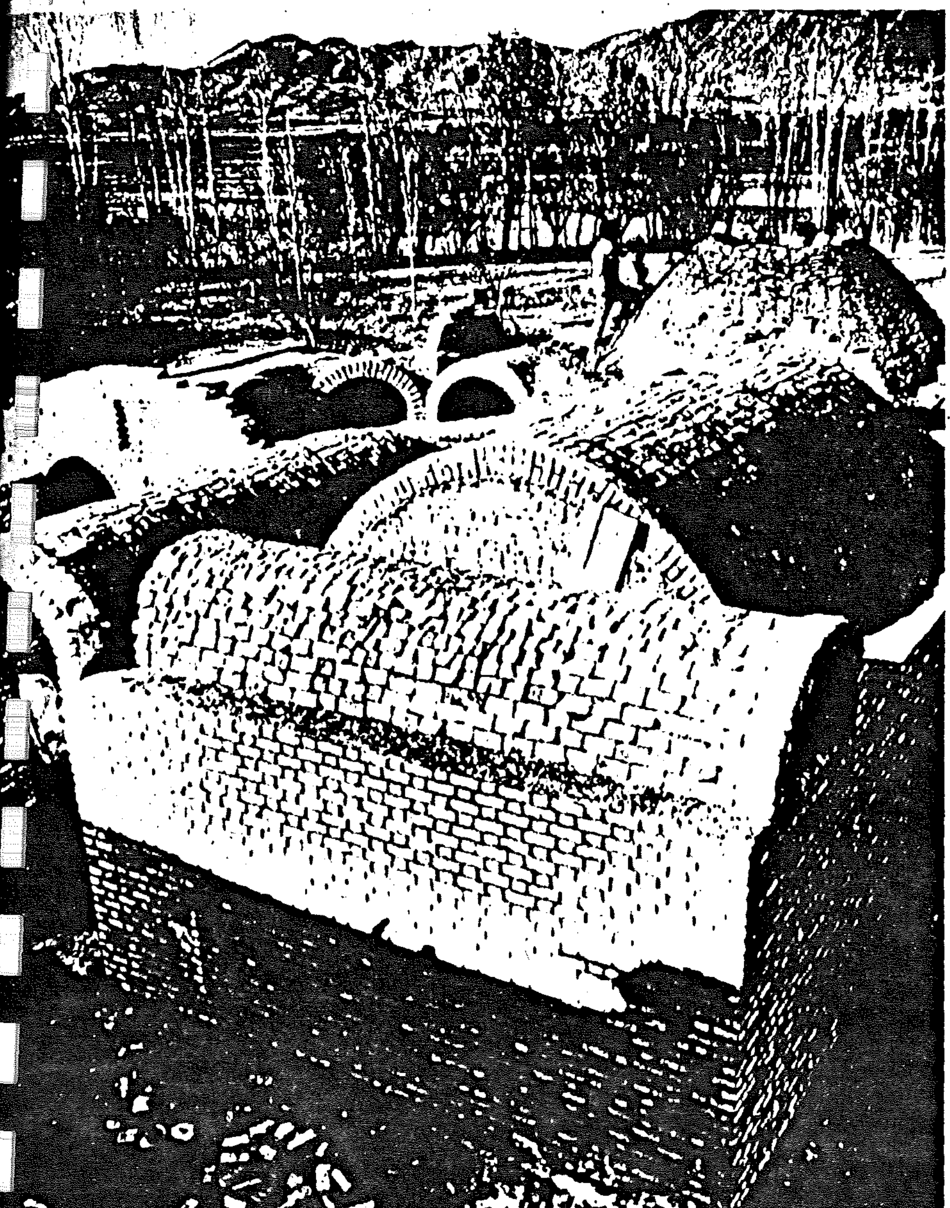


ATH HOUSE



is a prototype and raises many issues relating to using indigenous techniques. The Niazabad hamam was designed after a study of similar traditional ones in the area. Shower cubicles were used, since the communal bath pool is now prohibited for health reasons. The cubicles have low doors to maintain privacy but allowing users to keep contact through all stages of the bathing process. Other recently built hamams are usually rectangular, with shower cubicles in rows opening onto a narrow corridor, completely ignoring the hamam's social function as a meeting place.

Organising the construction

Niazabad Village, with a population of approximately 300 people, is located centrally enough to serve several villages where there are no hamams. As standard Project procedure in building in villages, we explained that the skilled workers and the materials would be provided if the village was willing to provide the land and the unskilled workers. After much discussion the matter was agreed.

The village divided itself into six sections based on extended family groupings – each grouping responsible for providing an equal number of workers. This is the system used during harvesting and other times when the village has to organise for a collective effort. There were two near-crisis situations: once was when the Niazabad villagers said that because the surrounding villages were not contributing they should not be allowed to use the hamam. After some debate the Niazabadis agreed that the advantage of having the hamam in their village warranted their additional effort. The second time was when, with winter approaching, some bread-winners planned to leave for their customary jobs in Tehran. Initially they refused to pay for someone to take their place. Once again after much debate, the fear of village ostracism and forfeiting the right to use the hamams, these villagers agreed to contribute.

1. Plan of the hamam at Niazabad.

2 Section. A clothes and baby washroom has been introduced to the traditional design.

3. Diagram of the roof plan of the hamam, showing the vaults and domes.

4. The hamam under construction. Precise structural geometry was calculated with stretched string and by eye.

5. Villagers watching the building of the patterned vault. Throughout the construction a regular audience observed with great interest as the art-technology of their country was re-presented to them.

International Conference on
RURAL DEVELOPMENT TECHNOLOGY : AN INTEGRATED APPROACH
Asian Institute of Technology, Bangkok, THAILAND

CASE STUDY OF SELSELEH INTEGRATED RURAL DEVELOPMENT PROJECT IN LURISTAN, IRAN

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Abstract

This paper looks at the problems of development in rural Iran. It discusses various modes of development in light of the authors' work with an alternative project in Luristan, an underdeveloped mountain region in Iran.

The first part of the paper briefly discusses the processes of development and underdevelopment and looks at some of the characteristic problems of underdeveloped regions. The importance of rural development within national planning policies is stressed.

The second part, land reform and rural development planning in Iran is introduced, followed by a case study of the Fifth Development Plan's rural sector policies. This is the most extensive rural development plan carried out in Iran to date.

The third part looks at an alternative development model, presented in the Selseleh Regional Development Project, in Luristan, Iran. "Endogenous Development" utilising the creative potential of the local people to develop their own region using its indigenous resources is the motor force of this project.

Proposals for future action are based on the appraisal of the various case studies.

Part I

Processes of Development and Underdevelopment

Rural development is so closely related to the whole development process that one first needs to consider general development issues before considering the rural sector. The term "development" refers to a global phenomena which embraces many diverse national experiences.

Different theories have been expressed about the nature of development. Early, but still influential theories regard underdevelopment as an original state of people in less developed countries, where the model of the "developed" nations is presented to them to aspire to and follow. The major inadequacy of these "orthodox" theories is their lack of historical basis, resulting in the linear models of development. Such models cannot be followed by the Third World, due to different historic conditions in which these countries have to develop, compared to the conditions in which today's industrialised nations developed. By examining the development processes of the industrialised nations, it is clear that the development of the industrial nations is directly related to the underdevelopment of the Third World.

The growth of industrialised countries required increasing amounts of raw materials and larger markets. Traditional societies, many with existing highly advanced economies, technologies and social structures, were penetrated and often disintegrated by political, economic and if necessary physical force. Their members were assigned to the production of raw materials. The destruction of the socio-economic structures of these penetrated societies left them dependant upon the industrialised nations. In short, some nations have become better off to the detriment of others.

The Third World, whilst having no colonies for supplying resources, have still attempted to follow the Western development models. Their main thrust has been to industrialise using imported technologies, resulting in vast sums being paid to the industrialised nations for machinery - mainly for import substitution industries. The industries thus formed require substantial infrastructure which is only available in a few large urban centres in these countries. Thus the ruralareas of the Third World, which contain 2,500,000,000 people, the majority of the world's population, are neglected in favour of centralisation of capital and industry in a small number of cities. Even in the cities the profits of these industries are concentrated in the hands of a few industrialists. Thus the nature of capital intensive methods leads to inequitable distribution.

Such uneven development causes a large number of the rural population to migrate to the towns in search of employment. This process increases regional disparity in underdeveloped countries by robbing the rural areas of their potentially most productive workers.

Towards a Definition of Development

"Development" is by nature a subjective term, almost synonymous with betterment.

The income level of the population is perhaps the most important factor of development. The level of income has to be such that food and other basic necessities can be obtained by the population. A raised income level has also the effect of increasing the market for national industries, and thus aiding economic growth. However an increase in G.N.P. is not a sufficient criterion for development if the benefits are concentrated in the hands of a few while many are poverty stricken. Equitability of distribution is a major contradiction in development processes based on the Western industrial model.

A raised income level and its equitable distribution imply increasing the level of employment. Capital intensive methods in the Third World cause little increase in job opportunities and make the level of income more unequal.

Investment in human capital through education, health, and essential services should be a major concern in development.

To achieve these objectives the underdeveloped nations, essentially, need an integrated development programme within which the rural sector must be given the greatest priority, as by far the majority of the population live in the rural areas. This is to equitably raise the income of the population by providing employment for them in their own regions. It could, of course, be argued that the employment for the rural population could also be provided in the cities, as it is now often the case. However, such centralisation increases the regional inequalities that have already been discussed and which are a salient characteristic of the underdeveloped. Development in one region does not necessarily stimulate development in neighbouring regions, but on the contrary leads often to a backwash on these regions making them poorer than ever.

However, for any rural development plan to be successful, all the factors of economy, education, health and services must be tackled simultaneously. In this paper we hope to point out the need for an integrated approach to development and illustrate through the case studies two contrasting approaches to rural improvement.

Part 2

Land Reform and Rural Development Planning in Iran

Historical Background:

Traditionally, agricultural surplus from the Iranian countryside has gone to support the city dwellers, while the barest minimum investment needed to upkeep the level of production has been returned to the village. The residence of landlords in the cities and the peasants' lack of capital and incentive to raise production, along with the constant threat of pillage by alien tribes, prevented the building up of a large surplus in the countryside. Any investments were confined to the construction and maintenance of traditional irrigation systems (ghanats) which were essential for maintaining the level of production.

During the nineteenth and twentieth centuries agricultural production entered the international market, changing the crop and land ownership patterns. The creation of absolute property rights, registration of tribal lands in the name of the chiefs, a fall in terms of trade, and rising prices of manufactured goods compared with agricultural products, worsened the position of the peasantry.

There were large disparities in wealth, both between regions and within villages. Regional variations existed between villages in different districts according to the availability of water resoures, fertility of land, etc. In the rich northern provinces, the average income of a peasant family was eleven times greater than the average peasant income for the rest of the country.[1]

There were also internal stratifications of the population within villages which related to the ownership of means of production, such as land or draught animals. Unlanded peasants had to win favour of the landlord in order to ensure full time employment.

Land Reform:

Several attempts at land reform had been made, but the most important was that begun in January 1962, which stated: landlords should sell all land in excess of one village to the government who, in turn, would sell it to certain categories of cultivators, on a fifteen year repayment basis. The peasants were to become owners of the land they were farming, but those who had provided the means of production, e.g. oxen, water, etc., received priority. Thus, between 40-50% of the peasants, who were merely labourers received no land in the villages redistributed.[1]

The second phase of the land reform, reported complete in 1967, reduced the allowance of the landlords to between 30 and 150 hectares. In both phases the landlord was allowed to keep any mechanised farm or plantation and land worked by wage labourers.

In the second phase, according to official figures, 10% of the population in the 60-70% of the country's villages affected, received land.[1] However, sufficient land was distributed to destroy the power of the feudal landlords and create a new larger class of small-holders and petty entrepreneurs. Some of the landlords shifted their interests into industry and urban property. Thus the land reform was partly responsible for replacing feudalism by capitalism in Iran.

After the reform the government was faced with the problem of finding substitutes for the organisational and physical services, some of which were formerly the responsibility of the landlords. Consequently the government organised co-operative associations, locally elected village councils and "Houses of Justice". Their functioning was somewhat hampered by their domination by the more powerful members in a still highly stratified rural population.

To provide services, the "literacy", "health" and "extension and development " corps were mobilised from those serving their compulsory National Service. Of these the literacy corps is the largest and its activities have been much more noticeable. They have set up primary schools where they teach children and sometimes adults to read and write.

In the Fourth Plan, 1965,[2] rural development was, for the first time, allocated its own specific chapter. The Ministry of Rural Affairs was set up to administer this plan, which included building of rural roads, public health and sanitation, provision of potable water supply and the construction of model houses. The most important aspect of the plan was the encouragement of self-help and the subsidisation of public buildings, organised through the village councils. Nevertheless the magnitude of the problem was far greater than the attempts made to alleviate it.

Rural Development in the Fifth Development Plan of Iran:

Today, about 57% of the country's total population live in 66,000 villages. Although projects for rural roads, drinking water, and educational establishments for some villages have been proceeding, nevertheless, provision of other facilities such as clinics, high schools, public baths, and cultural establishments in all of the 66,000 villages was considered impractical and uneconomic.

It was decided that the fastest, most economical and practical way to provide these services to the rural population, was to be the installation of the needed facilities of several neighbouring villages, with a collective population of 8-12,000, in a central village which had the potential for expansion and development.[3]

Through the implementation of this Plan it was hoped that "population migration from smaller villages to larger villages and towns will be stabilised, thus checking undesirable migration from rural to urban areas. It is envisaged that this will later lead to a favourable situation for the natural amalgamation of small villages into larger ones." By concentrating development activities in the larger villages, a larger proportion of rural population will benefit from welfare facilities.

Appraisal:

The importance of the Fifth Plan's rural development programme lies in its wide national scale, and that it has the potential of, at last, providing desperately needed investment for services and infrastructure in some of the villages in the country.

Although the regional centre will be one of the most populated settlements in the region, most people are likely to be scattered in the satellite villages with 250 people. Therefore, to achieve the greatest coverage of services, it must be assumed that a majority of people from the surrounding area will use the centre and its facilities. Careful consideration of the conflicting interests and loyalties that exist between villages, and even within one village, is essential in deciding the location and distribution of facilities.

The nature of activities taking place in the facilities provided also need consideration. For example, the schools of the Ministry of Education and the literacy corps only provide primary school education in most villages. This is the initial stage of a city based, national education programme, and serves to introduce the more comprehensive package offered in the city. As further education is not available in the village, the children have to go to the city to continue their schooling. Technical and vocational education has been organised in most regions of Iran. However, the graduates from these schools find themselves unemployed in the rural areas because there are not sufficient job opportunities for them in their village. If thepresent situation is to be altered and the objectives of the plan fulfilled, the rural education should be a comprehensive, self-sufficient programme and not city dependant. Furthermore, it should be directly related to the needs of the people and regions that it serves.

Due to the the large scale of the development plan and lack of skilled and professional manpower, the facilities (such as schools, baths, clinics and public buildings) are built according to nationally standard prototype designs. These standard plans are prepared by the central government and therefore cannot always suit the varied conditions of the different regions of Iran.

These designs are implemented by city based contractors who will export the profits of the investment to the city. This contradicts certain aims of the development plan such as increasing rural income and employment. The contractors also buy their building materials from the city. This too, benefits the city's materials merchants and further reduces the benefits of the investment to the villagers. Moreover, these materials and the techniques used to build with them, are alien to the environment and the built form of the villages and the peasants are unable to continue building in the same way or repair the existing building. Hence, these methods of implementation increase the dependance of the peasantry upon the city and the central government. They also ignore the recommendations of the plan to respect the existing customs and traditions, the environmental and climatic conditions and the relationship of the new to the old.

On theother hand, local builders with a little training and supervision are capable of meeting nearly all the building requirements of their region. Also, indigenous materials and techniques that have developed over centuries to suit the particular environmental characteristics of their locality, if used, would reduce the reliance upon the city and increase the benefits of the investment for the area for which it was designated.

As the reduction of rural-urban migration is one of the principal aims of theplan, these following points should have been given higher priority: a narrowing of wage gaps between the city and the country, and correction of terms of trade concerning agricultural products. Rural employment could be increased not only in the construction sector implementing the plan's projects but by direct investment in labour intensive agricultural and manufacturing plants.

Part 3

The Selseleh Regional Development Project S.R.D.P.

S.R.D.P. has been set up as an experimental project to investigate and put into operation alternative rural development policies. The concept of "endogenous" or internalised development which the project is dedicated to, calls for the improvement of the living conditions within the regions through active participation of the community and by the use of local resources (as far as possible). For this reason only the minimum necessary decisions and activities of the project are preconceived, leaving room for decisions to be made in the field through ongoing research and discussion with the indigenous population. Without the involvement of the communities concerned, development work will become both authoritarian and ineffective.

Socio-Economic History of the Region:

Luristan, within which the Selseleh region is situated, is a mountainous and remote province of western Iran. It's population of approximately 400,000 consist mainly of tribal agriculturalists and sheep and goat herding nomads.

Until the 1930's no sedentary villages existed in Luristan. The Lurs lived off agro pastoral activities and sold their animal products in the bazaars of the major towns.(Boroujerd and Khoramabad). Each tribe had a leader (Khan) who claimed leadership through heritage from his ancestors. In the socio-economic hierarchy, the position below the Khan's family was occupied by a group who owned large herds and land. This group made up five percent of the total population. Another five percent (5%) were economically independent and owned sufficient land and sheep to ensure a satisfactory standard of living. The remaining population lacked either sufficient flocks or land or both to maintain economic independence and relied upon employment as farmers or shepherds for the upper group.

Early in 1930's the government's sedentarisation policy was enforced and large numbers of nomads were made to settle on land traditionally known to be used by the tribe for grazing. This policy, however, did not ensure an equitable division of the land between the settled population and it was the most powerful lineages that, despite fierce competition, gained control of the best irrigated and most fertile land.

In the 1950's new roads linked the most remote villages to bazaars in the towns by a two day journey. This increased the contact with the persian plateau and brought a flow of consumer goods which helped to undermine tribal values and the nomadic lifestyle. During this period many other nomads settled voluntarily. This was partly due to death of sheep stock and partly for reasons of political and economic security.

Consequently, a novel socio-economic organisation evolved which still operates today. The "Agro-pastoral combine" forms the basis of rural Luristan's economy.[4]

The head of the extended family, with the aid of some of his sons or brothers, farms the land which is normally sufficient to provide the families' annual consumption of wheat. At the same time, one or more of his sons, or close male relatives, are delegated to herding the sheep and carrying out the twice yearly migrations from the summer pastures in the north to winter grazing grounds in the south of Luristan. This system is flexible and well suited to the needs of the population as members can be withdrawn from the nomadic camp to help with seasonal tasks in the sedentary side, and vice versa.

During the process of Land Reform the old tribal leaders, who were now settled landowners, were not absentee landlords (as in many oth parts of Iran) but were alert and prepared for the forthcoming event The Khans divided their land between their families and those in their favour. They themselves took leading positions in most institutions set up after the land reform, such as: city council, villag council, co-operative chief, etc. Thus the old hierarchies have in effect remained the same even if they have taken a different appearance.

The Selseleh Region:

This high basin, ringed by the Zagros mountains, is the field area for the first phase of the development project. It consists of a land area approximately 400km^2 and contains a population of 40,000 scattered in about 250 villages. Most of this population are settled in the plains which also contain most of the fertile land in the region. The plains settlements are therefore predominantly agricultural, while the economy of the settlements in the three major valleys in the north and east of the plains is based on animal husbandry. However, as the majority do not own sufficient land or sheep or any other means of production, there exists in the region a large labour force that seasonally migrates to major cities in search of jobs.

The villages are scattered and vary in population from settlements formed of one extended family, to major villages of about 1,000 people. The town of Alashtar is the administrative centre of the region. It houses almost 6,000 people and acts as a market town. Alashtar has the only clinic and secondary school in the region.

Selseleh Regional Development Project (S.R.D.P.):

Education, Health and Agriculture - The integrated approach to rural development taken by the S.R.D.P. has manifested itself in activities in the fields of education, health, agriculture and physical services. The main bias of the development project is educational and the four activities mentioned above are introduced into the region through education, so that, while the immediate needs in the four fields of activity are being met, the local population are at the same time being trained in those fields. This will enable them to carry on the development work themselves without having to rely on the members of the development project.

S.R.D.P. Training of "Front Line Workers" - Ninety volunteers from the villages in the region were chosen and given a broad training in the fields of agriculture, health and education. The period of training was set at about one year, after which the Front Line Workers had to return to their villages where they would work with the local people to improve the conditions of the area.

Selection Procedure - It has been proposed that the region be divided into thirty subregions each with an approximate population of 1,200. A central village within each subregion will be chosen to act as a base for the three Front Line Workers. Here the education group will hold classes, for both children and adults, in which basic reading and writing will be taught in courses that are geared to the lifestyle and culture of the people. The agricultural worker will be available for consultation when he or she is not visiting the villages in their subregion to help with veterinary matters, prevention of insect attack on crops, advising on improved farming methods or ensuring that cultivators are not deprived of their rights in transactions such as sale of crops, purchasing seed, fertiliser, etc. In addition, a 120 hectare plot of good land has been donated by a village to the agricultural group where different cultivation and animal-husbandry techniques are being researched in order to establish improved methods which are suited to the region. The health worker will also be based in the central village and will be provided with a surgery where she or he will carry out curative treatment. However, they are expected to spend at least fifty percent of their time in carrying out preventive measures to reduce the causes of ill health in the villages of their sub region. The final part of the Front Line Workers' training consisted of a common programme in which each group was to learn the skills of the other two groups to a level enabling any one of them to carry out, in the absence of the other two members, the basic necessary actions for example, the teacher should be able to give preliminary treatment to a sick person in the absence of the health worker.

In addition to these functions the Front Line Workers are a further link between the development project and the people. They are being involved in most of the activities of S.R.D.P. and as well as helping in the implementation of these, discuss the programmes with the communities concerned and express their views and desires to the staff of the development project.

S.R.D.P. Administration:

The employees of the Selseleh Development Project collectively form the administrative body which deals with the day to day'running of the development project, and co-ordinates its programme. The S.R.D.P. also works closely with locally elected village and town councils and rural co-operatives. The project assisted in organising local elections. These elections were an invaluable educational experience for the local people who have traditionally been subject to oppressive rule from the elite. Most of the day to day problems facing the people of Selseleh, from marriage disputes to complaints of overpricing in local shops, are brought to the attention of S.R.D.P. which involves itself in nearly all aspects of life in the region.

S.R.D.P. Services and Physical Infrastructure:

The provision of basic services and infrastructural installations such as roads, water supply, rural clinics, public baths, schools, etc., should be an integral part of all development projects. However, the most important aspect of this activity is not merely the creation of the physical structures, but the way they are created (i.e. the process), and the nature of the activities which these structures envelop (i.e. the function). As already mentioned, the implementation of all S.R.D.P. projects is regarded as an educational process and in the services section, already many local builders and craftsmen are being trained in working with improved traditional or appropriate techniques. Also a good proportion of the building projects will house the activities initiated by S.R.D.P. such as adult literacy classes and rural clinics. In addition, an important part of the task of the services section, is the creation of productive and employment generating small-scale industries, such as brick kilns.

The Road Programme - The development project has embarked on the construction of a major road which will link the Selseleh region to the city of Boroujerd, the second largest city in Luristan.

Concurrently, a small-roads programme is also being implemented which will link villages to existing roads. This is a self-help road building programme. Both the major roads and small roads are constructed using low cost and labour intensive techniques as far as possible.

The Building Programme - The development project's building programme is the activity with which we are most involved. From the outset a building policy for the region and how to implement it was closely integrated into practical construction activity. The policy was:

1. Research and Development of local materials and technologies.
2. Training and Education of local builders.
3. Promotion of Small-scale Building Materials Industries.
4. Building Projects that met basic needs while also acting as vehicles for the above points.

We were confronted with two types of building activity: projects financed directly by the central government and those arranged by the Selseleh Project.

Government Building Projects - These were mostly schools and housing for teachers. The buildings could only be built by officially recognised i.e. city-based, contractors, and their standardised designs used brick, steel and cement. Thus the construction budget would largely go to city contractors and materials' merchants. We pressured the official organisations through S.R.D.P. to allow us to use local builders to implement these projects. We re-designed the projects to suit the local social and climatic conditions. We used local materials and technologies and in some cases improved on these. Through the construction process we trained local builders in these techniques. In these ways we also insured the majority of the government budget for the projects went to the local community.

S.R.D.P. Building Projects - These included public baths, water-supply projects, schools and bases for the Front Line Workers in the villages. They were built in partnership with the village. The village generally requested the facility, provided the site, the unskilled labour and some of the materials while the project provided the design, the skilled labour and other materials. Designs were developed in consultation with the users. Thus the people participated in both the decision making and implementation level. A brick and lime kiln has also been constructed as a first step to regional self-reliance in building materials. The kiln will be devolved to a local co-operative once it proves economically successful.

Builders' Workshop - A two month intensive workshop has been organ-

ised through the winter when building construction ceases, to further develop the on-the-job builders' training and the local technologies. The workshop includes practical work on the best ways to use mud and timber, the use of appropriate traditional technologies better developed in other parts of Iran (such as vault and dome construction), experiments into improving local technologies, plan reading, work organisation and builders' co-operatives. A literacy programme run concurrently links literacy to the builders(vocation.
Hence the services programme, like the other S.R.D.P. activities, fulfils two objectives simultaneously. It provides needed facilities while setting up the mechanisms that will enable people to provide these facilities self-reliantly.

Conclusions and Proposals:

The aim of the Selseleh Regional Development Project is to create the motivation and impetus in people to develop their region. Through the process of participation in satisfying basic needs, the population gain the skills, both technical and organisational, to fulfil needs which grow out of new and changing local conditions. Once these mechanisms are established the project can withdraw and the process will continue.

The Barriers to Development:

Yet, there are obstacles that retard and often prevent the upward mobility of the peasantry. The problems are at the local level, internal difficulties that are a heritage of a hierarchic, unstable and an oppressed society. Land, the basic resource in rural areas, is, despite the effectiveness of the Land Reform, still unevenly distributed. The oppressive relationship between those in positions of ownership and influence to those without, still persists. Thus increased production and surplus from the land benefits the few, destroying the incentive of the majority of the rural population for raising the level of production.
There are other hindrances. Tribal, kinship, and compound family loyalties create conflicting interest groups within a village or between villages in close proximity. As a result of this, community projects have hardly ever begun by the people themselves and poten-

tials of co-operation, collective effort, and the pooling of resources are diminished. The instability of the recent history, together with their state of poverty, have given rise to mass insecurity. This causes an "each man for himself" situation, strengthening individuality and competition while further hampering collective activity.

Can a development project, operating in a small area, within an international socio-economic system that perpetuates these contradictions, combat them?

On Agriculture:

Reaching a higher economic level is a common need and therefore one of the strongest motivating forces. Agriculture is still the major productive activity in rural areas, as in Luristan, and the agricultural programme of S.R.D.P. can have a substantial influence. The people's interest in diversifying their crops and investing in more long term ventures, such as fruit gardening and production of honey, is a sign of this influence. Yet without significant change in patterns of ownership and methods of production, these improvements will benefit mainly the more privileged land owners who are i a position to invest in new techniques and different varieties of production. The small, very scattered, individual plots of land which were mostly distributed through the Land Reform, are individually uneconomic. These can be collectivised into a number of larger, economically viable units and their owners aided to operate them as a co-operative venture.

The land in Selseleh, though fertile and possessing abundant water, is not used efficiently and its productive potential is not utilise This is due to lack of expertise in farming, irrigation techniques, and crop diversification which results in large areas being dry farmed. Also wheat and soya beans which are the only two major crops grown in this region, have a relatively low market value. Therefore, the income of the large landowners from their land which is usually farmed by landless share-croppers, is much lower than the land could provide. This allows the formation of a co-operativ which guarantees the landowner's present level of income as his share in the co-operative for donating the land. The land can then be farmed using improved techniques and more profitable crops and the increased income is distributed amongst the other members of the co-operative - the people who farm the land.

Small-scale Industries:

All the landless peasants cannot be absorbed in agriculture. Alternative sources of employment have to be sought. Small-scale, labour intensive industries dispersed throughout the rural areas can be a source of employment and increased income for this section of the population. In this field the Selseleh Development Project has begun the construction of small brick and lime kilns, to be organised as co-operatives. The handicraft programme as well has great potential for increasing the income, particularly of village women.

Education:

Yet another way of raising the economic level of the rural population is through investmeht in human capital by means of facilitating education.

Increased investment in education should be simultaneously accompanied by increased productivity and employment opportunities in the villages so that the school leavers can be employed in their own regions.

In this field the Selseleh Development Project has been most active. Education is the central theme within its policies and the training of Front Line health, education and agricultural workers, illustrates the need to approach development as an integrated, homogenous process.

Health:

Health, for example, is directly related to the economic situation of a community as well as to its level of education. Malnutrition and deficiencies of protein and essential vitamins, one of the major causes of poor health in the less developed areas, is precisely the result of the poverty that reigns in these areas. Unsanitary houses, w.c.'s, stables and polluted drinking water sources are all caused by a lack of relevant education and subsistence incomes. The peasant needs to know the sources of diseases and have the capability to combat them.

Clearly, a combination of curative medicine and disease prevention work is required. The medical doctor and the public health engineer, though not specifically trained to combat rural health problems, are nevertheless the only professionals available in this field. Most villages however, are deprived of the services of these professionals and need to seek them in the nearest city. The training of Front Line Health Workers in both curative and preventive medicine, undertaken by the Selseleh Development Project is a major step towards better rural health. This training should equip the trainees to seek out problems independently from their teachers and to take actions towards solving these problems, rather than teaching them certain set prescriptions to simple, common diseases.

Physical Services and Infrastructure:

Services and physical infrastructure encourage investment in productive fields, both industrial and agricultural, thus playing a crucial role in raising the level of income that would not be possible without the existence of infrastructure such as roads, drainage, water supply, electricity, etc. The creation of such services and infrastructure however, needs capital investment which the present level of economy of most peasant communities does not allow. An initial government investment is required, which, if correctly utilised will provide the needed services and infrastructure and trigger off economic growth.

Our task in the Selseleh region is to use the limited funds available, not only to build the maximum number of needed service installations but while building them, provide the local population with a methodology, technical and organisational skill which enables them to perpetuate the process and build for themselves. This is done through research and development in the improved use of local materials and techniques which leads to prototype building projects. In theprocess of building these, local builders are trained in improved traditional techniques of construction and better use of locally available materials. As a result of the practical training programme, a group of knowledgeable builders emerge, who then undertake a period of theoretical training. In this period they are taught certain design principles, how to read plans and architectural drawings and methods of work organisation, especially ways of forming building co-operatives.

When the training programme is complete and the builders have formed themselves into viable groups or construction teams, greater responsibility will gradually be devolved to them. Each unit will then take charge of a certain building project and, under supervision, carry it to completion. Every project will be allocated a certain budget, which will be given to the construction units during the process of building, and they will divide this sum through their co-operative organisation. Thus the region will possess organised teams of builders who are capable of directly undertaking government contracts, and by using materials that are available locally, making the region self-reliant in building terms.

Conclusions

The establishment of a methodology with which the S.R.D.P. approach can be applied to other regions would be an invaluable result of this project. To provide this methodology, the members of the Luristan Project need to carefully assess their past achievements and propose a plan of action for the future based on this appraisal. This planning process would also be extremely useful to the Selseleh Development Project itself. So far the activities of this project have been pragmatic and little has been done to bring decision making and implementations within a coherent framework. Yet lack of long term planning can lead to piece-meal activities and make co-ordination between different tasks extremely difficult. Also, the project's activities may concentrate unduly on a particular area and give rise to inequality and poor distribution.

Such a planning process needs extensive research but is essential in perpetuating an internalised development process. The field area could be divided into sub regions of a suitable magnitude.

The institutions responsible for economic activity (agriculture and industry, education, health, and physical services) could be based in each sub region. The Front Line Workers trained by S.R.D.P. in agriculture, education, health and building can already form the core of these bodies. What is lacking, however, is an administrative section which would deal with legal and institutional matters not covered by the Front Line Workers.

The members of the economic, educational, health services and administrative organisations could form a council, which would have the collective responsibility of distributing development funds in areas of greatest need and organising the implementation of projects to meet those needs; organising and assisting co-operative agricultural, industrial and commercial ventures and facilitating the sale of their produce. In short, these councils will gain increasing responsibility until they can carry out all the activities of the development project and finally replace it.

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Appendix

The Development Workshop is a group of architects, planners and researchers who work collectively carrying out research and development and projects on indigenous building methods in Third World Countries. They have worked in Egypt, Oman, Turkey, India and various other countries. Education is a primary aim and workshops have been carried out with both village builders and university level students. The Development Workshop is presently working as architects and planners for the Selseleh Regional Development Project in Luristan, Iran.

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INDIGENOUS METHODS FOR LOW–COST HOUSING: A CASE STUDY OF MUD–BRICK VAULT AND DOME BUILDING

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ABSTRACT

The potentials of indigenous planning and building methods have been neglected in most Third World Countries. They have been replaced by western methods that are often inappropriate to local conditions and needs. Indigenous methods are most evident in the villages, the traditional city quarters and the more recent squatter settlements. The architecture of these indigenous settlements have evolved over thousands of years. They reflect a country's accumulated expertise on how to build appropriately to the local social, economic, environmental and cultural conditions. Furthermore, the majority of people live in these settlements. Thus the approach to both understanding shelter needs and improving them in a Third World Country is through first understanding and developing the indigenous methods reflected in these settlements.

This paper is in two parts. The first looks at the potential role of indigenous methods, particularly related to the built environment, in Third World development. The second part of the paper takes "Mud-Brick Vault and Dome Building" as one example of an indigenous system, which if developed could play a major role in meeting shelter requirements for low-income communities.

Indigenous Building and the Third World

Indigenous Systems

By "indigenous systems" we mean those systems that are traditional to a country. A "system" can be simply defined as a set of related parts denoting "organisation". Many traditions, far from being backward or illogical as often supposed, do in fact have an underlying rationale or "system" which is closely related or "indigenous" to their particular region.

The potentials of indigenous systems have been neglected in most Third World countries. Instead they have been replaced by Western methods often inappropriate to local conditions and needs - physical, economic, social, cultural and aesthetic. The visible material success of the Western industrialised world has made it the obvious model for Third World countries. The very term "developing countries" implies a correlative "developed" world which would act as an ideal. Over the years, the values, objectives and methods of the West have been adopted by the other countries through a combination of imposition and emulation. The British model of parliamentary government has been implanted intact into countries with very different indigenous political organisations. Western medical methods have been unquestioningly applied, often to the complete neglect of long-practiced local methods of healing.

Today there is a growing awareness that such literal transference of methods rarely works. Nor is it adequate to start with basically Western objectives and methods and then modify them to local conditions; the Third World has very different social, cultural and economic bases (and in most cases, different physical environments as well).

Furthermore, in the global context of political economy, the Third World is now in a very different position from that in which the Western World developed, when it had the rest of the world to draw its resources from. Yet today the Western world itself is beginning to have grave doubts about the validity of its own socio-economic models. Profligate consumption of energy and resources has precipitated the energy crisis and aggravated a major economic recession. Over-specialisation and industrialisation have taken control out of the hands of the majority of the population and left them alienated. Moreover, at the time that the Western world was developing, it was concurrently shaping the socio-economic systems of the rest of the world, often to its own advantage and to the detriment of the country in which it was acting. Much of what is considered "modern" today in a developing country was fathered by this shaping process and continues to work to the detriment of the country. However, amongst the many inappropriate imported models, those indigenous systems that were through neglect least affected by this shaping process may now paradoxically have the most to teach us. Many of the indigenous systems remain relevant to local needs, are based on low and local use of energy and resources, and work in harmony with the natural environment.

For an example that illustrates the above points, let us consider housing. An old Arab saying loosely translates as "The day you stop building your house you will die". This is not some mystical quote but factually reflects the indigenous system of housing. In Salala, Southern Oman, the occupant of an old town house, whose family had lived there for generations, described to us how his house had been built. The house had started as one room on the plot of land and had gradually been added to as family size and fortunes increased, until it reached its present three-storey courtyard shape. And today on the top floor yet another room had been built, and a second room, still in timber and corrugated iron, was soon to be converted into more permanent materials so as to house a new arrival in the family. In the recently allotted plots in the town the same process could be observed. The new arrivals lived in a tent whilst building their first limestone room; the longer established houseowners had already inscribed a courtyard on the ground floor and were making further additions.

Thus, to paraphrase John Turner's words[1], the indigenous system of housing is one in which it is very much a process intimately related to the users' needs and finances, and very much in theusers' control The idea of housing being the production and distribution of a number of units by the government or a private institution to a passive recipient population is one of the misleading models set up by Western countries. Today, with chronic and increasing housing shortages in the wealthiest industrialised nations, people like John Turner are saying that the idea of housing as a product is unworkable. Instead they are turning to the housing "processes" found in the indigenous systems of the Third World to draw lessons for their own countries. Meanwhile in developing countries housing as a product continues to be sold as the most modern idea, along with a whole range of other dubious ideas on design, construction and building types. Thus as Western architects begin to realise the damaging social costs of high-rise apartment living, they become a major feature in many Third World countries.

The successful selling of Western ideas depends on the assumption fostered in people in developing countries that Western methods are superior to their own. Perhaps the most insidious effect has been their loss of self-respect and identity. In Oman, when we asked a ten year old school boy (with just two years formal schooling) to draw his own flat-roofed mud-brick, courtyard house, he drew us a pitched-roof Western bungalow with a front garden. He drew his family and himself in shirts and trousers, although in reality he was still dressed in the traditional galabeya.

The situation, however, can be reversed. Another owner-occupier of a mud-brick and palm-stem house in Oman told us he would like to live in a concrete house, indicating a bunker-like room near him. But after he had taken us through his own house and explained the rationale behind the use of the different materials and rooms and how they performed in his environment, he changed his mind about the concrete room. He preferred his own house, but asked if the permanence of the materials could be improved.

It is often the educated professionals and policy-makers of Third World countries who are the most convinced of the superiority of models offered by the Western countries. Their training and education is too frequently limited to these Western models. Since the majority of their people are still operating within indigenous systems[2], it is the professionals who are alienated in their out-look and in what they can offer. A re-evaluation of their own counties' indigenous systems would not only help these professionals regain their self-respect and identity, but also realign them with their own people and equip them better to be of service. In China, medical professionals seriously re-evaluated the ancient indigenous system of acupuncture, so that today it largely replaces Western anaesthetics. The Ujamaa village council of Tanzania was derived from the indigenous tribal organisation and it now forms a basic political unit of the country.

The Indigenous Built Environment

By "the indigenous built environment" we mean the built-environment of the rural areas, the older sections of the cities, and to an extent the unofficial settlements (such as squatter settlements) of the newly urbanising areas in the Third World. It is in these areas that the traditional methods of building and design are most apparent. That they are often the most run-down areas is more to do with wider economic conditions such as overcrowding, poverty and neglect than with the traditional methods themselves.

Housing

In his book "House, Form and Culture"[3], Amos Rappaport writes:-

> All housing needs to achieve four objectives in order to be successful.
>
> 1. It needs to be socially and culturally valid (here traditional housing possibly works best).
>
> 2. It should be sufficiently economical to ensure that the greatest number can afford it (in primitive contexts most, if not all,

people have houses).

3. It should ensure the maintenance of health of the occupants (in relation to climate, traditional housing succeeds; in relati to sanitation and parasites, it usually fails).

4. There should be a minimum of maintenance over the life of the building.

Traditional housing may, therefore, be much more acceptable- if not, in fact, desirable- than has been assumed, and housing atti tudes should be adjusted accordingly. At the very least this offers a fruitful field for research.

Whether one agrees with Rappaport's objectives or not, they act as useful set of criteria against which one can assess indigenous buil ing. Unfortunately indigenous building has inspired formalistic mi icry more often than serious assessment. For example, in Sudan the conically roofed, mud-and-thatch family-house cluster is recreated concrete and brick, with a backyard, and laid out in straight rows a low-cost housing scheme. The indigenous social and cultural vali ity is lost in the transition of form from the family cluster to the rigid layout. The change of materials decreases the climatic perfo mance of the new house and increases its costs beyond the range of most Sudanese. It also places the building of the house out of the owner's control. On the other hand, thematerials are more permanent require less maintenance and harbour fewer insects and parasites. However, these latter improvements could have been gained without losing the more fundamental advantages of the traditional example, if the approach had been to work from a thorough understanding of the indigenous system.

Rural Development

The lessons that can be derived from the indigenous built environment can be applied not only to housing, but also to more specialised buildings such as schools, workshops, markets, and public baths, and also to infrastructural design, such as layout, and access for people and services.

Probably the clearest example of this potential remains in Hassan Fathy's Gourna village,* which was built in the late 40's.

The village, near Luxor, Egypt, is built entirely of sun-dried mud brick, and the whole design from housing to communal buildings and layout is based on traditional concepts. Perhaps more importantly, Professor Fathy worked out an economic and organisational base, so that the production in the village derived from local crafts and local organisational patterns. The achievements and failures of Gourna deserve a thorough assessment.

A quarter century later, Fathy's approach is of increasing relevance as rural development becomes more of a priority. To quote Barbara Ward :[5]

> If de-centralised operations are to be supported, as the Chinese have shown, then development must be concentrated on the village, the market centre and the intermediate town. To prevent people from leaving the villages only to become unemployed in the big cities, intermediate centres are needed, with local storage units, and co-operatives, local banks and light industry, local family clinics, schools and health services.

Different versions of the development outlined in the quote have been put into operation in several Third World countries. An example from a village settlement in Oman serves to illustrate the pitfalls found in a too-simplistic approach. In this case little attention was paid to upgrading existing buildings. The new buildings - hospital, school, and mayor's house - were located some distance away from the traditional centre, which they rivalled rather than complemented. The new building reflected the "professionalism" of the city architects and contractors, a foreign firm. Neither in materials, layout nor design were they appropriate to the local environment - both physically and socially. For example, in the hospital the patients complained about the glare and heat in the rooms, which was caused by the layout, the huge windows and the concrete block walls. The heat gain was even beyond the capacity of air-conditioning, which was in any case an extra expense. Furthermore, by representing progress, the new buildings encouraged in the minds of the local populace ideas of what an appropriate building should be, and by implication denigrated the indigenous buildings. The only part the local population played in the development was through the few who gained temporary unskilled employment during the construction period. In theyears to come the net effect could be the creation of a new settlement around the new centre, physically apart from and alien in materials and form to the indigenous buildings, life-style and culture of the people and the physical environment. The traditional settlement, being officially ignored, would be allowed to decay into a slum while still housing a large section of the indigenous population.

If, however, the indigenous built environment had first been understood, if local materials and technologies had been used to the maximum (improved where necessary), and if local builders (perhaps a co-operative) had been in control of thebuilding, there would have been a much greater and lasting benefit to the community. Government investment for the project would have gone directly into the community, and a local building industry could have been revived, capable of developing the local built environment in a self-sufficient way.

The Urban Environment

It has been argued by Koeningsberger and others that indigenous methods of building are of limited potential, since they are mostly found in rural areas while the main problems for Third World countries are urban.[6]

This is true to a point, but not to the extent sometimes put forward. First, to refer back to Barbara Ward's statement that "development must be concentrated on the village... to stop migration from the countryside to the cities, increasingly rural development seen to be the solution to urban pressures. Secondly, there are ma developing countries that do have long urban traditions. Many old city centres, such as those in Isfahan, Cairo and Delhi[7] are example of indigenous urban building methods. Up to now, cultural pride an the tourist industry have done more to preserve such old city centr than any belief in their relevance for today. Essential as preservation is, it can imply a museum-piece view, branding such areas as fossilised relics of the past. However, far from being relics, the old quarters should be studied from a number of aspects; in aesthet terms: the sense of scale and proportion, vistas, and the juxtaposition of open and closed spaces; in climatically functional terms: the shaded streets, orientation according to the sun's angle, and the benificial air-movement generated by the street layout; or more fundamentally in terms of socio-economic organisation: with lively and sociable communities operating with economic efficiency.

The fact that many Third World countries may not have an urban tradition does not exclude the possibility that lessons could be learned from a neighbouring country with similar environmental, social or economic conditions, and which does have an urban tradition. The urban traditions of Egypt or Iran could for instance be more relevant than the garden-city concepts of Britain to countries like Oman.

Finally, even in an urban environment, rural-based indigenous systems of building, social organisation and values in general often seem to work. In his recent study of a squatter settlement in Lusaka, Zambia, Richard Martin* showed how the indigenous rural methods of building, social clustering and communal organisation are adding up to more successful settlements than those officially laid out and run by government bureaucracies applying alien methods.

Let us summarise why we believe Third World countries should thoroughly re-evaluate their indigenous systems.

Firstly, while the policies of many Third World governments still emulate Western values and techniques, the daily life of most of their citizens still lie predominantly in indigenous systems. Understanding and expanding the potentials of these systems to meet contemporary needs would enable development to be more appropriate and acceptable to the majority of the people.

Secondly, most Third World countries are also at a stage in which their comparatively limited resources are being exhausted by the many demands placed on them. This is within an international context, with governments becoming increasingly aware of the finite nature of the world's resources, and in which the costs of imported goods are rapidly rising. Indigenous systems represent hundreds of years of accumulated expertise on how to employ what is locally available to meet local needs economically - in monetary, energy, and resource terms. To realise this potential would give Third World countries greater self-sufficiency. In today's world such an approach to planning is perhaps the most realistic.

Case Study

Mud Brick Vault and Dome Building

The mud-brick vault and dome system evolved centuries ago in countries like Egypt and Iran. Their invention came about largely out of necessity in hot-dry semi-arid regions where roof spanning materials such as timber and reeds became more and more scarce as populations grew. Although mud-brick building reached an extremely sophisticated level, in public and domestic architecture alike, it has in more recent times been neglected in favour of building methods from the west which are automatically assumed superior. Interest in mud-brick developed again in the late 40's and 50's and can be seen in the work of Hassan Fathy in his Gourna village in Upper Egypt*, in research on alternative cements carried out by building stations particularly in India.

The need to seriously evaluate the potentials of such indigenous technologies has never been more evident than today, with the world wide crisis caused by theover-exploitation of energy and resources. Local timber reserves are being depleted in many countries by ambitious building programmes, and more and more the building industry becomes dependant on expensive imported or manufactured materials and components. Reinforced concrete roofing for instance puts the price of housing well above what the majority can afford and the accompanying technology outside of what the owner-builder can hand

The less expensive corrugated iron roof produces interior environments which are excessively hot. Our own research in Oman bears this out. There, concrete and steel are being imported at exhorbitant prices and the owner house builder is finding it more and mor difficult to provide housing for himself. In many such areas there exists local mud-brick building industries. Walls were built of mud-brick and in the past the roof structure was usually timber. There exists a potential for the up grading of the traditional mud-brick building industry in the introduction of vault and dome roof technology.

Structural Performance

Sun dried mud-brick has been used most commonly for load bearing structures. The brick itself has strength in compression but not in bending or tension. The vault and dome are responses to this. The traditional vault follows a geometry similar to an inverted catenary. The catenary is the pure tension curve that a chain or rope takes when it is allowed to ahng free, suspended by its ends. Thus an inverted catenary shaped vault of mud-brick is always in compression and is one of the most efficient forms possible.

Vaulting in the European tradition involves the laying of the masonry over a wooden supporting formwork which is later removed when the vault is dry. The particular adhesiveness between mud-brick and mud mortar combined with the indigenous method of building vaults and domes makes supporting framework unnecessary at any stage of the construction. Vaults are built so that courses of brick are sloped and lean into the end wall which supports the vault while it is being built. Vaults that we built could be stood on immediately after being constructed. Domes are usually semi-circular, the geometry and the slope and placement of the bricks being determined by a string with one end anchored at the centre of the circle, and the other end tracing out the arc of the dome. The dome, like the vault, is built without any supporting formwork.

Climatic Performance

When looking at the climatic performance of buildings made of mud-brick and those made of concrete the advantages of the former are obvious. Mud-brick's high resistance to heat flow and the thickness of a mud-brick building's walls ensure that interiors of houses are insulated from extremes of heat and cold. Similar structures of concrete tend to heat up excessively due to solar radiation and will require extra expensive mechanical air conditioning to achieve comfortable conditions within.

Vehicle for Training Skilled Builders

Mud-brick through history has shown itself to be an excellent tool for exploring and learning about structural principals of building. Because the material can only take compressive forces the built forms reflect the structure directly; there are no hidden stresses. The very cheapness encourages experiment and the small size of the unit, the brick, allows for adjustments during building. Pope, in his Survey of Persian Architecture 1939, says: "Trained in the instructive school of raw and fired brick the masons of Persia.... mastered many fundamental forms which were soon carried to a high degree of perfection. The construction of huge but relatively thin shelled domes... and the construction of vaults a hundred feet in width are all proof of a command of constructional forms that modern mathematics could scarcely have bettered."

While training in Egypt in vault and dome construction we experienced how instructive this building medium is. Today when there is a need for the training of skilled builders in Developing Countries the instructive potentials of mud-brick building should be utilised in practical educational programmes.

Economic Potential and a Decentralised Building Industry

It goes without saying that mud's universal availability and cheapness when compared to any other material are great advantages today when prices of most other materials are rocketing and shortages are being felt. Mud-brick remains unaffected by the international market system which gives inflated prices to other materials.

The material's wide availability makes it possible for a building industry incorporating mud-brick technology to operate in a decentralised, self-reliant way, as there is no need to import materials from outside. Local masons could be trained to form a core of skilled builders or a building co-operativ to deal with the more complicated problems of building, such as roofing or large public building. Investment in local materials and expertise means that money spent on building remains in the lcoal area rather than passing to a city based contractor, or being lost abroad.

Conclusions

Mud-brick vault and dome technology has been presented as a case study of an indigenous building method which has potential for development. This is not to say that advanced and intermediate technologies do not have an important role to play in developing countries, but indigenous technologies have been the most neglected. Much pressing work has to be done. The trend in many countries, even where a strong vault and dome roofing tradition exists, is to put all the investment for new building into western capital-intensive methods. As a result highly skilled traditional masons find no market for their trade. New apprentices are not being trained. Before such skills are lost they must be reassessed and developed. The shortcomings of such indigenous materials and methods must be analysed and improvements suggested in the light of modern research. For example, improvements can be made in the mud-brick's strength properties and more importantly in its resistance to water damage, abrasion and insects. These improvements must be fed directly back into the indigenous industries.

Finally, the feasability for the use of vault and dome roofing should be explored in other developing countries where the environmental and economic conditions are appropriate and modern roofing techniques are proving too expensive.

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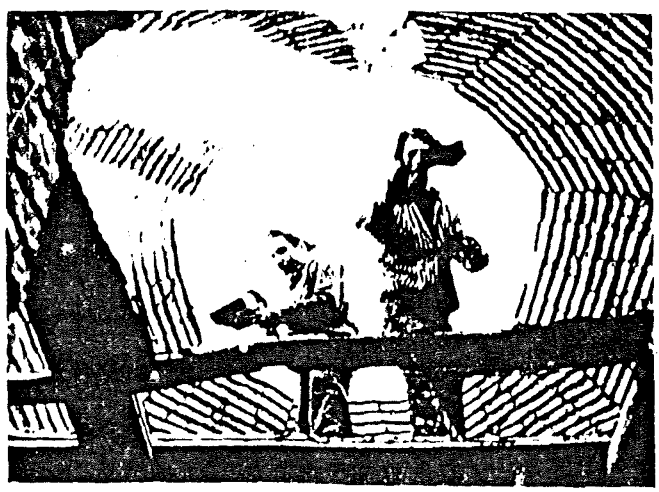
The Development Workshop 1977



Dome Building (Iran)

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Appendix

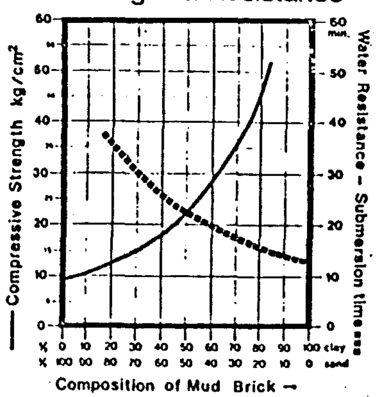
The Development Workshop is a group of architects and researchers from a number of countries, working collectively on the research and development of indigenous methods of planning and building. They have been involved in projects in Egypt, Sudan, Oman, India, Turkey, Iran, and various other countries. Research and development work is carried out into methods already having a mass base, and which remain in the hands of Third World communities.
Education is a primary motive. Workshops have been conducted with builders and young trainees in rural communities in order to develop upon existing skills and methods; and with university students to equip them to be of more use to the majorities in the Third World. Educational materials in the form of publications, exhibitions and films are being prepared.
The promotion of co-operative development of local building and small-scale industries is another aim of the Workshop.

Mud-Brick

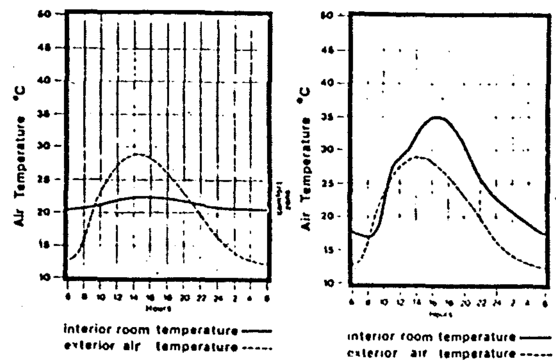
CLIMATIC PERFORMANCE

Partly due to the thickness of mud walls and partly because of mud's low thermal conductivity rooms built of mud are known to be much cooler in hot areas than those made of any other material. Mud walls and roofs effectively insulate room interiors from the external extremes of heat and cold. Similar rooms of concrete tend to heat up excessively due to solar radiation and will require expensive mechanical air conditioning to achieve comfortable conditions within.

Mud Brick
Strength & Resistance



Climatic Performance
Mud Brick Room
Prefab Concrete Room



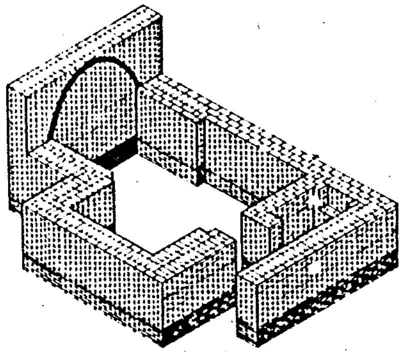
STRENGTHS

In the soils used for brick making sand provides resistance to abrasion and water, while clay provides structural strength. By mixing various proportions of sand and clay the brick can be engineered to suit a particular building or structural requirement.

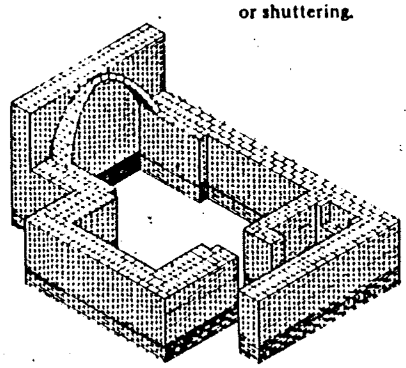
Sun dried mud brick has been most commonly used for load bearing structures. The brick itself has strength in compression but not in bending or tension. Thick walls result, but the cheapness of the material means that the cost of construction remains minimal.

Vault and Dome Housing

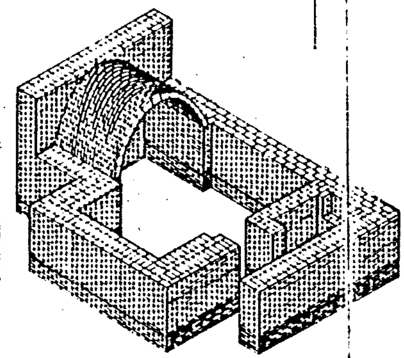
Illustrated here is a house built recently, in Egypt, by a group including the authors, which shows the principals of one of the methods of mud brick building without centering or shuttering.



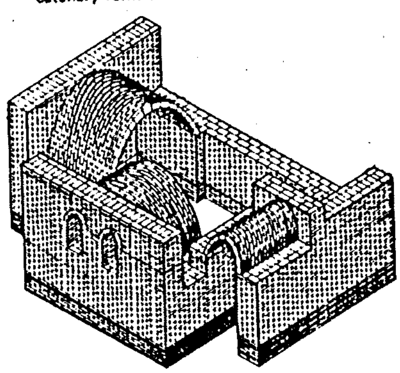
Walls built up to the level of the spring points of the vaults. End wall built up for vault to lean on. Inverted catenary form traced on end wall.



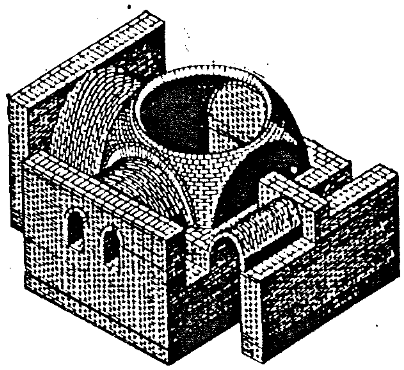
Vault building with courses leaning towards end wall so that no form work or shuttering is needed.



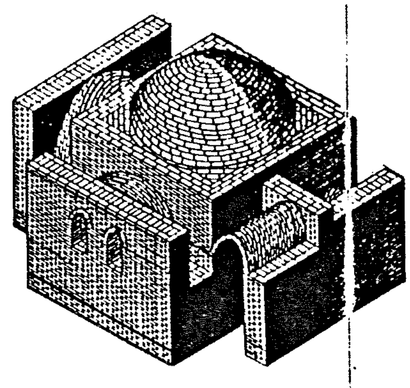
Vault completed.



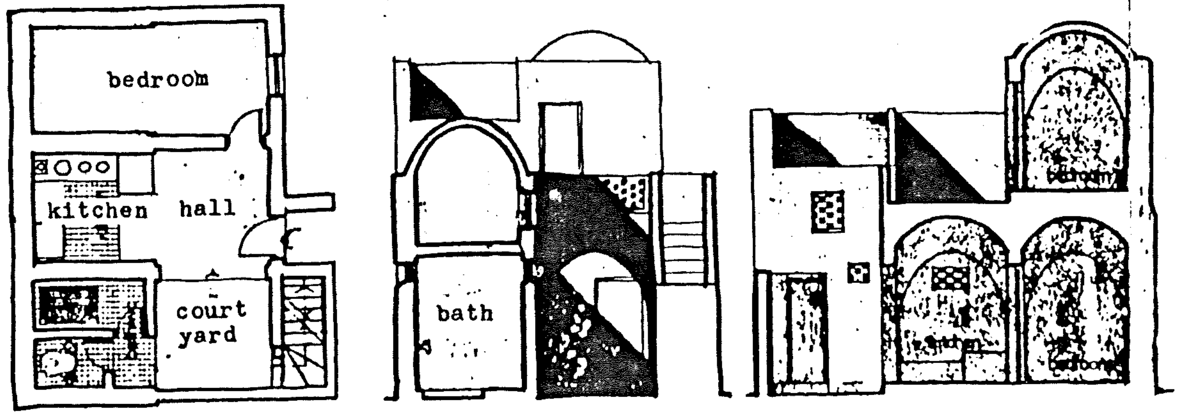
Small vault built in same way as large ones. Loose bricks removed from window openings.



Pendentives completed, forming continuous course from which dome can be completed.



Brick courses of dome incline increasingly until dome is finished.



INDIA Award Winning Scheme for housing competition (Delhi, India) which invited ideas for alternatives in low cost housing.

Development Workshop consists of Farroukh [A]fshar, Allan Cain, Mohammad Reza Daraie, and John Norton. The authors work collectively on the research and development of indigenous planning and building. They have been involved in projects in Third World countries such as Egypt, Sudan, Oman, India, Turkey, and Iran. The authors have been working as architects and planners for the Al-Ashtar Selseleh Integrated Development Project in Luristan, Iran and are presently working with the Centre for Endogenous Development Studies.

[T]he potentials of indigenous [b]uilding technologies

[by] Farroukh Afshar, Allan Cain, Mohammad-Reza Daraie,
[Jo]hn Norton, The Development Workshop
[C]entre for Endogenous Development Studies

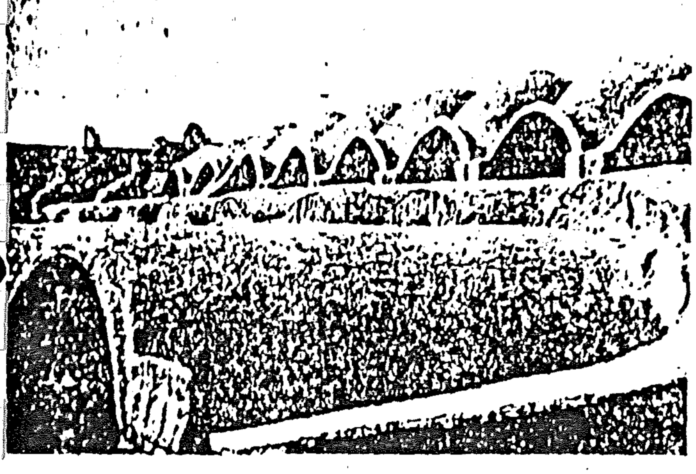
This paper presents the view that to develop an appropriate technology Third World countries should first thoroughly study, develop and share their indigenous technologies. This paper concentrates on indigenous building technologies to make this point.

[1.] The Case for Indigenous Building Technologies

Indigenous planning and building methods have been neglected in most Third World countries. Yet these countries still have some highly developed indigenous technologies evident in their villages and traditional city quarters. The architecture of these indigenous settlements has evolved over thousands of years and reflect their countries' accumulated expertise on how to build cheaply and appropriately to the local social, cultural, economic and environmental conditions. Squatter settlements are often one of the few areas which drew from this experience. Furthermore, the majority of people live in the villages, traditional city quarters and squatter settlements. Thus the approach to developing an appropriate technology is through first understanding and improving the indigenous technologies being used in these settlements.

The irony is that Third World countries are importing methods that are being seriously questioned in the countries of origin. For example, high-rise becomes a major feature in many Third World countries at a time when the West is beginning to realise the damaging social effects of high-rise living, the high energy requirements and the costs to keep them even minimally comfortable and functioning.

Meanwhile, the indigenous courtyard house with its many energy-saving devices, providing a climatically comfortable and quiet atmosphere (increasingly important in noisy and polluted cities) is in fact being ignored. The potentials for achieving high densities using the courtyard house form as illustrated in Third World cities' older quarters is also ignored (high densities are one of the most often quoted defences of high-rise).



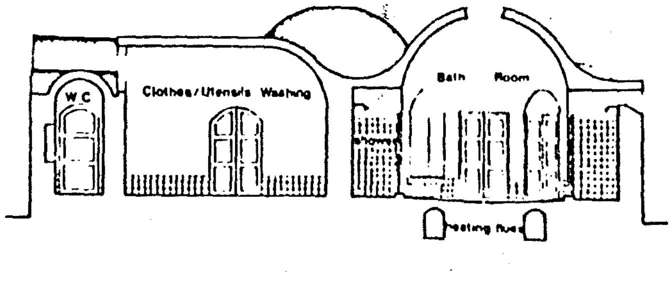
Old city centres such as those in Isfahan, Cairo and Delhi are examples that have much to teach us and should be studied from a number of aspects. In aesthetic terms: the sense of scale and proportion, vistas, and the juxtaposition of open and closed spaces; in climatically functional terms: the shaded streets, orientation according to the sun's angle, and the beneficial air-movement generated by the street layout; in terms of traffic control: the use of a rational hierarchy ranging from major vehicular thoroughfares to residential pedestrian access and the above mentioned ability to achieve high densities with low-rise. Again it is ironic that while many Third World planners seem oblivious to such practical lessons offered by their indigenous methods, Western planners are implementing similar principles in their work. The fact that some Third World countries may not have an urban tradition does not exclude the possibility that lessons could be learned from a neighbouring country with similar environmental, social or economic conditions, and which does have an urban tradition.

In general it can also be said that in a world of dwindling energy resources, indigenous technologies, not least indigenous building technologies, show us energy saving methods on a variety of levels, from materials such as mud-brick to elements such as the wind-catch. Unfortunately, the recent interest in indigenous building has more often "inspired" formalistic mimicry, expressed in arched facade treatments and concrete vaults rather than serious assessment and application.

2. Indigenous Building in Regional Development

A common situation in Third World countries is one of burgeoning, increasingly unmanageable major cities drawing labour from the rural areas, undercutting the agricultural food base and creating imbalances between a few large cities and the rural areas. National Development Plans should place more emphasis on the development of the rural areas, their villages and service towns, leading as far as possible to self-reliant regional groupings.

On the construction aspects, in most official rural development projects the physical services and infrastructural networks are planned in centralised offices by people who have little knowledge of the socio-environmental conditions of the field area. If the project is on a national scale, often the same building designs are applied to all the regions. This approach results in the buildings being alien to their environment, and almost invariably reduces their effectiveness and usability. Furthermore, since the designs are usually implemented by city-based contractors, a considerable proportion of the building investment is absorbed by them and the city materials merchants, and not by the local community. The



local population is left with a structure which they cannot easily repair and maintain themselves nor use as a model for their own houses, since the structure is too expensive and technically complicated.

An effective strategy for meeting shelter needs requires a much more comprehensive, integrated and grass-roots effort.

Locally based teams working within regional development projects should act on the following closely inter-related levels:

1. Research Experimentation and Development work on local building resources materials, technologies and skills.
2. Training of local builders to develop a cadre capable of implementing most building projects independent of extra-regional professionals and contractors.
3. Stimulation of local building materials industries such as quality controlled mud-brick yards, and brick and lime industries, to make regions largely self-sufficient in materials.
4. Construction of essential buildings such as schools, clinics, houses and village baths in a way that demonstrates the use of indigenous technologies, and training local builders during the construction.
5. Plan for the growth of the major settlements of the region, demonstrating how settlements can grow in continuity with their indigenous settlement pattern, as well as develop traditional planning methods.

The one fundamental principle underlying these proposals is that the local people, such as the local builders, are often both the best sources of information and the most effective implementors. The extra-regional cadres can best act as temporary catalysts. The authors have been involved in implementing this policy within the Selseleh Integrated Development Project in Luristan, Iran.

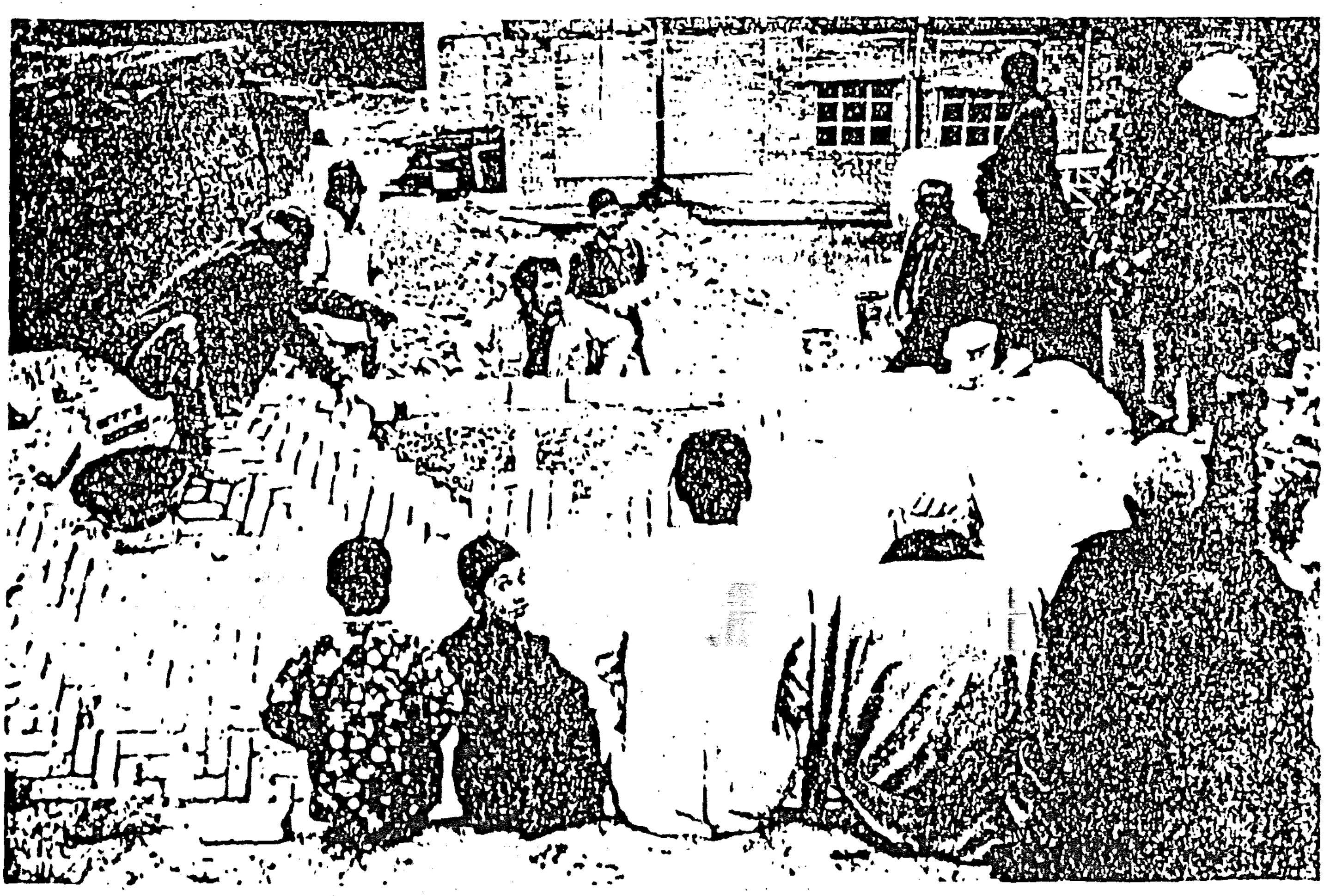
3. Mud-Brick Vault and Dome Technology

INTRODUCTION:

Here mud-brick vault and dome technology is being presented as an indigenous technology with particular potential in low-cost housing for developing and sharing between Third World countries. The mud-brick vault and dome system evolved centuries ago in countries like Iran. Their invention came about largely out of necessity in hot-dry semi-arid regions where roof spanning materials such as timber and reeds became more and more scarce as populations grew. Although mud-brick building reached an extremely sophisticated level, in public and domestic architecture alike, it has in more recent times been neglected in favour of building methods from the West which are automatically assumed to be superior. Interest in mud-brick developed again in the late 40's and 50's and can be seen in the work of Hassan Fathy in his New Gourna village in Upper Egypt, and in research on alternatives to cement carried out by building stations, particularly in India.

The need to seriously evaluate the potentials of such indigenous technologies has never been more evident than today, with the world wide crisis caused by the over-exploitation of energy and resources. Local timber reserves are being depleted in many countries by ambitious building programmes, and more and more the building industry becomes dependent on expensive imported or manufactured materials and components. Reinforced concrete roofing for instance puts the price of housing well above what the majority can afford and the accompanying technology outside of what the owner-builder can handle.

The less expensive corrugated iron roof produces interior environments which are excessively hot. Our own research bears this out. For example, in many rural areas concrete and steel are being brought in at exhorbitant prices and the owner-house builder is finding it more and more difficult to provide housing for himself. In many such areas there exists local mud-brick building industries. Walls are built of mud-brick and in the past the roof structure was usually timber. There exists a potential for the upgrading of the traditional mud-



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Vaulting in the European tradition involves the laying of masonry over a wooden supporting formwork which is er removed when the vault is dry. The Middle-Eastern vault nstruction method does not require supporting formwork, ether one is using fired or sun-dried brick. In the case of the ter the particular adhesiveness between the mud-brick and mudmortar is additionally useful. There are a wide variety vault and dome types, both in shape and construction thod. A common type is a vault which is built so that urses of brick are sloped and lean into the end wall which pports the vault while it is being built. Vaults that we built uld be stood on immediately after being constructed.

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Vehicle for Training Skilled Builders :

Mud-brick through history has shown itself to be an excellent tool for exploring and learning about structural principles of building. Because the material can only take compressive forces the built forms reflect the structure directly; there are no hidden stresses. The very cheapness encourages experimentation and the small size of the unit, the brick, allows for a core of skilled builders or a building co-operative to deal with the more complicated problems of building, such as roofing or large public building. Investment in local materials and expertise means that money spent on building remains in the local area rather than passing to a city-based contractor, or being lost abroad.

Mud-brick vault and dome technology is a case of an indigenous building method which has potential for development. This is not to say that advanced and intermediate technologies do not have an important role to play in Third World countries, but indigenous technologies have been the most neglected. Much pressing work has to be done. The trend in many countries, even where a strong vault and dome roofing tradition exists, is to put all the investment for new building into western capital-intensive methods. As a result, highly skilled traditional masons find no market for their trade. New apprentices are not being trained. Before such skills are lost they must be reassessed and developed. The shortcomings of such indigenous materials and methods must be analysed and improvements suggested in the light of modern research.
For example, improvements can be made in the mud-brick's strength properties and, more importantly, in its resistance to water damage, abrasion and insects. These improvements must be fed directly back into the indigenous industries.

Finally, the feasibility for the use of vault and dome roofing should be explored in developing countries where the environmental and economic conditions are appropriate and modern roofing techniques are proving too expensive.

Indigenous Building Workshop

The following case study is offered as an example of how indigenous building technologies can be developed and taught through research and training workshops with village builders.

The local builders in villages and small towns are

traditionally responsible for most of the construction, both public and private. These builders are both a valuable source of experience on indigenous building methods and also an appropriate channel for the introduction of improved indigenous building techniques.

A workshop for upgrading the skills of rural builders was organised by the Development Workshop in conjunction with the Selseleh Integrated Development Project in the spring of 1977. The workshop was carried out in Yazd in south central Iran, an area of advanced indigenous building techniques. Builders from villages in Luristan province, Iran, participated in the two month programme. They were involved in experimenting with improvements to their local materials and building technologies. Experience was shared between workshop participants, who included village builders, architects and master builders from other regions of Iran. Solutions to village settlement problems were arrived at through discussion, then tested in the field.

There were two closely inter-related aims; firstly, to develop indigenous building methods through the pooled knowledge and participation of the village builders; secondly, to train these builders in practical and organisational skills so that they were equipped to meet most rural shelter needs without dependance on city based contractors, engineers and building materials.

Methodology :

The workshop methodology adopted was: learning through discussion, through practice and through experimentation.

For example, discussion on building methods, design, and drawing principles was introduced by asking each participant to draw their own house and discuss its advantages and disadvantages. From these discussions village housing and detailed building problems were identified and drawing skills were developed.

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   - the role of the village builder as a development cadre
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4. Foundations:
   - for differing soil and site conditions differing building requirements
5. Walls:
   Mud, mud-brick, fired-brick, stone, and mud-brick and fired-brick combinations. For each type of wall the costs, structural, physical and climatic properties were compared. Builders learned the best methods for compacting mud, making mud-brick, fired-brick, types of mortar, required wall thicknesses, brick laying methods, etc.
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   Timber roof types in Iran and other countries, new alternative timber roof types and timber trusses. Through construction and experimentation each type was evaluated.
7. Vault and Dome Roofs:
   The most widely applicable vault and dome types were selected. Builders learned how to construct these types, the variations of wall thicknesses according to roof span, arch construction, roof span to vault and dome curve ratios, the physical, structural and climatic properties of vault and dome.

Finally, the aim of the workshop was to develop an educational methodology that barely literate builders could use to educate themselves and improve their indigenous methods. This methodology, based on problem identification and problem solving by sharing knowledge through the processes of discussion, practise and experimentation, proved successful within the workshop.

Conclusions

In conclusion we make the following proposals.

1. Third World countries should set up Regional Development Projects that deal with the problem of meeting local shelter needs in the comprehensive and integrated way outlined in Part 2 of the paper. In this way, not only would local building technologies be developed and applied but also the criteria for their selection would be made on a grass-roots level.
2. A programme should be implemented for Research and Development of Mud-Brick, Vault and Dome Technology for application in both the countries of origin and in other Third World countries.
3. Indigenous Building Workshops should be held with the participation of builders and professionals from different Third World countries, who have knowledge of their indigenous technologies so that this knowledge can be shared between these countries.

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MOBILIZING INDIGENOUS RESOURCES FOR EARTHQUAKE CONSTRUCTION

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ABSTRACT

This paper discusses indigenous village building methods in earthquake regions. The paper proposes a methodology for the upgrading of village building, to better withstand earthquakes, involving local people themselves and materials and technologies which remain in their hands. This paper is prepared in light of a survey carried out in the area of the Bandar Abbass earthquake in March 1977 in southern Iran. The second part of this paper proposes a methodology for the introduction of improved building techniques into earthquake areas. A programme of short training workshops held in rural areas, in which village builders participation is proposed as a way of upgrading indigenous building techniques. Through the development of indigenous building methods solutions can be reached which are economically, socially and environmentally suited to the region and remain within the control of local people.

The conventional approach to earthquake construction has two common features: developing earthquake resistant structures in technical institutions, and introducing these structures into a region usually through a resettlement programme after an earthquake has ocurred. The people of the region are neither involved in the development nor implementation of the structures, and these structures, although they may meet earthquake resistance requirements, often ignore other needs. In several cases the conventional approach has failed when people have left their newly provided houses and have repaired and moved back into their old homes.

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In areas of earthquake destruction, such as the rural Siah Ho region north of Bandar Abbass, whilst a certain amount of reconstruction work can be done with the help of external government aid, using the services of contractors and materials imported from the region, much of the reconstruction work and certainly most of the future building will be done by local people themselves. In a remote mountain area, a combination of extremely poor or non-existant road connections and local poverty make the large-scale importation of building materials and equipment impractical over a long term. Simple improvements in local building methods in the Siah Ho area would have prevented much of the damage and loss of life which did occur.

Survey of Earthquake Area - Siah Ho Region

A team from the Development Workshop, architects Mohammad, Reza Daraie and John Norton visited the Bandar Abbass area in March 1977 (Farvardin 2536), a few days after the major earthquake shocks occurred. The Siah Ho area, about 60 kms. to the northeast of Bandar Abbass was one of two areas that suffered the worst damage from the earthquake. The villages of Khoorgar, Sarkhah and Gishan were visited. In all three villages there was no buildings that were undamaged by the earthquake. An extremely high proportion of the buildings had either partially or totally collapsed. Of the range of buildings seen in the area, no one type appeared to have escaped earthquake damage, although certain elements and techniques had offered greater resistance to damage.

Three main local types of construction are used in the region: palm frond stem shelters; mud brick walls with flat timber and mud roofs, and stone walls with flat timber and mud roofs. In addition, a few buildings have been built using techniques and materials imported from outside the area.

Assessment of Damage to Indigenous Building Types

1. Palm Frond Stem Shelters - "Kapar"

Shelters using a timber framework, usually palm tree trunks, and using palm frond stem matting for covering the roof and sides, are used for summer houses and for animal shelters as well. Because of their framed construction and lightweight panel cladding, these shelters remained largely intact and provided valuable emergency shelter after the earthquake. There were some examples where part of the support for the matting roof had collapsed, usually where part of the shelter was supported by a mud or stone wall which had collapsed. However, these shelters indicated some important points in earthquake protected construction: firstly, that a framed construction that can move intact is less damaged; and secondly, that lightweight roofing, even in the event of collapse, causes less damage and injury.

The other two types of construction (mud brick and stone) both had flat roofs using timber beams, matting and mud.

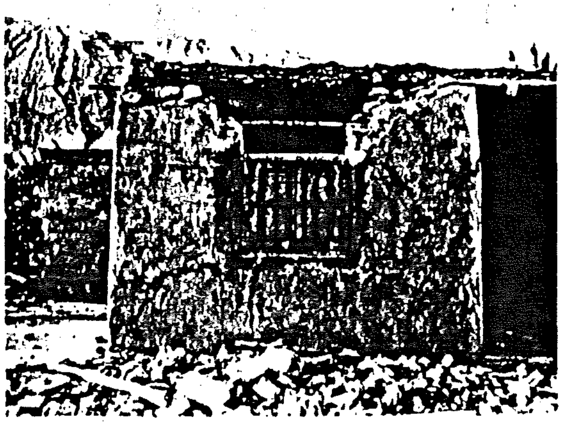
2. Mud Brick Walls - "Divaar Kheshti"

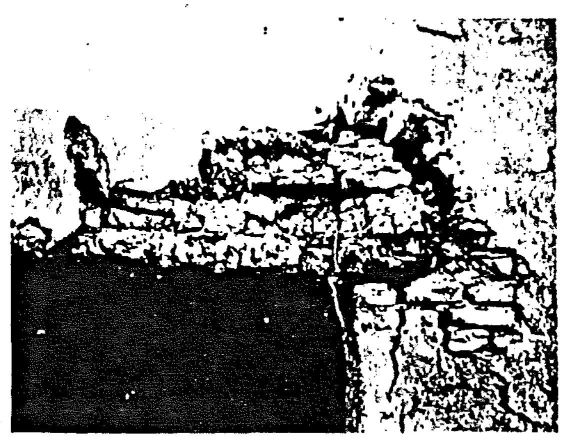
The failure of these walls was facilitated by the lack of bonding through the width of the wall. Walls were built with an outer and inner course of bricks, with only the mortar to hold the two halves together. These two halves tended to separate during the tremors, so that neither half consequently was strong enough or thick enough to stand up on its own or to support its load, leading to collapse. In the absence of observing the actual collapse of these buildings, it is not possible to state accurately which part collapsed first or exactly how; however, the lack of bonding would facilitate the total disintegration of the wall. There was also evidence that the strength of the walls had been reduced by termite bore holes, which seemed particularly the case for the mud mortar used between the bricks, which may have been prepared with less care than the mud bricks themselves. Similarly, where timber had been embedded into the walls (basically a good practice in reinforcing and framing the walls of a building for earthquake protection), it had been attacked by subterranean termites and substantially weakened. There were some instances where walls had fallen intact as a result of the movement. Examples of this were particularly apparent where existing openings had been filled in at a later date with no bond to the sides of the opening and with nothing to resist the collapse of the added wall, which in several cases was seen lying almost intact on the ground. In all these cases, the instability of the wall was increased by substandard foundations, or none at all.

3. Stone Walls, Rubble and Mud Mortar

Stone walls were most commonly built using mud mortar, which provided practically no adhesive bond between the stones, and therefore little to stop the whole wall collapsing into a heap of rubble when shaken.

Bandar Abbass Earthquake Damage
Siah Ho Region





Lintels over doors and windows were not embedded deep enough into walls

No bonding between wall
and external surface

Total collapse of rubble walls
and heavy mud and palm roof

Examples of wall failure due to lack of internal bonding

Additionally, stone walls were built with no bonding, small round stones placed on top of each other formed the two sides of the wall, with general rubble and earth filling in the gap between. In many cases the other surface had simply peeled off. Elsewhere the two sides had separated and had both falled away. If walls are load bearing any such failure will cause the roof to collapse. There were very few examples of stones being laid in such a way as to bond one side of the wall to the other. Where stone had been properly laid with a bond, and good mortar used, the building had suffered far less damage.

Corners

In both stone and mud wall constructions the corners were the weakest points, and even where the building had not totally collapsed, there were severe cracks at or collapse of the corner. This is due to the weakness resulting from the two different orientations of the walls in relation to the movement of the ground, causing conflicting movement in the walls. Once again the absence of proper bonding has increased this effect.

Openings

Nearly all the openings had been spanned with timber lintels. Because in most cases the lintels projected only a small amount into the wall on either side, the timber pulled out and the structure above collapsed. Even where the projection was sufficient, severe cracking on either side of the opening occurred. The position of the opening was also important. Where openings occurred close to the corners, the combined effect of the corner and the opening resulted in greater cracking and more often collapse.

Roofs

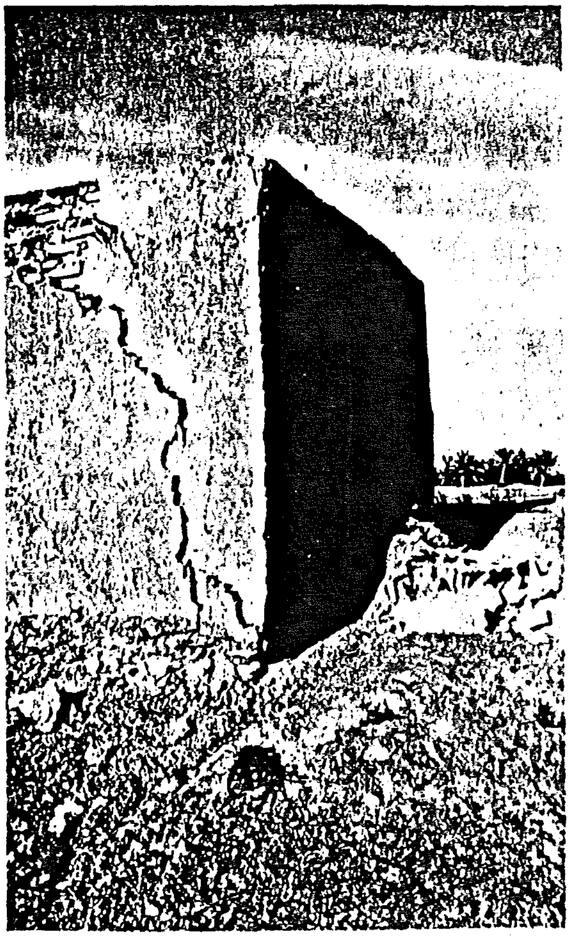
Clearly the collapse of walls supporting a roof will cause the roof to collapse as well. However, it was noted that walls carrying a roof load were more likely to fail, than those carrying their own weight. Where the timber beams did not project far enough over the wall, the outward movement of the wall resulted in the beams slipping off and pushing the wall over as the roof fell. Thus the roof itself can increase the likelihood of the wall collapsing, where the junction between the two is not properly built. This situation was also seen with steel I beam construction. Timber roofs using a large number of thin beams (of approximately 10cm diameter) tended to remain in place better than roofs using fewer but larger beams. The load on the former type is more evenly distributed along the length of the wall, so that no one point is under too much pressure. The palm matting used over the timber beams was also helpful, since being flexible and in large sheets it could take up some of the movement.

New Materials

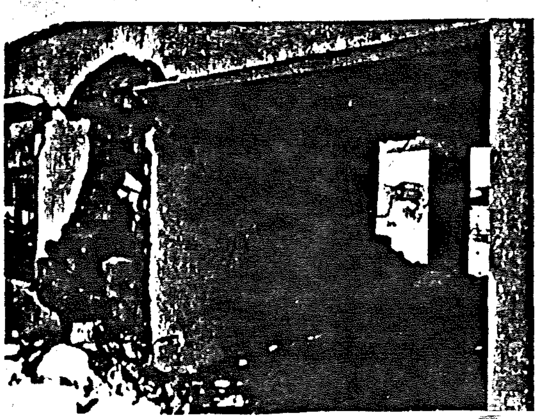
Only one building, a school, was seen during the visit that used materials and techniques not readily available in the area. The walls were of concrete block and the roof made of steel I beams with brick jack arches. There was a sheet of chicken wire mesh under the roof structure, into which the plaster had been applied. All the walls were cracked and one of the loadbearing walls had totally collapsed. The roof had collapsed. The steel I beams had not been tied together and overall the building had suffered from insufficient and in parts nonexisting framing. With the movement of the steel, the jack arches had also collapsed.

As a general comment, the standard of building was extremely poor, with very little technical ability. Much of the damage could have been avoided if the materials had been used properly and carefully.

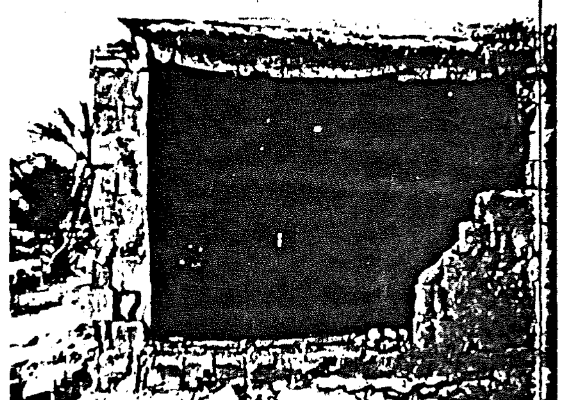
Bandar Abbass Earthquake Damage
Siah Ho Region



Examples of corner failures, due to stress concentration, poor bonding and lack of reinforcement



Corner failure and collapse of concrete block school



End Wall Collapse due to lack of corner bonding

Village Builders' Training Workshop - Yazd, Iran, 1977. Learning through discussion, practice and experimentation.

Village Builders' Training Workshop (a case study)

A local rural builder, who is traditionally responsible in each village for most of the construction, both public and private, offers an appropriate channel for the introduction of improved building techniques and solutions to rural shelter problems. It is with these people that research should be carried out into more appropriate building in earthquake prone regions. Short workshop training programs for local builders in post disaster situations could equip them to meet reconstruction needs with improved building techniques.

The following is a case study of a builders' training workshop which dealt with building in earthquake areas as just one subject among many building problems. The Workshop methodology could be easily adapted to focus more particularly on building for earthquake protection.

A workshop for upgrading the skills of rural builders was organised by the Development Workshop in conjunction with the Selseleh Integrated Development Project in the spring of 1977. The workshop was carried out in Yazd in south central Iran, an area of advanced indigenous building techniques. Builders from villages in Luristan Province, Iran, participated in the two month program. They were involved in experimenting with improvements to their local materials and building technologies. Experience was shared between workshop participants, which included village builders, architects and master builders from other regions of Iran. Solutions to village settlement problems were arrived at through discussion, then tested in the field.

Aims:

To develop the practical and organizational skills of village builders so that they are equipped to meet most rural shelter needs without dependance on city based contractors, engineers and building materials. This also means that capital investment in rural building remains in rural areas.

Methodology:

The workshop methodology adopted was: learning through discussion, through practise and through experimentation.

For example, discussion on building methods, design, and drawing principles was introduced by asking each participant to draw their own house and discuss its advantages and disadvantages. From these discussions village housing and detailed building problems were identified and drawing skills were developed.

Each aspect of building construction, from different types of soils and foundations to walls and roofs were discussed in turn. On each subject the participants contributed their experiences and optimum solutions were agreed upon. Each building solution was tried out in practise in a yard set aside for such testing. At the same time, experiments were carried out on local materials like timber, stone and mud brick. Soils were tested using simple sedimentation techniques that could be mastered by any local builder. Stabilisers for mud brick and renders for improving earth walls against rain and wind weathering were developed for local soil types.

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   - site planning and orientation
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   The most widely applicable vault and dome types were selected. Builders learned how to construct these types, the variations of wall thicknesses according to roof span, arch construction, roof span to vault and dome curve ratios, the physical, structural and climatic properties of vault and dome.

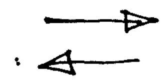
8. Building in Earthquake Areas:
   The following are illustrations and notes from some of the workshop's discussions and experiments on earthquake construction. Earthquake considerations were discussed at each of the stages of building, i.e., foundations, walls, roofs, etc. and were also dealt with in specific workshop discussions on this problem.

Workshop Notes 1

Action of Earthquake on Structures:
Motion at the focus of the earthquake is normally vertical and is actually less damaging to heavy structures than the sideways horizontal motion of the earthquake's periphery.

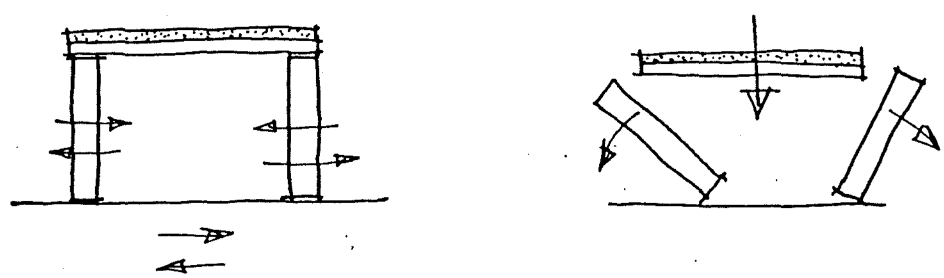
▽

Centre of Quake – 

Periphery (most common) 

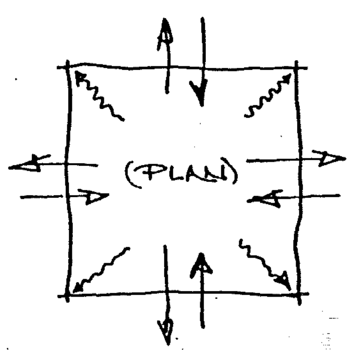
If walls are supporting heavy roofs the sideways sway gathers momentum and walls fall outward causing the roof to collapse.

▽

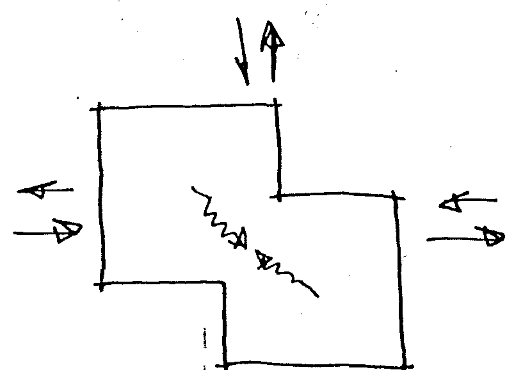


Stress due to earthquake movement is known to concentrate at the corners of a building or at joints between building elements. These areas need special design and construction attention.

▽



stress at corners



stress at joints

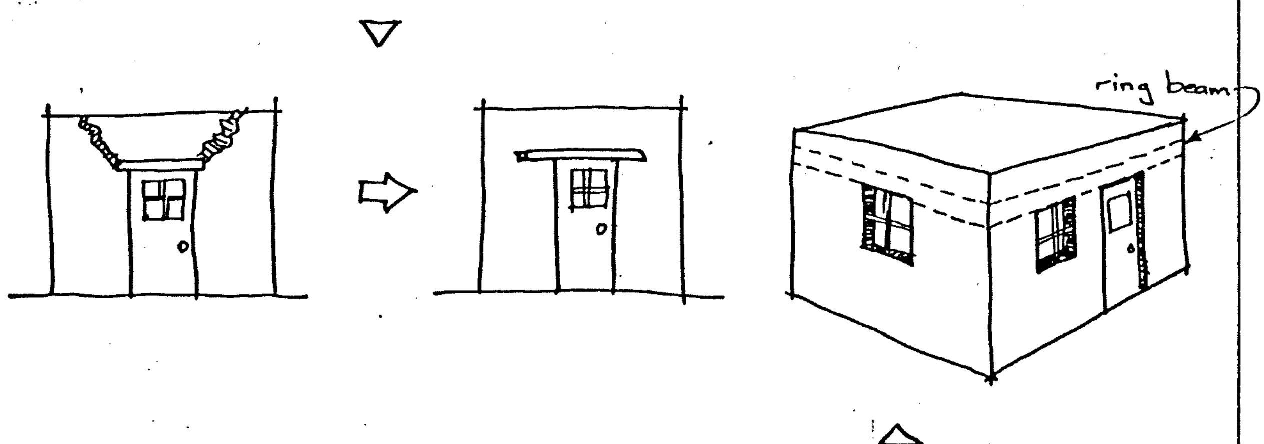
Workshop Notes 2

Design and Positioning of Openings

Because of stress concentration openings should be avoided near corners of buildings.

Therefore it is better to position openings centrally on the walls.

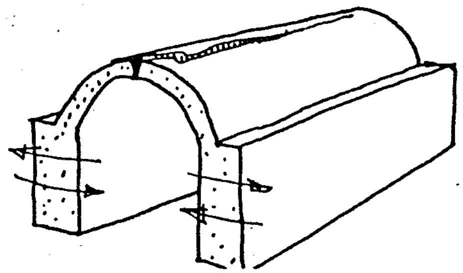
Cracking and failure often occurs above door and window openings. These areas can be strengthened by extending lintels deep into walls or by using continuous reinforçed ring beams as a common lintel above all openings, with extra reinforcing at corners.

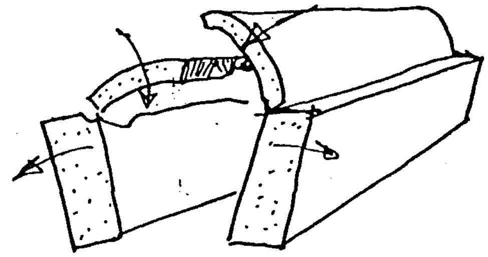


Such ring beams serve a double function in tying walls together to prevent movement which could cause roof collapse.

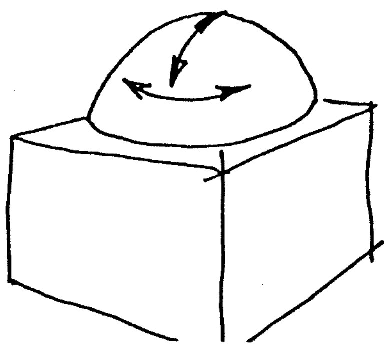
Workshop Notes 3

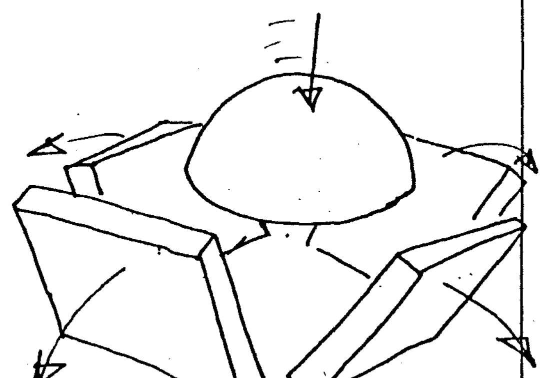
Vaults are much more susceptible to earthquake damage than domes. Any movement of walls upon which the vault rests will cause cracking in and failure of the roof.



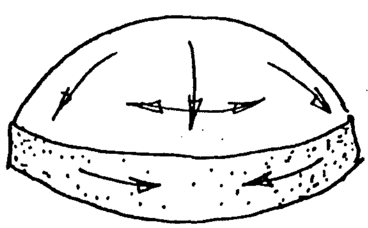


Domes, unlike vaults, have a double curvature and are able to withstand forces and movement much more easily. In many cases where walls have collapsed due to earthquakes, domed roofs have simply fallen intact.

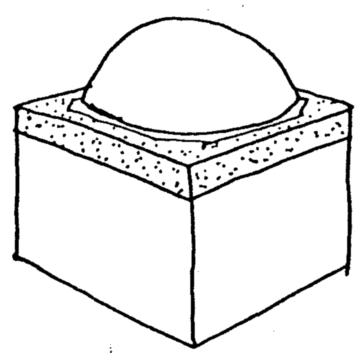




Ring Beam Reinforcing for Domed Roofs



tension ring



continuous beam ties
walls together

Workshop Notes 4

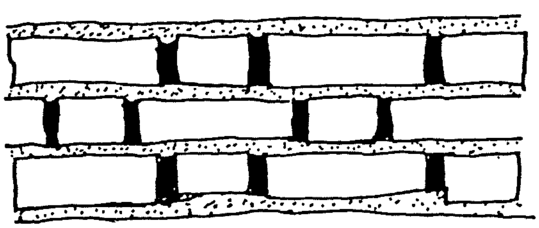
It can be seen from the survey of the Bandar Abbass earthquake area that poor bonding was a major reason for wall collapse. Better mortars and building practises can largely remedy this problem.

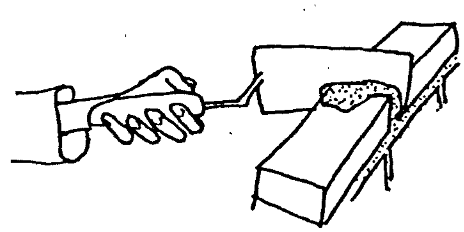
Mortar Mixes: mortars should provide good adhesion between bricks or stone, but should not be stronger than the brick or stone unit itself.

Mortar mixes:

1 cement, 3 sand
or 1 cement, 3 lime, 9 sand.

Preparing Bricks: bricks should always be thoroughly wet by submersion in a bucket of water before they are laid. This greatly helps adhesion between brick and mortar.

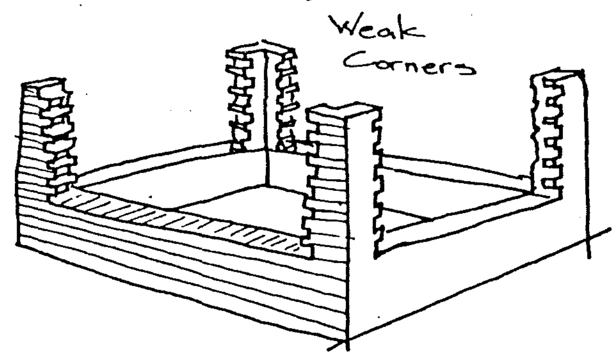




Mortar Joints: it is a common habit to save on mortar by applying mortar only to horizontal joints. By properly filling vertical joints the strength of a wall can be increased by 20% to 25%.

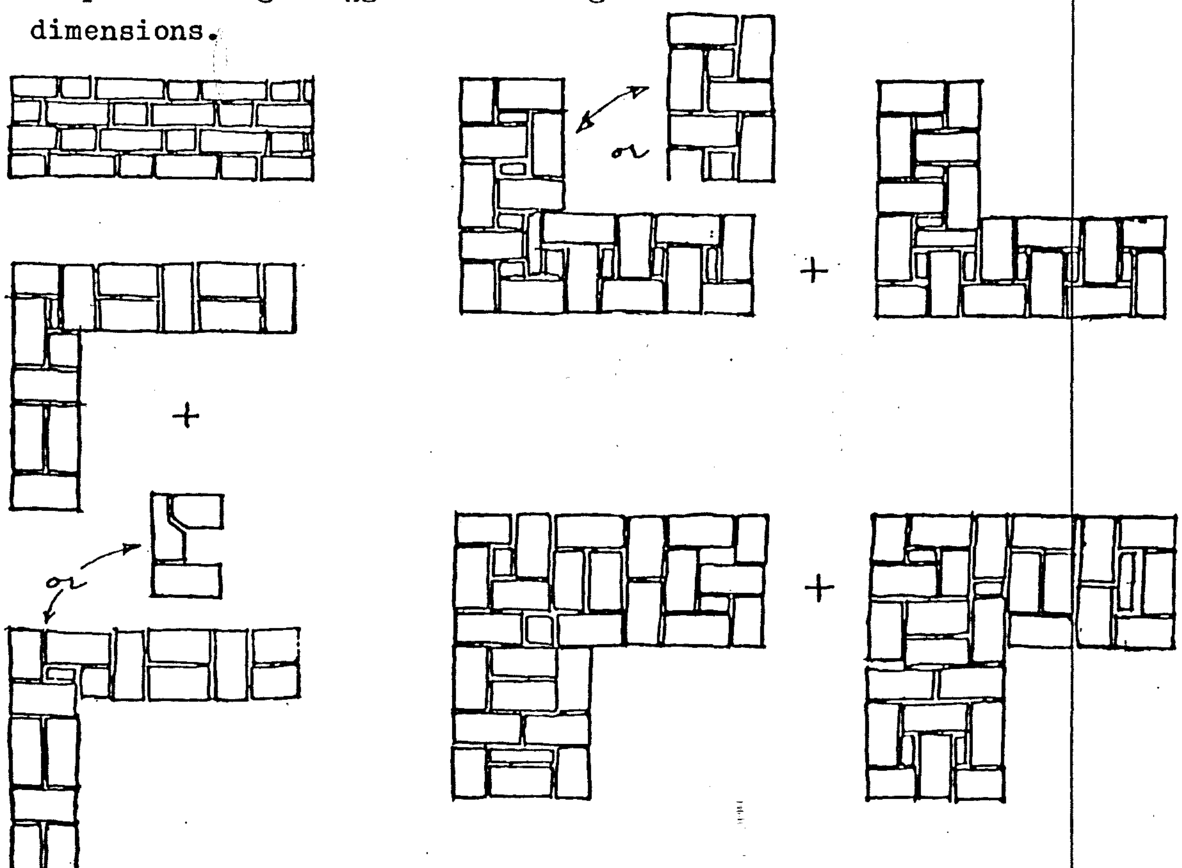
Workshop Notes 5

Corners: it is a common practise in Iran to build up corners before infilling the wall. This is done to simplify the problems of lining up and leveling. This practise produces badly bonded and weak corners.



Since corners are critical stress areas this practise should be discontinued. Brick courses should be laid continuously and wall building should progress evenly.

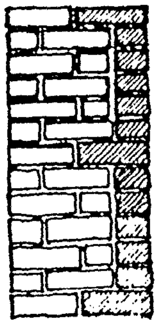
Proper Bonding: suggested bonding for brick walls of various dimensions.



Workshop Notes 6

From Bonding Experiments

1) poor bonding
2) good bonding
3) good bonding



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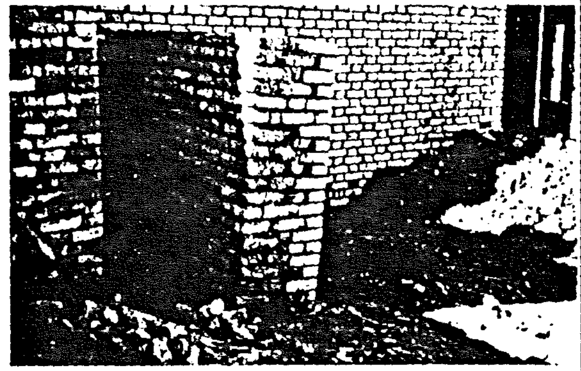

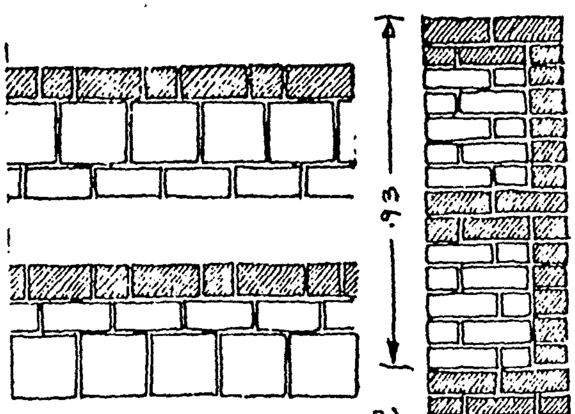

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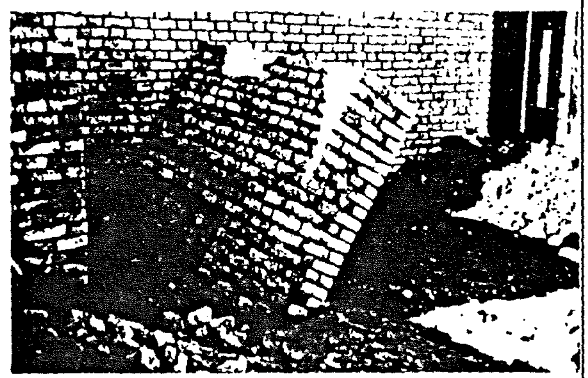

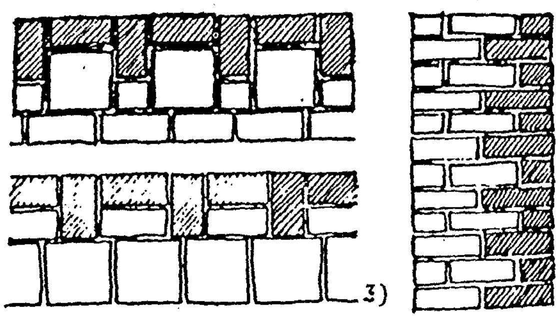

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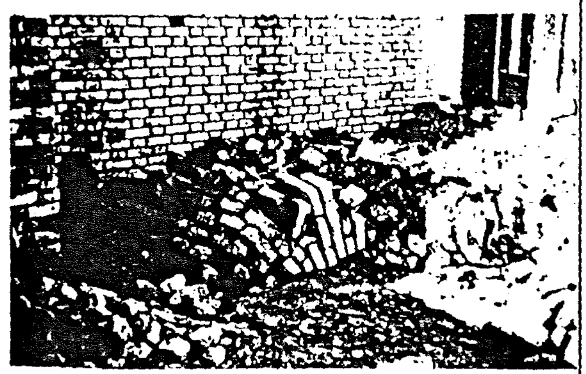

Bonding Unlike Materials

In many areas of Iran it is a common practise to use kiln fired bricks as an external skin to protect mud-brick walls against weathering and water damage.

Mud-brick walls with fired brick facing usually is unsuited to earthquake areas because the fired brick tends to peel off and falls outward, threatening people in the street. Since this practise is widespread and an efficient and economical system for protecting mud-brick walls, experiments were carried out in the workshop to develop a better bonding system.

Walls were built using different systems of fired and mud-brick bonding. Each wall was undermined and destablized and its collapse was studied for indications of bonding failure.

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