

BATINAH COAST · 3

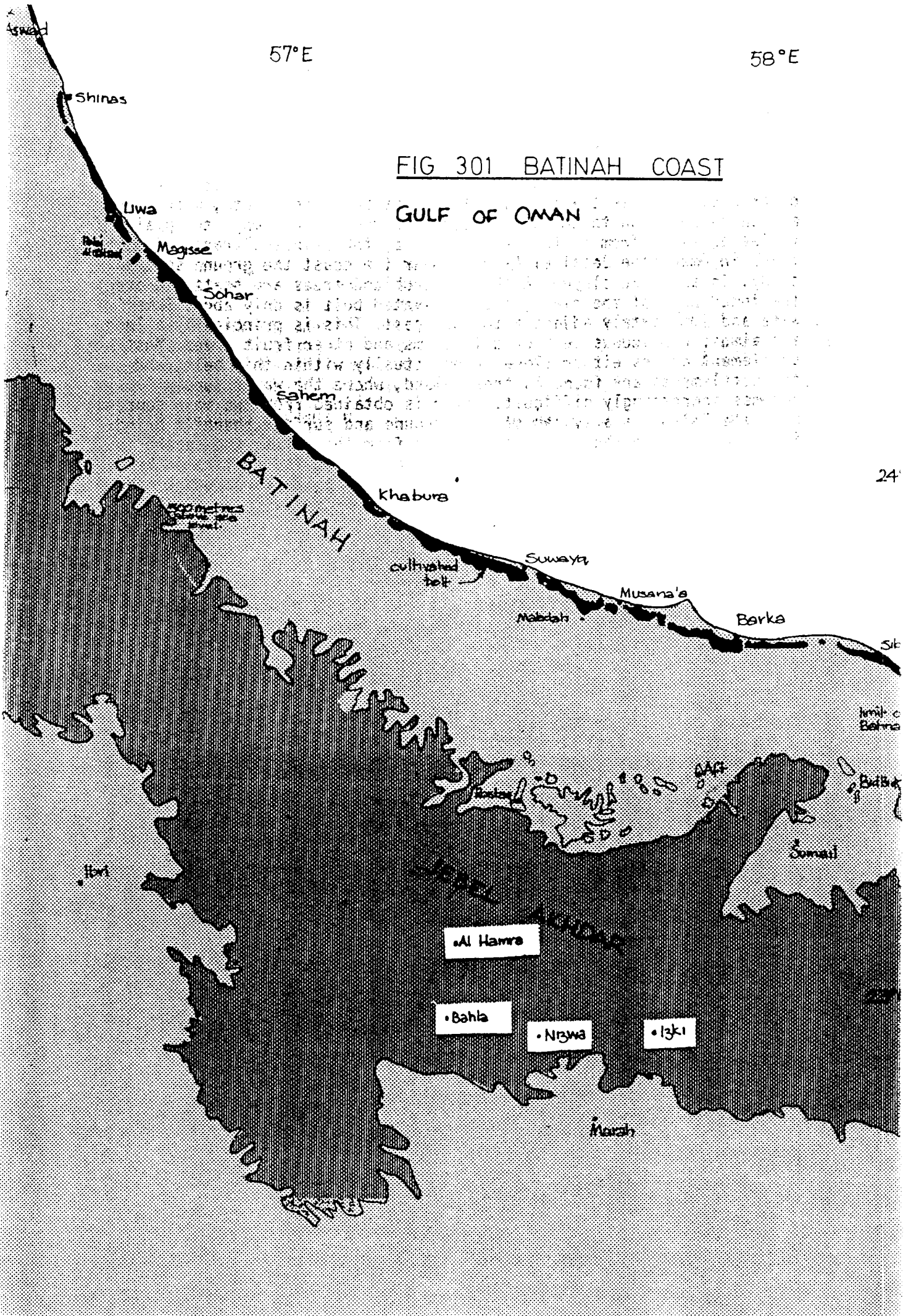


57°E

58°E

FIG 301 BATINAH COAST

GULF OF OMAN



3.1.1. Physical Description

A narrow strip of coastland stretching from the frontier with the Union of Arab Emirates in the north, down to Azaiba in the south, where the mountains run down to the sea. Altogether some 270km long, the plain varies in width from 10 to 30km, backed by the principal range of mountains in Oman, the Jebal al Akhdar. Near the coast the ground soil is sandy, inland more clayey. Although scrubland trees are scattered over the inner part of the plain, the cultivated belt is only about 3kms wide and immediately adjacent to the coast. This is principally a long and almost continuous belt of date palms and other fruit trees. Most settlement occurs either close to or actually within this belt, and few settlements are found further inland, where the water supply becomes increasingly difficult. Water is obtained from two main sources; one, the Falaj, is a system of underground and surface channels bringing water down to the agricultural area from the hills; the second is wells, which supply most of the water, and, along the cultivated belt, appear to be reliable and capable of supplying quite large quantities.* About 150,000 people live in this area.

* Source: Scott Kirpatrick and Partners: water survey.

3.1.2. Climate

The Batinah Coast has a climate directly affected by the proximity to the sea. The moisture content of the air (due to its proximity to the sea), and the latter's steady temperature has a modifying effect on the temperature pattern. Maximum temperatures occur in July (40°C) and minimum in December (15°C) (Daytime max. 25°C). The average annual temperature range is 25°C. The diurnal range is on average only 10°C. Both annual and diurnal range increase with distance from the sea. Relative humidity reaches 75% during summer and winter months, but drops to 50% during spring and autumn. Even though humidity is relatively high, rainfall is minimal and occurs usually during the winter months, and occasionally in August. Total rainfall for February is only 30mm, and decreases up the coastline, so that Azaiba has more rain than Sohar.

The beach and the cultivated belt, and, to a lesser degree the area inland, are all affected by land/sea breezes. These winds are the result of the unequal heating of land and water; in brief, subject to the same intensity of Solar radiation, the temperature of the land rises faster than that of the sea and likewise cools faster.

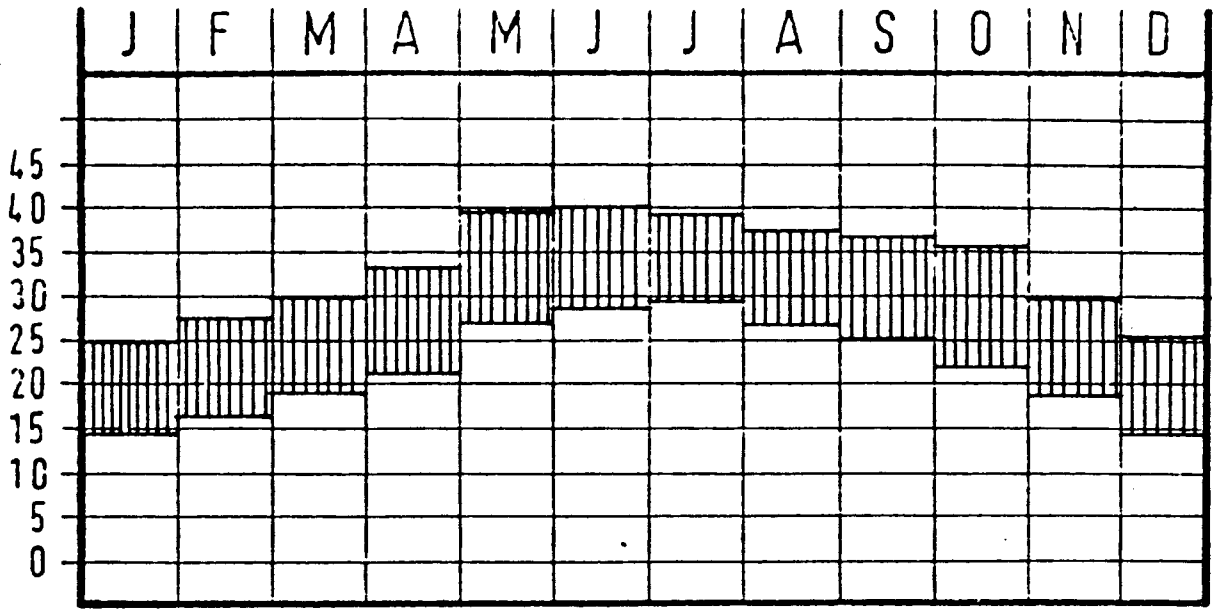
Because during the day the land is hotter than the sea, a relatively low pressure area is created and a convection system develops over the land. Hot air rising is replaced by cool air drawn in from over the sea at low level, while an upper air current blows the other way. The greater the difference between land and sea temperatures, the stronger the wind becomes, so that as the land temperature in the afternoon decreases, the velocity drops until the direction is reversed at nighttime, the sea being warmer than the land.

The on shore/offshore breeze effect is a local or micro-climate phenomenon and is predominant within 3 or 4km of the shore. Prevailing winds also modify this condition (See Fig. in climate introduction). Most of the year there is a prevailing onshore wind except for a couple of months in the summer. These prevailing north or north-westerly winds strengthen the daytime sea breeze and hinder the night land breeze. This results in strong daytime winds most of the year and a weak or non-existent nighttime breeze especially in the spring and autumn months. In July and August, due to shifting continental pressure systems, there is a prevailing off-shore effect with a south-westerly wind strengthening the night-time breeze and reducing the daytime breeze.

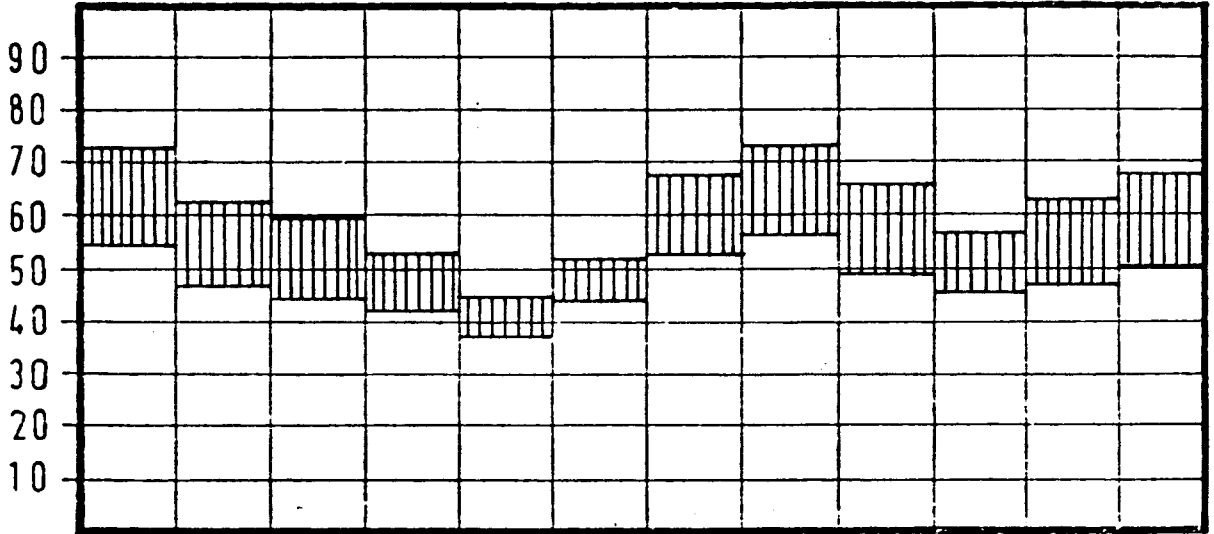
Inland of the cultivated belt, the prevailing wind takes over from the offshore sea breezes.

AZAIBA

AIR TEMPERATURE °C

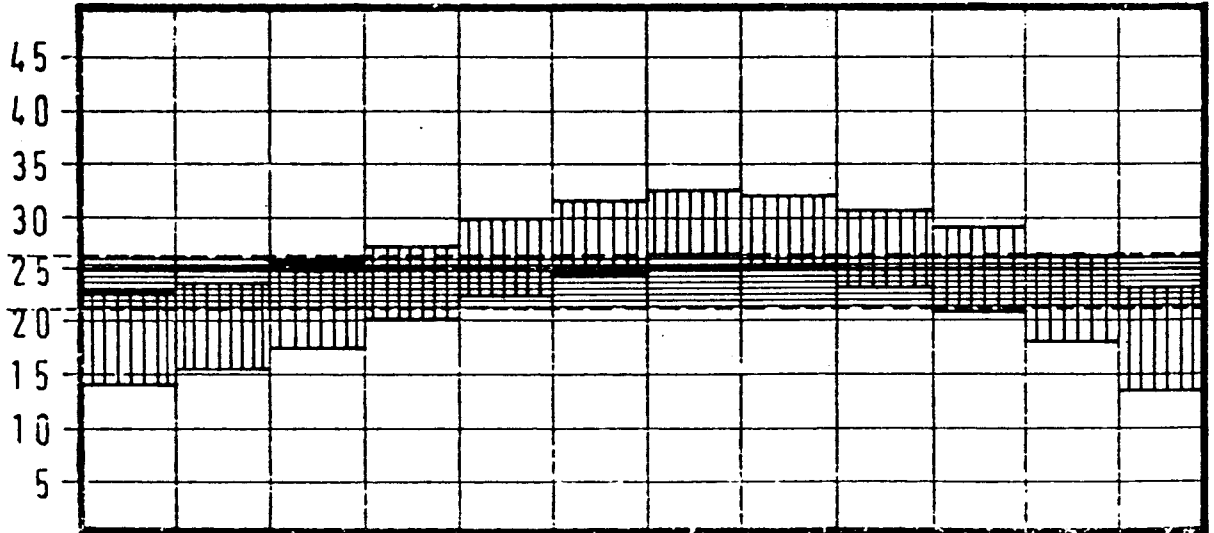


RELATIVE HUMIDITY %



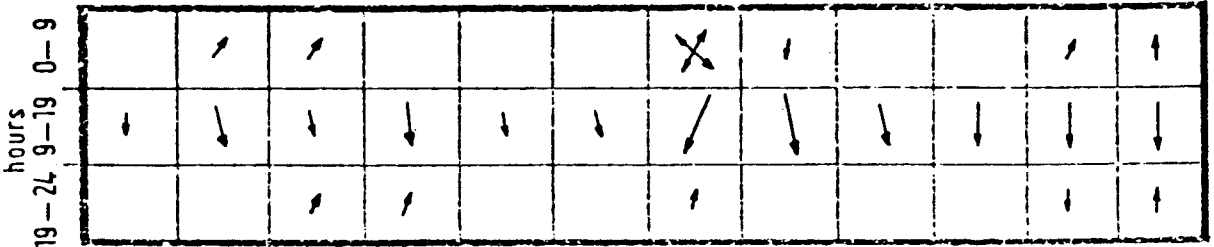
EFFECTIVE TEMPERATURE °C

comfort zone



WIND

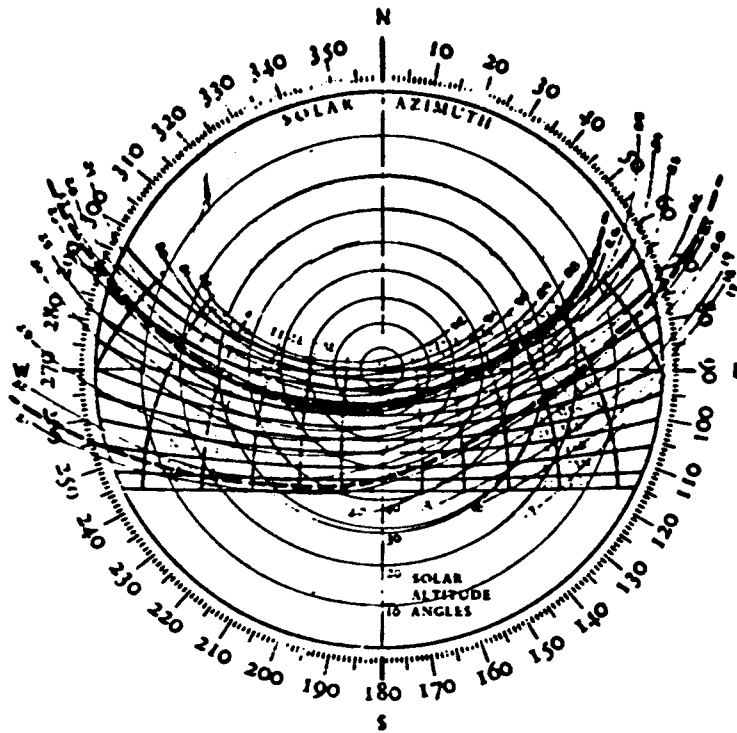
Direction and Relative Velocity



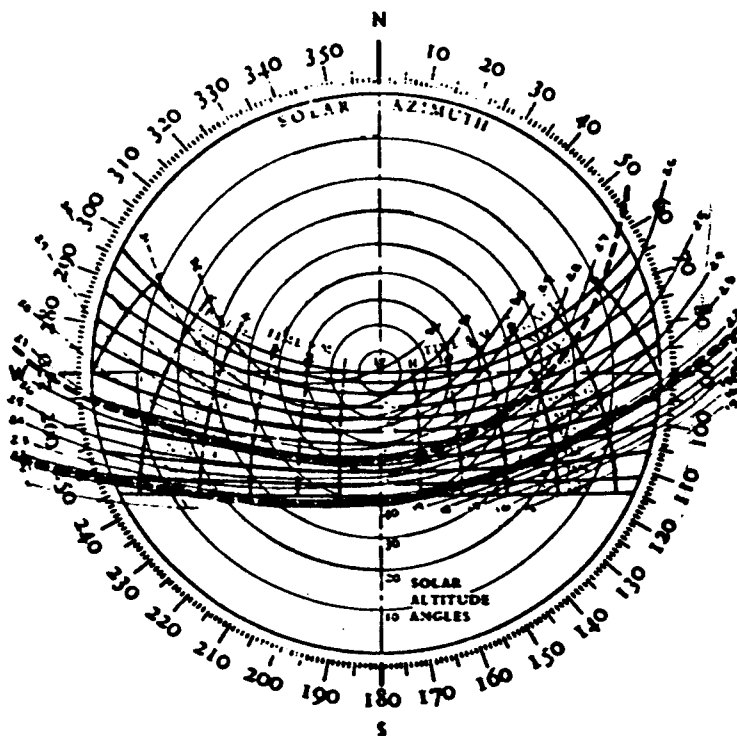
RAIN

mm.





JANUARY - JUNE



JULY - DECEMBER

SOLAR CHARTS WITH TEMPERATURE OVERLAY
AZAIBA

Micro-Climatic Comparison

Tests were made to evaluate the influences of the onshore and offshore winds on the micro-climates of three adjacent areas as one moves inland from the Sohar beach to the date palm grove planted belt, and finally to the inland semi-desert open scrub land. Three stations were chosen, one in each area, and a fourth offshore in shallow water. A series of climatic tests were made using portable instruments in each area every two hours for a 24 hour period.

When this information is graphed (See Fig 304) one can see clearly the daily pattern in the micro-climate of each area.

The temperature (Chart 1) of the water is clearly more stable than the land temperatures, fluctuating only about 4°C between day and night while the land temperatures fluctuate as much as 9°C . It should be also noted that the peak in water temperature lags several hours behind the peaks in air temperatures. The same is true for the coolest temperatures.

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 (Chart 111) 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 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 (Chart 11) (on the beach) is about 10% higher on the beach during the day than the two stations further inland though they are much the same at night.

The beach micro-climatic area would seem to be more comfortable than the other areas since it has a somewhat 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 (Chart 111), 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.

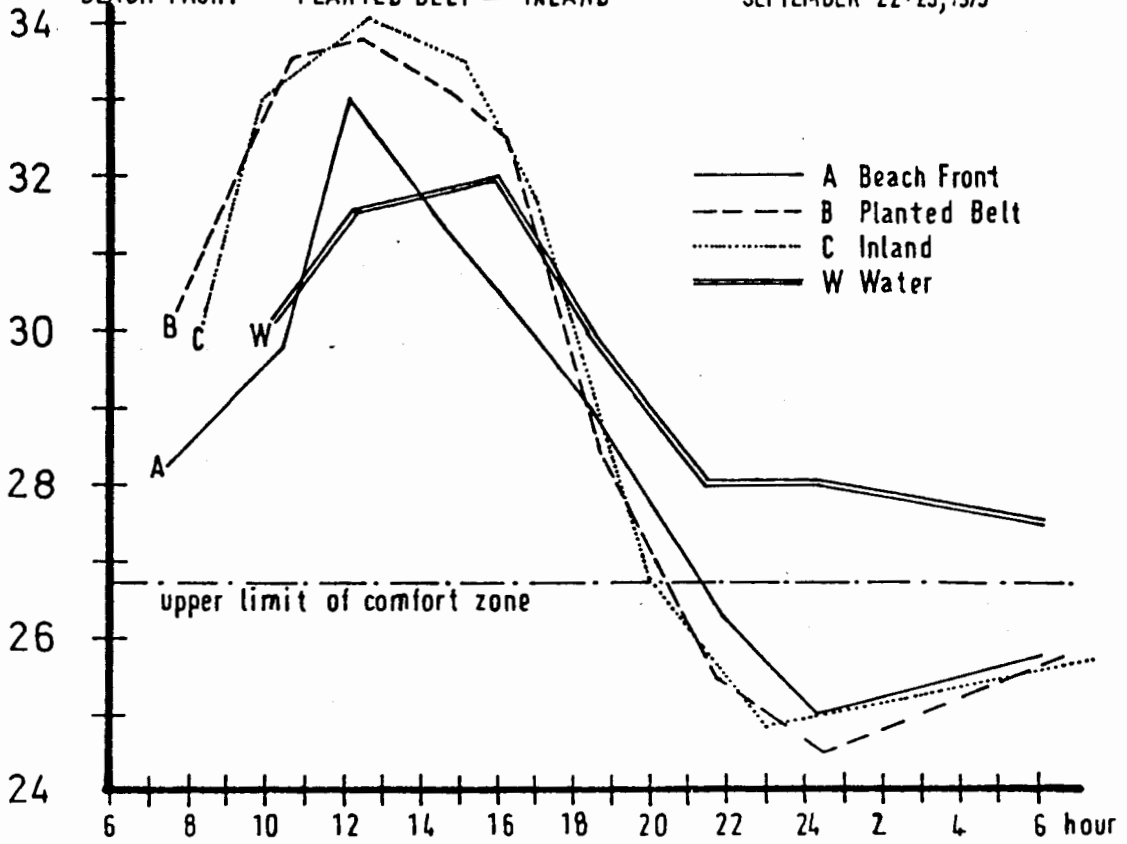
MICRO - CLIMATIC COMPARISON

SOHAR

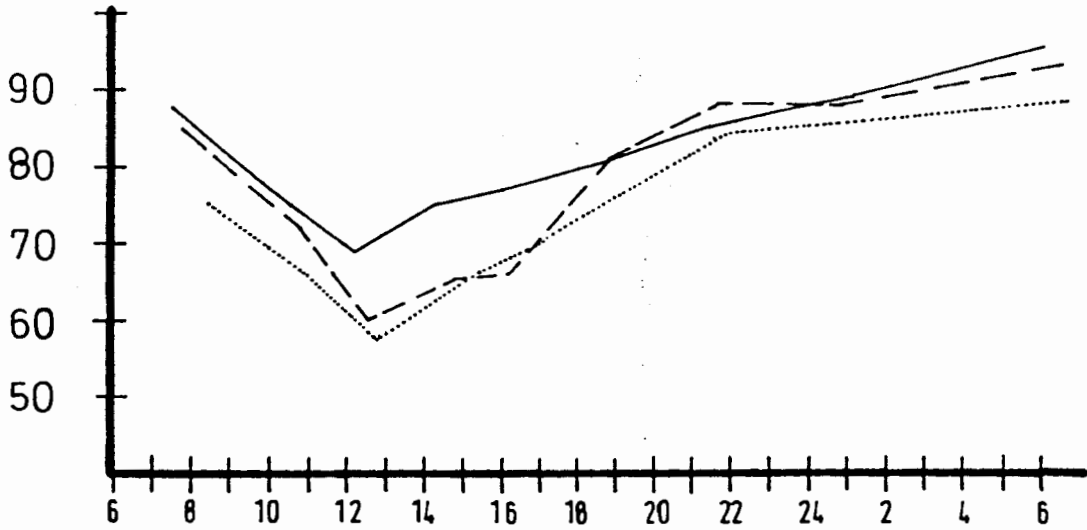
BEACH FRONT — PLANTED BELT — INLAND

SEPTEMBER 22+23, 1973

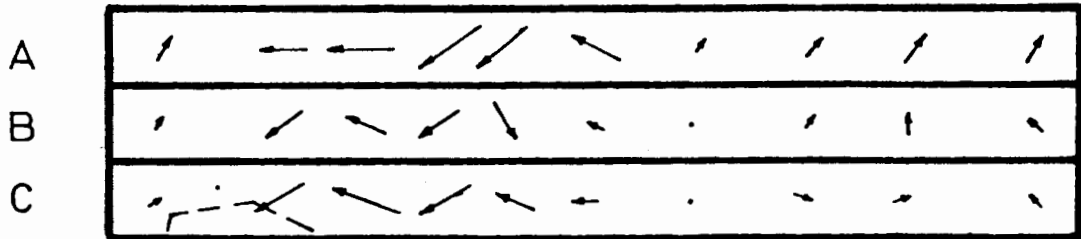
TEMPERATURE °C



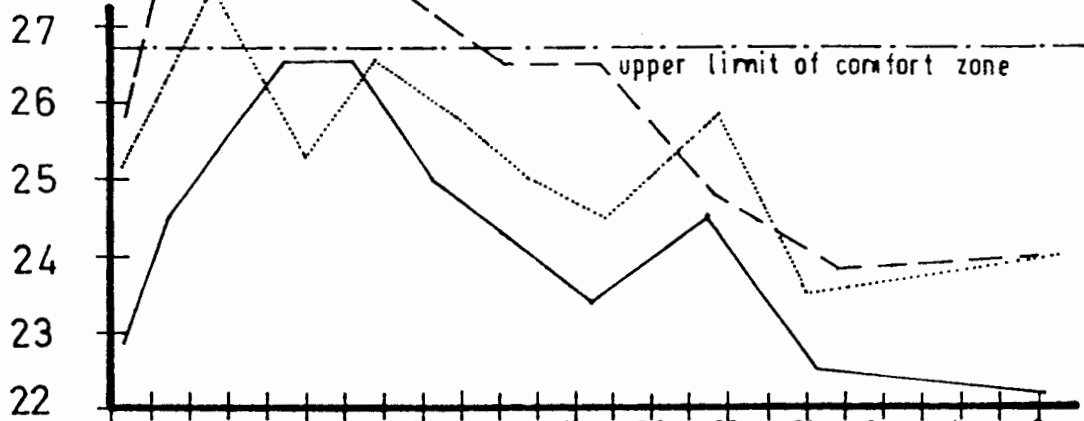
RELATIVE HUMIDITY %



WIND
DIRECTION &
RELATIVE VELOCITY



EFFECTIVE TEMPERATURE
DUE TO COOLING FACTOR OF WIND



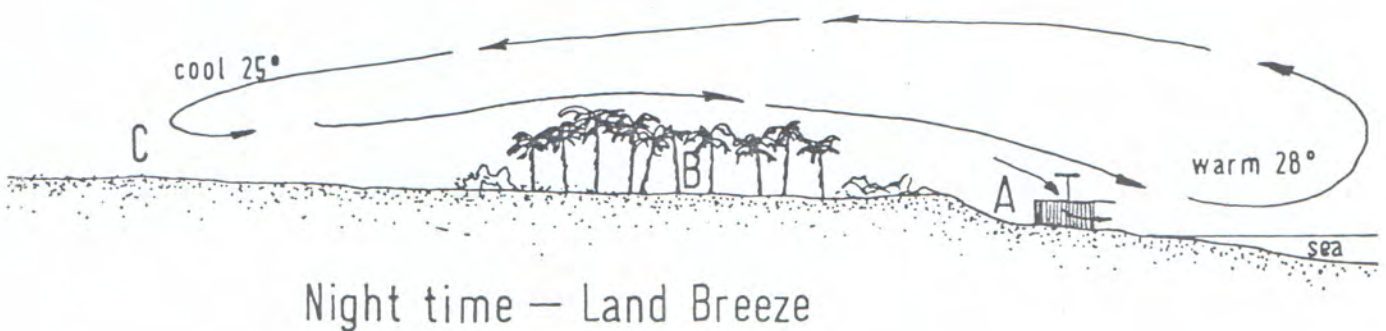
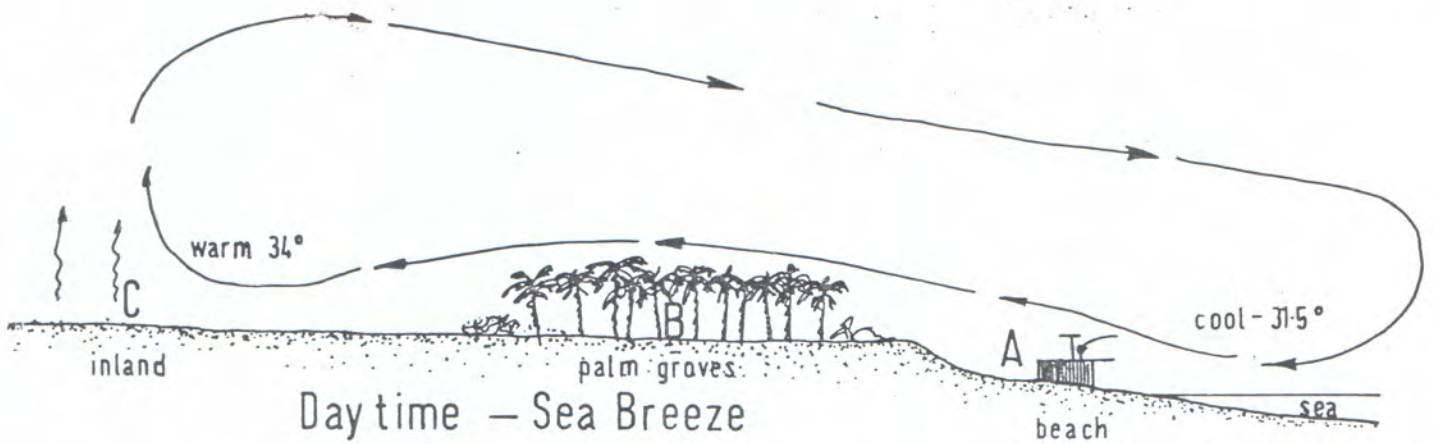
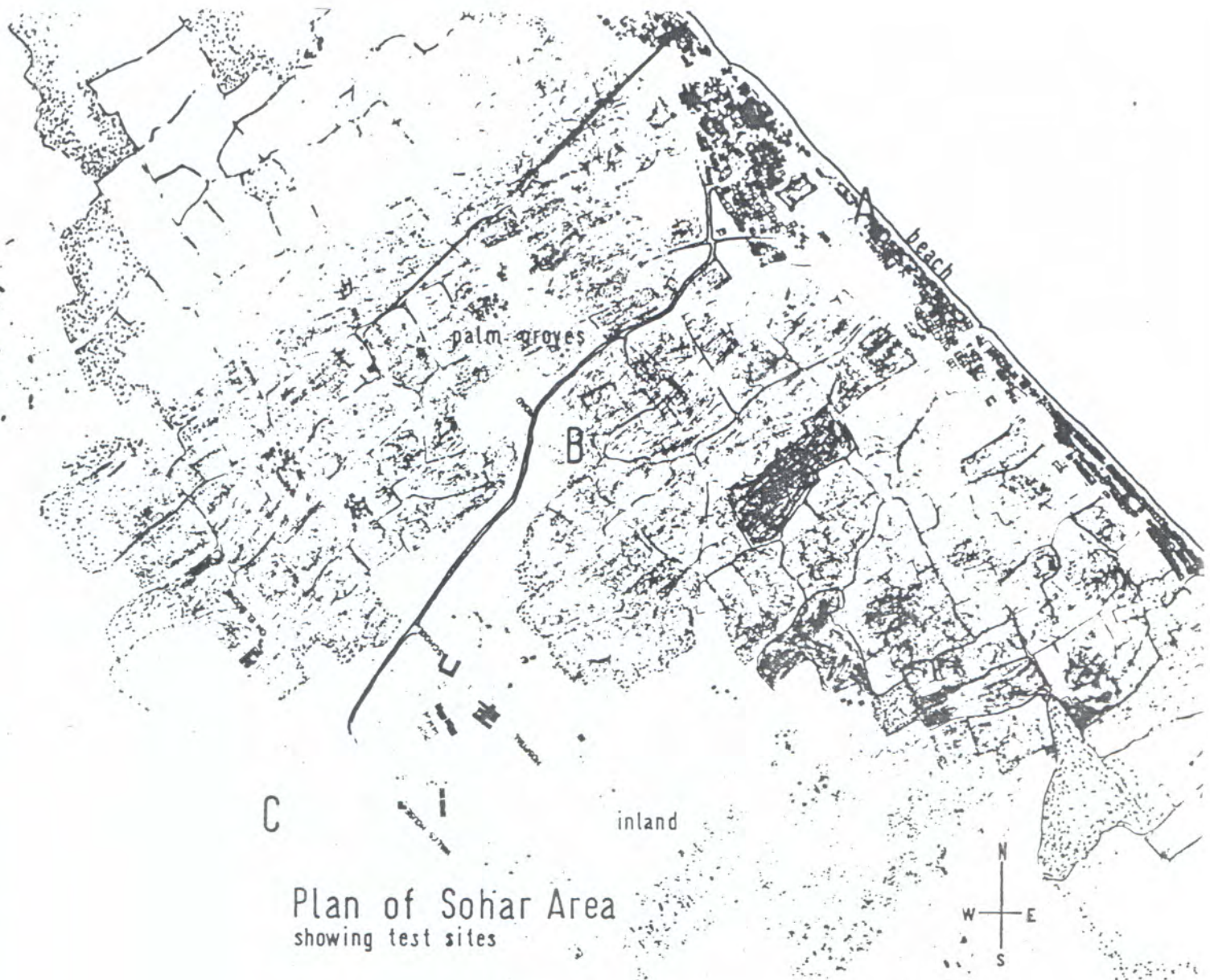


FIG 305

3.1.3. Social Economics

The economy of the Batinah coast is based principally on agriculture and fishing. A small percentage of the population is engaged in trading and some service activities, such as the hospitals and schools.

Nearly all the fish are sold directly from the boats or in the local market, and only a small part of the catch is taken out of the area, most of all at the southern end of the Batinah coast, where communication is better.

Various crops are grown along the cultivated belt. The continuous date gardens comprise one of the biggest date palm areas in the world, but the dates are mostly consumed locally. Other crops produced include limes, mangoes, bananas, lucerne and onions, as well as a few other minor crops. Limes are the only crop exported on a large scale. Otherwise produce is consumed by the producer or the local market.

Basically it is a self-contained economy with money circulating within the local populace. Few people appear to be living in great poverty, and most can afford to have a fairly large house, and often two. A proportion of the population can afford to buy more expensive building materials, and in these cases, very often the materials used in their houses are an attempt to enhance their prestige in relationship to their economic status. This applies among the larger landowners and prosperous merchants.

The area in which the house is built affects the quality of the house, since the quality of the cultivated land varies, and, proportionately, income; and some areas, because of local amenities, will attract specific types of people with specific trades, which are more profitable. A proportion of the population have no agricultural property of their own and now work either for local landowners, in local government posts, or move down to Muscat and Mutrah, where there is the lure of better job opportunities. Houses do sometimes show signs of deterioration where the husband has moved to another area to work. Overall, there appears to be a degree of equality in the dwelling standard within local groups.

With the advent of the asphalt road leading to Muscat and Mutrah and the new industrial area, many of the new government buildings are developing near the road; for instance in Sohar, the hospital, the new school, the police station, the wali's house, and, of longer standing, the government farm. These have produced a new pattern where people can get work away from the old town, and the influence of the new buildings is reflected in the people's houses. The road also allows people to work away from their local area, and to return for weekends, now a short journey. A new class of people is developing, with new standards and a different economic status.

3.1.4. Materials

The importance of the date garden is not only in the produce of fruit, since the palm tree and the palm frond stem are an important and cheap source of materials. Many of the coastal houses use palm tree trunks as structural members, and the palm frond stem (barasti) is used for walls, roofs and floors. Small fishing boats are also built out of the palm frond stems (shasha), fish traps use split stems, and rope, bags, mats etc. are all made. The income of many families is not large enough to be able to afford expensive materials, and therefore the palm tree is an important commodity.

Other materials used locally include mud brick and concrete, and in the past a small amount of fired red brick has been used.

Building materials are discussed later in detail.

3.2.1. Settlement Patterns

Settlement on the Batinah coast falls into three main groups:

- a. The beach settlements.
- b. Settlements inland of the cultivated belt.
- c. Settlements within the cultivated belt.

a. Beach Settlements.

The occupations of people dwelling directly on the beach front clearly have a bearing on the way the area is settled. Many of the people who live on the beach front earn their living from the sea, and their choice of site will be as close to the water front as possible. Most fishermen embark from the beach directly in front of their house, and keep their boats pulled up on the beach below their property.

Major settlements have developed on the beach because before the advent of road transport, still in an infant state, all produce came in by sea, which is still the case for many towns. Merchants and tradesmen naturally live near to their work when possible. Nearly all the main settlements of the Batinah coast occur on the beach front. These include the towns of Sib, Barka, Musana'a, Suwaiq, Khaburah, Sahem, Sohar and Shinas. Numerous other villages are strung out along the shore.

Except in major concentrations of settlement, where markets and public service amenities now exist, houses are built facing the beach, to make maximum use of the land/sea breezes, so that a row of houses develops in a linear form (Fig 37). As more people build in the area, a second, and in a few cases, a third row will develop. Further development behind this is limited by two factors; firstly that the date garden usually prohibits further development back from the beach, an important factor in view of the value of the palm tree, which deters the replacement of date gardens by housing areas; and secondly, that the houses placed too far back from the beach lose the benefit of the sea breeze, being sheltered from it by those nearer the beach.

In some areas where there are natural open spaces slightly inland from the beach and which are not liable to flooding, another row or two may develop, but again in such a way that the wind can blow freely in from the sea.

Major concentrations occur on sites where there is some natural formation to encourage their growth. Houses will develop further back from the beach where there is a rise in the ground level, raising those houses slightly inland up above the houses on the sea front, allowing air to pass over the lower houses to those behind. The spread of settlements back from the beach does not seem to happen purely because an open space is available. For example, in the case of Sohar it would appear that the open space inland of the town centre was not built upon, being lower down than the town itself, and therefore in a sheltered area with hotter conditions and less air movement to ventilate the dwellings (Fig 38).



BEACH FRONT

FIG 307 Linear beach housing

3.2.1a. (cont)

A major development has been the asphalt road linking the Batinah coast to Mutrah and Muscat with their associated developments. New Government building has recently taken place by the road in the case of Sohar. This in many ways is causing the town's focal point to be moved, in that the police station and school are three kms from the town, a distance that has to be walked daily by the school children.



SOHAR TOWN

FIG 308 Sohar town centre

b. Settlements inland of the cultivated belt.

Quite a number of medium size settlements have developed inland of the cultivated belt, and this trend is now being increased with the advent of the asphalt road running up the coast inland of the cultivation.

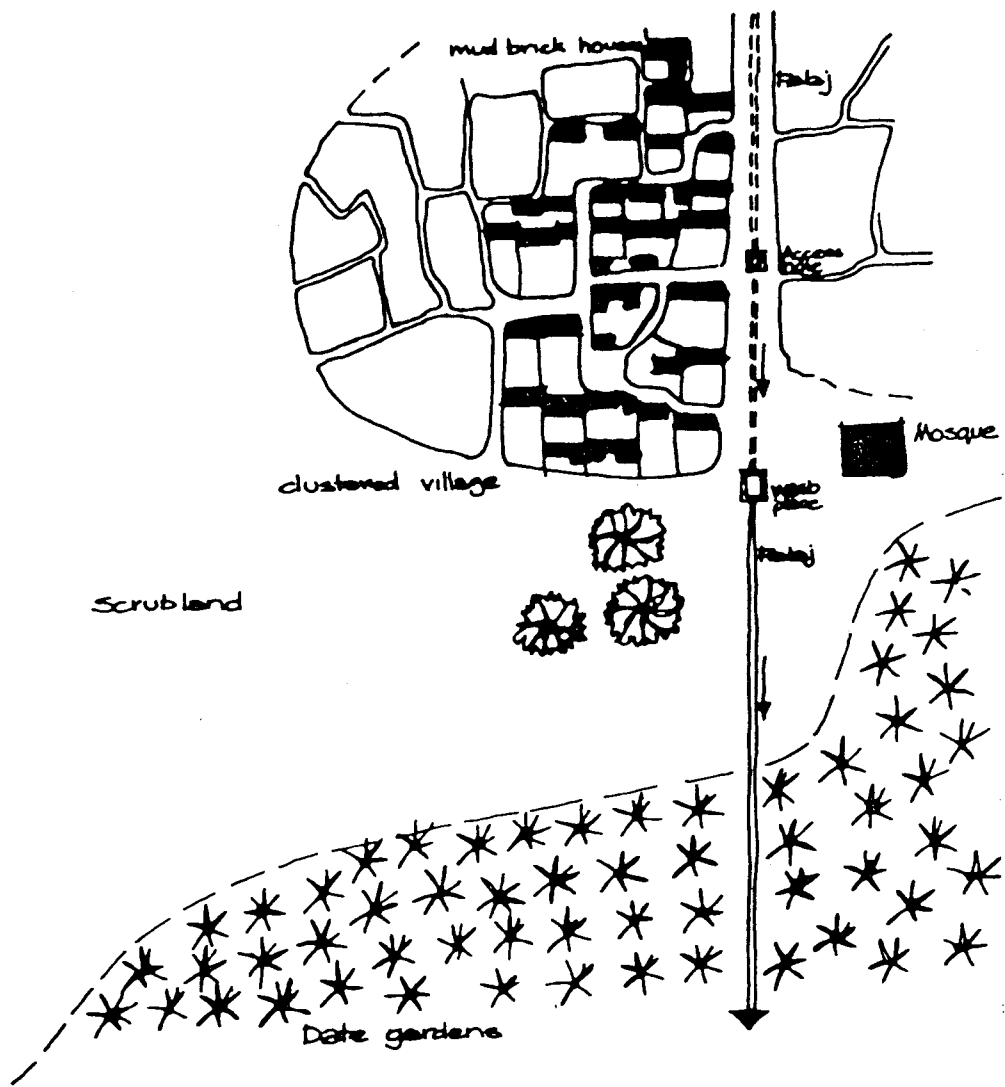
These settlements relate to the cultivated belt, where the occupants gain their living. There is also the use of the scrubland behind for grazing purposes. A large number of goats, donkeys and camels are left to feed in this area.

Two basic types of settlement have been noted, both of which owe much of their formation to the nature of their water supply. Two examples are used here to demonstrate the differences and the drawbacks and advantages.

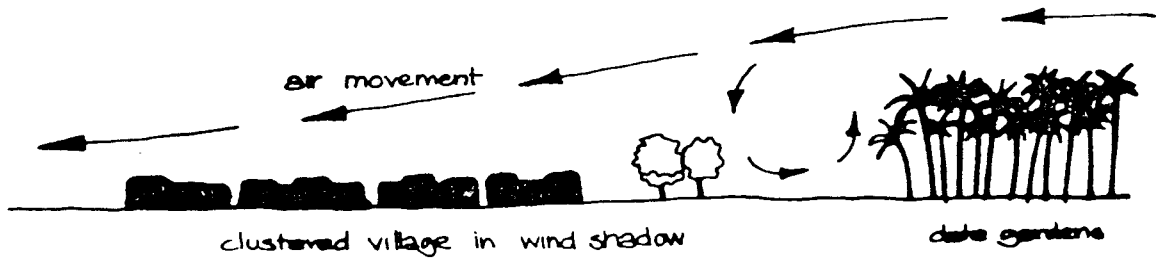
b.i. Falaj al Qabael near Sohar

This village relies upon a single falaj - an underground and surface channelled water system coming down from the mountains - for its water supply, passing through the village with occasional access water holes and a washing area down-stream just before it enters the date garden (Fig 39). The village is situated very close to the palm trees. All the houses are packed tightly together, so as to be near the water supply. Houses are built predominantly of mud brick. Because of the tightly packed formation of the village, and its proximity to the date gardens, air movement passes over the village (Fig 310), so that the beneficial summer cooling effect of the wind is lost. This is a winter village and the mud brick houses are a reflection of this, protecting the interior from the cold nights, and limiting what little air movement there is from entering the house. For the performance of one of these houses see section on materials. 3.3. Mud Brick.

Local villagers said that the village was intolerable during the summer months.



Diagrammatic site plan of Falaj al Oabael
Fig. 3.9.



Section
Fig 3.10

b.ii. Maladah in the Wilaya of Musana'a.

This village relies upon wells for its water supply. Each house or small group of houses uses a well. The effect of this is that the houses are spaced apart from each other. The whole village is further away from the date gardens and the cultivated built, and therefore does not lie in an air movement shadow (Fig 311).

More important than this is that each house is situated far enough from its neighbour to allow it to have a free passage of air round, and when necessary, through it (Fig 312).

In consequence, this village is occupied all year round, summer habitation being tolerable. Houses reflect this in that many of them combine various building materials - a room of mudbrick for the winter, with a flat mud covered roof, another room with mud walls and a palm frond stem (barasti) roof, and a third room made completely out of palm frond stems for summer use. Different rooms can be used in different seasons, and there is no need to move to another area in the summer.

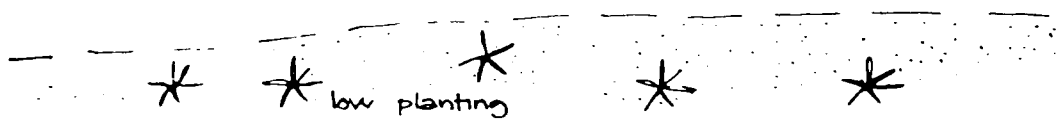
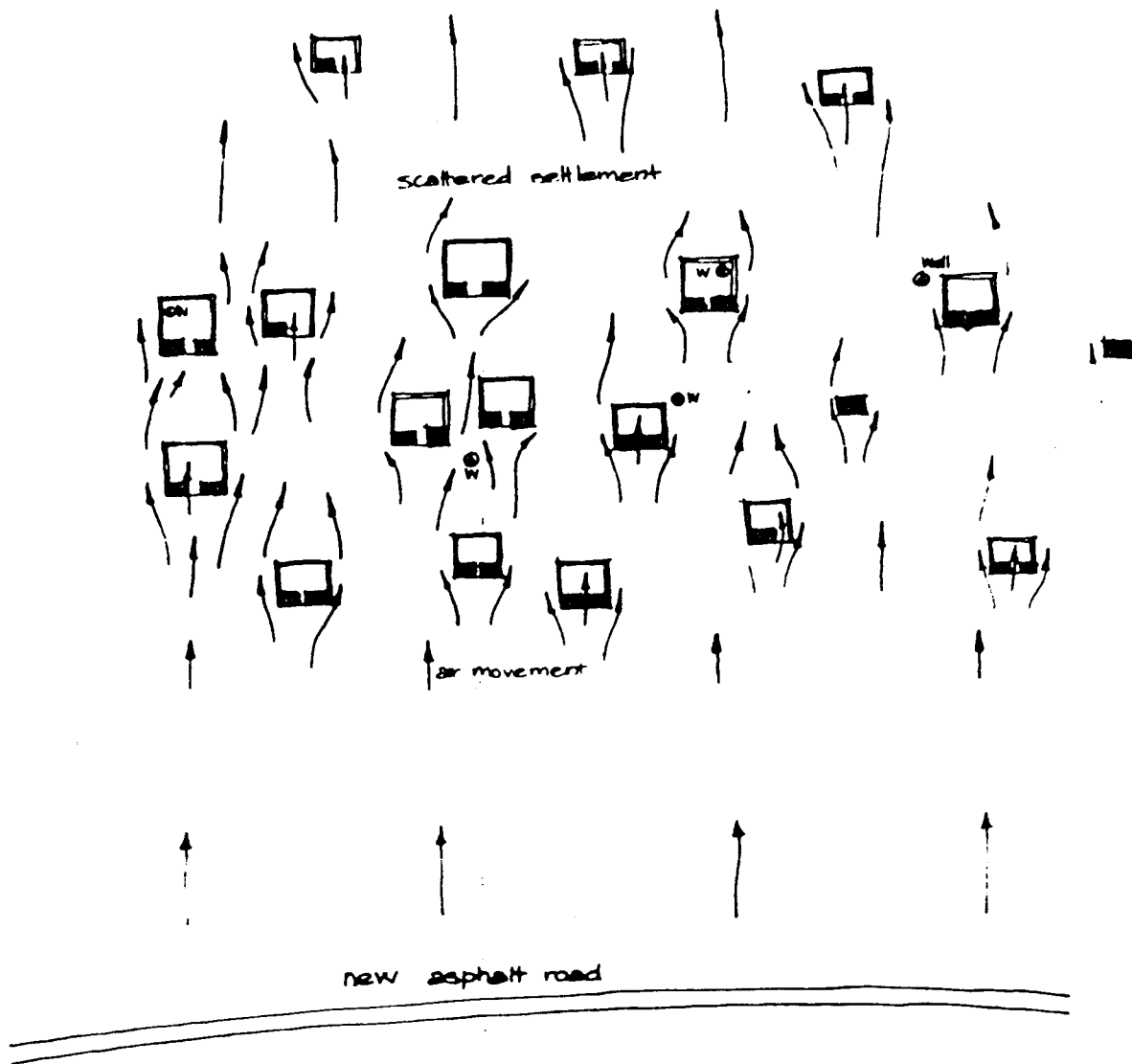


Fig. 3.12.

Diagrammatic site plan of Maladah showing air movement

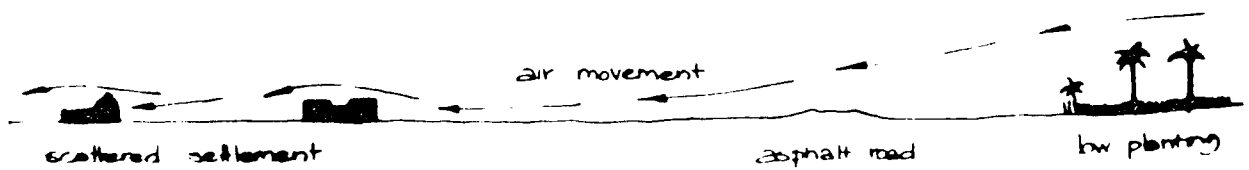


Fig. 3.11.

Section

c. Settlement within the cultivated belt.

A number of dwellings and the occasional village are situated within the cultivated belt. Many people living in villages outside this strip during the cooler months move into the cultivated belt during the summer because it is more comfortable in the shade of the trees. Most of the houses here are situated within individual plots of land, so that there is less of a rigid pattern of housing. People also move to the cultivated belt at times when there is a lot of work to be done, although as dwellings these houses are predominantly for summer use.

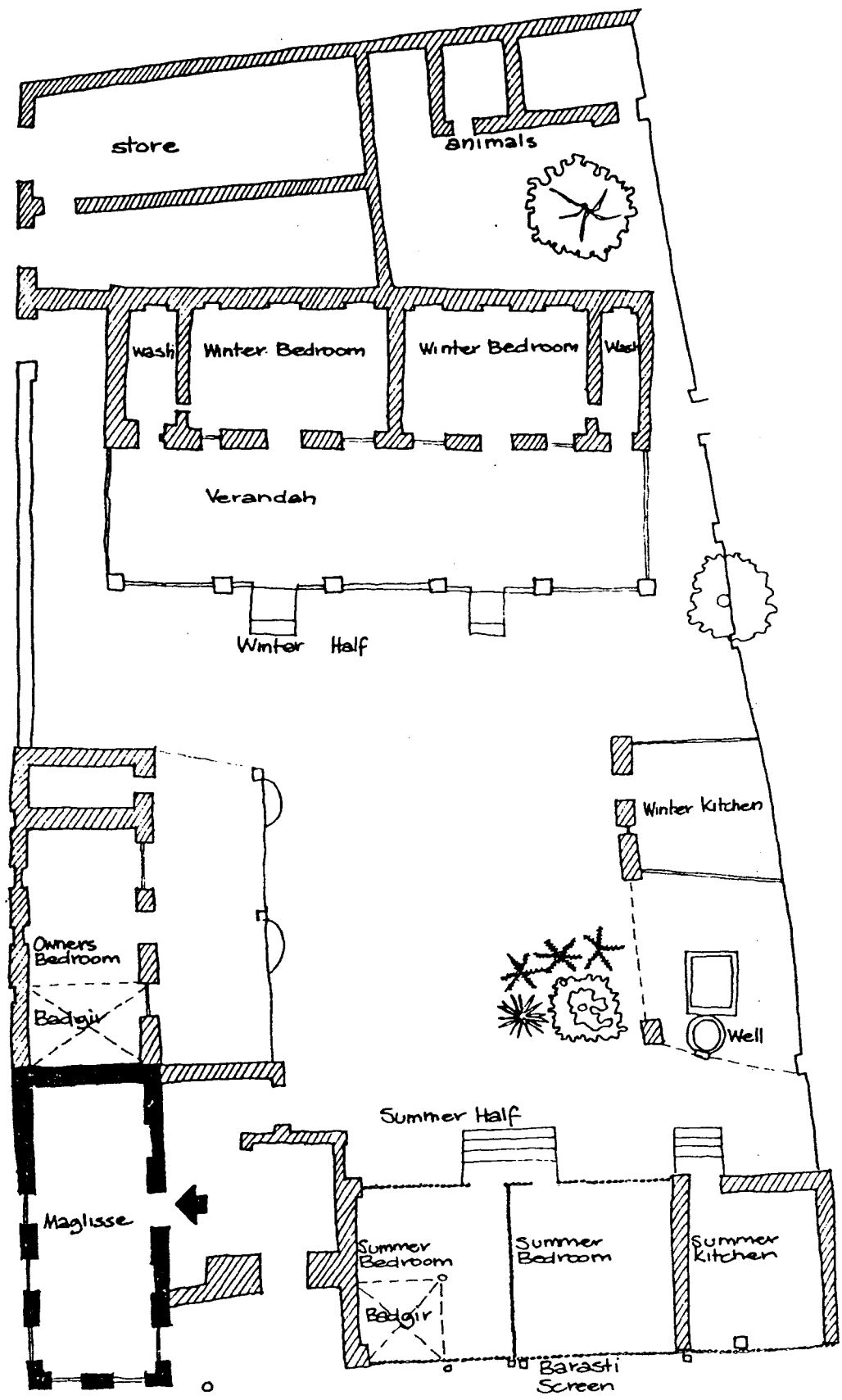
A few villages occur in open spaces within the cultivated belt, and these are in use all year round. There is a predominant use of Barasti for the building of the houses. Nearly all of the houses are positioned facing the prevailing winds - land/sea breezes, but otherwise tend to be grouped in a fairly random form, perhaps controlled by land ownership. Spacious settlement as in the case of Maladah is not so important since summer conditions are cooler.

Some houses in this area, principally where they are isolated dwellings, form the summer counterpart to winter houses and villages such as Falaj al Qabael.

3.3.1 Social Influence on Room Use

Although various elements of the house form are a natural part of almost every dwelling, certain rooms and areas with the northern Omani house have specific functions promoted by the social pattern. Where there is a lack of plumbing which does not therefore locate a function rigidly, rooms such as kitchens have a climatic response but do not necessarily limit themselves to use only as a kitchen. Room use can quite easily change. Under the heading of social influence, perhaps the most prominent feature of the Northern Omani house is the Maglisse (Fig 313). This room is used for entertaining special visitors and for special occasions, and has a counterpart in households all over the world where one room is often kept for special occasions. This room is nearly always situated adjacent to or actually outside the entrance of the house, which allows life inside the house to continue undisturbed. The function of this room has been retained in urban situations where special guests are entertained in a special room. Neighbours and close friends will more often than not be taken into the main body of the house, since they will not disrupt the routine of the household. As a general living area during the summer months, the courtyard of the house is the focal point of the whole building and much of the activity of the household takes place here. The arrangement of bedrooms is in most cases for climatic expediency, and at the present time the sanitation facilities are limited, and the countryside or beach are used by most people, although more attention is now being paid to this in quite a few households.

Details of house form in response to climate are given in the following two sections.



Beach Front

HOUSE OF MOH'D SHERIF ABDULLAH
BEACH-SOHAR



Fig 3-13

3.3.2 Climatic Factors

a. Human response to seasonal climatic and activity changes in house forms.

House forms along the Batinah coast show a definite attempt by the owner to have one type of structure for the summer period and one for the winter. In relation to a family's economy and its yearly cycle of activities and the climatic variations through the year, there is a range of examples of this pattern demonstrating a varying degree of sophistication.

Although it appears to be predomenantly a climatic response, the man who owns a date garden and a house on the beach, will move to the date garden not only because it is cooler, but also because he needs to live near his work. The lowest income families will have to modify their one and only house to cope with the climatic changes through the year, representing the basic lack of response to the climate.

It should be noted that, although this section concentrates on the Batinah Coast the phenomenon is not restricted to this area, and other examples can be found elsewhere in the country.

Various levels of response are given below:

a. The lowest income bracket where one house is modified through the year to suit the change in climate. There is no change in location. Modification consists of adding or removing palm frond stem screens (da'ams) to restrict or encourage the passage of air. Even though a variety of rooms may be used, they are in use throughout the year (Fig. 314).

b. One house family, with three rooms where each room has a specific climatic function and is used at one particular time of the year (Fig 315).

c. Mirror image house, where one half of the house is used for the winter time and the other half facing it across a courtyard, reflects the same room use and relationship, but is designed for use in the summer time. These houses are either in the form of a winter half using barasti as well as the summer half, but barasti used in a different way for each half, or houses where the winter half of the house uses mud or concrete block, while the summer half is built with barasti.

Both types of houses make use of air movement in the summer to create a comfortable micro-climate, and attempt to restrict the passage of air through the winter half, to keep the temperature as high as possible. Occupation of these houses is all year round, but represents an increase in the financial status of the family. The most common examples are found on the beach front (Fig 316).

d. Depending on the standard of the family wealth some people migrate between a winter house and a summer house. Each house has been designed to suit a specific season, although summer houses do sometimes incorporate more sophisticated features such as the windcatcher (Badgir) which allows an even greater control over the micro-climate, in that it can be taken down as winter approaches, without necessitating the immediate move to the winter house. The major principles involved here are the same as for the previous house types - protection from air movement in the winter and encouraging it in the summer (Fig 317 and 318).

Fig 3.14

Barasti house at Om El Boche showing addition of barasti screen for winter conditions.
a. before addition
b. after addition



a.



b.

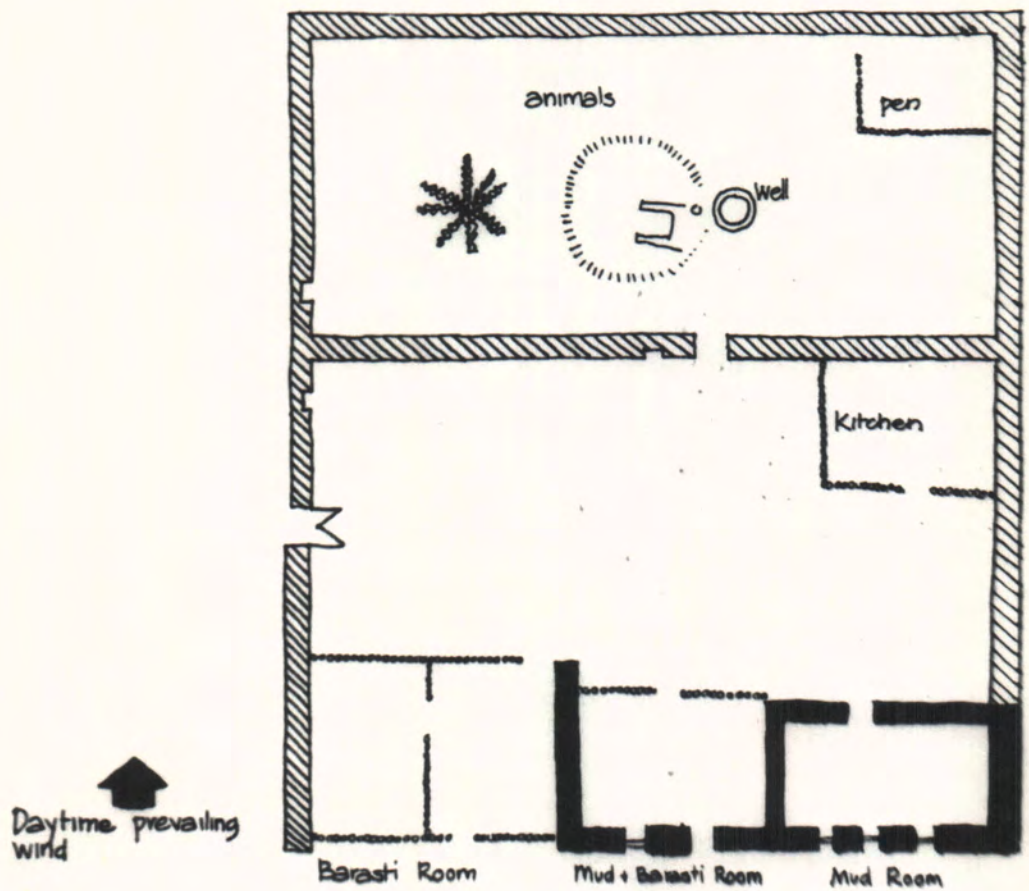
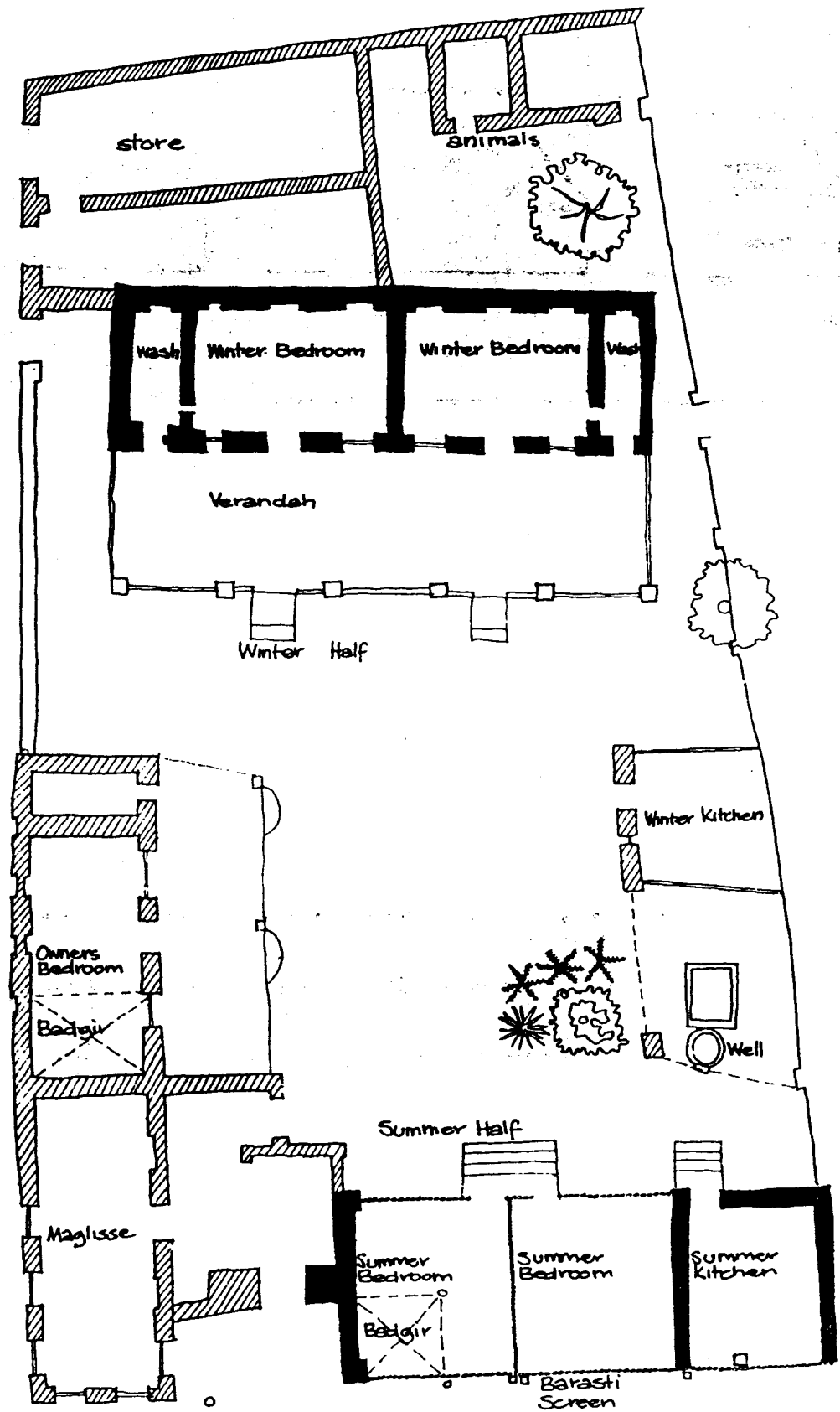


Fig 3.15 House at Maladah showing different rooms used for different seasons



Beach Front

HOUSE OF MOH'D SHERIF ABDULLAH
BEACH-SOHAR

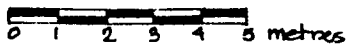


Fig 3.16

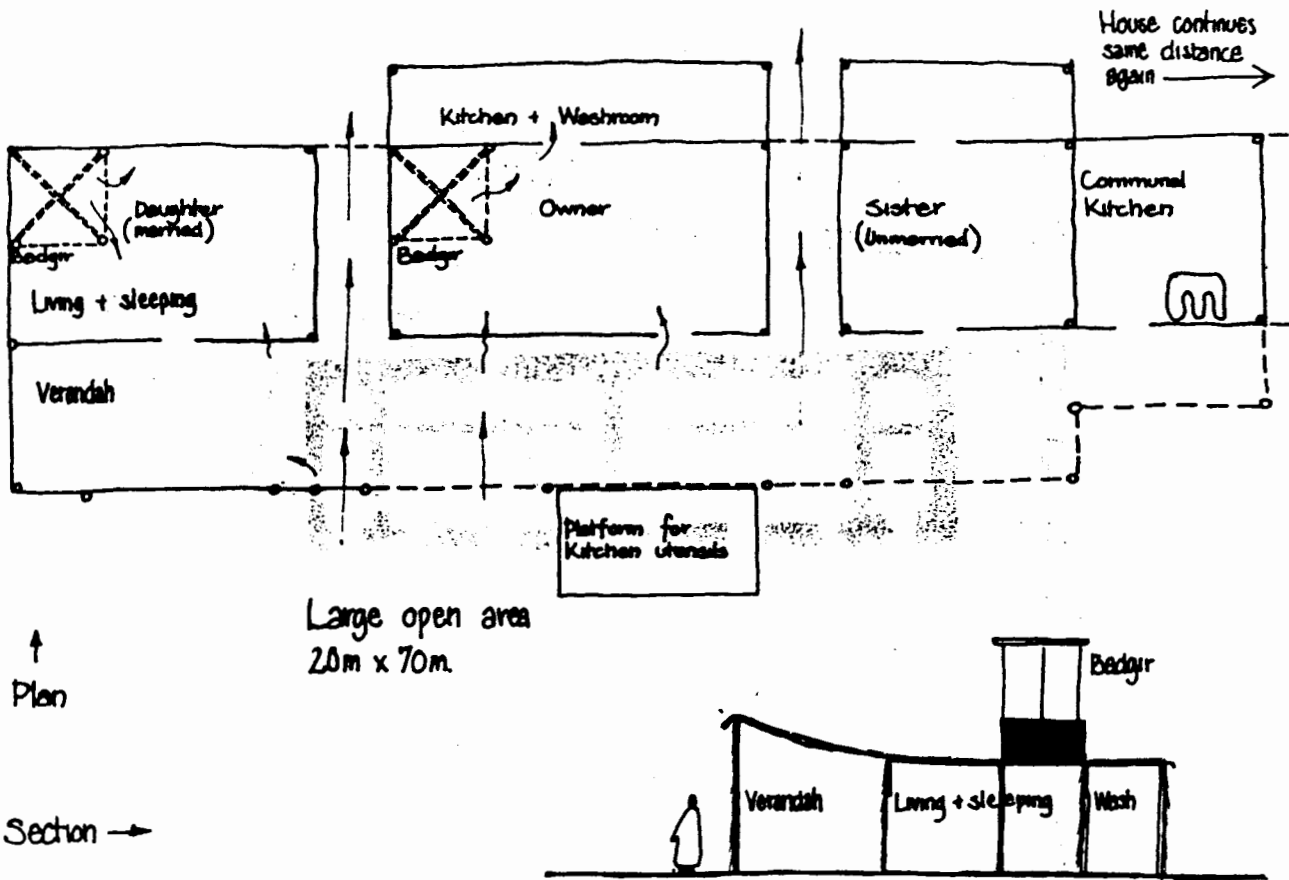


Fig 317 Magisse ~ Wilaya of Sohar ~ Ben Darwiche ~ Summer House

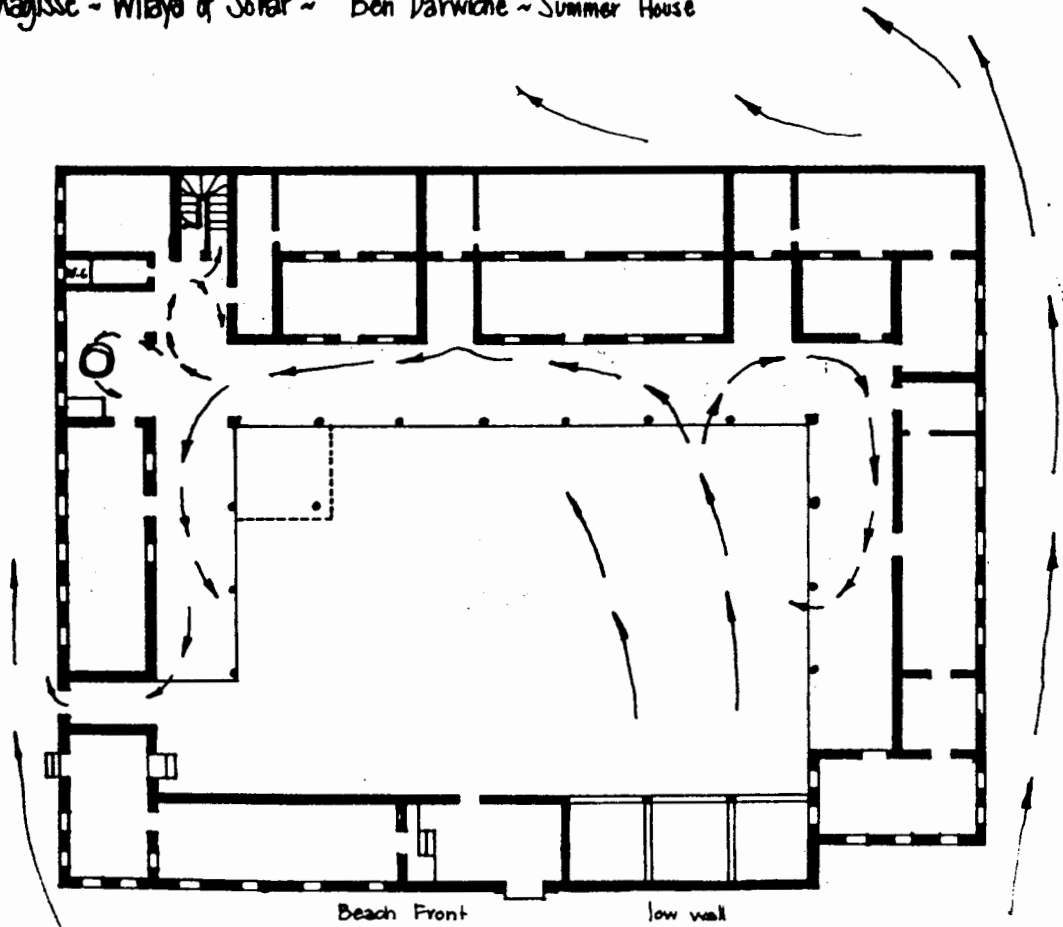


Fig 318 Magisse ~ Wilaya of Sohar ~ Ben Darwiche ~ Winter House

e. An extension of the previous house type is the migration of the whole village. Some villages are situated and arranged in such a way that life becomes unbearable in the summer months due to the great heat. These villages are almost completely evacuated during the summer months. Houses are designed for winter conditions with an increased use of solid wall materials for building, such as mud brick. Two principles involved are the retention of interior warmth, making maximum use of the daytime heat, and the minimum of air movement through the houses. The summer migration will be into the date garden belt, where cooler conditions prevail in the summer, and the villagers can also be near to their work. Summer houses are not necessarily grouped in any village pattern, but sited individually within the owner's date garden (Figs 319 and 320).



Fig 3.19 Winter Village Falaj al Qabael
Note mud brick houses and added matting on barasti roof.



Fig. 3.20 Summer settlement in date garden area.

3.3.2.

B. Air movement on the Batinah coast - Design Features

As with other features in the indigenous houses along the Batinah coast, air movement is made use of in varying ways, some more efficient than others, but depending closely upon the local environment. The importance of air movement during periods of overheating has been outlined in section 3.1.2. Climate. The simplest form of shelter occurs where a man or family settle underneath a tree. The principle involved is to provide shade from the direct sun, and hence reduce direct radiation, and allow the wind to pass freely underneath the tree, cooling the skin temperature of those dwelling there.

Exactly the same principle is followed in even the simplest Barasti houses on the Batinah coast, where at least one part of the house is composed solely of a roof and two side walls, with the two sides of the structure standing in the line of the prevailing wind left uncovered, so that the air movement can pass unchecked into and through the sheltered area, where the occupants receive its full cooling benefit. (Fig. 3.21)

Where a degree of privacy and security are required, the complete room must be enclosed, but again the same principle is followed, where the two walls in line with the wind are made up of open space Banasti panel which allows free air movement, but provides privacy and security.

This is making use of air movement at a very basic level and although applied to most levels of housing, is most important amongst those owners who cannot afford summer and winter living areas.

Without attempting to emphasise any one feature, since all have distinct values in making use of air movement, four house forms or features are studied, and it must be emphasised that these can in many cases be used in conjunction with each other.

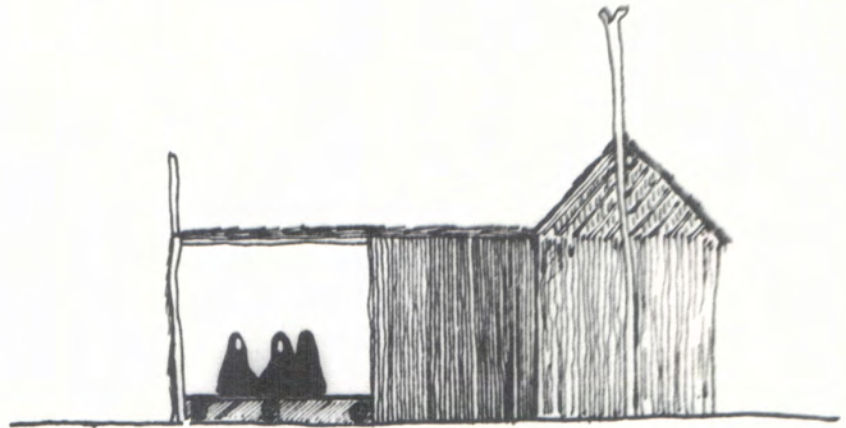


Fig 3-21

Section of barasti house showing shelter allowing free air movement through it.



a. Passage Way House

This house form occurs in all areas of the Batinah coast, and can equally be built entirely of barasti, or mud brick and other solid materials in conjunction with barasti.

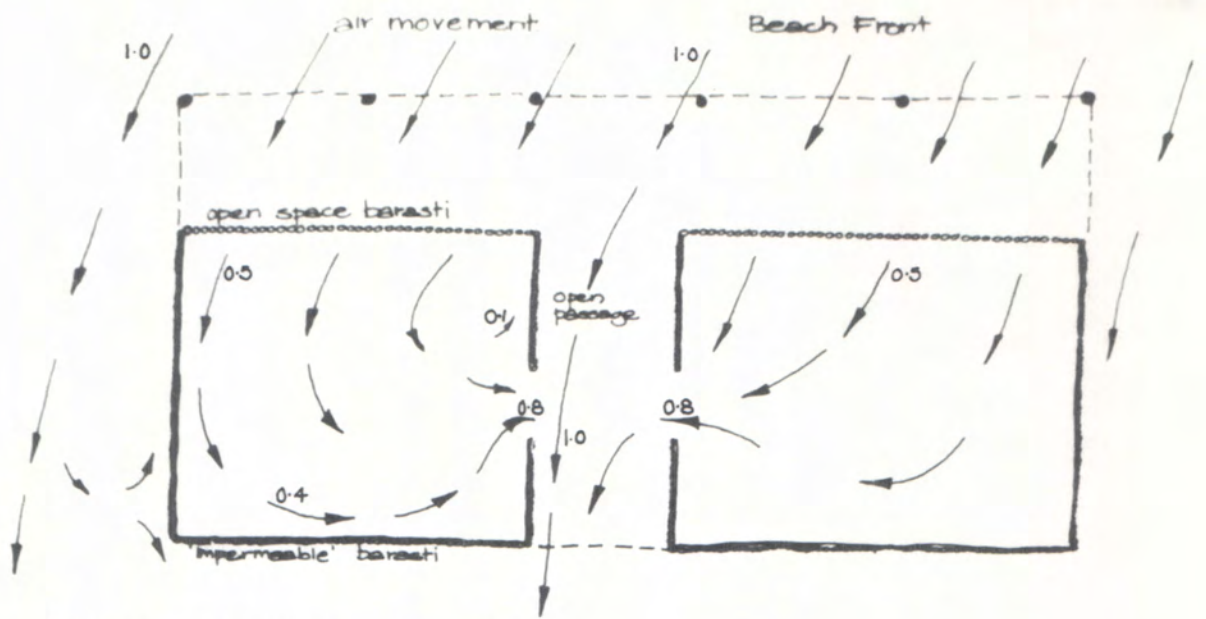
The example taken here shows a basic two-room unit, but the same principle can be used repeatedly in a row of rooms.

Two rooms are built, with a corridor in between which has no walls at either end of it, only a roof. In both of the two rooms the wall facing the prevailing daytime wind is constructed of a material allowing free entry of air into the room. In all cases seen, this screen was made of barasti. The remaining walls are made of an impermeable material, which can be mud brick, concrete block or barasti packed tightly together, to limit the passage of air through these walls. The wall adjacent to the passage way has a door opening in it.

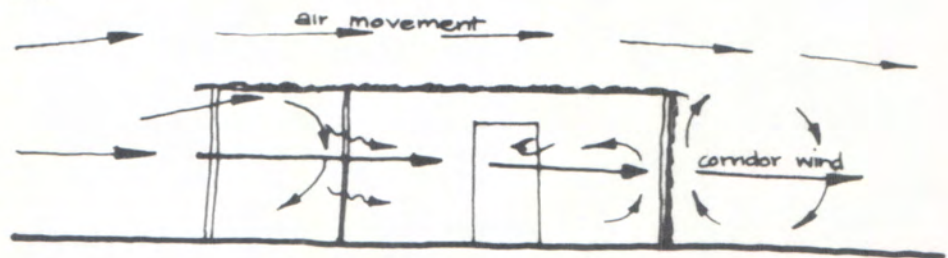
Wind blows into the rooms through the 'open' walls. The greater velocity of the air movement through the passage (wind velocity is increased as air is channelled into the passage way, which has no restriction at the exit end) causes air in the doorway to be sucked out because of the negative pressure created in this area, and a vacuum is created in the vicinity of the opening within the room, which is filled by air drawn in through the 'open' wall. The air at the end of the passage way is helped out by the negative pressure zone on the leeward side of the building, enhancing the effect. At nighttime, cool air from inland is channelled round the building and through the passage way, since the walls facing the nighttime breeze are impermeable. Slight air movement will occur as a result of air drawn out through the door, creating sufficient ventilation for comfort at night, when lower velocities are required (Fig. 322, 323 and 324).

b. Two Storey House

In some areas of the Batinah coast houses are built with a living room at first floor level, with a shaded space underneath. By simply raising the level of the building, more air movement is available, since velocities at ground level are usually less than those higher up. This house type is found principally in the cultivated belt, where families move in the hottest season. Rooms are built to allow the free passage of air in the same way as the simple barasti shelter already described (Fig. 325, 326 and 327).



Plan of passage way house
Fig. 3.22



Section
Fig. 3.23



Fig. 3.24



Fig 3.25

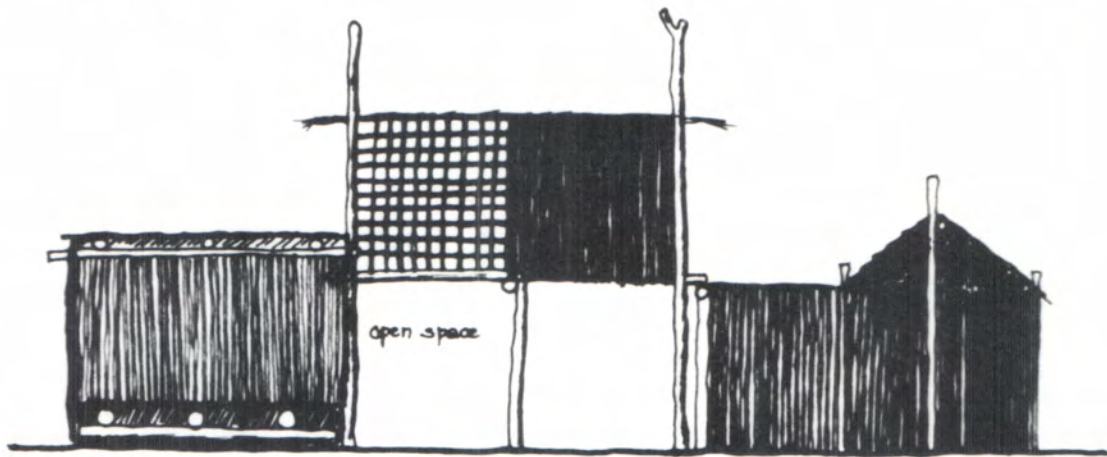
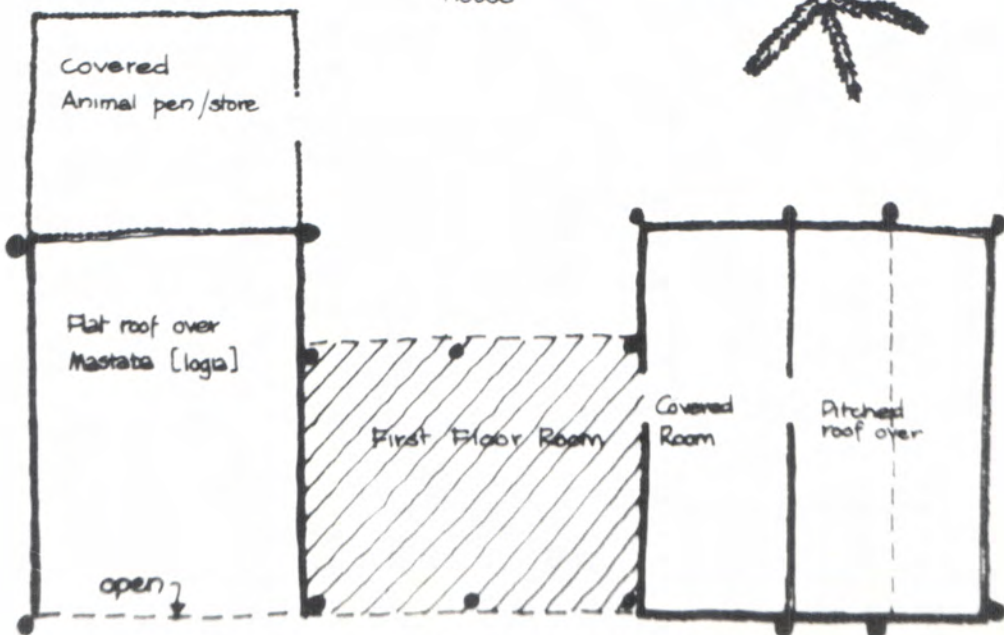


Fig 3.26
Elevation

Date garden surrounding house



Plan
Fig 3.27

↑ Daytime wind direction
Two storey barashi house at Musanala

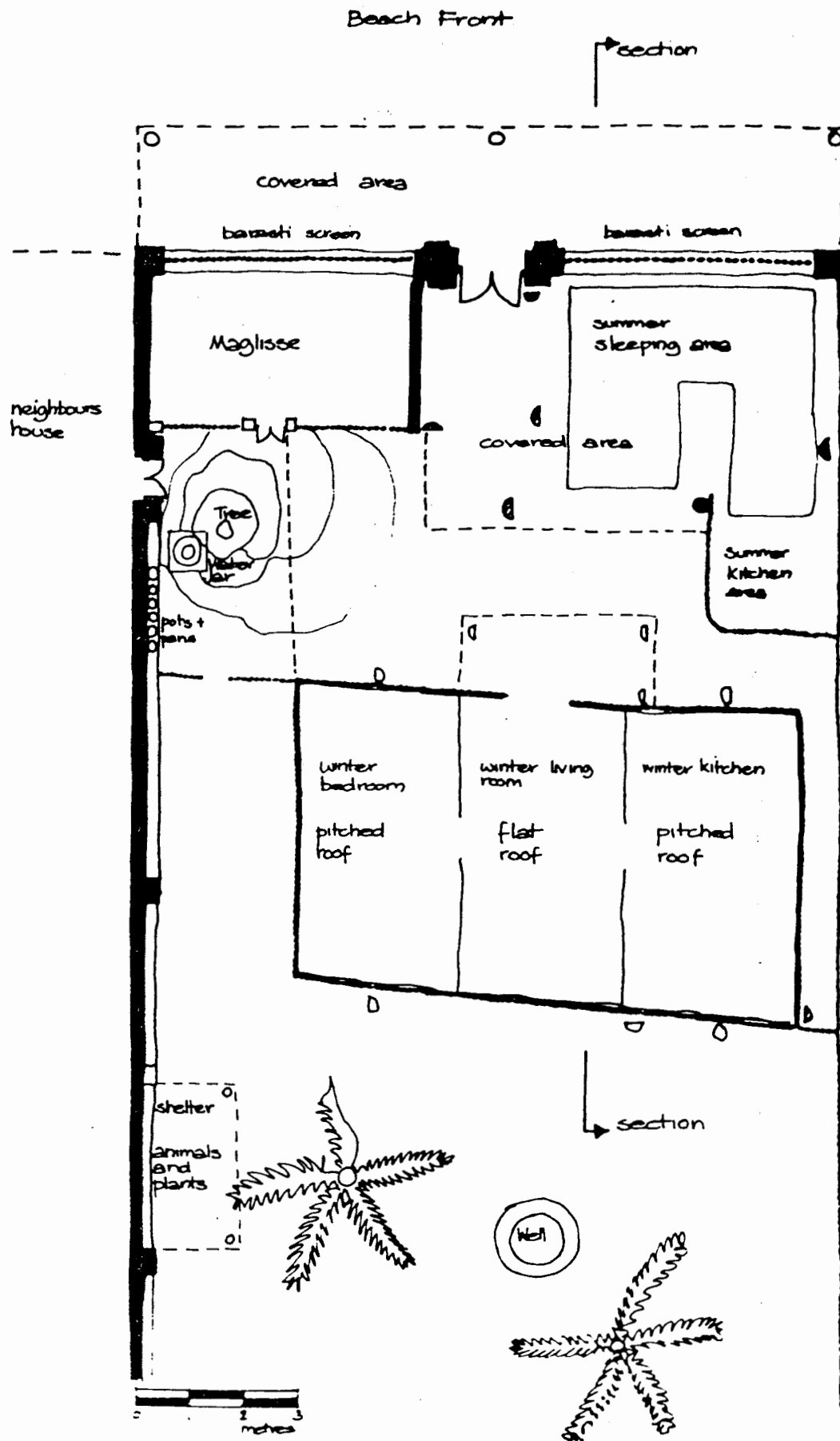


Fig 3-29 House of Mohic Abdullin Beach Front - Sohar Plan

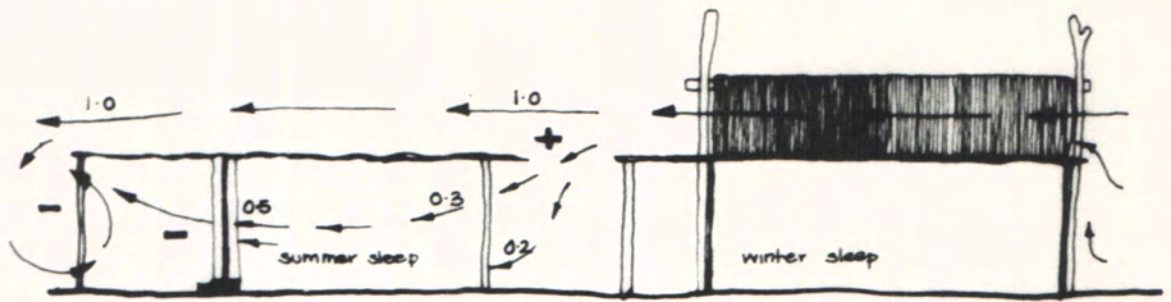
c. Air movement through summer halves of mirror image houses or summer and winter living areas in one house.

As described in section 3.2.2. human response to seasonal climatic and activity change, some houses have two separate halves, one for summer use and one for winter use. Most of these houses occur in the vicinity of the beach. The winter half attempts to restrict the passage of air through its structure, by using impervious materials as much as possible. The summer half encourages air movement through it, this being a major characteristic.

Fig 329 shows the relationship between the winter and summer halves. As shown, the daytime wind blows through the wall facing the beach (Fig 330 land sea breeze Page 2) (this wall is normally leafless barasti but could be claustre work) and then passes out through the gap between the winter and summer structures.

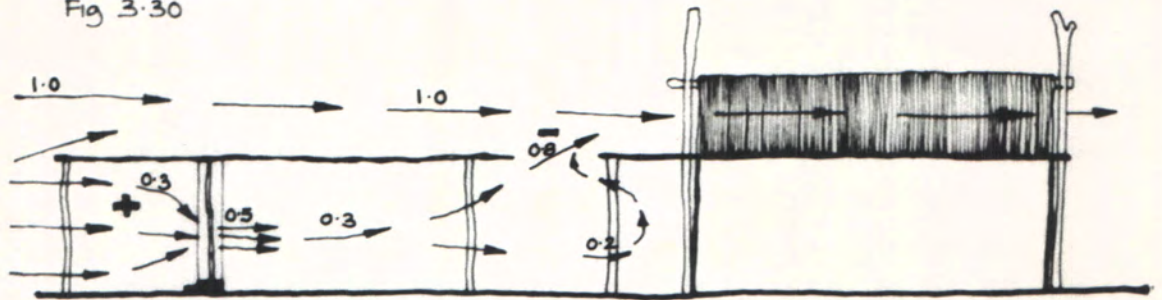
This air flow is encouraged by the small windows found in the barasti wall facing the beach, created by spacing the stems further apart than the rest of the wall, and placed low enough that one can see outside when seated (Fig.332). At nighttime these openings help to draw air over the summer sleeping area, and their proximity to the ground is of double value. Air blowing over the house at night will form a low pressure zone on the beach side of the house, which in turn will help to draw air through the wall openings and, in this way over the people sleeping inside (Fig. 331). This air flow in turn draws air in from the gap in the roof between the summer and winter halves.

As in the previous example, wind velocity through the house is less at night in proportion to the unrestricted air speed than it is during the daytime, a condition desirable for comfort at night.



air movement at night

Fig 3.30



air movement in the day

Fig 3.31

House of Moh'd Abdullah. Beach Front - Sohar. Sections

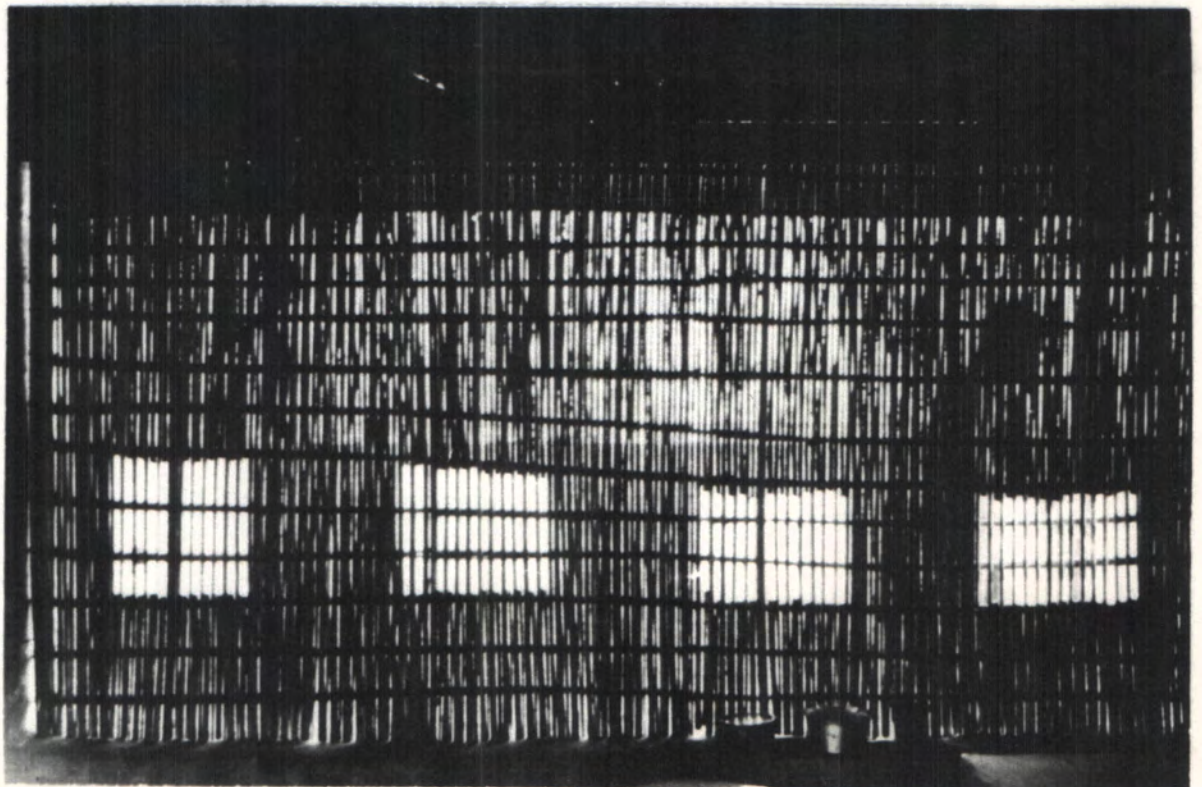


Fig 3.32

Fig 3.34
Cloth Badgir

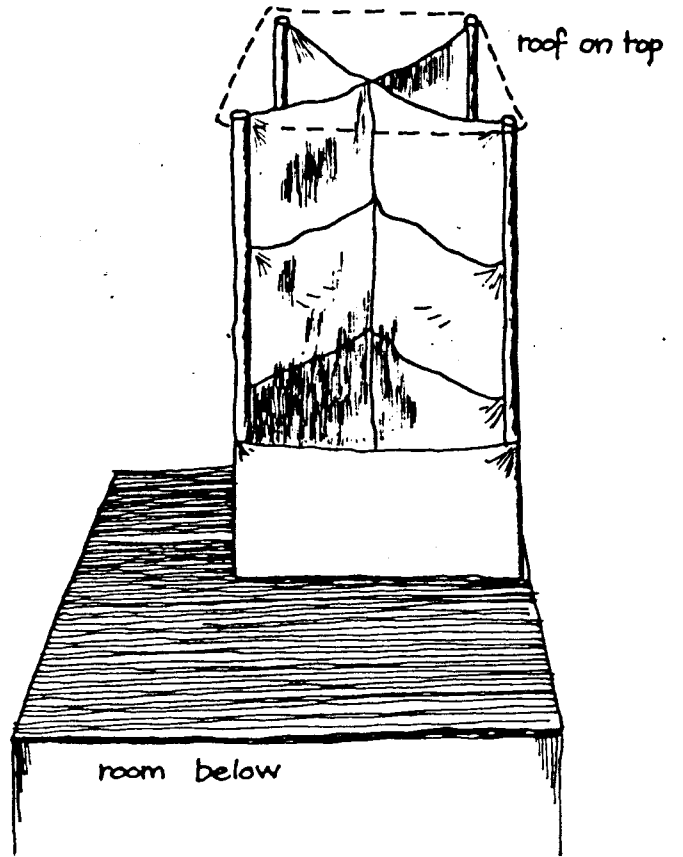
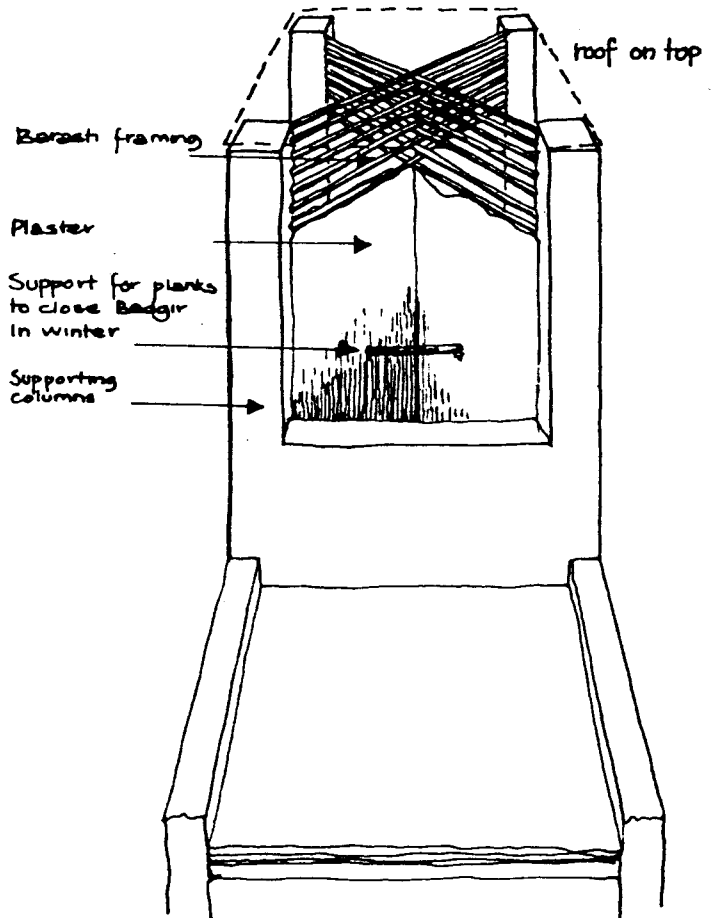


Fig 3.33
Plastered Badgir



d. Windcatchers (Badgir)

The windcatcher is a device designed to funnel air from the unrestricted upper levels down into ground level rooms which might not otherwise have sufficient air movement to achieve a comfortable micro-climate.

On the Batinah coast these windcatchers are multi-directional, so that no matter from what direction the wind is blowing, air movement will be caught and channelled down into the room below. Multi-directional windcatchers are probably Persian in origin and similar examples to those found in Iran can be seen in the Bastakia area of Dubai. Those seen on the Batinah coast of Oman are not as ornate but equally effective.

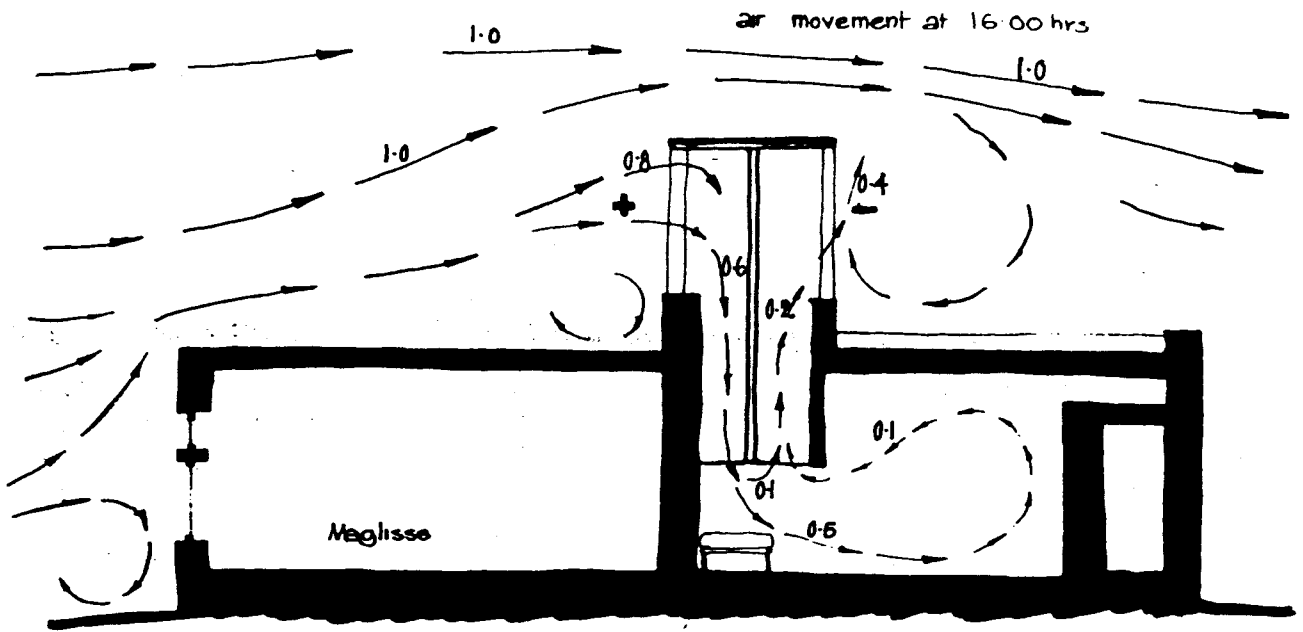
Variations in the room layout and the materials used lead to differing degrees of efficiency, which are illustrated below.

Two types of windcatcher are shown here in detail. Both examples are in Sohar.

The first example channelled air into a concrete block bedroom, used all year by the owner of the house. The windcatcher is built with concrete block columns rising up above the roof of the house, a column at each of the four corners of the windcatcher. From a height of about 1½ metres above the floor up to the top of the windcatcher, the tower is divided by an 'X' formed of palm frond stems covered over with gypsum plaster. In this way the tower can catch wind blowing from any direction (Fig. 333). The arrows on the figures indicate how wind blows into the tower and is channelled down into the room, where part is sucked back up the opposite shaft of the tower, and part enters the room. In the case of (Fig. 335) which is the case for daytime air movement, air blows down the shaft, and out across the room at low level. A small proportion of this air movement rises up the leeward side shaft; some of this air comes directly from the downward shaft. A larger proportion of the air leaves the room through the doorway and window openings. This process is advantageous for the daytime use of the room, when its central space is in use and therefore is the area requiring air movement to cool the occupants.

At night the wind direction reverses (land/sea breezes) and air blows down the opposite shaft (Fig. 336). As can be seen, only a small proportion of air actually circulates round the main part of the room, and the surface of the bed, and then back up the opposite shaft. This is beneficial in that the bed is the area that needs night-time ventilation. Air is sucked up the opposite shaft to the inlet shaft because of the negative pressure on the leeward side of the windcatch, which creates a vacuum effect (see plus and minus signs on Figs. 335 and 336). During the winter months, when air movement is unwanted, conditions being too cold or at least cool enough, the openings at the top of the windcatch can be covered with planks.

The other windcatch is constructed with four timber posts, with the tower divided up in the same 'X' form, but using sackcloth instead of plastered palm frond stems (Fig. 334). Entry of air movement into the windcatch is the same as in the previous case, but the room below is different, affecting the air movement pattern. This room is built of palm frond stem walls.



Section

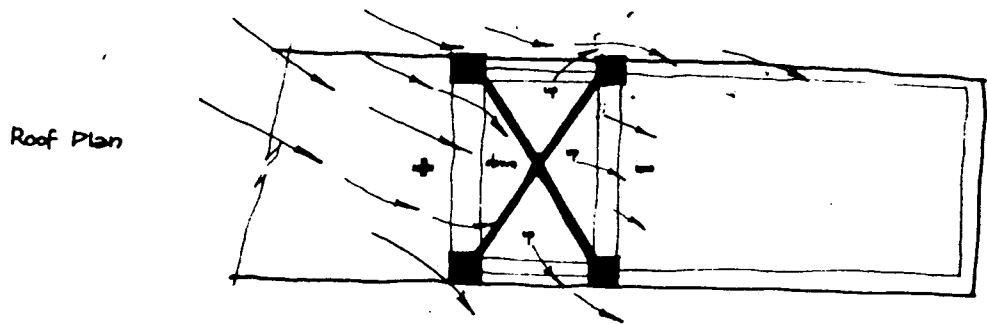
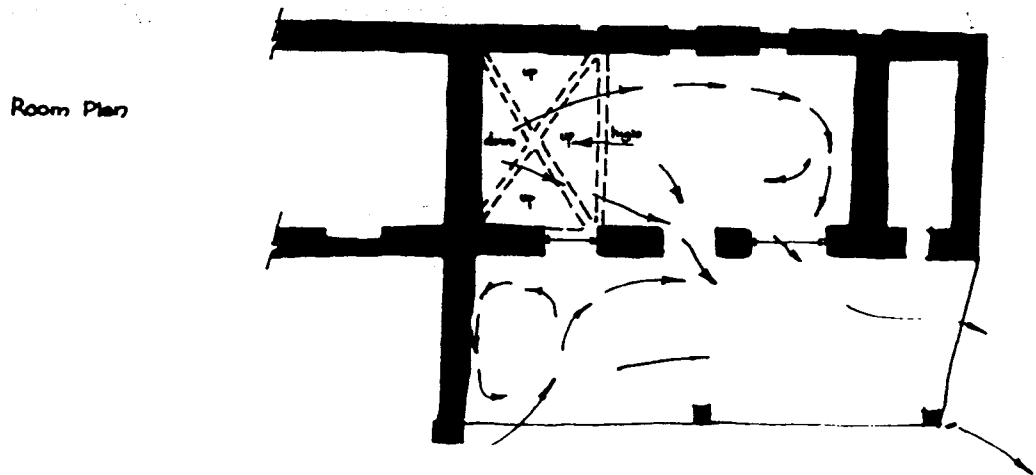
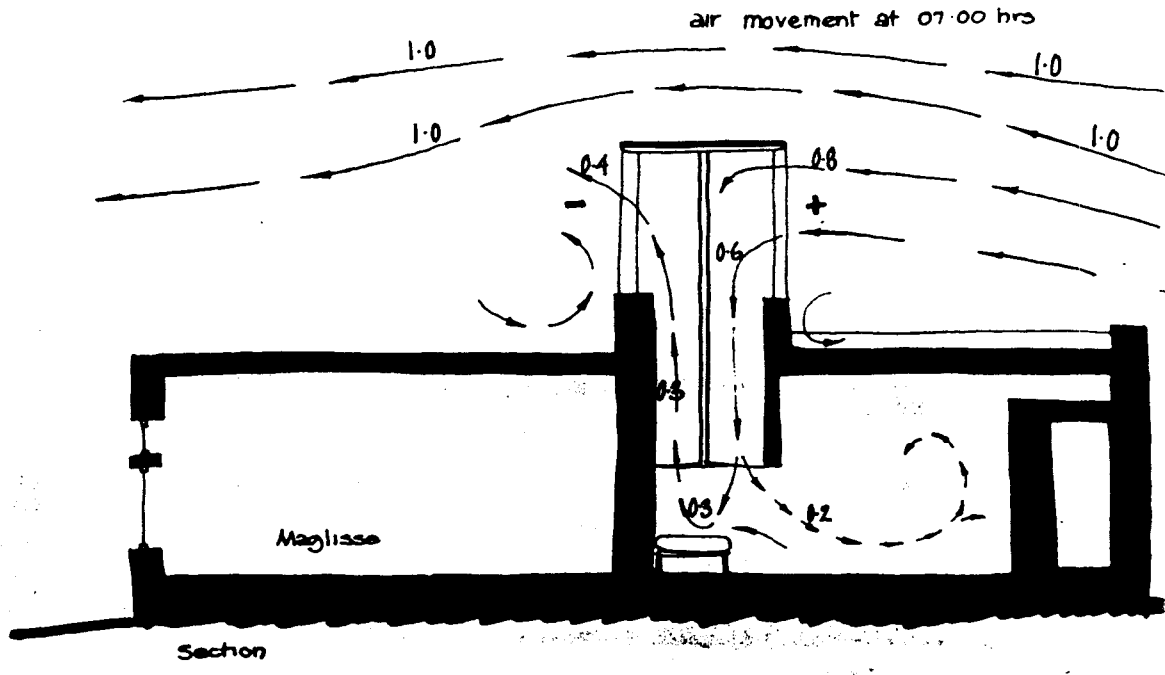


Fig 3.35 Plastered Badgir





Roof Plan

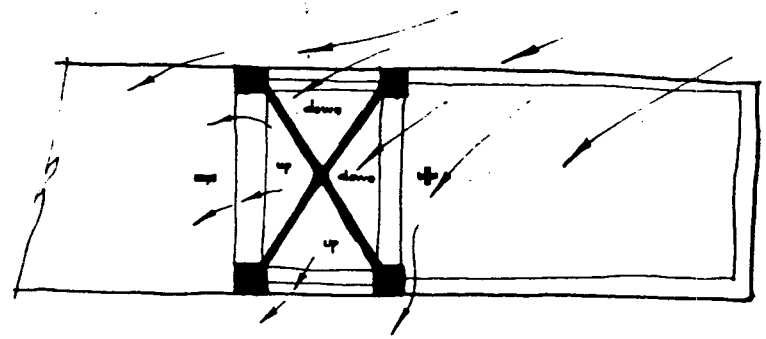
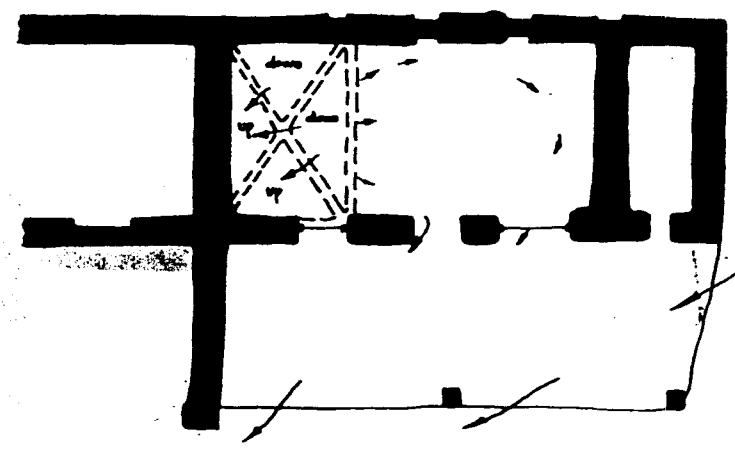


Fig 3.36 Plastered Badgir

Room Plan



Although the two walls on either side of the room are made of impervious or relatively impervious panels, the two end walls in line with the prevailing land and sea breezes are made of open space barasti, forming a wall which allows a free passage of air through it.

During the daytime (Fig. 337) air being channelled into the room through the windcatch is joined at the bottom by air entering through the wall. This means that whilst the area immediately below the windcatch will benefit directly from the air blown downwards, the rest of the room will be ventilated as much by direct air movement through the room from one side to the other.

At nighttime (Fig 338) the reversed wind direction blows in, in the same way as for the plastered windcatch, but at the bottom a proportion returns back up the opposite shaft, and the rest blows out through the adjacent leeward partition, both effects helped by the negative pressure zone on the leeward side of the building. None of the air from the windcatch is drawn into the rest of the room, which therefore relies upon air coming in through the windward side partition. The advantage of this is that where there is a less organised use of space and several people may sleep in the same room, there is air movement throughout the room. The windcatch helps to increase the velocity of the air movement, and therefore, in the summer, the degree of beneficial cooling. In the previous example the windcatch is the only source of air movement, but in this case an equally important proportion comes in through the walls, which gives more widespread air movement at night.

As the climate gets cooler in the late autumn, the cloth windcatch is removed and the roof opening covered over, leaving only the supporting posts (Fig 339).

The windcatchers in the Bastakia area of Dubai are far more ornate (Fig. 340) but perform in the same way as the plastered windcatch in Sohar. Rooms served by windcatchers can be equally on the ground or first floor, but in most cases have now been closed up and replaced by air conditioning units.

air movement at 16.00 hrs.

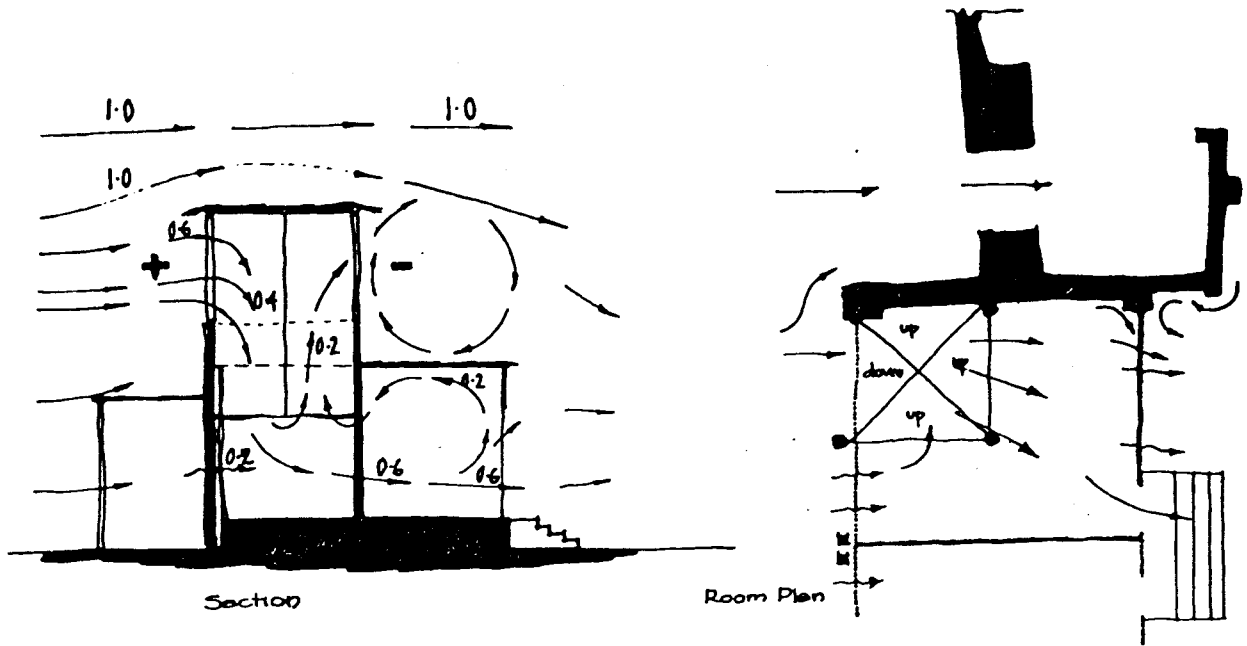
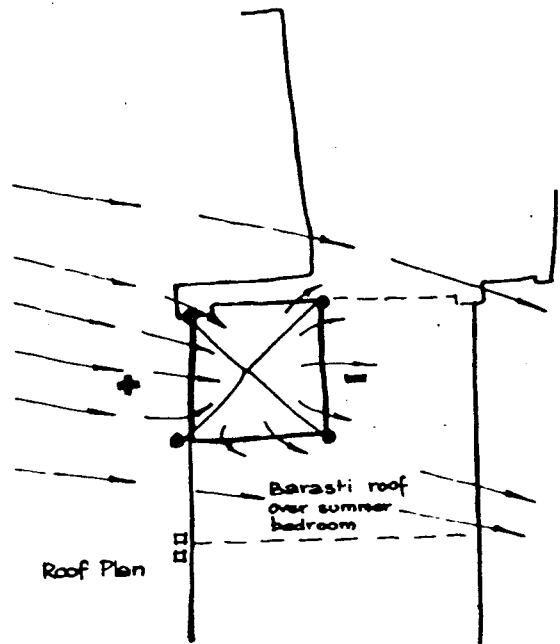
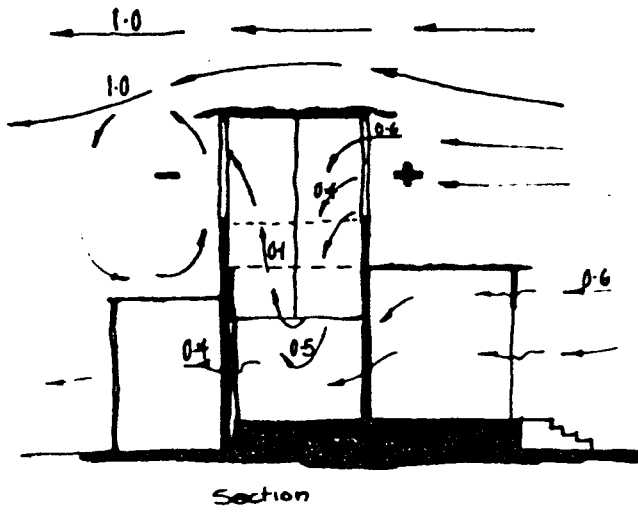


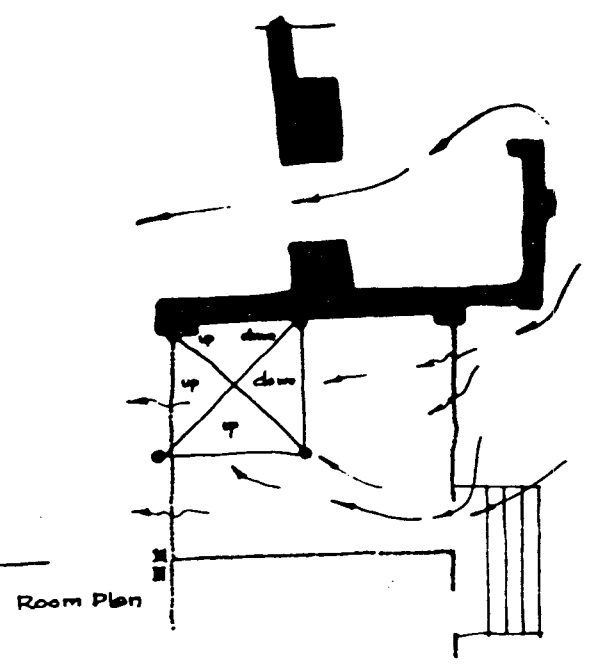
Fig 3.37 Cloth Baggr



air movement at 07:00 hrs

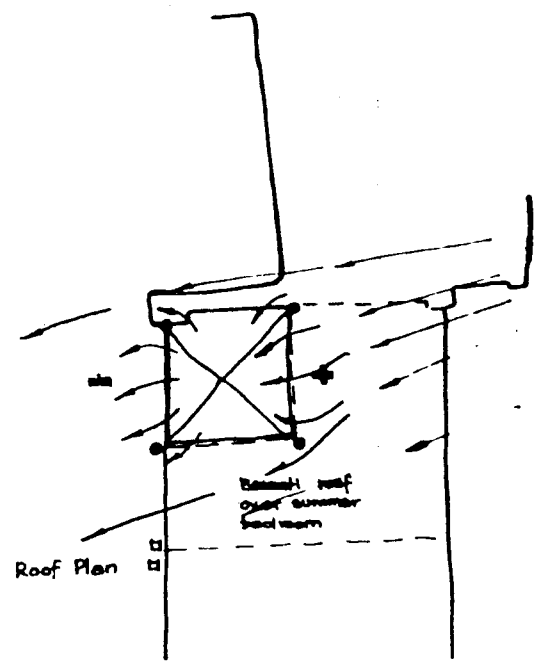


Section



Room Plan

Fig 3-38 Cloth Bagging



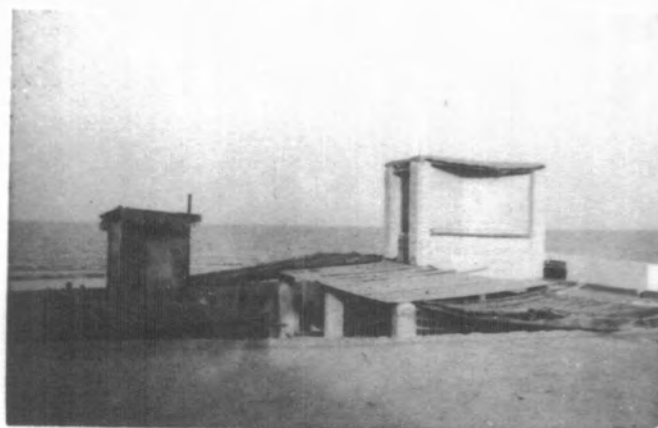
Roof Plan

Fig 3-39

Plastered Badgir and
cloth Badgir at Sohar



View from other side



Cloth Badgir in use



Cloth Badgir framework
after adaptation to winter use.

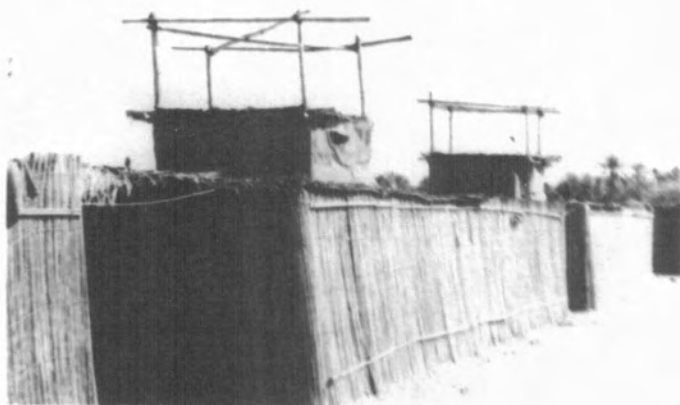
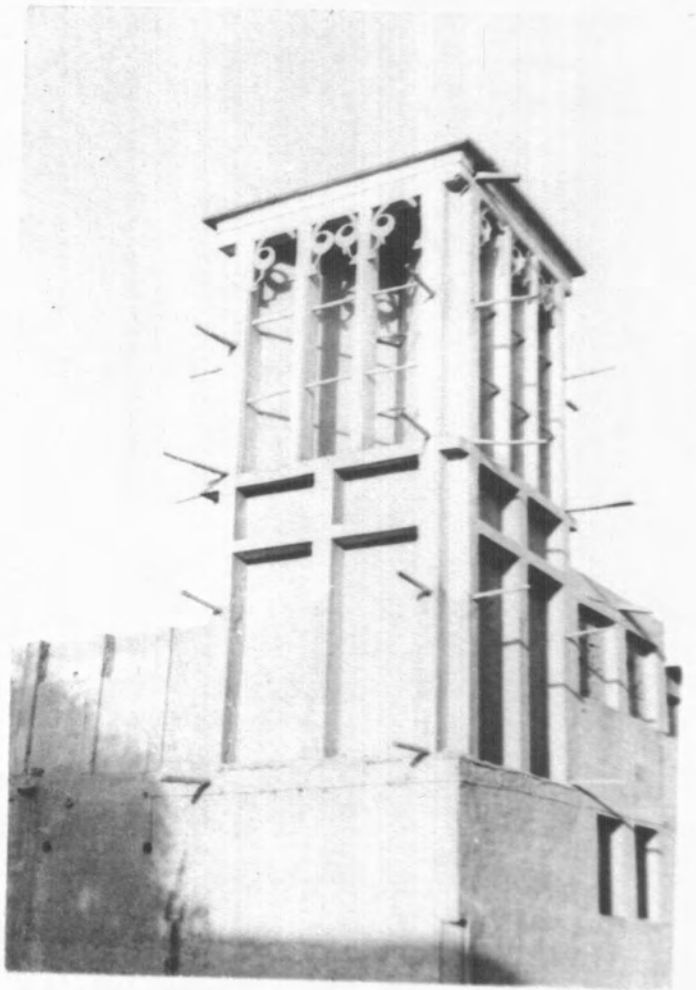


Fig 3.40

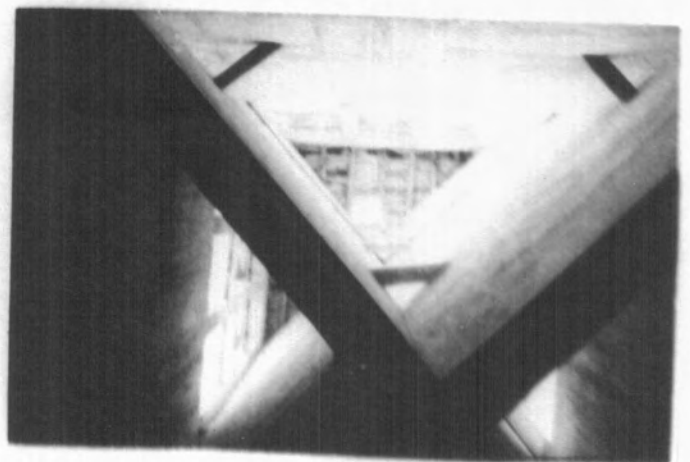
Bastakia area of Dubai
with Badgir



Dubai Badgir



View up Badgir shaft
showing divisions





3.3.3. Materials - Barasti

- i General
- ii Physical Properties
- iii Construction Methods
- iv Panel Types
- v Response to Climate
- vi Costs
- vii Problems and Potentials

i Barasti is the Omani name for the palm frond stems used as a building material. Most commonly found along the Batinah Coast, it is used on its own or in conjunction with mud brick and more recently, concrete block.

Houses along the beach front and in the cultivated belt are often built entirely with Barasti, although close to the towns it is used increasingly in conjunction with other materials. Inland of the cultivated belt its use decreases, some houses using it only as a ventilating screen and for animal pens and store rooms. This is a reflection of the climatic change inland from the coast. The effect of the land/sea breezes decreases the further one goes from the shore, relative humidity drops and the diurnal and annual temperature range increases. The use of mud brick in this context is discussed in the next section. At present one of the great drawbacks of Barasti is its short lifespan, and even in areas where Barasti is the major building material, many of the richer inhabitants are using more permanent materials. The problem of extending the lifespan of Barasti is covered in this section. There is also a degree of prestige involved in the use of new materials which do not necessarily perform as well in relation to local climatic conditions in comparison to indigenous materials, but which enhance the status of the owner.

Although the use of Barasti occurs predominantly on the Batinah coast, palm frond stems are also widely used in Salala, Sur and the Oases settlements. Construction methods differ in Salala and Sur from those of the Batinah. This section deals with Barasti as used on the Batinah Coast.

The basic component of Barasti housing is the palm frond stem, which is used in several different ways depending on the purpose it is to serve. A single palm frond stem (Zorha) can be used either with its leaves left on or stripped. Single stems are tied together to form a type of mat (da'am) usually of a standard size, 2.20 metres high by 4 metres long, although the length is variable. It requires approximately 140 stems for a single thickness da'am. It can be bought ready made in its simplest form, or, where a man owns some palm trees, his own stems can be bound to form a da'am.

A da'am is usually supplied with each stem tied to the next one in such a way that the top of one stem is adjacent to the bottom of the stem beside it, giving equal strength and thickness throughout, and negating the tapering of the stem itself, which also gets weaker the thinner it gets.

Da'ams are also made up in different combinations to suit varying conditions and functions within the building of the house. Each stem is tied to the next with string, and in the basic da'am, this is the only binding used, so that the da'am can be rolled up and stored or carried about more easily. Certain panels are used which have horizontal bracing members. These can be either added to the da'am in the formation of a more stable wall covering, or a complete panel can be constructed from single stems to form a lattice. Individual stems are used in making up the framework of parts of the building, but the stem itself is not used as a major structural

ii Physical Properties

Barasti stems as used in house construction were obtained from a builder in the Seeb area in order to carry out structural tests at the Materials Testing Laboratories at London University, using modern test equipment and standardised methods (Figs 341 and 342).

Tests were carried out on the stems for tension, compression and bending in both dry and wet conditions, repeated a number of times so that results could be statistically averaged to provide the figures given below.

Wet tests were conducted using the same experimental methods as for the dry tests, but 'wet barasti' indicates that stems were submerged in water for 8 hours prior to testing. It was noted during the soaking period that the Barasti stems absorb water more readily up the grain than through the out skin.

The results of the tests are given in Fig. 343 for tension, Fig. 344 for compression and Fig. 347 for bending.

a) Tension (Fig. 343). Graphs of the results from both wet and dry tests are given here, from which it is possible to determine the point at which a barasti stem of a given diameter will show the first signs of yielding under tensile loading and likewise the load under which the member will finally fail resulting in a fracture. It was found from the data collected in these experiments that on average the maximum tensile stress *1 that the barasti stem can take before failing is 3.50 Kn/cm^2 or 343 Kg/cm^2 in a dry state and 3.00 Kn/cm^2 or 294 Kg/cm^2 when wet. The average Tensile stress*1 that the Barasti stem can take before showing signs of yielding is 1.80 Kn/cm^2 or 177 Kg/cm^2 when either dry or wet. These results suggest that the moisture content of the barasti stem has little effect on the strength of the member when it is under pure tension. A comparison of the results of these tests with those made on other materials shows that the ultimate tensile strength of bamboo*2 is approximately 2000 Kg/cm^2 , while mild steel is approximately 3200 Kg/cm^2 . *3

*1 Stress (In Kn/cm^2 or Kg/cm^2) is the quantity of load per unit of area of the Cross-Section of the members.

*2 The Use of Bamboo and Reeds in Building Construction

P.P. 72 United Nations. Department of Economic and Social Affairs 1972.

*3 A.J. Metric Handbook p. 172.

Fig 341
Tension testing machine.
(Avery)

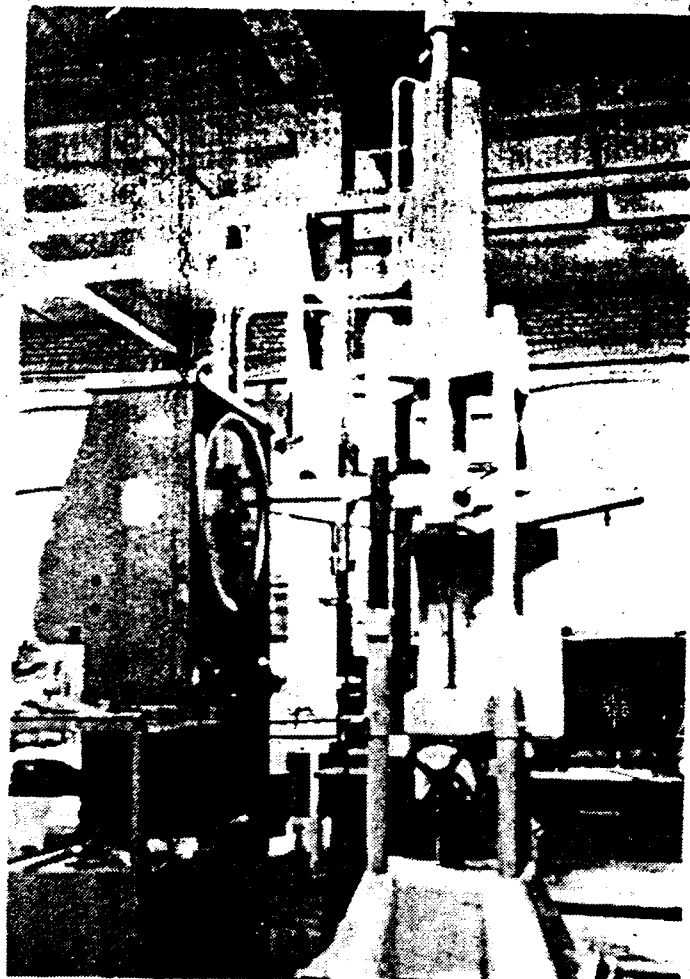
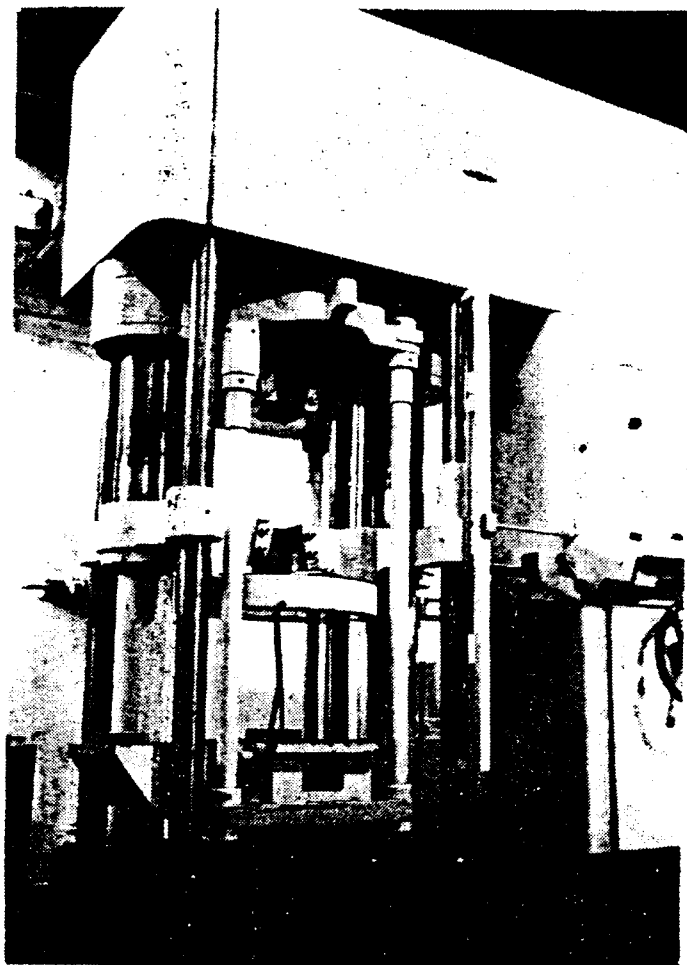


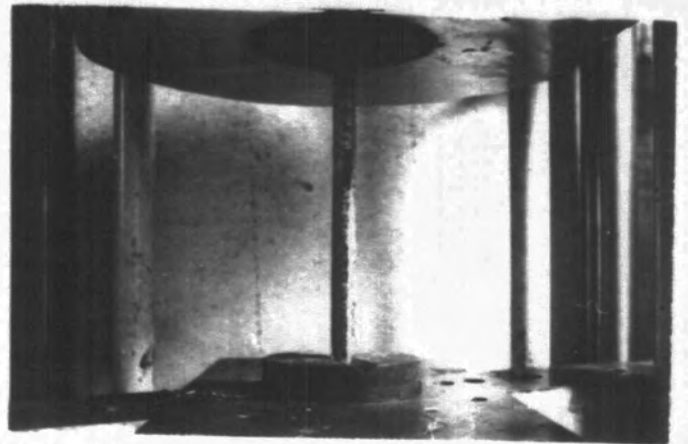
Fig 342
Compression testing
machine. (Denison)



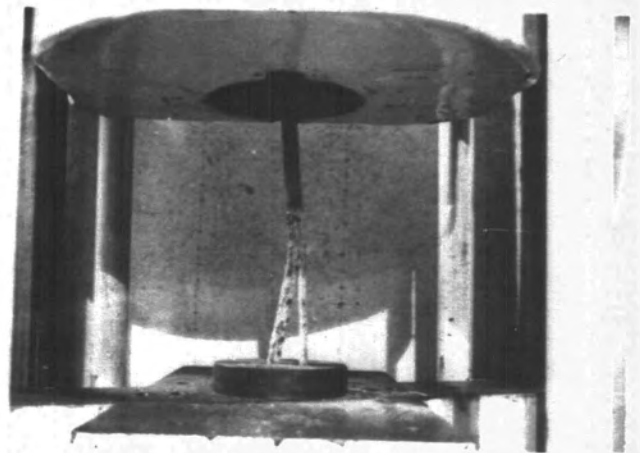
b) Compression (Fig 344). Graphs of the results of both dry and wet tests show the average maximum compressive load that a barasti stem of a given diameter will take before failing. It is found from the data collected here that the stem fails under a load of 2.20 Kn/cm² or 216 Kg/cm² when dry, and 1.10 Kn/cm² or 108 Kg/cm² when wet. The Barasti stem apparently loses half its compressive strength when it becomes wet. While the dry barasti stem tends to split or fracture in compressive failure (Fig. 345), the wet barasti's fibres lose their rigidity and separate under the compressive load (Fig. 346).

c) Bending (Fig. 347). Graphs of the results of wet and dry tests are seen here. They show that wet barasti is somewhat weaker than dry barasti in bending; a thin stem under a centre point load will deflect to a much greater extent than one of greater cross-sectional area. A wet stem under increasing load will not fracture cleanly, but will fold in much the same way that a steel bar will fold. This seems to be on account of the fibres slipping linearly rather than breaking (Fig. 348). A dry barasti stem behaves somewhat differently; with the load applied at the centre the stem will break cleanly at this point, once the load reaches the critical failure level. However, with the load applied at a point along the thin tapered end, the stem will not fracture at the load point, but will split and partially fracture somewhere between the load point and the tapering end (Fig. 349).

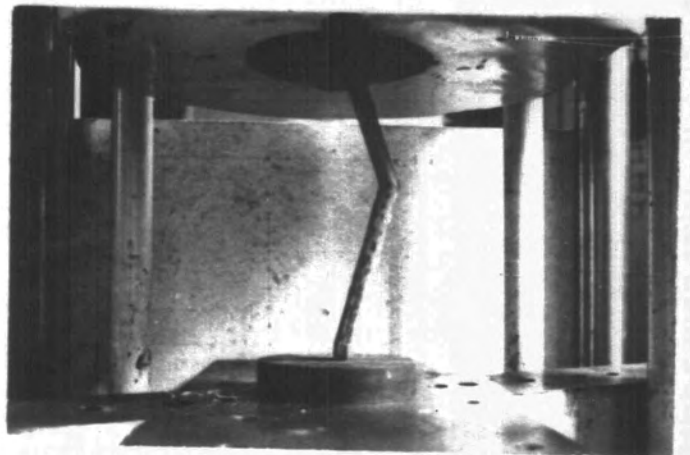
Stem before compression



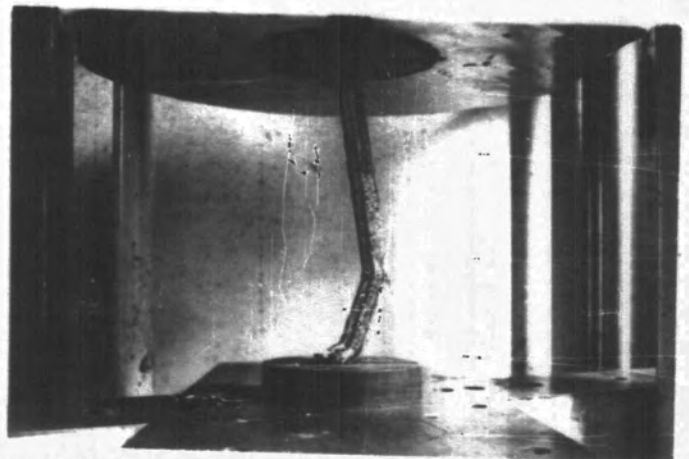
Thin end under compression
Note split failure



Center section under compression



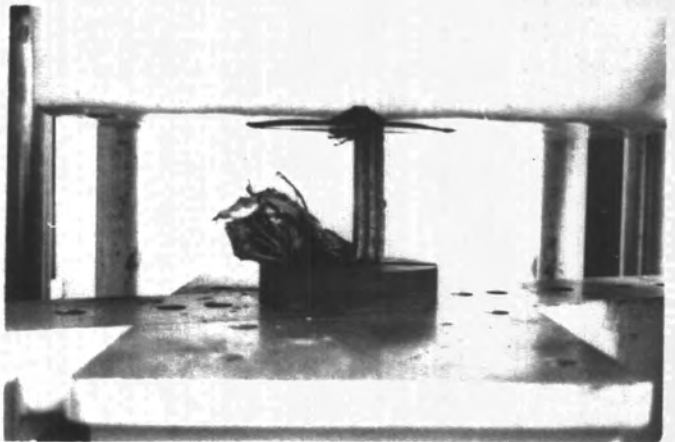
Thick end under compression
Fig 345 Compression tests



Wet barasti under initial loading



Wet barasti compressed to half its length showing shredded fibre



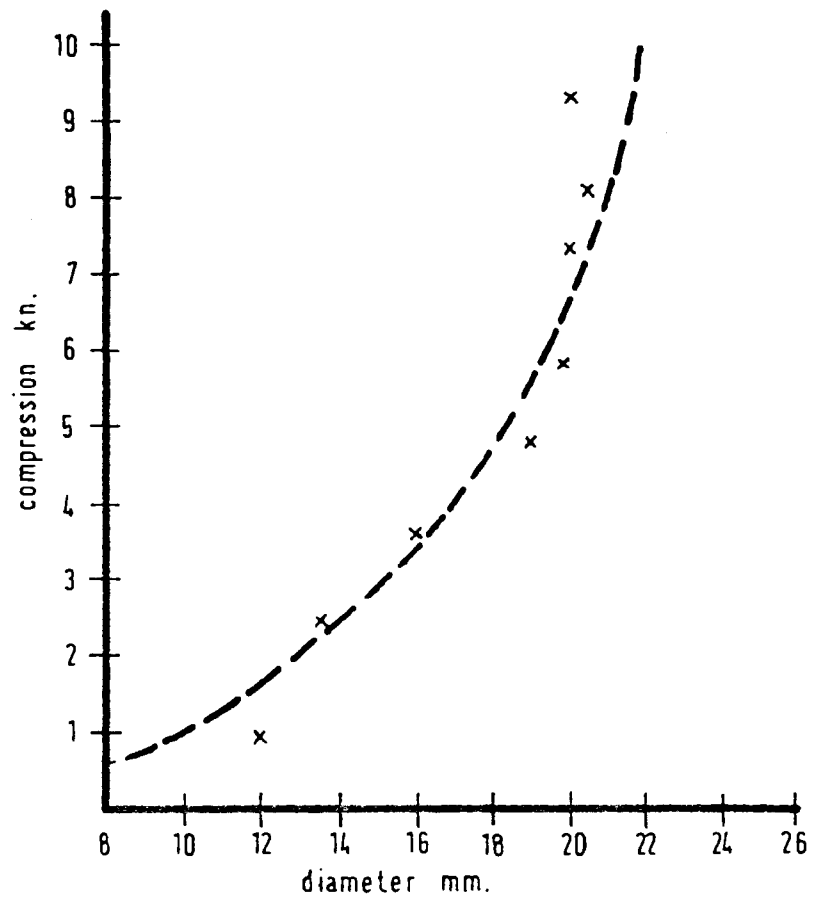
Detail of compressed fibre showing breakdown of fibres
Fig 346



Compression

Dry Test

Average maximum compressive stress (point of failure) for dry palm frond stems (barasti) was calculated from graph to be 2.20 kn/cm^2 or 216 kg/cm^2



Wet Test

Average maximum compressive stress (point of failure) for wet barasti 1.10 kn/cm^2 or 108 kg/cm^2

--- Point at which member fails

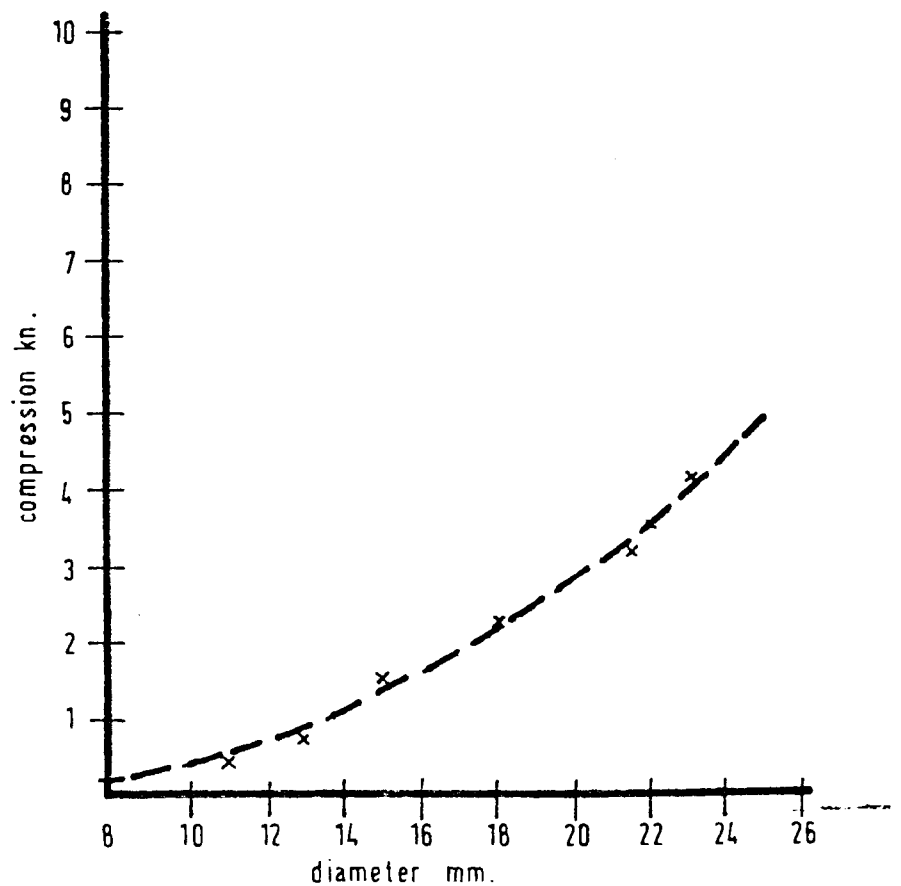
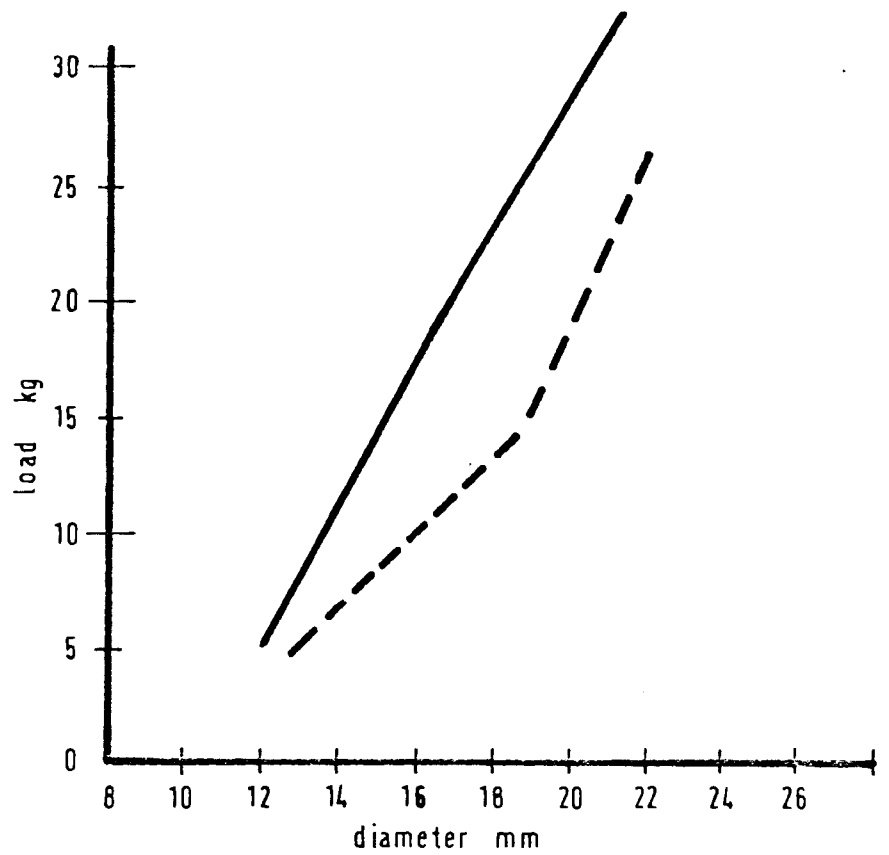


Fig. 344

Bending

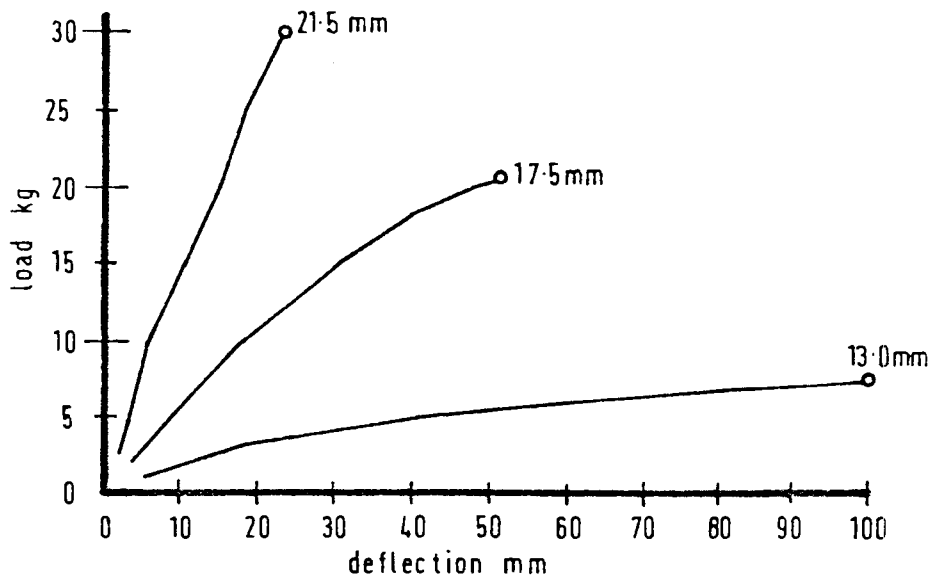
Graph showing failure limits due to applied centre point loads, for dry and wet date palm stems (barasti).

— Dry test
 - - - Wet test



Dry Test

Graph showing deflections corresponding to applied centre point loads for barasti stems of various diameters.



Wet Test

Graph showing deflections corresponding to applied centre point loads for barasti stems of various diameters.

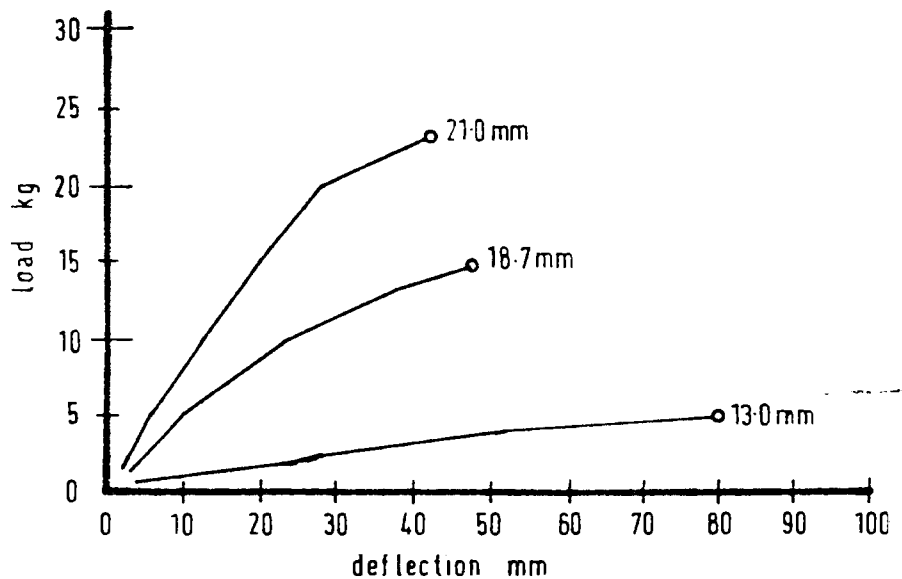
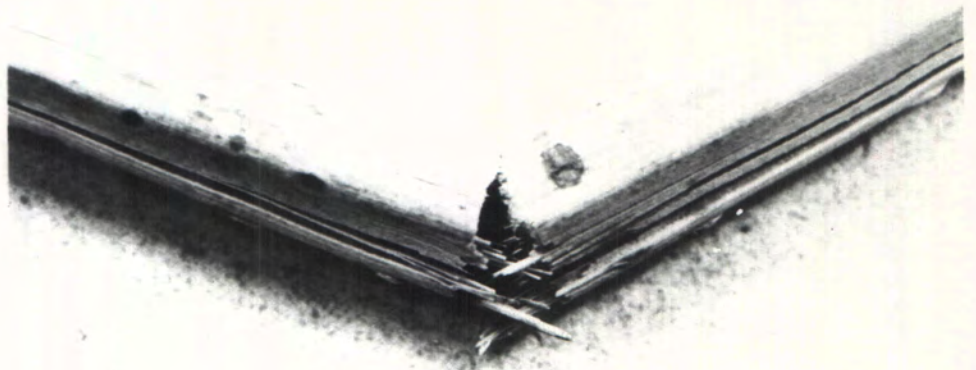
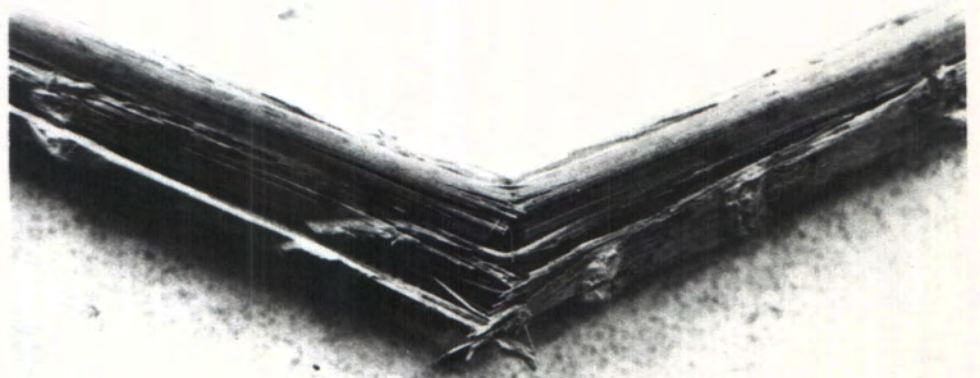


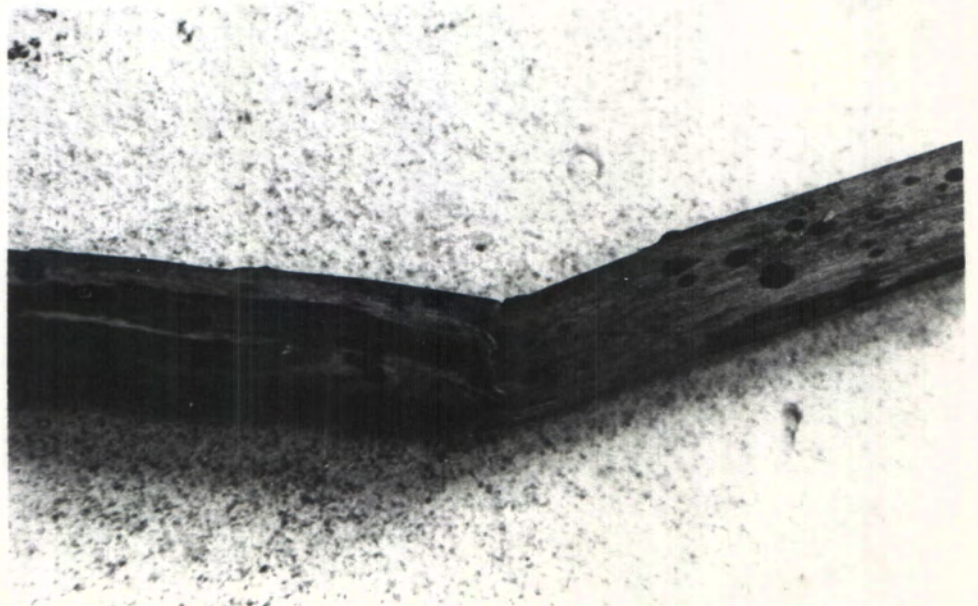
Fig 347



Clean fracture at thick end of stem



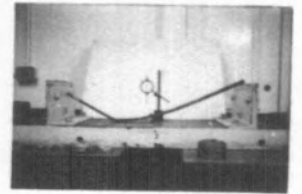
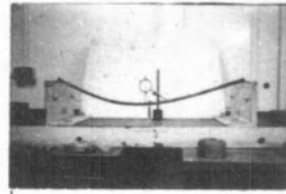
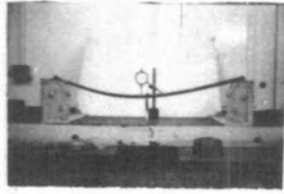
Splintered fracture at thin end of stem



Folded failure of wet stem

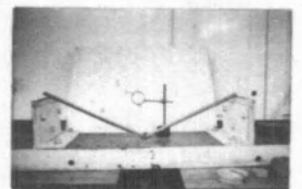
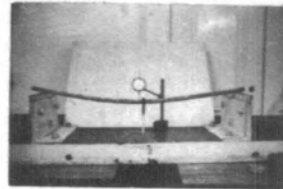
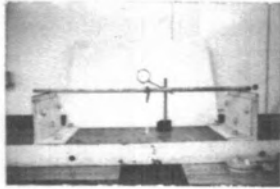
Fig. 348
Behaviour under
loading

thin thick



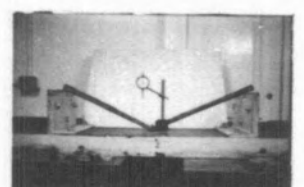
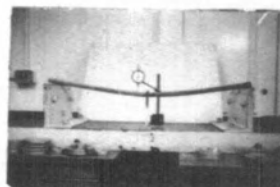
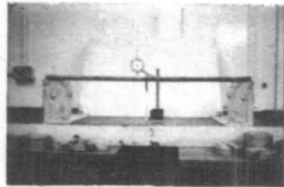
a
b
c
THIN END OF STEM

thin thick



a
b
c
CENTRAL PART OF STEM

thin thick



a
b
c
THICK END OF STEM

Fig 349 Behaviour under loading

Barasti as Reinforcement.

Tests have been made on organic materials as reinforcing members in conjunction with concrete and other primarily load-bearing materials:

"Reed culms were traditionally used in Iraq as a reinforcement for lime mortar in lintels and arches. Reeds embedded in gypsum mortar have been found to be in perfect condition when examined 40 years later" *2

Barasti has been used as reinforcement with gypsum in the construction of wind towers (badgir) in the Sohar area (Fig. 333). Barasti stems and mats are used with mud and other materials throughout the region in the construction of the roofs, just as barasti and mud are used together in wall construction in Salala. Professor Hassan Fathy has experimented with the engineered use of the palm frond stem as a reinforcement for gypsum and concrete in his design of the 'folded slab roof' at the Building Research Station in Cairo.

As stated earlier, the U.N.'s report on the use of bamboo and reeds indicates that bamboo's ultimate tensile strength in direct tension is approximately 2000 kg/cm², and that its use as reinforcement in concrete is feasible. The report goes on to say that because bamboo has a smooth surface its bond strength with concrete is lower, and in practice could only withstand tensile stresses from 560 to 700 kg/cm². Even with this consideration the bamboo increases the load capacity of concrete 4 to 5 times when it occupies 3 or 4% of the cross-section of the composite member. *2

From the tests made (Fig. 343) we can see that barasti's ultimate tensile strength is 343 kg/cm², or about 50% of the tensile strength found in practice for bamboo. Since the surface of the barasti stem is rougher than that of bamboo, because of its coarser texture and leaf stubble, it may bond to concrete in a superior way. If bamboo reinforcement can increase concrete's load capacity 4 or 5 times it is possible that barasti may increase concrete's load capacity 2 or 3 times.

Since no quantitative tests have been undertaken to this end, it is suggested that they should be carried out. The use of organic materials such as bamboo, reeds and barasti in reinforcement of concrete could go a long way to reducing the use of expensive steel bars. More research should also be done into the use of these organic materials for the reinforcement of materials other than concrete, which is very expensive in many areas of Oman. Barasti could be used in mud brick wall construction in the form of continuous horizontal binders to provide resistance to lateral forces in the structure (see Salala section 8 Fig. 825). Stabilized mud or earth could employ barasti reinforcement in similar ways to its use in concrete construction. Further research should be carried out in these areas.

iii. Construction Methods

Barasti rooms divide up into two basic types, pitched roof and flat roof. There are various room types using different panels to control the micro-climate as required.

a. Pitched roof room. (Kaargeen or Shonasia depending on use) (Fig. 350)

A main supporting framework is set up, with four corner posts and two principal posts supporting the ridge pole, all set in the ground. On each side the two corner posts are linked by a beam at the top. Rafters are placed linking the ridge pole to the eaves, usually about four to each side, and where the size of the roof requires it, additional horizontal rafters are placed on top of the vertical ones, half way down the pitch of the roof (Fig. 351). The timber is usually a palm tree trunk or a locally named timber called Kandela.

The side walls of the room are then covered by a da'am or da'ams, which are tied to the timber framing (Fig. 352). Varieties of thicknesses and types of panel are outlined in the next section.

The da'am walls are usually reinforced by three or four horizontal barasti stems (Zorha) which are tied at intervals to the panel itself.

The end walls are covered in the same way, up to the eaves height and sometimes higher. The triangle formed by the gable end is usually covered with a panel set diagonally across the area, but can equally be a grid, with vertical stems inside and horizontal outside. There is no set pattern, and other variations can be seen. This often depends upon the skill of the builder, and the degree of pride that he takes in his work, which is sometimes considerable.

For the completion of the roof, a barasti grid is laid over the rafters (Fig. 352) on top of which a palm leaf mat is sometimes placed, (and more rarely, a layer of roofing felt or plastic sheeting on top of the matting). Finally, the roof is covered by a da'am made up of a number of stems tied together, and all pointing downwards to encourage the run off of rain water. Local builders say that except in a rare heavy rainstorm water will not penetrate through this outer layer. The shape of the leaves and their being tightly packed together provide an efficient runoff. All elements of the roof are secured with string. The roof is always the last part to be built (Fig. 353).

The other basic room type has a flat roof (Agreesh) (Fig 354). As before the four corner posts are set in the ground. Two beams are tied to each pair of posts and timber rafters are placed over these, spanning the area to be covered and securing the whole structure. Barasti Da'ams are secured to the four walls as before, and another da'am laid onto the roof. Depending upon how much care is being taken and the use to which the room is to be put, a grid is sometimes laid over the rafters similarly to the method used in the pitched roof, a layer of palm leaf matting, an impervious layer of roofing felt or plastic sheeting and the da'am on top. More than one layer of Barasti is often used.

For less permanent shelters two da'ams are sometimes leaned against a ridge pole, but this type of space is rarely used for human occupation.

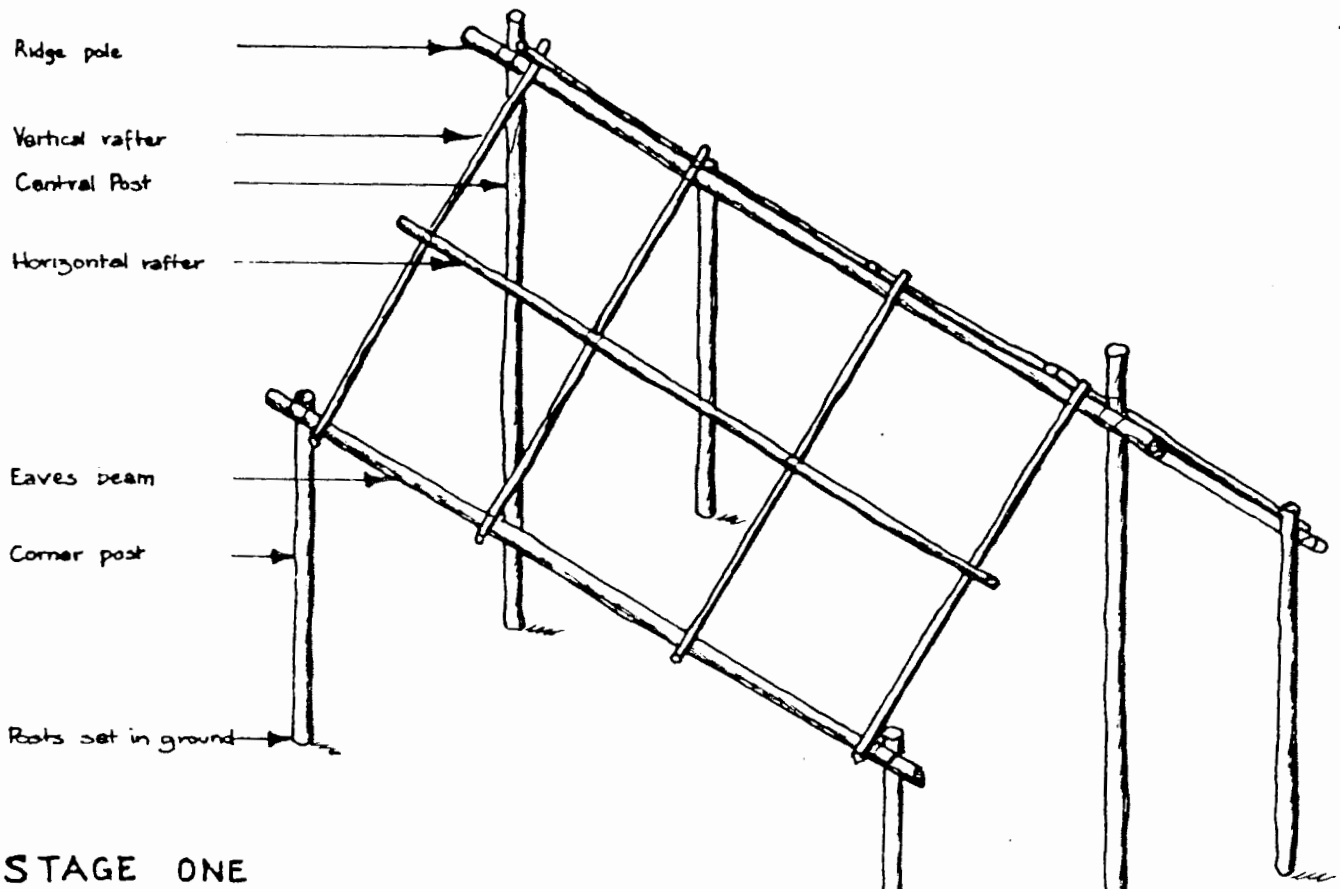


Exterior view of pitched roof rooms [Kargeen]



Interior of basic pitched roof room

Fig. 350 Pitched roof room



STAGE ONE
Fig 351

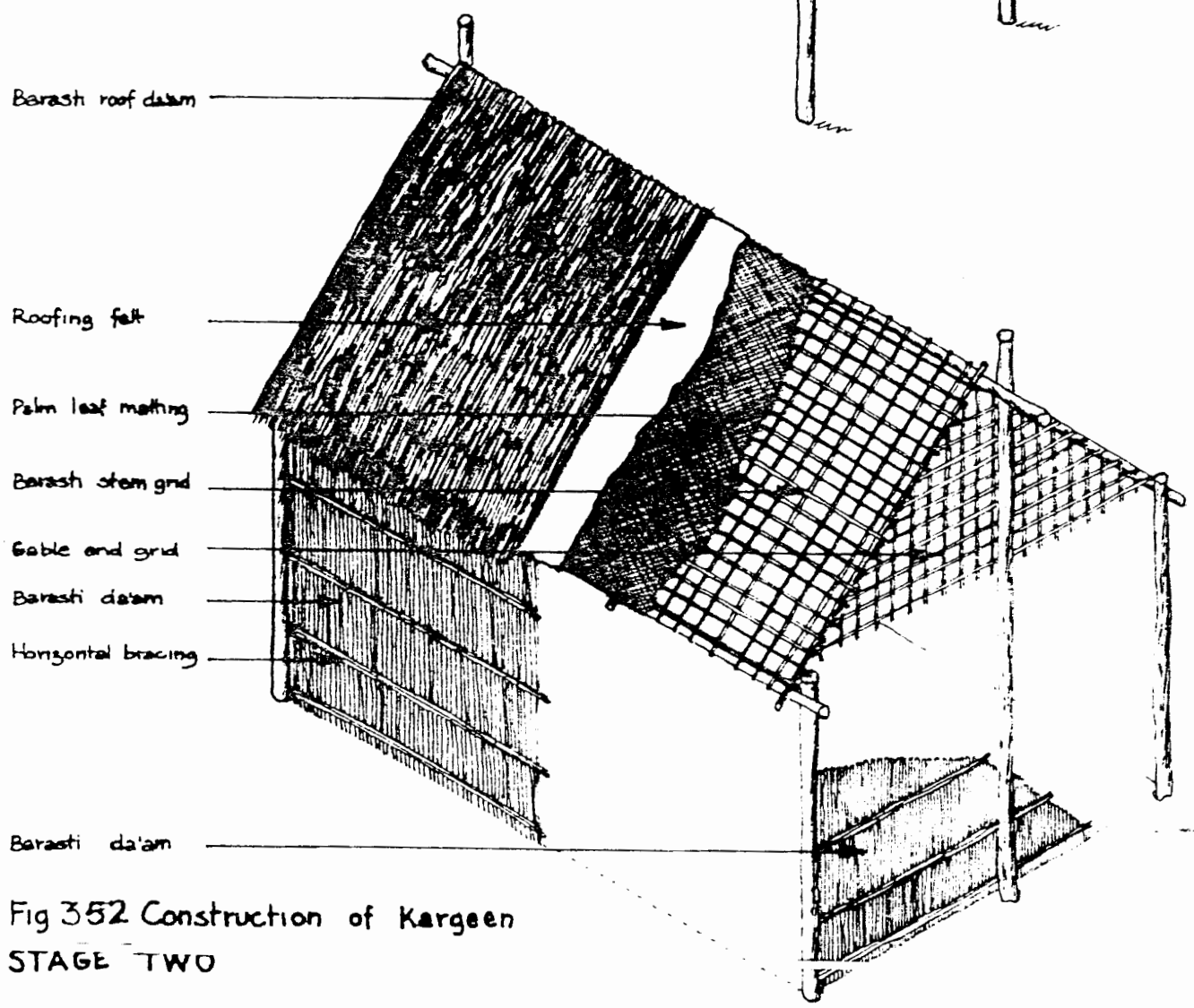


Fig 352 Construction of Kargeen
STAGE TWO

Roof framework with completed
gable ends and walls

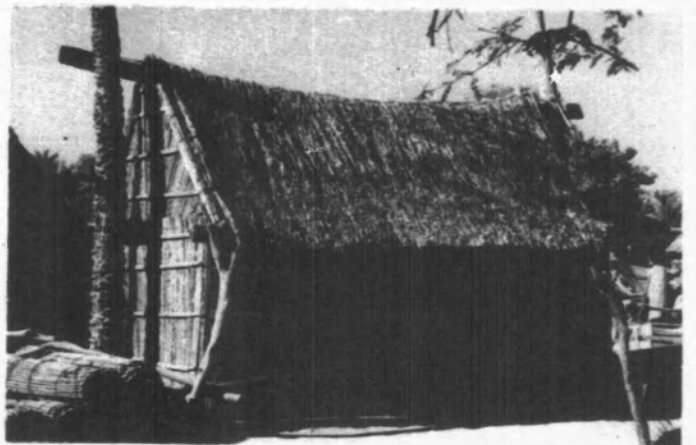


Detail of joint between central
post and ridge pole showing gable end



Completed roof

Fig 353. Roof construction.



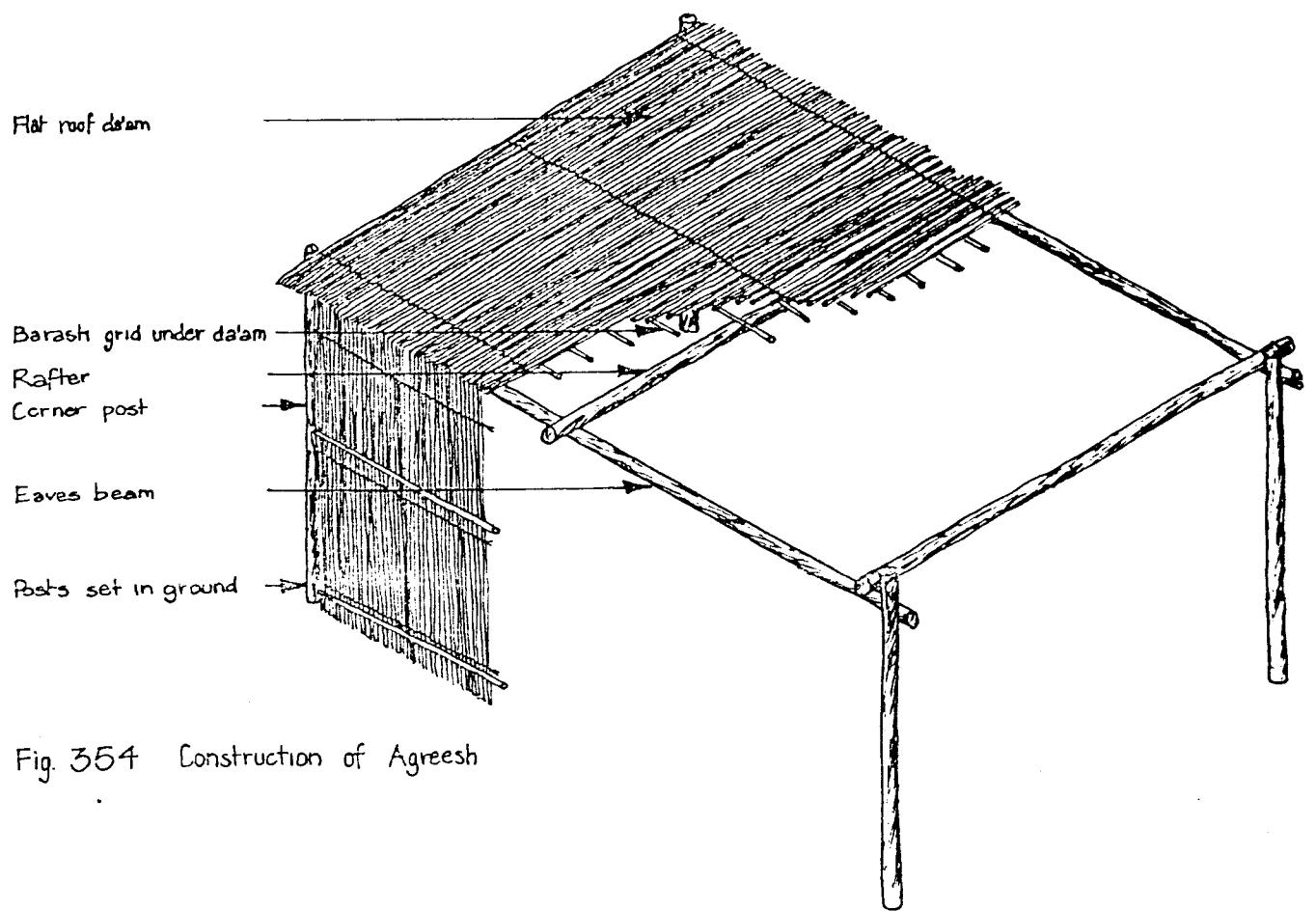


Fig. 354 Construction of Agreesh

Floors.

In many cases the bare earth is left in covered to provide the floor of a room or simply has a mat placed on it to reduce the amount of sand that gets disturbed. In particular for winter rooms and in areas used for seating, a raised floor is used, first of all laying beams on the ground, over which a da'am is placed, forming a low raised platform (Mastaba). Mats can be placed over the da'am for increased comfort. This can be for either part or all of the room.

iv: Types of Panels and Use

Different types of panels are used, all of which are held together with string. The full variety of panel types depends upon the builder, but some of the more common variations are given here.

a. A simple screen, often used as a perimeter wall to the property, uses stems with their leaves on, but all standing the same way up. The bottom part of the screen has no leaves on it, which can allow the passage of air through it, but has leaves at the top which give privacy. These screens and fences can have a rather untidy appearance because of the leaves hanging down. Where this type of screen is used as a wall, horizontal bracing members are added, which will help to keep the leaves in place and tidy up the appearance. When used in this way, privacy and free air movement through the bottom half are the characteristics of this type of panel. (Fig. 3.55).

b. Panels are often constructed of stems with their leaves removed. The spacing in between each stem varies, depending upon what it is being used for. These again are light screens used as walls which let air movement through, and not only provide privacy but allow the occupant to look out undetected. Persons looking in from outside will see nothing, as the dark interior will be in contrast to the bright exterior. Some of these panels have window-like openings in the lower half, which allow an increased view outside and also let in an increased amount of air. (see section 3.3.2.c.) These panels always have horizontal bracing except when used as simple screens and fences, where they can be rolled up and removed when not in use. (Fig. 3.56).

c. Many panels for walls are formed of barasti stems tied top to tail, so that there is an equal distribution of leaves and thickness of stems, giving a regular screen. Da'ams are usually bought in this form. When in position, bracing is used to give strength and keep the leaves in place, since the tighter the leaves are packed, the greater the amount of insulation achieved. Some panels are formed with every other stem stripped of its leaves to reduce the bulk. This type of panel is one of the basic ways of insulating the room, and can restrict some of the air movement if the leaves are packed tightly. Its main characteristic is to provide shelter from the sun, and wind in the winter.

d. The most used panel for winter rooms is similar to the previous pattern, but has a double thickness, usually in the form of two da'ams tied to each other so that the leaves from each one are pressed together in the centre. Some of these panels also used stripped stems to reduce the bulk, since if every stem has leaves on it, it becomes difficult to tie two stems close together, the leaves taking up quite a lot of space. The plain stem in between each leafy stem enables each stem to be in contact with the adjacent stem, with all the leaves inside. The thickness of the panel considerably reduces the amount of air movement that can pass through, and at present this panel is the best insulator in use where barasti is the only material used. (Fig. 3.57).

e. Roof panels can be of one or two layers of barasti, but always have their leaves pointing down the slope of the roof. In the case of a double layer, the top layer is basically a protection to the under layer, which keeps any water out. The outer layer shades the inner layer, keeping out

Fig 355
Plain screen with leaves on



Fig 356
Stems with no leaves on

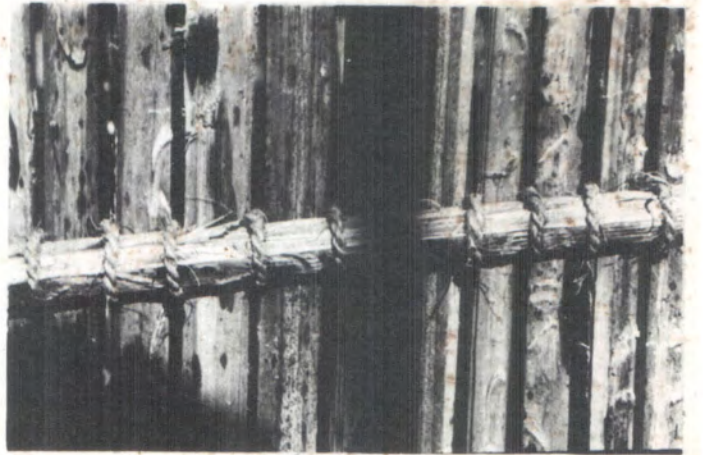


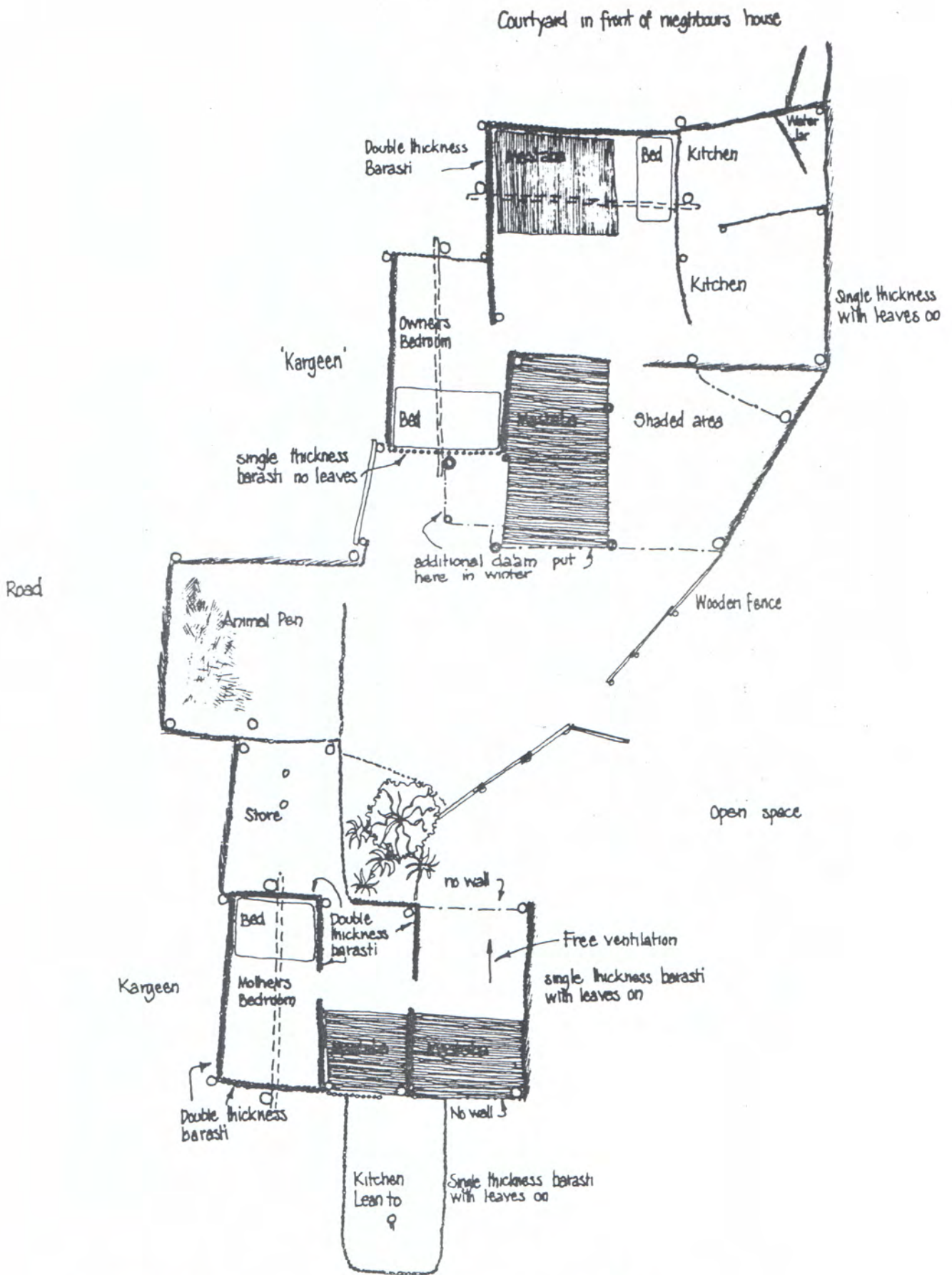
Fig 357
Double skin with leaves on



Fig 358
Roof panel



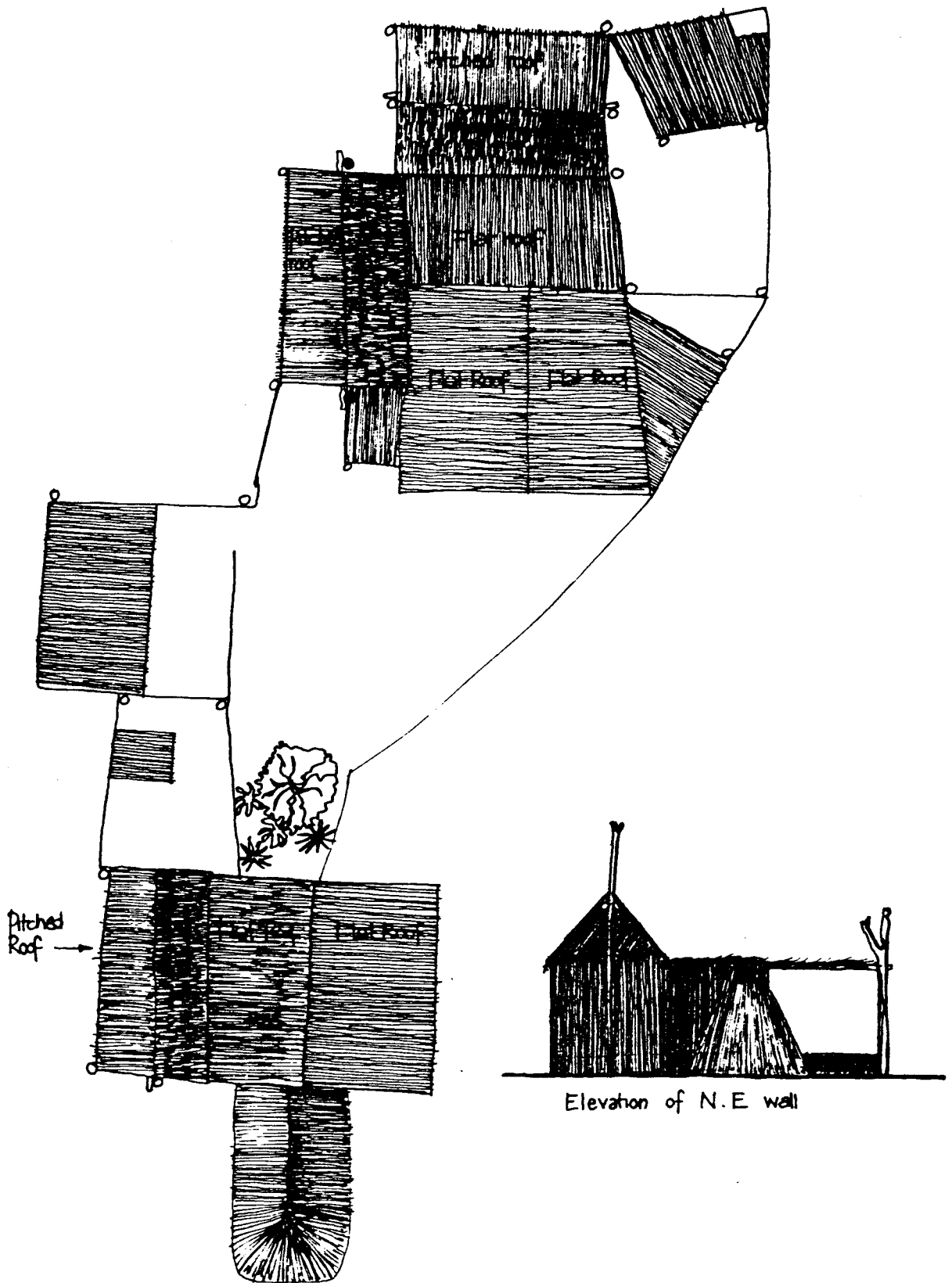
the dessicating effect of direct sunlight, which by drying out the materials almost daily, will cause the surface of the stems to become brittle and crack. This layer therefore helps in prolonging the life of the inner layer, which is the main roof panel, sometimes used on its own, and formed by using several short lengths of barasti stem tied one below each other in layers, so that there are always plenty of leaves. (Fig.3.58). Figs 3. 59 and 3.60 show the complete plan of a typical barasti house with the different panels.



Floor Plan



Fig 3.59 Barasti house - Salem Ben Abdullah - Om el Boche Wilaya of Sohar



Roof Plan



V. Response to Climate

The affect on the interior micro-climate of heat transfer through building materials used on the Batinah Coast.

The principal indigenous building materials used on the Batinah Coast are barasti and mud brick, while more recently concrete block has been introduced and is now quite common. Although the two indigenous materials generally serve very different functions in house building it has often been asserted that concrete block can replace them both. This assertion is evaluated here in terms of thermal properties, but the other climatic factors should not be ignored, and are covered later in this section.

Figs 361-3 show the results of a comparative study carried out on all three materials to demonstrate their individual responses to the thermal environment. The concept of 'heat transfer' has been explained in section 2 (General Introduction) but it is worth paraphrasing in the direct context of this section. Solar radiation striking a surface, be it a wall or the roof of a building, will cause that surface to heat up, depending upon the amount of radiation absorbed by the surface, and the amount reflected (a dark coloured surface will absorb more heat than a light one and will therefore become warmer). At night the process is reversed and the surface will radiate heat to the cooler night sky. The diurnal temperature range of surfaces exposed to sunlight will be much greater than the diurnal temperature range of the air. Another factor influencing the surface temperature of walls and roofs is the air movement across their surfaces. The rougher the surface the greater the effect of the air movement. The cooling effect of the wind increases proportionately with greater velocity, and in this context, the rougher the surface is, so more benefit will come from the cooling affect. This is dealt with in detail later in this section.

The heat generated on the surface is transferred by conduction of heat energy from one molecule of the building material to the next, until at some time later a proportion of the heat will reach the interior wall or the ceiling surface. The time that it takes for the heat to pass through the wall, or 'time lag', and the percentage of the original heat that actually reaches the interior is dependant upon the thickness of the wall and the thermal properties of the particular building material, primarily its 'thermal conductivity'.

The heat that has reached the interior surface is then transferred into the room by convection and radiation, and directly effects the air temperature of the room.

It must be remembered that the effect that heat transfer through the walls and ceiling has on air temperature inside the room is only of importance when air changes within the room are minimal. If air is continually passing through a room the exterior air temperature will be conveyed directly to the interior. On the other hand, radiant heat transferred to a body from the walls and vice versa will not be effected by air movement, albeit that this is not a major heating and cooling factor in this case.

To make the comparison between the thermal responses of the three building materials mentioned above, a number of rooms were tested in various houses in the Sohar area during September 1973. Walls chosen for testing had an unobstructed exposure to the sun's radiation, according to each wall's

Fig 361

Mud brick
room
Falaj al Qabail
Sept. 30, 1973

— External wall surface
- - - Internal wall surface

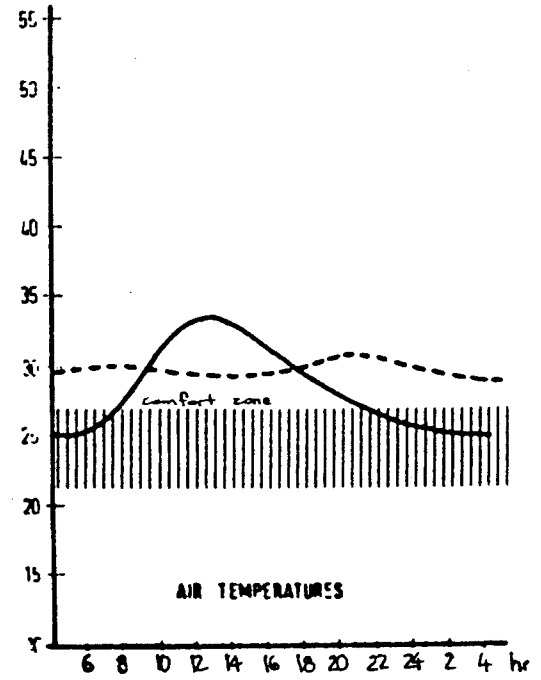
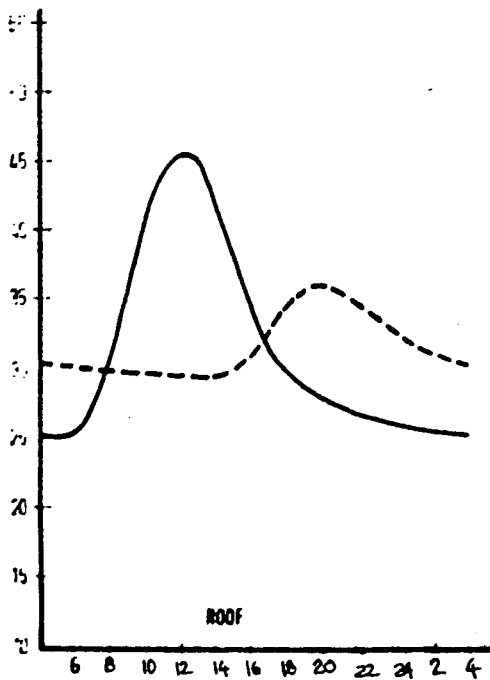
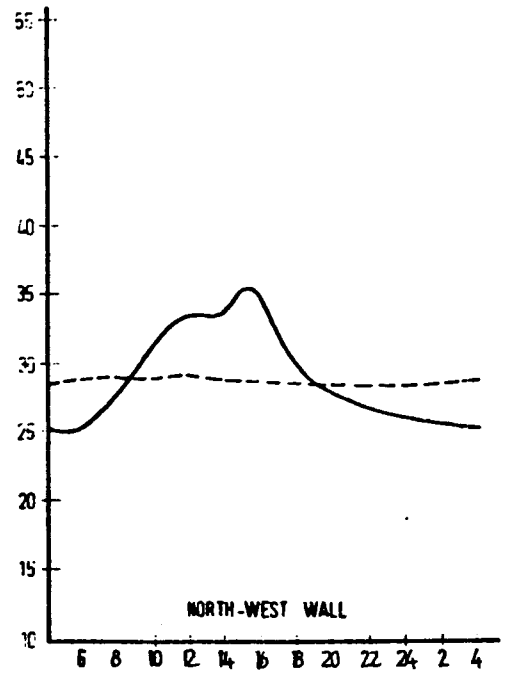
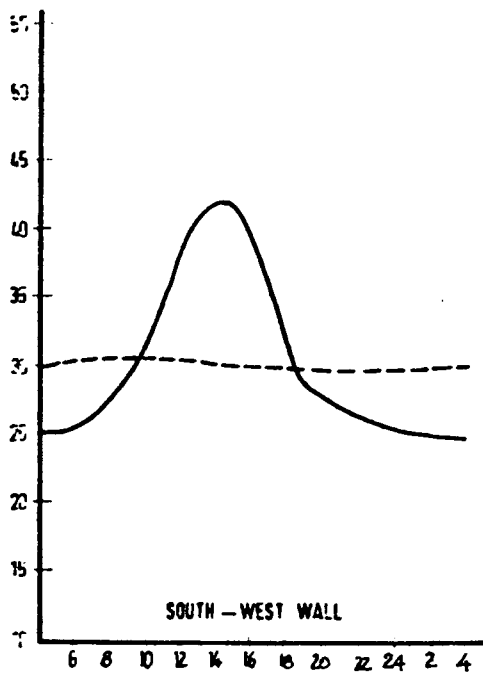
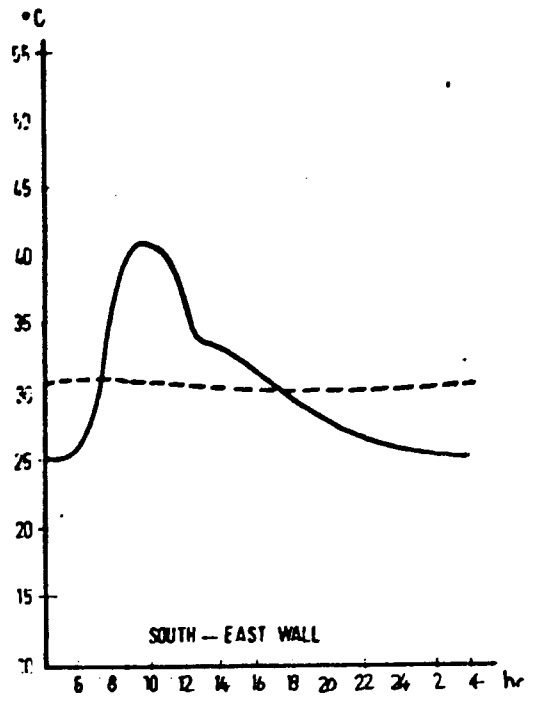
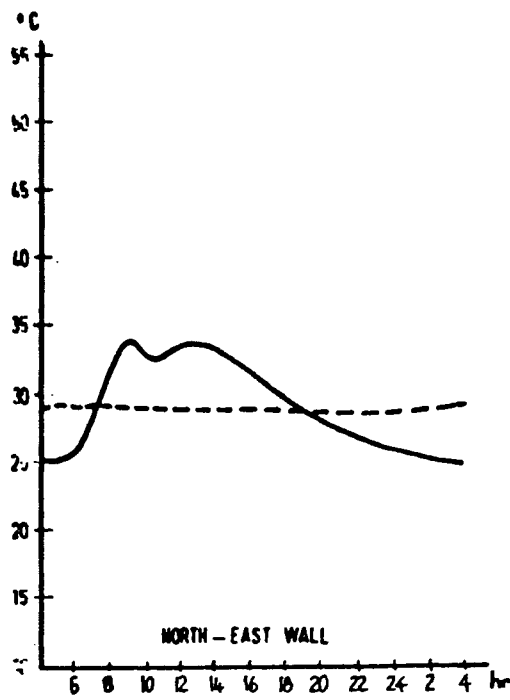


Fig 362
 Barasti room
 Om el Boche
 Sept. 28, 1973

— External wall surface
 - - - Internal wall surface

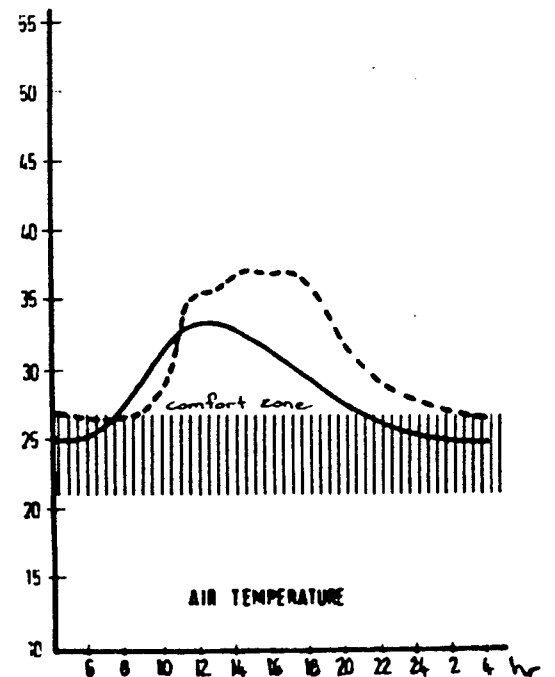
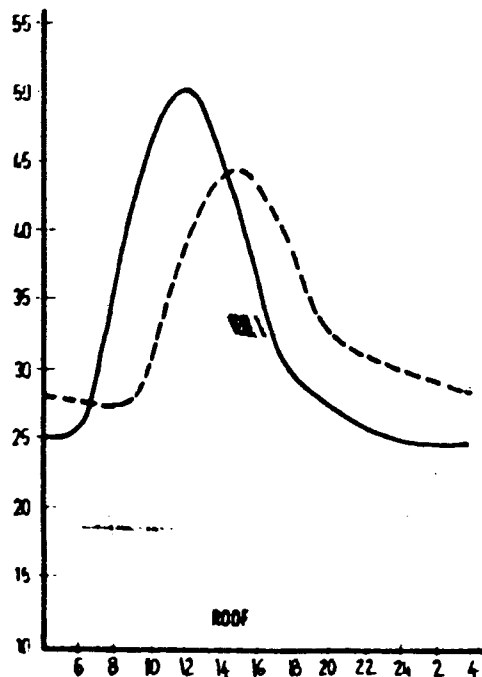
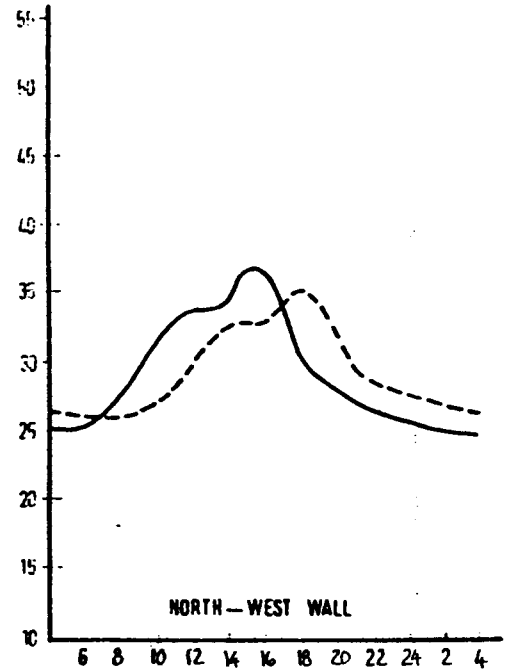
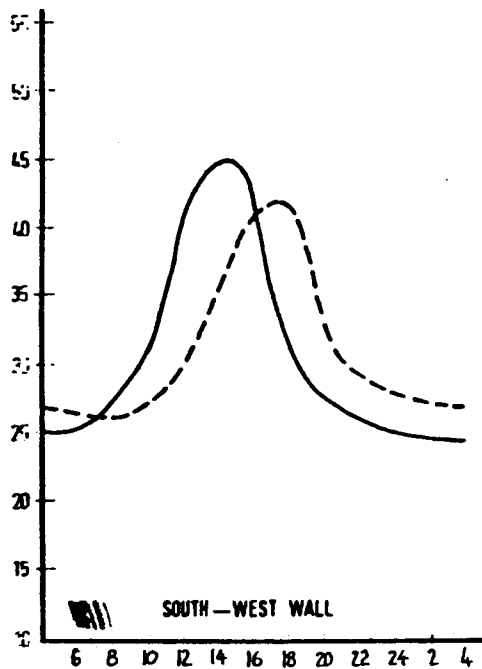
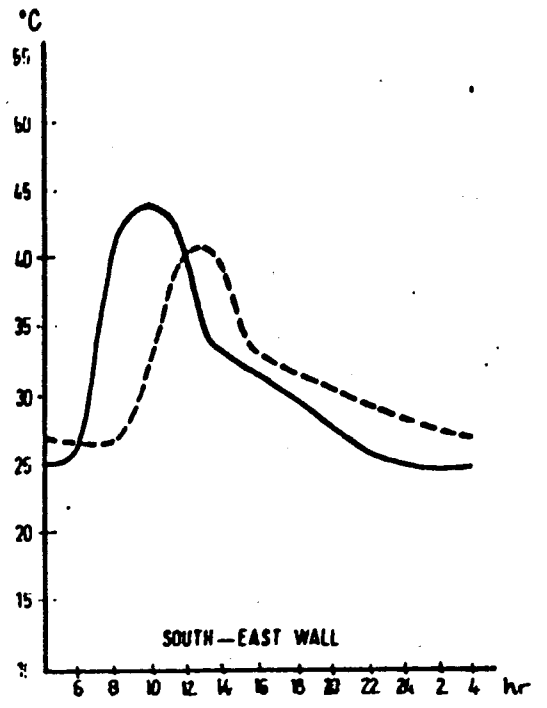
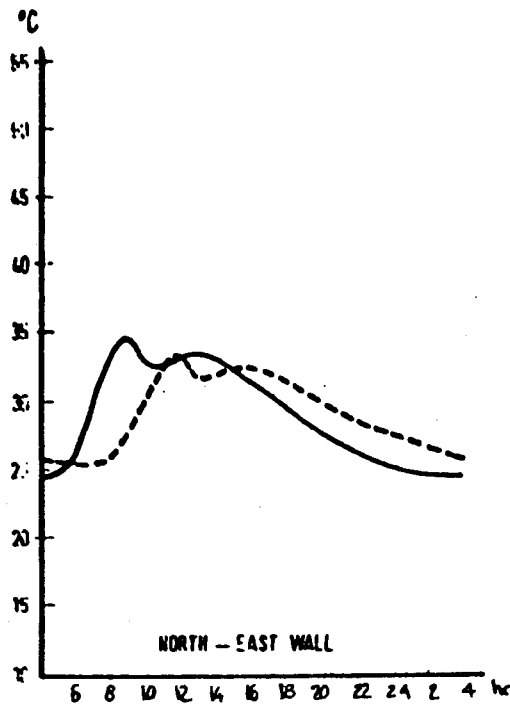


Fig 363

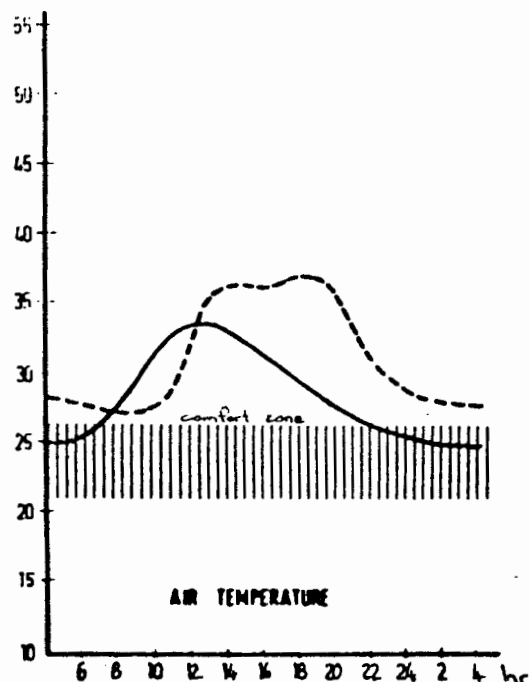
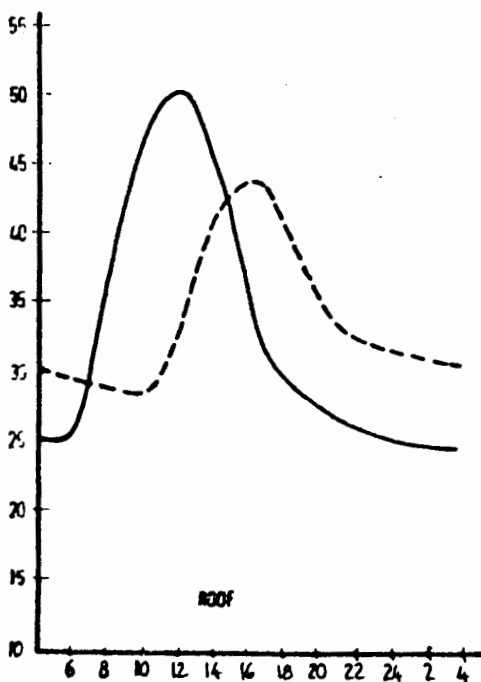
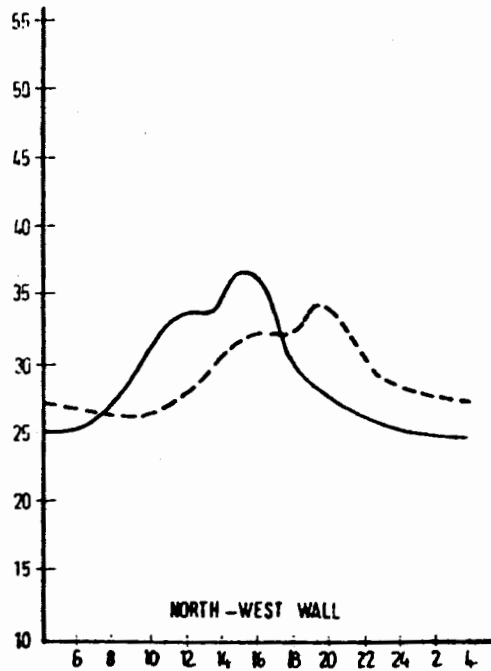
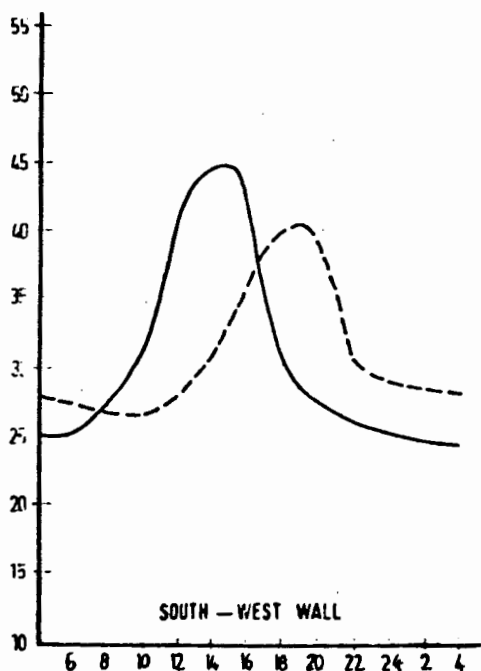
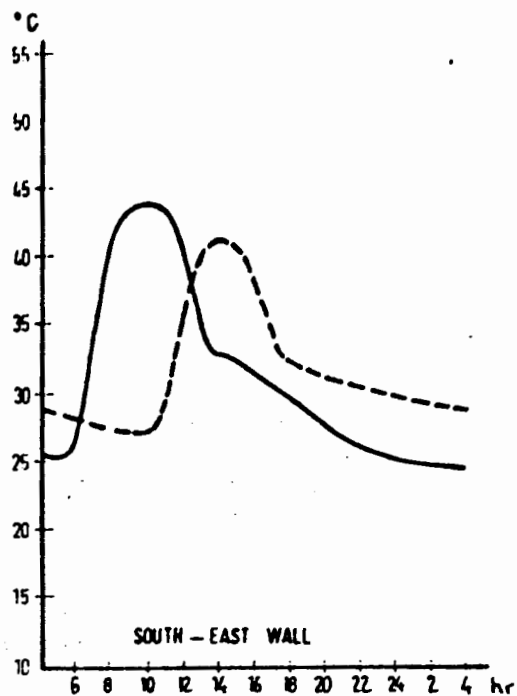
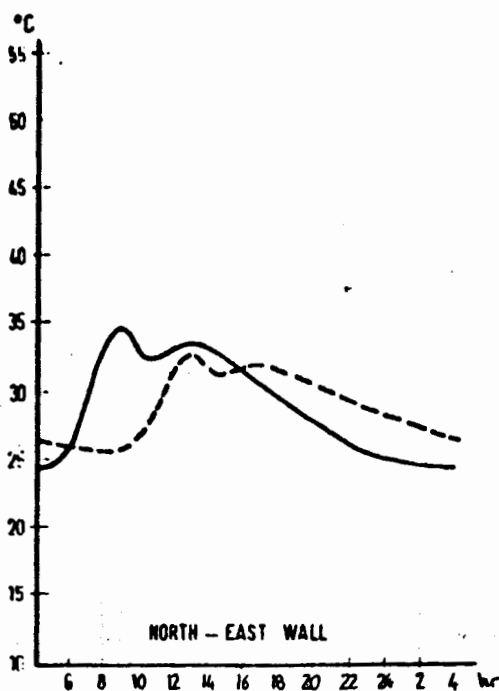
Concrete block room

Om el Boche

Sept. 29, 1973

— External wall surface

- - - Internal wall surface



particular orientation, and were sheltered from winds in order to isolate the solar radiation factor.

As most of the houses in the Sohar area are orientated in the same way, it was not hard to find rooms with walls having the same exposure. During the late September period of observation it was found that the mud brick exterior wall surfaces exposed to the sun heated up to a lesser extent than similarly exposed barasti or concrete walls. This is because the mud wall is a lighter colour than either of the other two. The 'time lag' and the proportion of heat transferred through each type of wall can be estimated by comparing the graph of the daily range of external wall surface temperature with that of internal wall surface temperature.

The mud brick wall, approximately 50cm thick, has a time lag of about 24-30 hours and only transmits to the internal wall surface about 5% of the peak temperature heat built up on the external wall surface (Fig 361). The internal wall surface temperatures are found to be relatively constant and represent the average of the diurnal temperature range for the external wall surface.

In the case of barasti, testing a double thickness sandwich panel about 5.5cm thick (See 3.3.3.iv.d), the time lag was found to be about 2½-3 hours and the proportion of heat transferred from the exterior wall surface to the interior surface was about 85% (Fig 362).

The concrete block wall, 15-18cm thick, had a time lag of about 4 hours (Fig 363), and the proportion of heat transferred from the exterior surface to the interior was about 70%.

When these findings are considered in relationship to the climate of the Batinah Coast during the Autumn, it can be seen that in all three cases the interior air temperature produced by the heat transfer through the individual materials lies above the thermal comfort level (except in the barasti example when for a few hours in the morning the temperature falls to the upper limit of the comfort zone).

For most of the day the air temperatures outside of the house are cooler than those inside and for this reason air movement is encouraged in the design of rooms for use in the hot season (Section 3.3.2). Air movement aids the evaporative cooling process on the skin's surface. In almost every case studied, houses of the kind experimented with above were uninhabited during the hottest season, being reserved for winter use. Maximum use is made during the summer of the good ventilating qualities of Barasti screens (Section 3.3.2 and panel types in this section).

Fig 364

Mud brick
room

Falaj al Qabail
December

— External wall surface
--- Internal wall surface

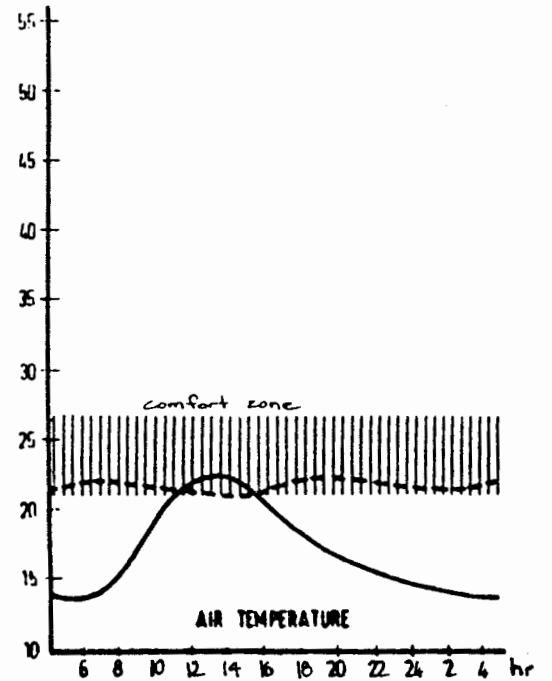
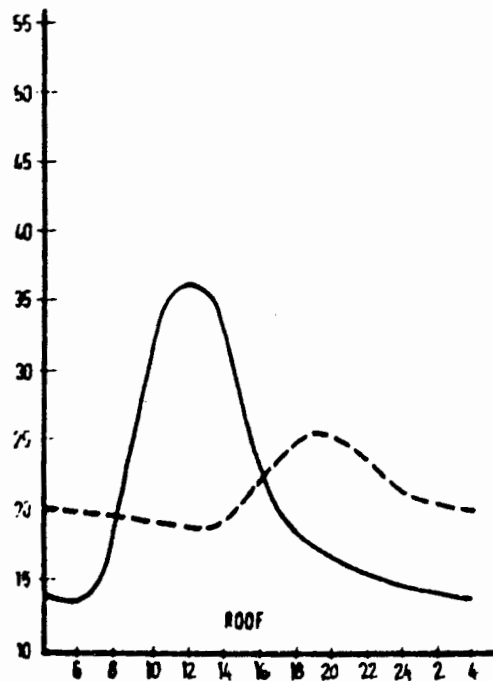
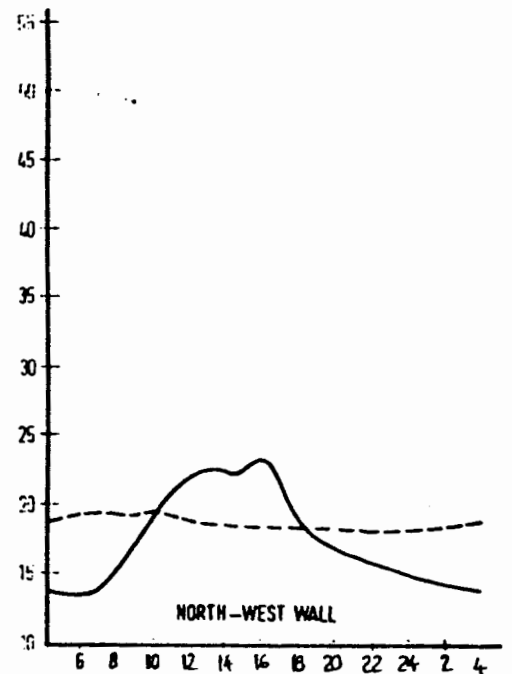
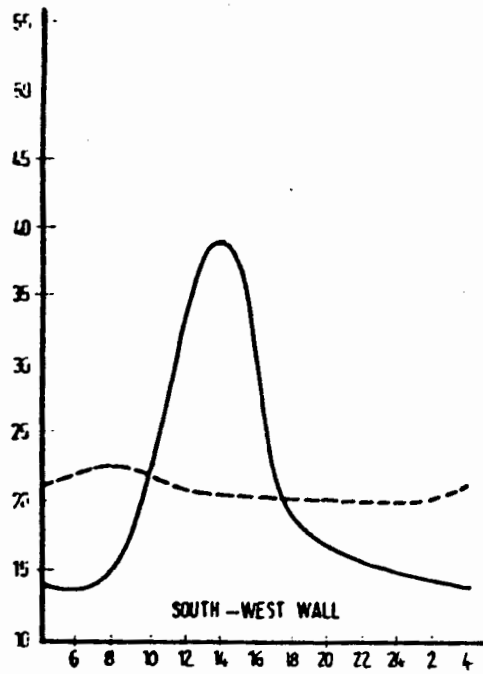
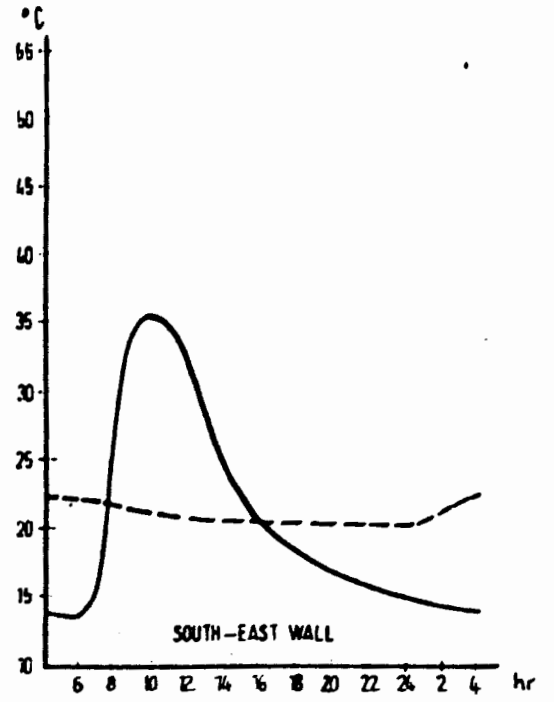
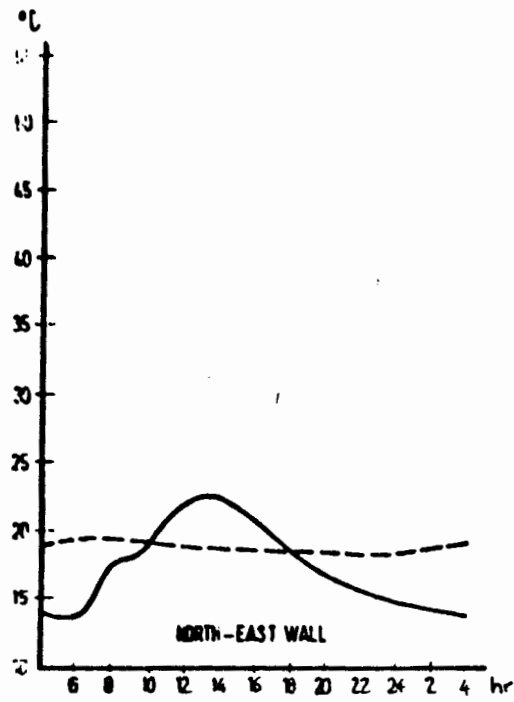


Fig 365

Barasti room

Om el Boche

December

— External wall surface
- - - Internal wall surface

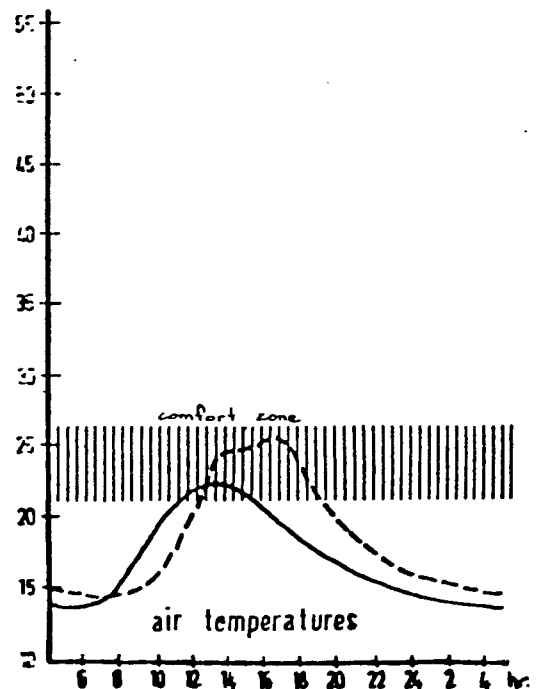
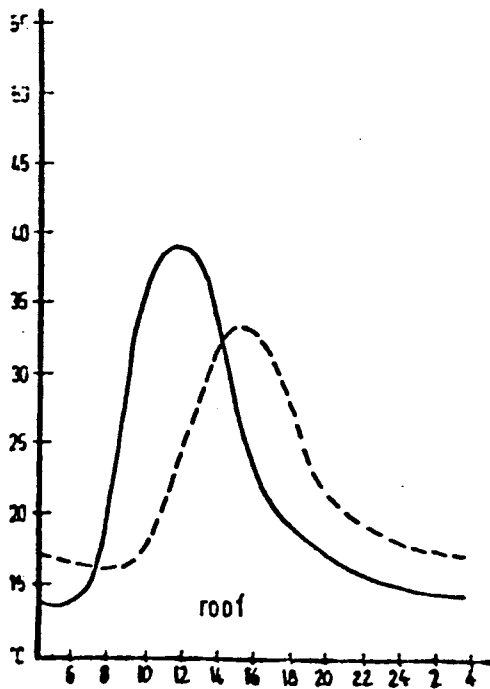
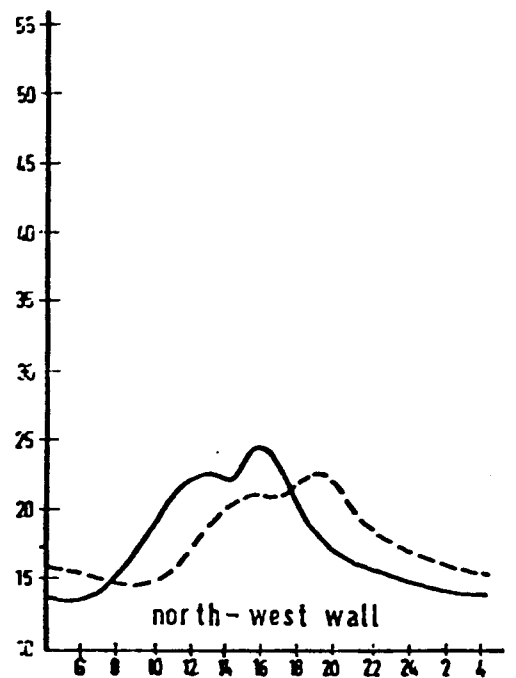
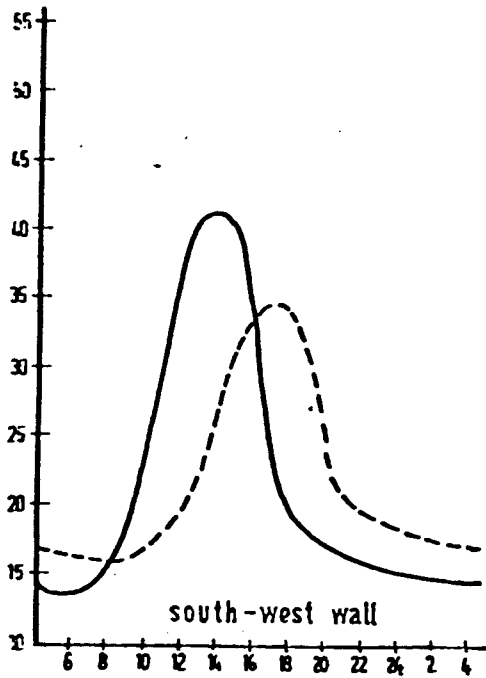
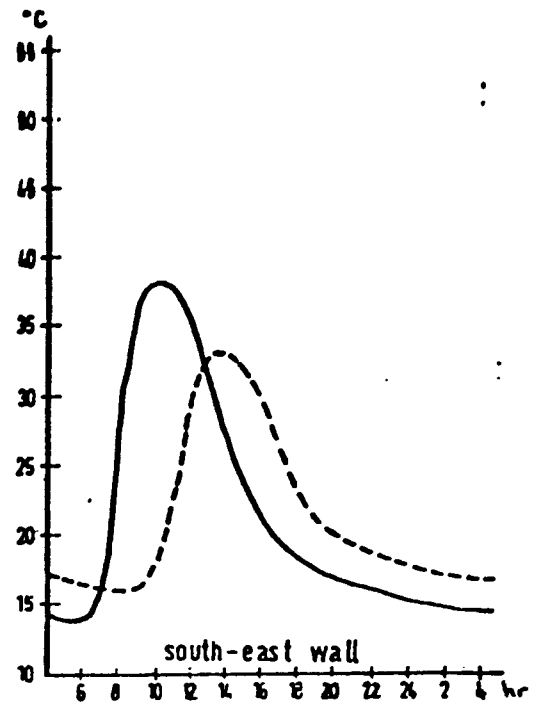
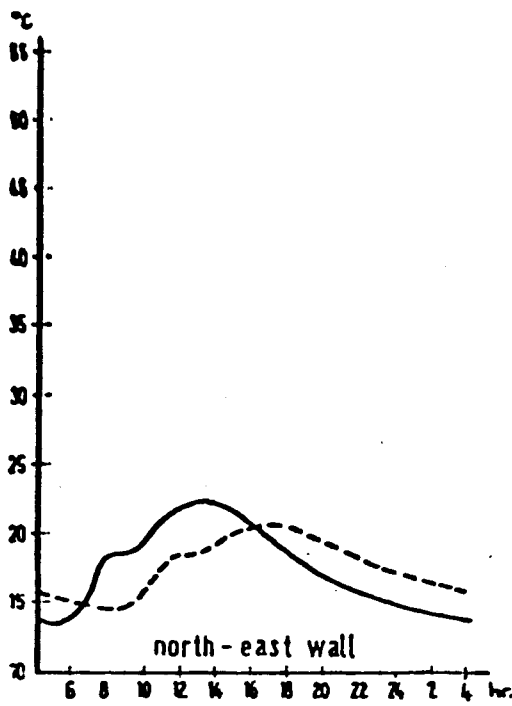
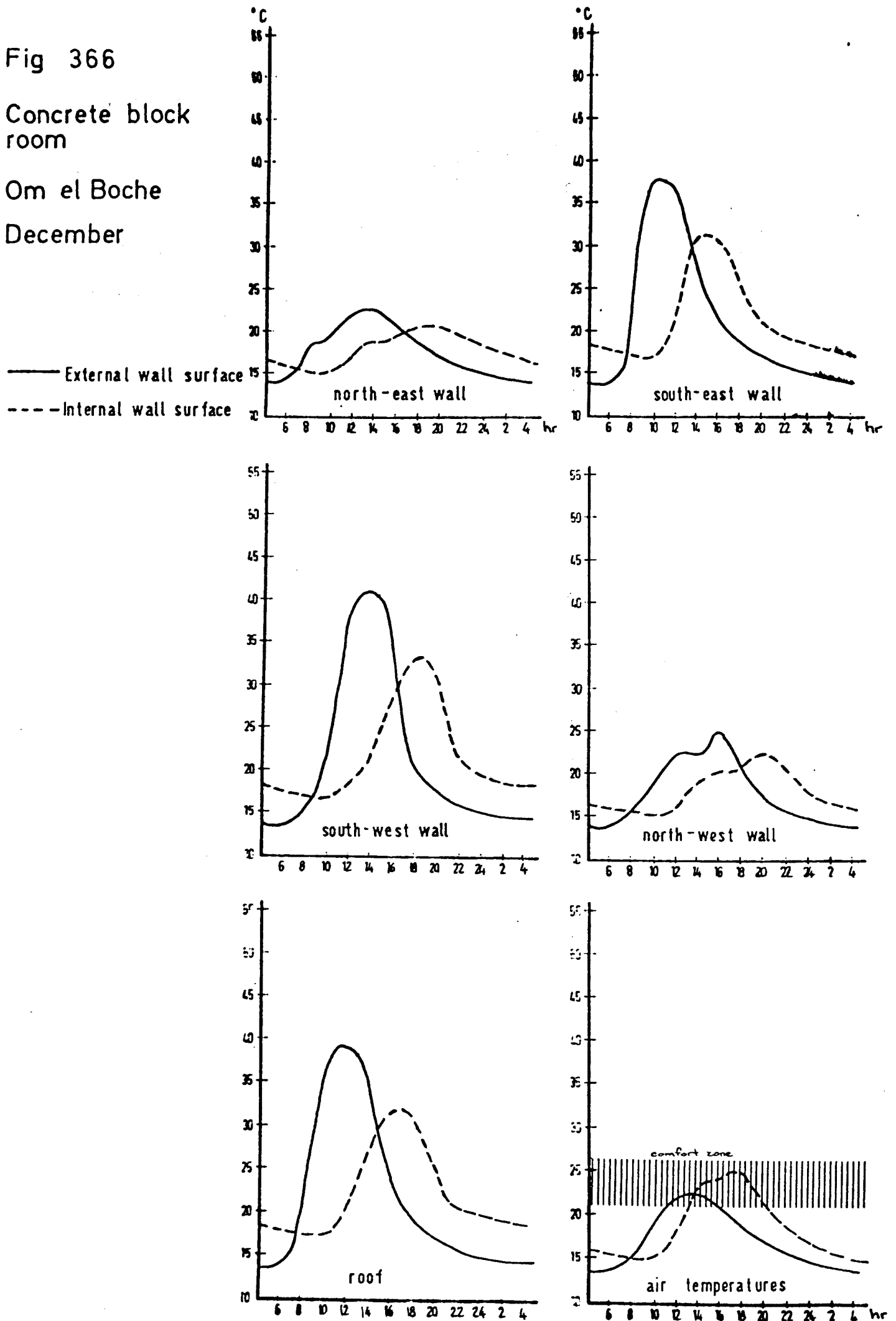


Fig 366

Concrete block room

Om el Boche

December



Using the findings obtained from the tests shown above, and information obtained from the climatic charts and graphs available for the Batinah Coast (Section 3.1.2), an extrapolation of conditions can be devised for the same rooms in the coolest winter month of December (Fig 364-6), which can be considered a critical month because for most of the day the outside air temperatures are below the comfort zone limits. During this season the interior air temperatures of the mud brick room are always within the comfort zone (Fig 364). The temperature inside the barasti room (Fig 365) and the concrete block room (Fig 366) are only within the comfort zone during the afternoon and early evening, and fall below at night-time and in the morning.

In conclusion it can be seen, when considering the effect of heat transfer through building materials on the thermal environment within houses on the Batinah Coast, that;

- a. During the summer, high solar radiation and air temperatures result in unfavourable interior conditions in houses built using any of the three types of walls mentioned, and that other climatic factors such as air movement must be incorporated in the house design to increase cooling. The effect of air movement can clearly be seen in Fig 304 (Micro-Climature Comparison).
- b. In the winter months when the air is cool and the diurnal range has increased, mud brick construction provides a superior thermal condition indoors than do either the barasti double thickness panel or concrete block construction.

Thermal conductivity of Palm frond stem (barasti) panels.

It was mentioned earlier that the proportion of heat transferred through a wall and its time lag are dependant basically upon two factors, firstly the thickness of the wall and secondly the thermal conductivity of the material used in the wall. Thermal conductivity is defined as the amount of heat passed through a unit volume of material to obtain a given temperature difference between the two sides, and is given in Watts/Meter °C. The lower the conductivity the greater its insulative value.

The 'thermal conductivity' of a building material is essential to a designer or engineer in order to calculate how a building will respond to the environment in which it is built. It is a useful design tool in determining wall thicknesses and in choosing materials.

Thermal conductivities for industrialized building materials and materials commonly used in developed countries are widely known and can be found in tables of standards. The thermal conductivity for average concrete is 1.140 W/M°C, limestone is 1.530 W/M°C and red brick is about 1.0 W/M°C. Figures for materials indigenous to developing areas are not always readily available since little research has been done into these materials.

Recent research on mud brick in Egypt has been done by different organizations i.e. Cairo University - Dr. Said Yusef and by the Third World Research Group. Mud brick's thermal conductivity is about 0.5 W/M°C. In a comparison of the thermal conductivities of the above heavy wall construction materials it can be seen that mud brick is the best heat insulator.

The structural and thermal properties of barasti had not been tested until the tests described here were carried out. A number of barasti wall panels, typical of the kind built on the Batinah Coast were assembled under supervision, by a local barasti builder in Seeb. As explained previously in Section 3.2.3. iv barasti panels are constructed in various ways to serve different climatic functions. The single thickness panel (3.3 cm thick) was made up of barasti stems containing leaves and tied in such a way that all the leaves appeared on one side of the panel. The second panel type was double thickness (5.5 cm thick) and was made up of two single thickness panels bound together with the leafy sides facing inwards. A number of these panels were shipped to London where laboratory facilities were available to test their thermal properties (Fig 367). The thermal conductivity of barasti panels was found to be 0.065 W/M°C. (Technical data sheet is available in appendix 1). Barasti's thermal conductivity is the same as 'wood fibre soft board' and can be compared to polystyrene foam insulation which is 0.033 W/M°C. Barasti walls therefore have a quite high insulative value.

It has been observed in the Batinah area that with the approach of cool winter weather, barasti house-holders will put up extra panels to certain walls of their house. (See Human Response to Climatic changes. Figs 313-4). These often convert rooms, which in the summer use open spaced barasti walls allowing air movement, into insulated winter rooms. If several panels of barasti with leaves on, were applied to an exposed wall a high level of insulation would be attained. (See Fig 368).

Fig 367
 Apparatus used to
 evaluate the thermal
 conductivity of
 barasti panels

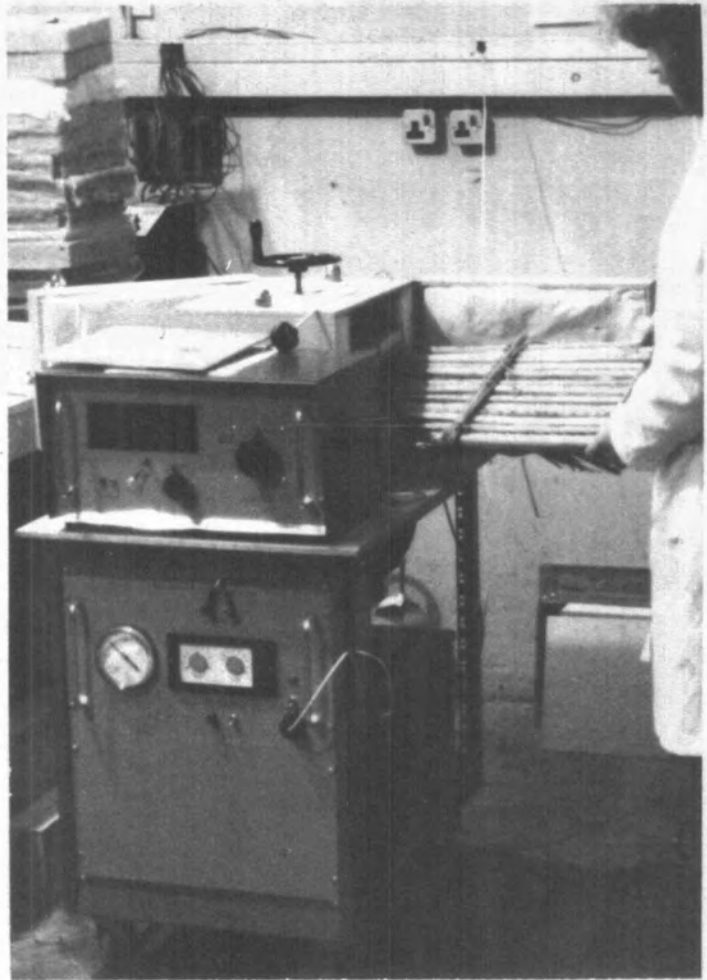


Fig 368
 Graph demonstrating
 the difference in
 daily temperature
 range of internal
 wall surfaces due
 to different barasti
 wall thicknesses.

- External surface
- INTERNAL SURFACE
- · - · - Single panel 3.3cm
- - - - - Double panel 5.5cm
- · - · - Four panels 10.0cm
- · · · · Six panels 14.5cm
- · - · - Eight panels 19.0cm

