DEVELOPMENT WORKSHOP
ON INDIGENOUS BUILDING METHODS IN THE THIRD WORLD
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ENERGY AND SHELTER

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Background paper for a proposed
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Contents

Energy and Shelter

Energy consumed by housing can be broken down into basic components: production of materials or elements, transportation from production site to construction site, the construction procedure itself and the energy used throughout the shelter's lifetime in order to maintain a standard level of service and comfort.

Housing Materials

There is an increasing use of commercial, high performance, high energy materials in housing in both the Industrialised and the Third World. In industrialised countries, housing consumes 65% of these modern materials produced for the construction industry. If we assume that a similar proportion of modern materials is used for housing within the commercial modern sector of developing countries, then housing represents a huge demand on scarce often imported commodities. In many cases these high performance materials could be diverted more profitably into infrastructural and primary construction. For example, imported steel and concrete are employed extensively for low rise or even single storey construction when local kiln brick or even stabilised earth blocks can easily meet specifications for three storey building.

Fig.1

	Energy Inputs	*Additional Environmental Impacts*
Cement	1800 kWh/ton	Localised air pollution.
Concrete	~500 kWh/ton	Demand for aggregate—beach damage etc.
Concrete block & pipe	~400 kWh/ton	—
Asbestos cement	2200 kWh/tons	Asbestosis of processing workers. Local asbestos water pollution.
Bricks (All types)	0.2 kWh/brick	150 acres/year dereliction of brick earth zones§
Plastics	2400 kWh/ton	Localised water & air pollution.
Slate	500 kWh/ton	Large transport component.
Plaster & Gypsum	300 kWh/ton	Localised pollution; waste disposal dereliction.
Steel & Iron	3.5 kWh/lb‡	Water & air pollution. Raised outflow of iron compds to sea.
Copper & Brass	5 kWh/lb	Local air & water pollution. Mine dereliction. Raised run-off.
Aluminium	8 kWh/lb‡	Fluorosis pollution.
Glass	6 kWh/sq ft	Localised air pollution.
Timber	70 kWh/cu.m	Much imported. Linked to overrapid forest clearance etc.

The energy cost in the production of commercial materials is high (see chart. Fig.1). If these commercial materials can not be manufactured in the immediate vicinity of the building site transportation becomes a major factor. In the case of bricks, the energy cost due to transportation of one hundred kilometres distance is equivalent to the initial energy input of production (see Fig.2). In the experience of the authors in rural Iran it was found that where bricks had to be transported between fifty and sixty kilometres from the kiln to the building site transportation costs were about 50% over the initial kiln purchase price.

Fig.2

Energy Input to Materials
for Standard Modern House
(3 bedroom unit 100 sq.m.)

Materials	*Energy Inputs*		*Site Preparation*
Bricks: 16,000	3200 kWh		Excavation/Handling: 2000 cu. ft = 6000 kWh
Steel: 1.2 tons	9200 kWh		Cement mixing and Miscellaneous machinery:
Glass : 320 ft²	2000 kWh		100 gals fuel = 4200 kWh
Concrete : 10 tons	5000 kWh		10,200 kWh
Cement: 2 tons	3600 kWh		
Plaster: 3 tons	900 kWh		
Timber: 4.3 cu. m.	310 kWh		
Plastics: 250 lbs	300 kWh		
Paint: 4700 sq. ft.	500 kWh		
Copper & Brass: 500 lbs	2500 kWh		
Others: —	4000 kWh		
	31,510 kWh		
Materials Transport			
Bricks 60 miles at 1.5 kWh/ton mile:		3200 kWh	
Timber 250 miles at 1kWh/ton mile:		1100 kWh	
Cement 40 miles at 1.5 kWh/ton mile:		400 kWh	
		4700 kWh	Total inputs 31,500 + 10,200 + 4700 = 53,700 kWh

Rural areas are at a particular disadvantage when employing modern commercial materials. Because these materials are normally mass produced their manufacture is centralised, often in urban areas. This means that a rural builder has to pay high transportation charges for commercial materials. Third World countries find themselves in this position with respect to industrialised countries who maintain a monopoly over many materials and building components. The purchasing of commercial materials from outside means that much needed capital is lost to the rural areas.

The choice of particular materials, technologies, and built forms is most often based on the image of "modernity" rather than any consideration for performance or functionality.

Indigenous building materials and technologies have, in each region, a long history of adaptation to social patterns, local economic needs and environmental conditions. They in many cases meet these local needs much better than recently introduced commercial methods. They have, as well, shown themselves to be much more energy efficient than industrialised materials and technologies (see Fig.3).

Fig.3 Energy Input to Materials for Improved-Traditional House and Traditional Unit (each: 3 bedroom units 100 sq.m.)

Alternative 1: 10% soil-cement blocks		Alternative 2: Rammed earth	
8 cu. yds. cement and handling:	12,500 kWh	80 cu. yds earth, 70 men days:	100 kWh
Soil: 50 tons (hand labour):	50 kWh	160 cu. yds. earth invert:	150 kWh
Localised wood supply:	150 kWh	Glass:	1500 kWh
Glass:	2000 kWh	Timber:	150 kWh
In situ rendering materials:	100 kWh	Rendering:	50 kWh
Metals:	1500 kWh	Metals	1000 kWh
Others	2500 kWh	Others:	2000 kWh
Total Inputs:	18,800 kWh	Total	4950 kWh

With today's changing needs and standards there may be a need to upgrade some traditional methods. By applying a scientific methodology to the research and development of indigenous technologies, shelter needs can be met in each region with solutions which are much superior to those which are imported.

Some manufactured materials, such as bricks, require only an intermediate level of production technology. These materials can be made regionally to serve rural markets. Decentralised production units can not only cut down on transportation energy costs but help form the basis of rural building industries. They can absorb excess local labour, keeping the productive potential of both people and capital within the region.

When building processes themselves are developed from indigenous practices and technologies, local village builders can participate directly in new building projects. When rural buildings are designed for steel and concrete, they most often employ city based contractors who are in command of the newer technologies. This is another source of drain of capital out of the rural areas.

Environmental Design

Energy consumed by a building throughout its life is much greater than the energy of material production and that of its construction.

A great deal of energy is usually used in heating or cooling of a building in order to maintain a comfortable internal environment. In modern housing these energies are usually consumed in the form of combustible hydro-carbons.

Fig.4

Housing: Yearly Energy Requirements
(Temperate Climate)

1.	Space Heating and Cooling	60%
2.	Water Heating	20%
3.	Servicing: water supply, waste disposal	15%
4.	Lighting	5%

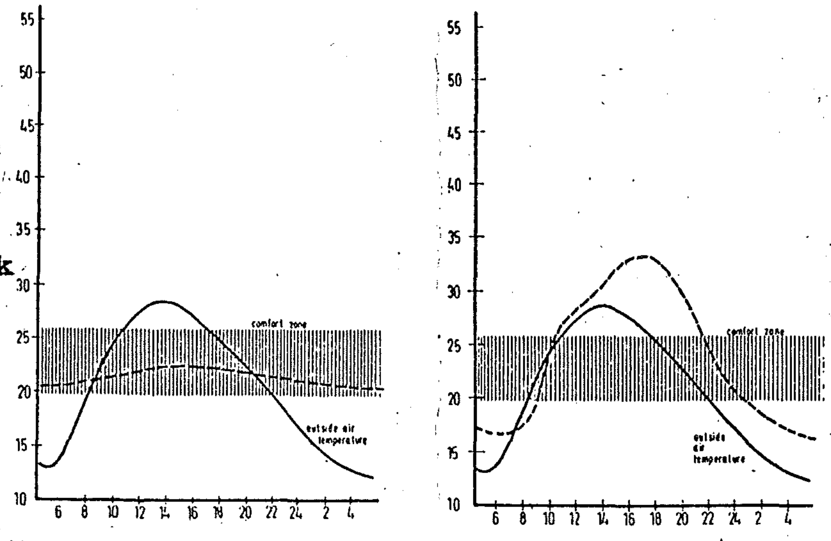
Recent construction in the Industrial nations is characterised by flimsy shell or prefabricated construction with light weight high energy materials and large expanses of glass. The same construction materials and systems are adopted by the modern sector in Third World Countries. Buildings of these types show poor thermal performance; their building materials are not able to protect internal living spaces from harsh external environments. Even in temperate regions 60% of the energy consumed by housing per year is in space heating and cooling (refer to chart. Fig.4).

Modern building systems are used internationally irregardless of environmental conditions. Buildings are adapted to various conditions by the addition of either a heating or a cooling system wherever appropriate.

Indigenous building systems, on the other hand, have themselves adapted to the environmental conditions particular to their location.

Fig.5

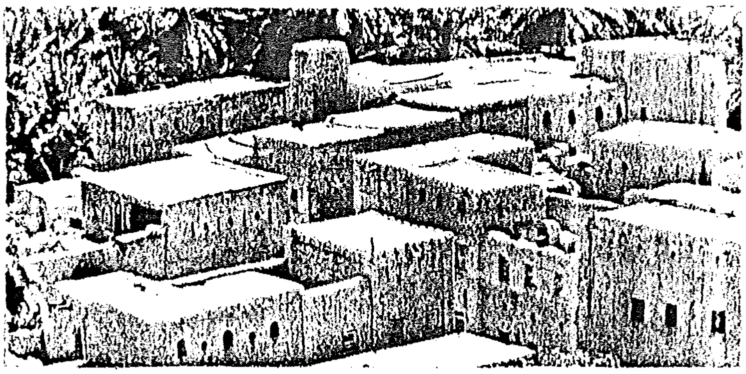
Comparative Thermal Performance of Indigenous Mud-Brick Building and Recently Introduced Reinforced Concrete Unit



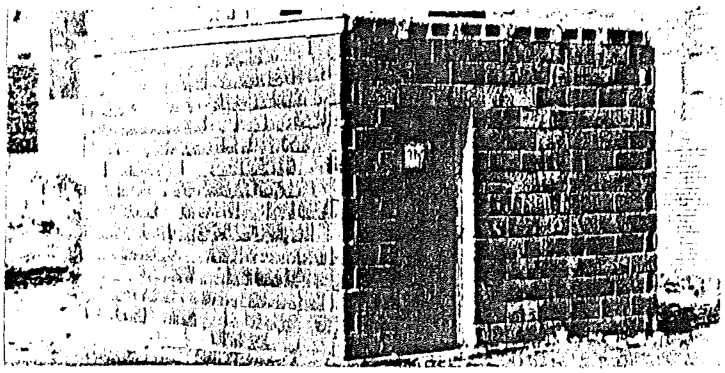
Mud brick room.
Interior air temperature – – –

Prufab concrete room.
Interior air temperature – – –

Experiments were carried out by the authors in Egypt in order to compare the traditional mud brick building system with new reinforced concrete housing types now being built. It was found that due to the thermal properties of thick mud walls, temperature inside a living space were kept within a comfortable range, day and night. Temperatures within a relatively thin walled, reinforced concrete housing unit not only exceeded comfort conditions but at times were above maximum outside temperatures, while nighttime temperatures were uncomfortably low.



Indigenous Mud-Brick Housing

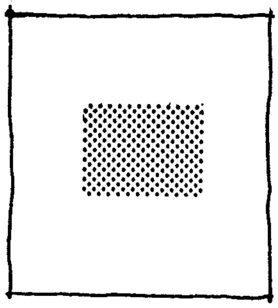


Concrete Model Unit

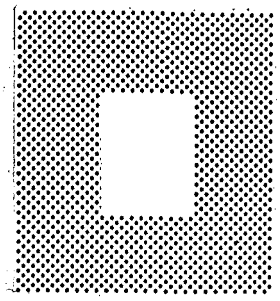
House Form

Fig.6

Western Model
Outward Facing
Centered on
Site

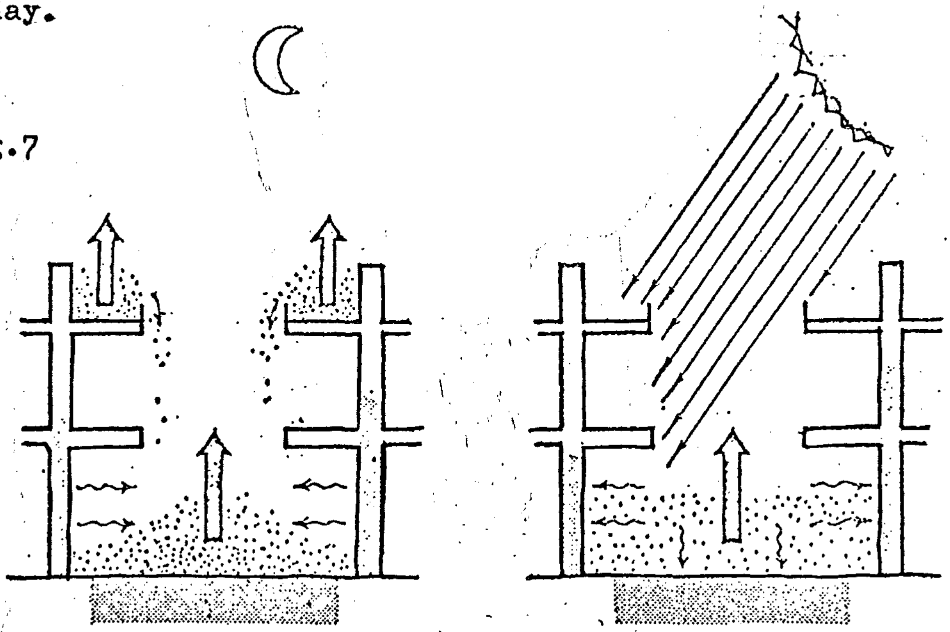


Indigenous
Courtyard Model
Inward Looking
Against Harsh
External
Environment



The house form of indigenous building is itself a reflection of environmental principles. The courtyard of the Middle Eastern or Mediterranean house has long been known for its cooling properties. The court acts as a well to trap cool nighttime air and retain it throughout most of the day.

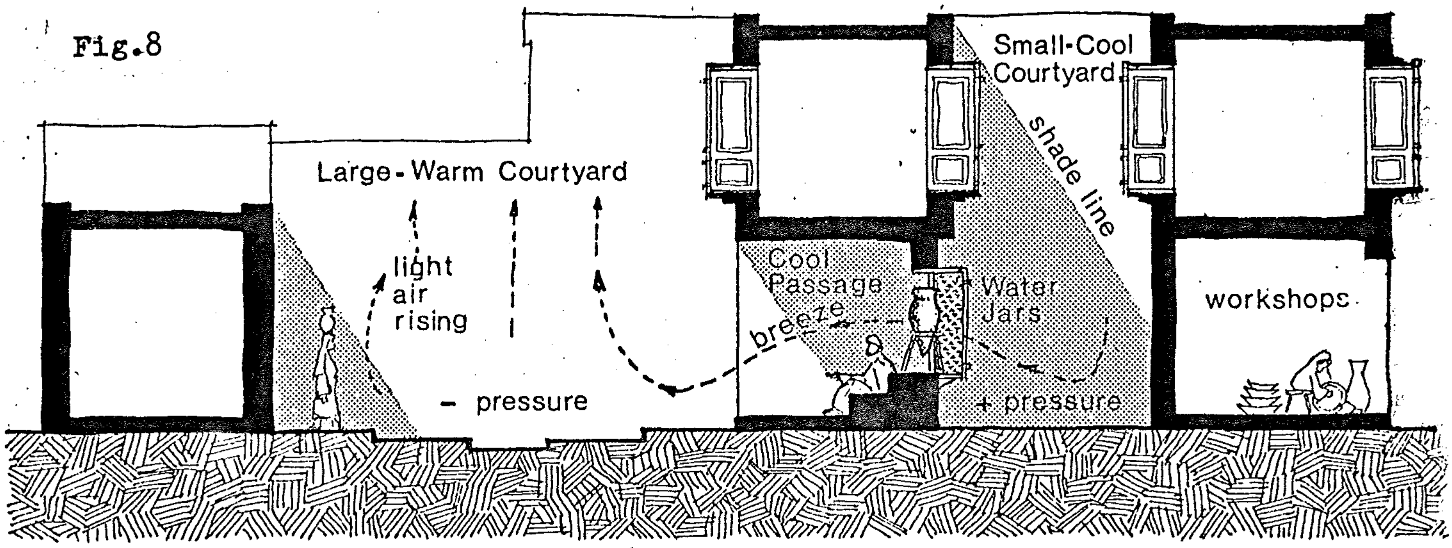
Fig.7



During the night cold air formed on the roof sinks into the courtyard. Radiation from the protected courtyard surface helps cool the house during the day.

An interesting adaptation of the typical case is the two courtyard house. One court is small and deep and therefore generally shaded and cool; the other is wide and open to the heating of the sun's radiation. Air in the small courtyard, being cool and dense, has a higher pressure than the warm air of the large courtyard, which tends to be lighter and therefore rises. If an opening or passageway connecting the two courtyards is well positioned, there will be air movement induced by convection from the cool courtyard through the passage to the warm courtyard. The air's velocity is controlled by the size and nature of the passageway, as well as the temperature and pressure differences between the two courtyards. In houses where this feature is employed, the inhabitants spend the hottest hours of the summer days in this cooled space between the courtyards.

Fig.8



TWO COURTYARD HOUSE – AIR MOVEMENT INDUCED

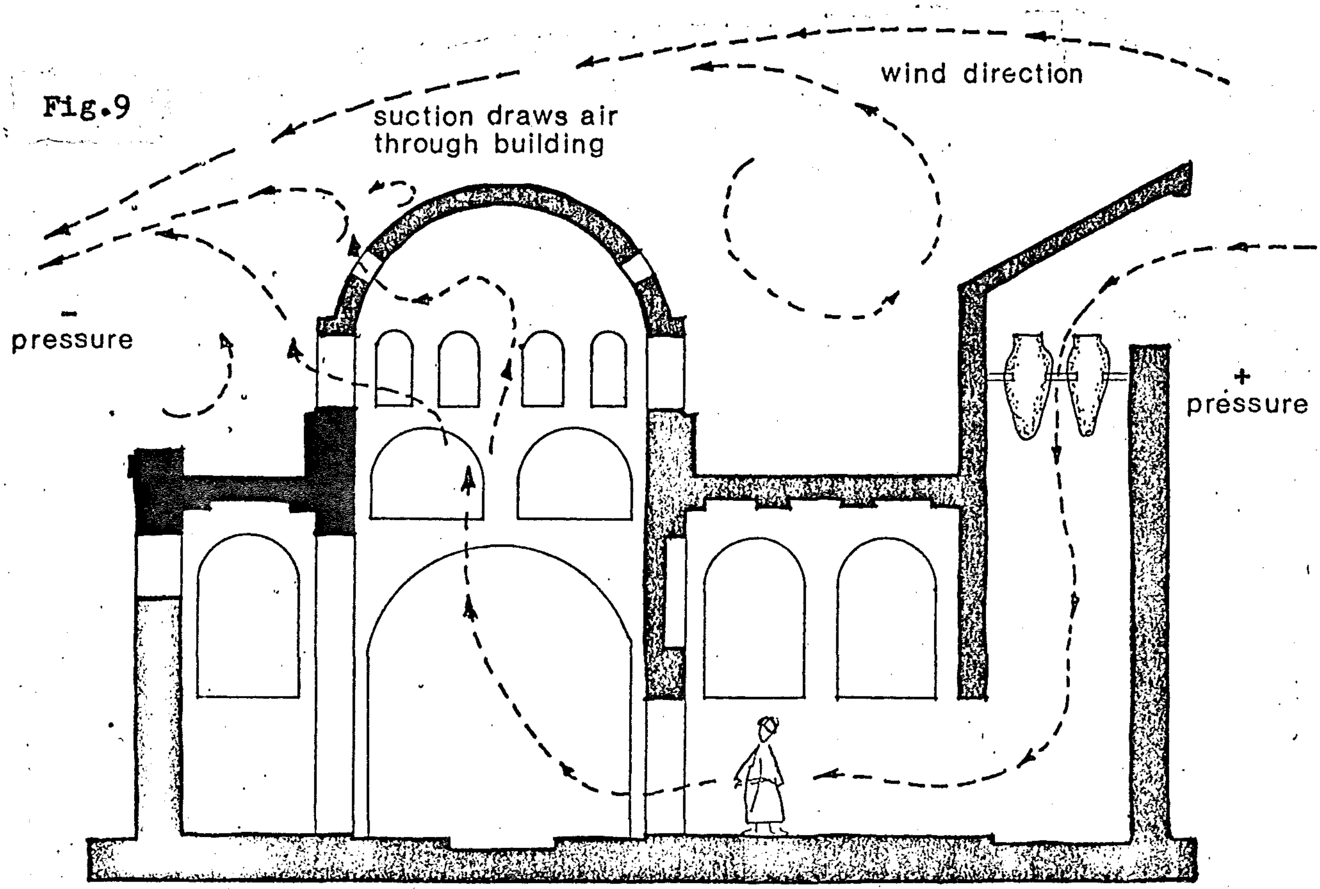
Convection system between courtyards.

The Wind Catcher

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

As shown in the drawing, the wind catcher, in having its intake as high above ground as possible, obtains air which is cooler and cleaner.

Fig.9



Wind Catcher with Cooling Jars

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

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

A simpler and more common solution to shifting winds is the multi-directional wind catcher (badgir) found in the Arab Gulf region and

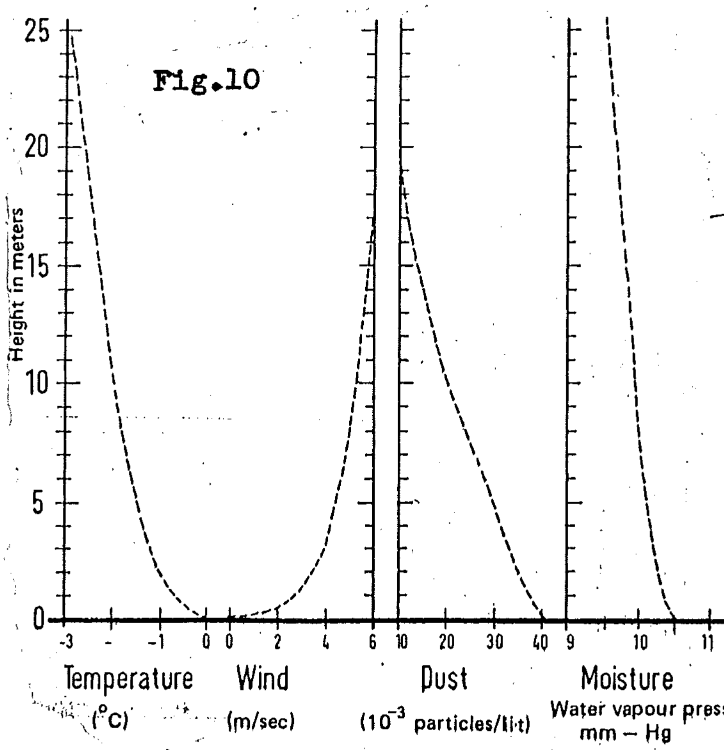
Iran. In urban areas, these towers are elaborately sculpted and decorated. A horizontal section through one of them would show an X configuration. Winds from any direction are thus admitted into the house. This kind of tower is found usually on the coast where land-sea breezes are in effect. During the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

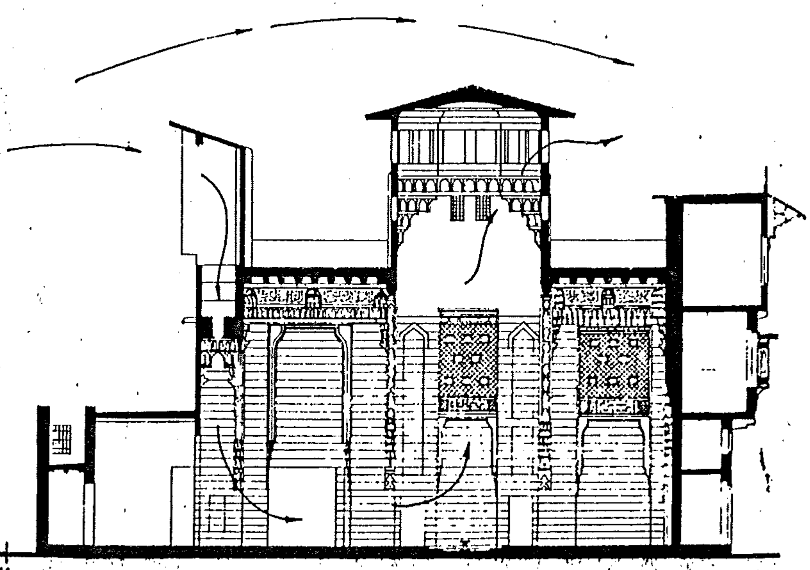
In rural areas, on the Batina Coast of Oman, cloth sails like wind catchers are used, which have a similar X configuration to those of the Arab Gulf. These, in some ways, are more directly responsive to the climate as they are demountable and can be taken down and stored in the winter.

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

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

Fig.10





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