SOLUTIONS TO LOW INCOME URBAN HOUSING PROBLEMS IN THE SUDAN

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To my parents

SUMMARY

The study is concerned with housing problems for low income groups in the Sudan, with special reference to the Capital.

The analysis of the Capital's housing problem revealed a lack of a comprehensive housing policy or physical development plan. Haphazard land distributions systems exacerbated the rapid horizontal expansion of low density housing in the city. It was found that government sponsored housing assistance paradoxically tended to aid a highly paid elite. Lack of co-ordination between government units and departments concerned with housing policy resulted in wastage of limited public resources. The housing programme was further hindered by an inadequate modern building technology.

Socially, the housing shortage has been worsened in recent years by a continuous rural migration resulting in an over concentration of wealth and employment opportunities in the Capital. The huge growth in illegal housing and squatter settlements was the predictable result of this trend.

Lack of technical knowledge has resulted in the construction of housing with inadequate thermal control. Detailed thermal studies were carried out during the course of this study in order to determine optimum building orientation in Khartoum to achieve adequate standards of thermal comfort.

Sudanese social traditions were considered to have a great influence on housing design. An analysis of these traditions was prepared including the use of multi functional open space to serve the complex social activities.

The main objective of the Thesis was to arrive at an alternative solution to the housing problems. A study of non-profit and self-help housing techniques in housing development revealed a possible direction. Because of lack of both public and private finance, non-profit housing techniques were found to be the most appropriate for the Capital. Such techniques could cultivate the populations monetary and non-monetary resources. The solution proposed was twofold:

1) The establishment of adequate housing standards for non-profit housing associations catering for high and middle income groups.

2) Self-help, self-building housing for low income groups.

The Capital's housing needs were projected to 1990 and a detailed building programme set out to achieve the resolution of these needs. Careful analysis of government expenditure suggested that, with the application of non-profit techniques, only a relatively modest public capital contribution was required to begin the diminution of the housing problem in the Sudan.

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CHAPTER 1

SUDAN URBAN HOUSING PROBLEMS

1.1 Urbanization in the Sudan

Compared with most African states the urbanization process in the Sudan is not yet fully developed. According to the 1973 population census, urban Sudan comprises twenty major population centres of 20,000 people or more. Table 1 shows the total 1973 urban population in the Sudan.

Table 1 The population of urban centres in the Sudan 1973

	Town	Province	Total Population
1.	Atbara	Northern	66,116
2.	Shendi	"	24,161
3.	Port Sudan	Red Sea	132,631
4.	Medani	Blue Nile	106,776
5.	Ed dueim	"	26,257
6.	Kosti	"	65,257
7.	Sennar	"	28,546
8.	El Gezira	"	22,218
9.	Juba	Equatoria	56,737
10.	Three-towns Capital	Khartoum	784,313
11.	Kassala	Kassala	98,751
12.	Gedarif	"	66,765
13.	New Halfa	"	24,373
14.	En Nuhud	Kordofan	26,002
15.	El Obeid	"	90,060
16.	Waw	B.El Gazal	52,752
17.	Malakal	Upper Nile	34,898
18.	Geneina	Darfun	35,424
19.	El Fashir	"	51,932
20.	Myala	"	59,852
	TOTAL		1,853,521

Source: 1973 Population census Department of Statistics, Khartoum.

From this table it is apparent that an overwhelming proportion of the urban population is concentrated in the Capital of Khartoum, which itself is composed of three towns forming Greater Khartoum. Greater Khartoum accounts for 42.3% of the nation's urban population.

In all urban centres, the most common form of house is the single storey courtyard type. Houses are surrounded by high walls and fences which are particularly important to ensure privacy required by the life-styles of most families. Living activities are often pursued outdoors and sleeping zones are in courtyards or verandahs. It is usual to find separate quarters for men and women in the same house.

Most of the urban housing is constructed from local traditional building material. The most common material is the mud layer wall ("jalous"), abode bricks and straw. Red bricks, stone or concrete are rare. Flooring is predominantly beaten earth in both the major towns as well as rural areas. Roofing is usually straw and mud layers supported by timber rafters. Corrugated sheeting or concrete accounts for less then 5% of roofing material.

In 1968 Household Sample Survey indicates the catagories of housing stock and construction material.

Table 2 Percentages of household and population according to house type.

Type of house	Households	Persons
Straw huts	15.3%	12.8%
Mud and Abode Construction	64.4%	64.5%
Red Brick	19.9%	22.3%
Apartment House	0.4%	0.4%
Total	100%	100%

Source: Household Sample Survey 1968 page 25.

Table 3 Percentages of household and population according to wall construction of house.

Wall material	Households	Persons
Straw, branches	10.6%	12.5%
Mud walls	54.0%	53.6%
Grishra (abode) walls	7.3%	4.9%
Red bricks	15.8%	17.8%
Stone, cement blocks	3.5%	3.7%
Wood	8.8%	7.5%
	100%	100%

Source: Household Sample Survey 1968 page 27.

Table 4 Percentages of household and population according to flooring material of house.

Floor Material	Households	Persons
Earth	81.5%	78.8%
Bricks	3.7%	4.6%
Cement or Concrete surface	4.0%	4,8%
Tiles	10.8%	11.8%
	100%	100%

Source: Household Sample Survey page 27.

Table 5 Percentages of household and population according to roofing materials and house.

Roof Materials	Households	Persons
Straw, palm leaves	40%	37.6%
Mud Layer	25.5%	26.1%
Concrete	3.5%	4.0%
Asbestos, metal sheets	8.6%	9.5%
Wood	22,4%	22.8%
	100%	100%

Source: Household Sample Survey page 27.

According to Guada, R.E.[(1)], 85.6% of the urban housing stock is constructed from traditional local materials. Khartoum accounts for 73.4% of the nation's total urban housing stock.

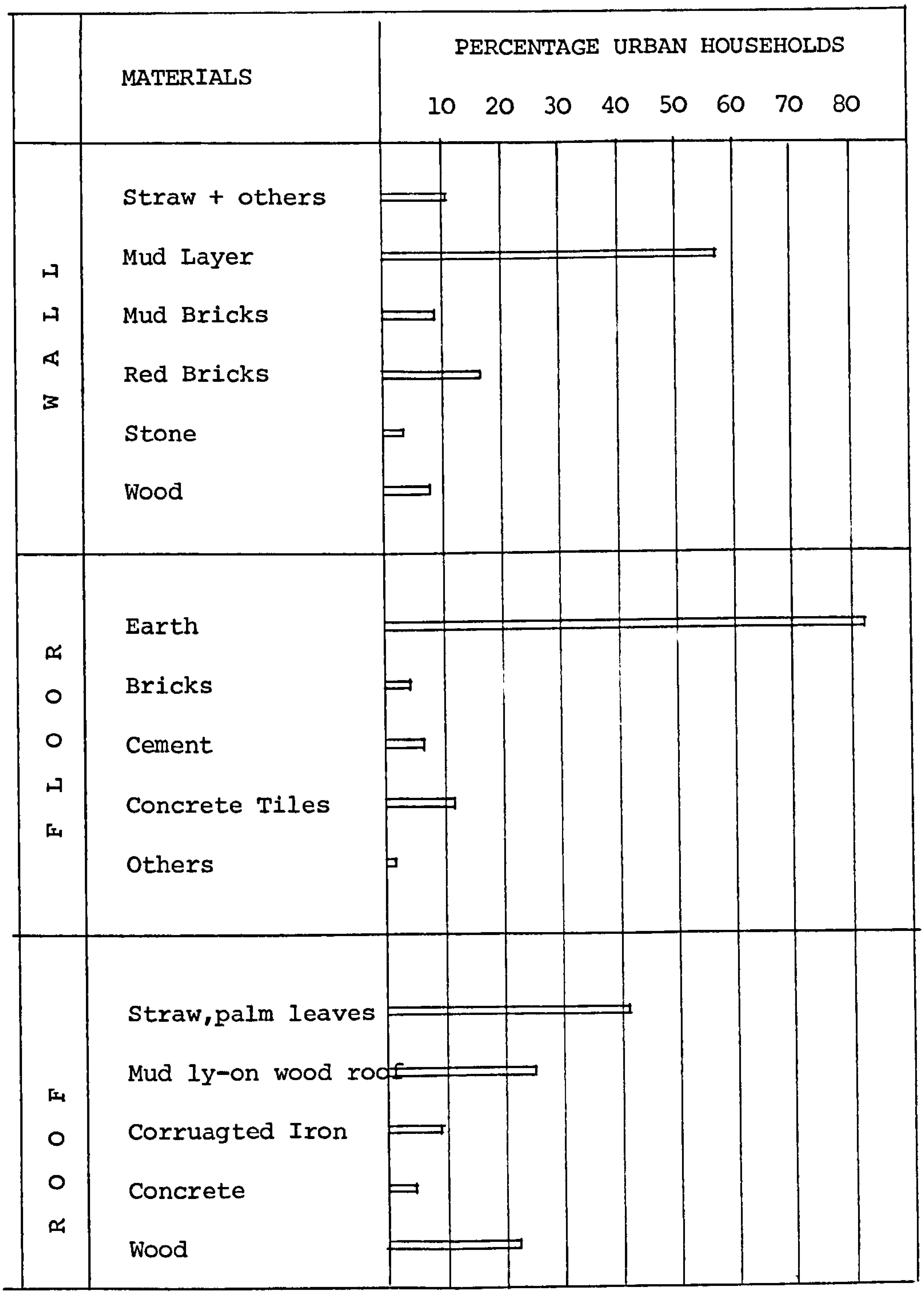
1.2 Catagories of urban housing according to income groups:

The urban housing stock may be divided into four basic income catagories. The upper income residential areas may be equaled with suburban areas in Western Europe. Below the first income catagory housing standards decline rapidly.

A similar situation can be found in site subdivision. All but the lowest (4th) income group tend to have houses on leasehold plots, whereas the lowest (4th) income groups have houses on strictly limited leaseholds. Like Khartoum, the two upper income groups are located in Port Sudan, whereas in other urban settlements there is little difference in standards amongst the three highest income groups. Uncontrolled squatter settlements occur in all urban areas.

(1) Guarda, R.E. "Proposals for an urban Area Housing Policy" Khartoum 1977

Table 6 Percentages of urban households according to wall, floor and roof materials of house.



Upper (1st) and upper middle (2nd) income groups account for a negligible proportion of the urban housing stock. The majority of houses are in the two lowest income catagories as well as uncontrolled squatter settlements. The 1975 Housing Policies statement of the government gave the following percentage of urban housing stock.

Table 7 Housing situation in Urban Sudan 1973

	No.	%
1st and 2nd class housing	11,510	5.5
3rd class housing	78,370	43.1
4th class housing	41,720	20.6
Illegal housing	62,280	30.8
TOTAL		100%

Source: New Housing Policy. Government of the Sudan July 1975 Khartoum.

It is clear from the table that the two lowest (3rd and 4th) income groups account for 64% of the total urban housing stock, whilst 30% lies in the catagory of illegal squatter settlements.

1.3 Urban community facilities

Apart from the obvious differences in construction standards, the different catagories of housing stock differ according to the availability of infrastructure services. The two upper income groups generally have the advantages of a full infrastructure system. Below these groups infrastructure systems are not available.

The upper income group (1st) has mains water supply, electricity, telephone, full sewage disposal systems, garbage collection, paved road as well as recreational and landscaped areas. Open spaces are maintained regularly by the local authority.

The 3rd and 4th income groups have few or no community facilities. Such groups are required to pay infrastructure costs in advance of installation; usually a period of 2-3 years after the completion and occupation of the houses. Even then, it is rare to find a full infrastructure system provided. Upper middle income (2nd) groups tend to have mains water supply, electricity, sewage disposal systems and open surface water drains.

In the 3rd and 4th income groups, no services are supplied except for electricity and a partial mains water supply. The table below indicates the inadequacy of services in the infrastructure system generally.

Table 8 Urban Households and persons provided with a water supply system.

Water system	Households	Persons
Pipes inside the house	61.8	64.8
Pipes outside the house	27.0	27.0
Wells	7.2	7.8
Others	4.0	3.4
	100%	100%

Source: Household Sample Survey. Government of Sudan (1968) page 30.

Table 9 Urban Households and persons provided with a sewage disposal system.

Toilet system	Households	Persons
No toilet system	20.0	16.5
Pit latrine	32.6	33.2
Bucket system	15.3	16.4
Water pivey	22.4	23.0
W.C.'s	9.7	10.9
	100%	100%

Source: Household Sample Survey (1968) page 31.

Table 10 Urban Households and persons provided with bathing facilities.

Bathing Facility	Households	Persons
Private Bath	45	47
Public Bath	13	20
No Bath	42	33
	100%	100%

Source: Household Sample Survey 1968 page 32.

In summary, the following points should be noted:

1. Most roads are not paved except those serving the first two (1st, 2nd) income groups, while in the 3rd and 4th catagories, few roads are levelled and none are paved. Roads are generally too wide in relation to their function, leading to excessively low density development and higher plot costs.

2. Throughout all urban areas, electricity and water services are inadequate, electric power is available to 54% of the urban housing stock.

3. Surface water drainage is universally inadequate except in small areas of major towns. Drainage is available to 24% of the urban housing stock.

4. A full sewage disposal system is only partially available in Khartoum. Other areas of Khartoum as well as other towns use pit latrines generally with the occasional use of septic tanks.

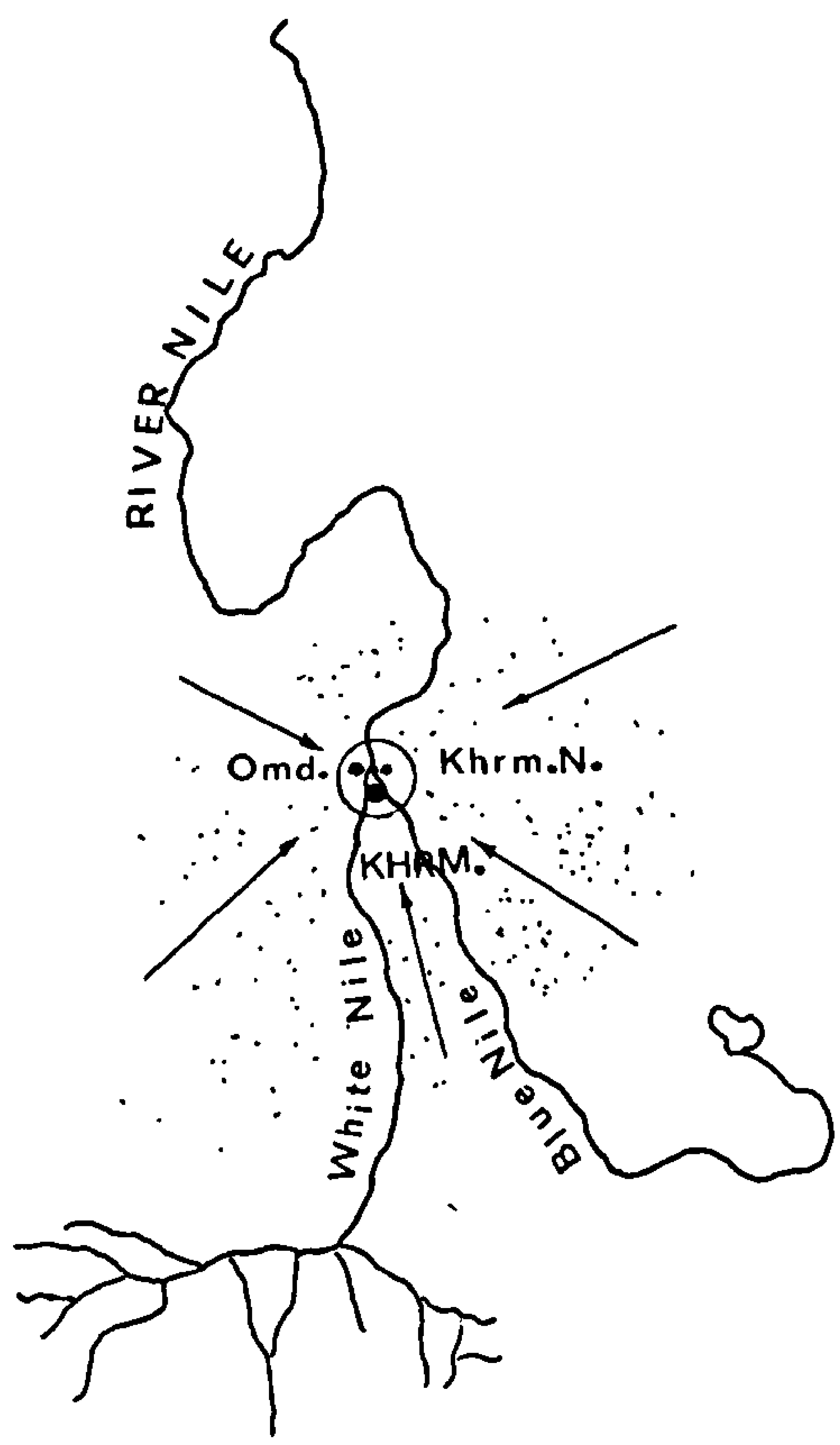
5. There is a disturbing increase in the deterioration of the present infrastructure system arising out of the fast growing population.

The main housing problems occur in Khartoum, where more than 43% of the urban population live. In other towns, chronic housing problems do not occur to the same extent, since most of them are in the first stages of urban development. This present study concentrates on the housing problems and needs of Khartoum (The Three-town Capital) with the implication that solutions for Khartoum may also be applied subsequently in other urban settlements when the need arises.

CHAPTER 2
HOUSING PROBLEMS IN THE CAPITAL

2.1 Foundation and recent history of Khartoum

Khartoum lies in the central part of the Sudan at a latitude of 15^{o},40' North and a longitude of 32^{o},33' East. Its ecology and landscape is strongly influenced by its situation at the junction of the White Nile from Lake Victoria, and the Blue Nile from Lake Tana. The site of Khartoum is flat and lacks prominent geographical features. Its location is at the meeting of the rainless desert of North Africa and the African humid belt on both sides of the Equator. Both the vegetation and desert landscape play an important environmental part in the environment of Khartoum.



Location of Khartoum in the Rive Nile

2.1.1. Recent History of Khartoum

Khartoum was little more than a village of straw houses until 1830, when it became the seat of the Egyptian government in the Sudan. The strategic importance of its location played an important part in this decision.[1]

Its subsequent history is one of cycles of plagues as well as recurrent depopulation. By 1840, its population was estimated to be 30,000 in 1846 it was 60,000 but had fallen to 30,000 in 1862 and to 20,000 in 1870.[2]

The town was an unplanned agglomeration of mud constructed buildings interspersed with native thatched huts. Between 1855-1897, The Mahdists established their capital at Omdurman on the opposite bank of the White Nile, but Khartoum rose to prominence again when it was selected by Kitchener in 1898 as the seat of the Anglo-Egyptian rule. The town was laid out, for military reasons, in a centralized axial plan which is largely unrecognizable now. At the same time, the smaller town of Khartoum North, on the Blue Nile, began to develop as an arsenal and warehousing zone. In this way the 'Three-towns capital' of Khartoum began to develop as the biggest urban complex in the Sudan.

2.1.2. The Growth of Khartoum.

Since the late nineteenth century, the growth of Khartoum can be defined as follows:[3]

1. The nuclear period, from the turn of the century to World War I.
2. The formative period between World War I and World War II.
3. The post-war years marked by very rapid expansion.

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(1) Walkley, C.E.J. "The Story of Khartoum" Sudan Notes and Records (1935) Vol.18, p.235.

(2) Edwards, F.A. "The Foundation of Khartoum".

(3) Sudan Notes and Records (1922) Vol.5 p.158.

From 1898 to 1914, the outermost limits of Khartoum did not extend as far as the railroad ring which encircled the city. Between 1914 and 1939, growth consisted mainly of the development of vacant sites within this area. The perimeter of the urban area slowly extended and eventually coincided with the railroad ring.

The third phase of Khartoum's growth accounts for most of the built-up area. The city extended beyond the railroad system and by 1960 Khartoum covered a total area of seven square miles.[(1)] By this time most of the population lived outside the railroad system - some 84,000 as against 15,330 within the system.

The rapid expansion of the city was generated by the growth of light industry during World War II. In addition, Khartoum's adminstrative role has operated a large bureaucracy and further growth has been caused by the migration of large numbers of people from other provinces. In the first population census[(2)], the total population of the three-town capital was 270,000 (1956).

Khartoum	98,000
Khartoum North	30,000
Omdurman	142,000
Three towns capital	270,000

Although Khartoum itself is the functional capital, Omdurman is regarded as the historic capital. Khartoum is a modern "European" city with full facilities and providing housing for the foreign communities. Few Europeans live in Omdurman. It is an unplanned "African" city with a bazaar claimed to be the largest in Africa. Khartoum acts as the work place for the vast majority of the people who live in Omdurman and Khartoum North.

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(1) Annual Report Khartoum Province 1958.

(2) First population census. Department of Statistics, Government of the Sudan, Khartoum. 1956.

Most buildings in Khartoum are single-storey and the three towns give the impression of a vast domitory suburb. Building density is low.

The Three-towns Capital. 1950.

2.1.3. The Growth of the Capital.

The encirclement of Khartoum by the railroad system was further defined by the construction of major army barracks at the strategic entrances. Land values within the rail loop rose steadily. Growth in an eastern direction was prevented by the location of the British barracks. To the south growth was prevented not only by the rail system, but also the cemetries, the airport and a series of slums known as the "Old Deims". These slums were built during the early days of the second Khartoum to house construction workers.

The "deims" were demolished in 1949 and the city grew beyond the railroad ring to form the present day Khartoum as well as the "New Deims". Khartoum has a present day north south axis, more pronounced than the older east-west axis and its urban structure is roughtly T-shaped. During the expansion southwards, the poorer families sold their houses within the railroad loop and moved away from the city centre.

The central part of Khartoum became the three-towns' main administrative and business centre drawing workers in from Omdurman and Khartoum North. Communications became important and the city is still the main transport interchange point.

After Khartoum had developed southwards, the outer zone became the most extensive residential district of the city, though there is a smaller zone in the western sector of this southern zone for industry.

In the residential areas themselves, there is a total segregation of housing according to income groups. Highest and lowest income housing are never contiguous. Before independence in 1956, the upper income residential area was known as the "European zone", though increasing social mobility has tended to diminish the class segregation to some extent.

There is a socio-economic decline in Khartoum II, Khartoum III and the New Deims. In Khartoum III which is a lower middle income area, the majority of workers are in government service as clerical workers etc. Private gardens or courtyards are not found and the majority of the houses are identical single storey blocks.

The new deims is planned on a gridiron system similar to planned low income settlements in Latin American metropolitan areas. All houses are single storey and though they were originally built of mud, many of them have since been rebuilt in brick.(1)

2.1.4. Recent expansion of the three towns.

During the 1960's the government concentrated heavy industrial growth in the three-towns capital. This industrial concentration obviously attracted mass migration from rural areas and caused in turn an overwhelming and unsatisfied housing demand. Because of land shortages, the government moved light industrial installations, previously located in the central area to planned sectors in peripheral locations. Noxious industry was isolated and most industrial areas were re-located well away from residential development. The major industrial area was the light industrial zone in the western sector of Khartoum. In Omdurman, the western area, between Hai-Al-Arab and Ombedda, was developed for industry. In Khartoum North the established heavy industrial area was further developed and became the focal point of industrial development in the Sudan.

After this industrial development, completely new residential settlements ("new towns") were created with a full infrastructure. Some of the more notable areas are El Sahafa, Gabra, and the new Khartoum extension. In Omdurman, two "new towns", each as large as the old Omdurman, were created in the western and northern parts of the old town, (OM Bedda "new town" and El Mahdia "new town"). In Khartoum North, El Safia, another "new town" was founded and this comprised mainly upper income housing areas.

Since the majority of these new extensions lies on both banks of the Nile, between Ondurman and Khartoum North, the communications, which were formerly by means of small ferry boats between Shambaat (Khartoum North) and Abu Rof (Omdurman), were plainly inadequate. A government contract was let to the Italian engineering company, RECCI, to build a bridge across the rive and this was opened in 1967.

The following map indicates the new extensions.

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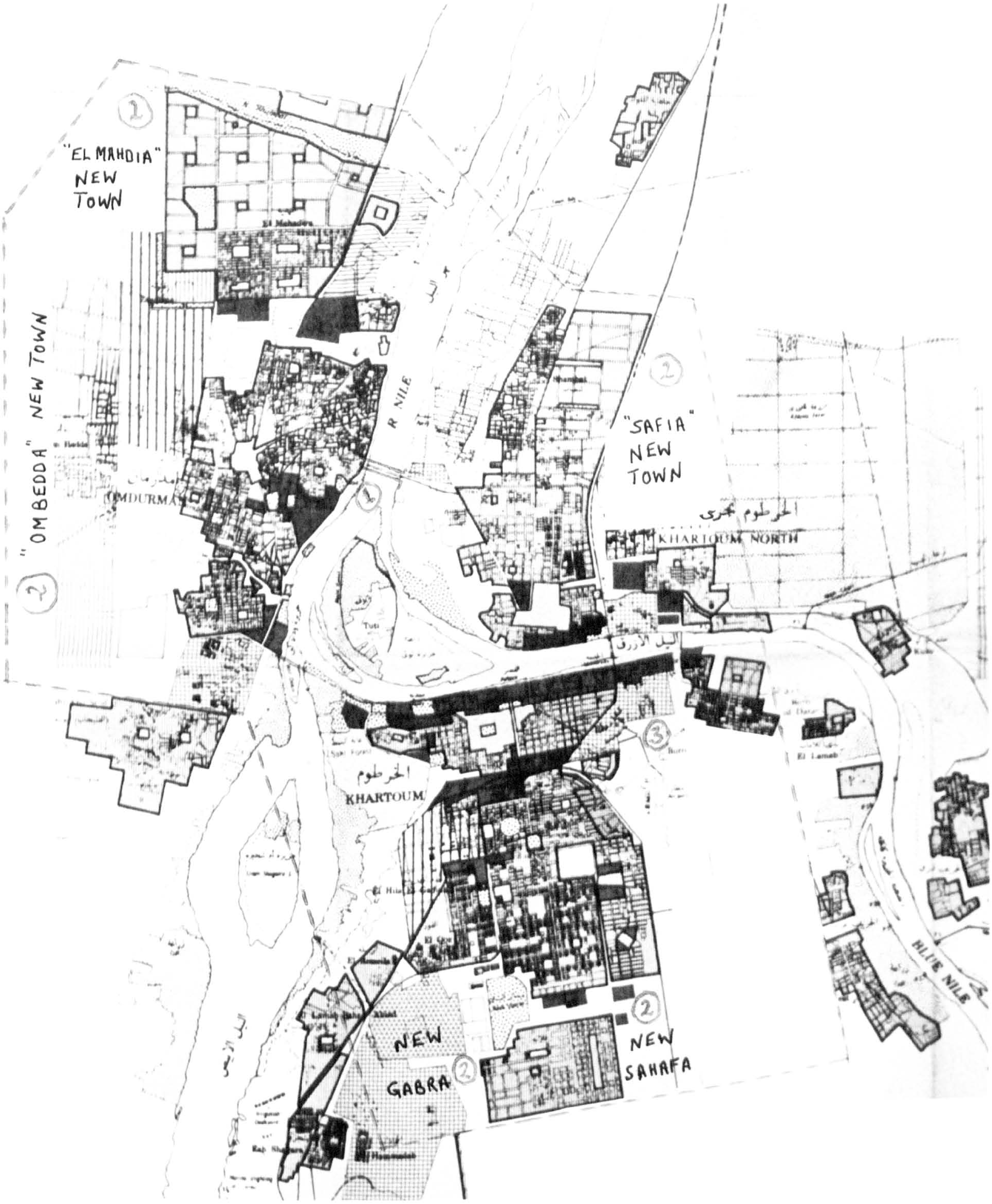
(1) Hamdan, Gamal. "The Growth and Functional Structure of Khartoum". The Geographical Review, Volume L. No.1 1960 pp.21-40.

The Three-towns Capital's New Extentions



CAPITAL"s BOUNDARIES Late 1960(s)

1 New Shambat Bridge over River Nile

2 New residential "TOWNS".

3 Army Barracks.

Even after the opening of the new Shambat bridge, excessive expansion still took place in all of the three towns because of the continuous migratory flow of people from rural areas in search of work. The horizontal expansion was further exacerbated by the planning policy of excessively wide streets and highways as well as public open spaces.

By the beginning of the 1970's, new housing of differing income groups had developed in all of the three towns. In Khartoum, upper income housing developed east of Khartoum airport. This occupied a gap between existing development in Burri and El Gerief West. Upper middle income housing at Arkawit was built in the south-east corner and lower middle income housing in the entire area south of Gabra and El Sahafa, up to the southern outer green belt.

In Khartoum North, new upper income development occupied the site of an old mud village east of Kober main prison, after its demolition. Former inhabitants of the village were moved to an area on the north-east outer zone of the city. A large development of 2nd and 3rd catagory housing was founded in the eastern part of the city at El Hag Youssif.

In Omdurman, in addition to the "new towns" of Ombedda and El Mahdia, the entire western part between the old town and OmBedda is occupied with catagory two (upper middle income) housing. Overspill areas were allocated to the residents of Beit El Mal and Abu Rof, after their houses had been demolished because of redevelopment proposals for the area.

It has already been pointed out that the majority of the population in the three-towns work in central Khartoum. Because of relocation policies, the journey to work time for the great majority of the people deteriorated, though with the opening of the new Shambat bridge, the journey-to-work times between Omdurman and Khartoum North were improved. The problem remains acute between Khartoum itself and Khartoum North. The only means of communication is by means of the old Blue Nile bridge erected in 1920, as a ten metre wide bridge, half of which is occupied by a rail track.

A further contract was let to the Italian company RECCI, to erect another bridge over the Blue Nile between Burri and Kober to give a better link between Khartoum and Khartoum North, where the heavy industry is located. The new bridge also allowed heavy

The Capital's New Extensions and the New Burri-Kober Bridge.

Three-towns Capital's Boundaries 1972.

1. New Blue Nile bridge
2. New Residential areas
3. Army barracks.

The Sudanese Capital's Present Boundaries.

vehicular access from outside Khartoum to enter the industrial area without passing through the city of Khartoum itself. The bridge was opened in 1971.

2.2. Concentration of resources

After independence in 1956, the new national government continued the former policy of administrative and economic centralization. Although the Sudan is divided into ten administrative provinces, Khartoum province as the administrative centre attracted most of the development. Political parties, trade unions, industrial developments, The Civil Service, were all concentrated in the three-towns; Khartoum as the centre of national government, Omdurman as the traditional city and Khartoum North as a manufacturing and upper income residential area.

Over 50% of white expatriates live in the three towns, either employed directly by government coporations (public utilities, and airways), with major commercial firms involved in importing and exporting as well as banking and shipping or else with Khartoum University or other centres of higher education.

Except for the Sudan railway workshops at Atbara, cement plants at Atbara and Rabak, some plants in Port Sudan and Kassala, as well as industries connected with the Zande scheme in South Sudan, all the nation's manufacturing activity is concentrated in the three-towns capital. Some 90% of the nation's vehicles are registered in Khartoum and Omdurman[(1)]. Power, water and industrial building resources are concentrated in these cities. Rail, river and air transport is concentrated in Khartoum, as well as commerce, trading and service industry.

Except for some trading in the Gezira agricultural region, all imported manufactured goods are retailed in the three-towns capital. This degree of centralization of investment may be seen in the following table:

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(1) United Nations, structure and growth of selected African Economies. E/3137/St/ECA/57 (New York) 1958, p.167.

Table 11 Public and Private Investments in the Capital compared with the rest of the Country.

	Khartoum	All Sudan
Banking activity	78%	22%
Non-governmental output	53%	47%
Public utility output	50%	50%
Ownership of buildings output	45%	55%
All government's output	41%	59%
All domestic service output	35%	65%
Manufacturing, transport and distribution output	25%	75%
Building and construction output	20%	80%

Source: The Bank of Sudan
"Report for the Year ending 31st December 1960"
Khartoum, March 1961.

The same degree of centralisation in output and production can also be seen in Table 12.

Table 12 Combined Output Sectors, Three Towns and Selected Other Main Regions.

(Regional output = 100%)

Selected economic Regions	1 Primary activity	2 Secondary activity	3 Tertiary activity	4 Utilities cons.govt.
Gash-Toker	50.6	4.2	10.1	35.1
Central Clay Plains	69.5	3.2	9.3	18.0
Desert Nile	44.4	10.0	10.7	34.9
Flood Plains	72.3	6.1	10.4	11.2
Three Towns	0.6	4.7	24.3	70.4
Sudan	60.6	4.5	9.5	25.4

Source: The Bank of Sudan ... ibid.

1 Farming, livestock, forestry and fishing industries.
2 Mineral, manufacturing and craft industries.
3 Miscellaneous, domestic services and ownership of buildings.
4 Public transport, passenger, goods, mail and aviation.

The three towns capital dominates in the tertiary sector of economic activity and particularly in utilities and construction. Because of the presence of a skilled labour force as well as the high income markets in the Capital. The manufacturing of consumer items also tends to be concentrated here.

On the other hand the capital only accounts for 43% of the country's total population, with most of the professional groups located here.

Table 13 Concentration of all Working Personnels in the Capital.

	Khartoum	All Sudan
Senior clerical category	60%	40%
Large commercial and industrial undertakings	39%	61%
Medical professionals	50%	50%
Semi-professionals and non-technical personnel	30%	70%
Protective services workers	25%	75%
Craftsmen and mechanics	20%	80%

Source: Peter F.M. McLoughlin
"The Sudan's Three Towns : A demographic & Econ. Profile"
Econ. Development & Cultural Change Oct.1963 No.XII/1

According to McLoughlin, the Capital contains only 2.3% of the nation's total labour force, but nevertheless accounts for 33.7% of the nation's management/professional groups, 19% of clerical workers and 17.7% of industrial (manufacturing) workers.

2.3 Migratory influences on housing problems

2.3.1 Overcrowing conditions in housing

The concentration of economic and industrial resources in the three-towns capital obviously acts as a major influence in attracting migrant workers from other parts of the country. Though this has been long recognized by central government there has been no change in planning policy to discourage these migratory trends. The continuous process of urbanization, the development of industry as well as recreational, health and commercial facilities, has facilitated the installation of a major urban infrastructure at the expense of the remainder of the country[(1)]. Social, political and cultural attractions also served as a major magnet, as well as the functional centre of exporting and importing and overseas travel via the only international airport.

In terms of the rural areas themselves, little or no physical development or improvement has taken place. The relative poverty and lack of facilities combined with unemployment acted as catalysts for the migratory worker[(2)].

The migatory workers come from all regions and ethnic groups in the country. They represent all skills required in the major conurbations.

An unatural accelaraction of the migratory flow to the capital occurred after 1960, soon after the establishment of the heavy industrial area in Khartoum North. This represented a major capital investment with international help from the United Nations organisation as well as foreign governments. Many different kinds of manufacturing industry are represented here, but the most significant was the establishment of the second largest textile plant in Africa with American financial aid. Prior to the establishment of the American Textile Factory, the Sudan exported all its raw cotton and this represented the primary cash crop of the country.

The centralisation of the manufacturing industries created a major employment demand, which in turn, created the migratory waves of workers during the 1960's. The intensive imigration created an insatiable demand for accommodation and, compared with living conditions in the rural areas, the housing available at first was considered to be of reasonable standards by the immigrant workers. The first settlements were adjacent to the Khartoum North Industrial Area, but later spread throughout the three towns.

Because of low wages, the majority of immigrant workers were unable to rent satisfactory housing in the later stages and many families shared houses creating insanitary and overcrowded conditions.

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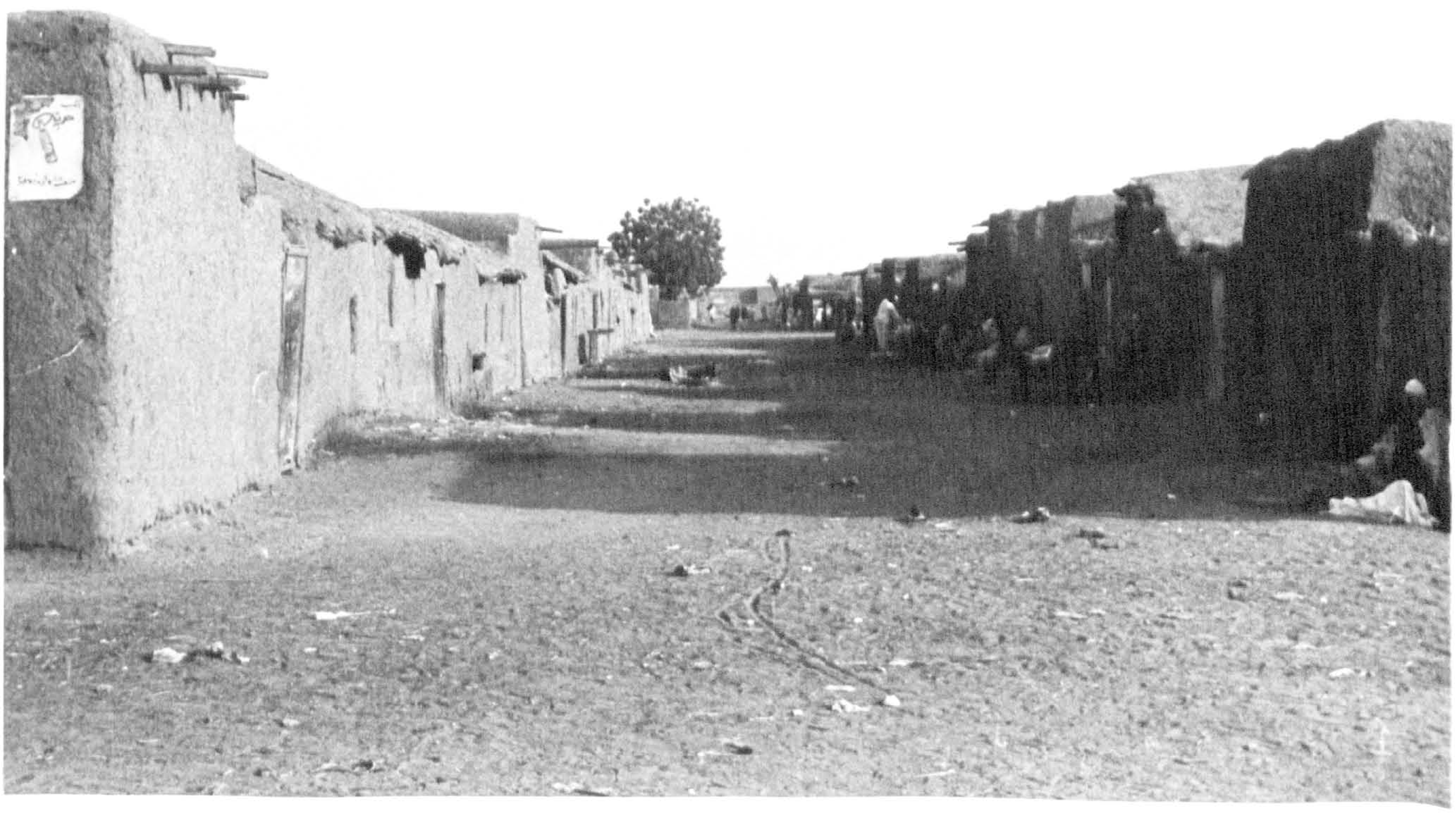
(1) Atiyah, Edward. "Progress in the Sudan" The Colonial Review June 1950, p.171.

(2) Barbour, K.M. "Population Mapping in the Sudan". Essays on African Population. Routledge & Kegan, London.

Within a relatively short space of time, the mass migration had exhausted the supply of available land within the old capital's boundaries. As the development of the Khartoum North industrial area continued, the migratory flow accelerated and attracted workers in the 3rd and 4th income catagories (see Chapter 1). The housing situation reached a point of crisis demanding government action.

The National Housing Authority set up a commission in 1962 to improve the housing conditions for low income workers. 1,000 low cost houses were built initially with government funds and distributed to low income workers with large families, on a long term mortgage repayment basis. After 1962, government policy allocated housing sites for different income groups in closed auctions. Land was sold on leasehold at nominal prices. For example, a low income group plot of land (300 square metres) was sold for L.S.60.00 (£90.00). The infrastructure costs were government subsidised and tenants paid a nominal charge of 5p per month for services.

Nevertheless, the majority of workers in the 3rd and 4th income groups were unable to build houses because of lack of finance and the high cost of building materials. These groups occupied the existing, decaying housing stock.



"DEIM FALLATA"

A 4th Class Residential Area in Khartoum.

2.3.2. Unauthorized housing (squatter settlements)

Even with the occupation of the old decaying housing stock, the housing demand was not satisfied. The later groups of immigrant workers occupied housing in the outlying villages beyond the captial's boundaries.

Housing land in the villages was usually distributed among the village population by the village sheikhs (chiefs). The villages saw the new housing demand as creating a new source of revenue from housing rents. The existing inhabitants tended to buy more plots than necessary and re-sell them to immigrant workers. The relatively cheap plots of land were attractive to the immigrant workers because the price differential between inner city plots and those in the outlying villages was as much as 10:1. Many immigrant workers already settled in older areas within the capital transferred to the village areas by selling the smaller but more valuable city plots to purchase larger village plots.

Another reason for the transfer to village sites was that the application of more rigorous building and planning regulations within the city areas precluded a great majority of lower income workers from building houses within their financial capabilities.

In Khartoum, the minimum plot size for 3rd catagory income housing must be not less than 300 square metres and must contain a minimum of two rooms, kitchen, bathroom and pit-latrine, and be constructed from good quality red brick. In 1960 the cost of a typical house was L.S.600.00 (£900), whilst the average salary of a third catagory income group worker was L.S.15.00 per month, or 40 working months purchase. It is clear from these figures that such planning and building standards put housing beyond the reach of workers in these income catagories.

The transfer to the villages of the immigrant families was primarily for economic reasons and since the villages in the outlying districts were still relatively close to the industrial areas, the journey-to-work times presented no particular problems. Stringent building regulations did not apply in the villages and most houses were constructed of mud, adobe or second-class brick.

2.3.3. Squatter settlements:

The settlement of immigrant families in the manner described above only applied to groups where the income was at a relatively high (3rd catagory) level. Many immigrant families' earnings fell below this level and they were not able to even purchase housing plots in the village areas. Lower income families formed squatter settlements throughout the three-towns region. "Shelters" were of the most primitive form of construction using paper, wood, tins and mud. The squatter settlements took on an air of permanence and attracted further immigrant families.

Some of the largest squatter settlements was El Hag Yousif (a village in the south-east of the Khartoum North industrial area). Six years after its foundation the residents sought permission from the municipality of Khartoum North to have the settlement included within the municipal boundaries and to have a full infrastructure of water, power, drainage and roads installed.

According to Mazari,[1] the number of people living in squatter settlements was between 15,000-20,000 people in 1965. This number had increased to 150,000 by the time of the last population census in 1973. By 1975, according to Guarda[2], squatter settlements accounted for 29% of the capital's total population or about 200,000 people.

2.3.4. Population increase in the Capital

In addition to worsening conditions of overcrowding and the establishment of unauthorised settlements, the migratory flow towards the capital continued to increase.

Hance[3] traced the continuous increase in the population of the three-towns capital, caused mainly by migratory flows from rural areas.

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(1) Mazari, S.A. "Urbanization in the Sudan". Ministry of Housing, Khartoum 1965.

(2) Guarda, R.E. "Proposal on Housing Policty in Urban Areas". Ministry of Local Government, Khartoum 1975.

(3) Hance, William A. "Population, Migration and Urbanization in Africa", Columbia University Press U.S.A. 1970 p.313.

Table 14 Increase of the Three-towns Capital's Population
(in thousands)

	1903	1926	1956	1967	1970	1973
Khartoum	15	14	83	185	195	334
Omdurman	58	70	113	175	185	299
Khartoum North	4	14	39	80	120	151
	77	98	235	440	500	784

Source: William A. Hance ...... op.cit.

Table 15 Three-towns Capital's Population by Place of Birth
(in thousands)

Place of Birth	Khartoum	Omdurman	Khartoum North	Total	%
Born in Khartoum	153	184	78	415	53%
Born in Provinces	181	115	73	369	47%
Total Greater Khartoum	334	299	151	784	100%

Source: 1973 Population Census, Dept. of Statistics, Khartoum

From the tables above, it is clear that almost 50% of the capital's population is the result of migration from the rural areas. Because of this continuous migration, the housing problem has not only been exacerbated in the cities, but community problems have occurred in the rural areas.

In the rural areas, the environment has deteriorated rapidly. Unemployment and lack of community development has forced the migratory trends causing a subsequent deterioration in the rural settlements. In the urban areas, overcrowding and obsolescent housing and squatter settlements have caused a deterioration in health standards as well as having adverse social and psychological effects.

2.4. Physical expansion tendencies.

Inadequate finance, the lack of an overall housing policy, an inadequate physical planning framework as well as inadequate planning expertise have all aggravated the capital's housing problem. The rapid horizontal expansion of the capital has taken place in the absence of any master or outline planning proposals for the city[1].

2.4.1. Distribution of housing plots.

The government was unable to meet the housing needs of a rapidly expanding population. The general policy was to allocate land for housing purposes according to different income groups and this would be disposed at closed auctions. Each year, several thousand plots are sold on leasehold at nominal prices, with the owners being responsible for the construction of their individual house.

Plot sizes were not determined according to present family size or life cycle, but according to financial status. High income families received plots of between 600 and 1,000 square metres, 2nd catagory income families received plots of between 400 and 600 square metres and the 3rd catagory income families received plots of under 400 square metres.[2]

Although the differing plot sizes applied to different income groups, within each residential area land was subdivided into identical plots of the same size and shape based upon a grid iron service road system. Although wide roads and open space are provided, the latter tend to be unkempt barren areas even in the upper income areas.

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(1) In 1974 The Italian Company MEFIT, signed a contract with the Government to prepare a Master Plan for the three-towns capital and this is due to be submitted for approval shortly.

(2) Town Planning regulations, Khartoum Republic of the Sudan 1957.

Wide dirty open space in 2nd class areas: Khartoum

It is interesting to note the width of roads provided are far in excess of their required vehicular capacity[1].

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(1) The hot dry climate of central Sudan is discussed subsequently, but it should be noted here that such wide roads and open spaces are not only unnecessary, but in fact a closer knit, denser development can traditionally provide shelter from dust storms, heat gain and solar glare.

Wide unpaved roads in one of Khartoum's residential areas

The Housing section of the Ministry of Local Government calculated that the proportion of roads and open space in terms of total land area was as high as 48.8% in parts of Khartoum and 30% in Omdurman. The official report remarked that: "In Khartoum roads cover an unduly high percentage of the total area, and planning is rendered uneconomic both from the angle of development cost and the communications' cost, owing to the wide area over which the town has spread."[1]

Plot density is therefore a critical factor in terms of the urban economics of the city and has had an adverse effect on the development of Khartoum itself. It affects the total cost of community development in the following ways.

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(1) Doxiadis Associates "The Future of the Capital". Preliminary document prepared for the Government of the Sudan. Athens. May 1959.

a) Cost of land.

b) Cost of construction and maintenance of roads.

c) Cost of additional building works such as peripheral wall construction costs as well as services costs (length of services).

d) Installation costs of services.

e) Community services costs (postal delivery, police, garbage collection, etc.).

f) Transportation costs for residents and goods delivery.[1]

The revenue budget allocation to the capital's local municipalities is very low. These limited resources are further reduced by excessive expenditure on unnecessary infrastructure caused by low density development. In the case of many distributor roads, paving was not possible and the surface is in the form of stone chippings which wears rapidly in the Sudan's climatic conditions.

The large area covered by the Three town capital (12 square miles) is not properly served by a full infrastructure system. The policy of low density development has resulted in the expansion of the three towns by 500% in the last 20 years. The average urban family of 4 persons has a residential plot of some 700 square metres. The addition of excessively wide service roads as well as open space has resulted in a density in parts of the Capital of under 4 persons per acre (gross). In the second income catagory areas the density is approximately 15 persons per acre. The overcrowded areas occur in the third and fourth income catagory areas around the the periphey of the Capital.

In 1965, Mazari[2] found that housing density in the new and old parts of the 3 towns varied from 15-20 persons per acre (gross) in the 1st income catagory areas to 60-65 persons per acre (gross) in the 3rd income catagory areas. Comparing the Sudanese population density with other African states, the density varies from 300 persons per acre in most North African urban areas to 150-200 persons per acre in East and West Africa[3]. Few African countries have

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(1) Doxindis Associates.
"The Size and Shape of urban Plots" EKISTICS. 1960 (9) pp.289-304.

(2) Mazari S.A. "Urbanization in the Sudan" 1965, Khartoum.

(3) United Nations. "Housing in Africa" Chapter 3. 1966.

densities similar to the urban areas of the Sudan. South Africa has a density of 40 persons per acre, but with residential plots ranging from 250-300 square metres.

Old Khartoum has an average density of 25 persons per acre compared with 100-150 persons per acre in other third world countries. Cairo, with a population of 3,346,000 in 1960 covered eight square miles which was the identical land area to Khartoum in 1956 with a population of 100,000.[1] If the area occupied by Omdurman and Khartoum North is added, then the three-towns capital occupies a total land area two and a half times as large as that of Cairo. The excessive borizontal expansion of Khartoum has created urban transport, infrastructure and economic problems.

The adjacent photographs provide a graphic account of the effect of low density development in the Khartoum city region.

(1) Fitzgerald, Walter. Africa (Tenth edition) London 1967, p.439.

2.5. Government urban housing policies:

A summary of government action in attempting to improve the housing situation, since independence in 1956, is worth examining:

1. Urban housing land was distributed in the form of differing sizes of residential plots according to income classification. This land was made available through closed auctions.

2. State-built houses were made available to high-ranking government officials in major towns, or alternatively cash housing allowances were given.

3. Relatively few low cost houses for low income groups were provided.

4. Government subsidies were provided in an attempt to improve the Public utilities.

2.5.1. Distribution of Residential Plots according to income groups.

Since 1960, local authorities in every province were empowered by central government to receive applications for housing land from the local population and distribute plots according to data received concerning family income and economic security. In the smaller towns, housing problems did not exist to the same extent and land was available to meet most requirements. The major problem occurred in the Three-towns capital.

According to the 1973 population census(1), 25% of all urban residents in the country live in the Capital. The lack of an overall housing policy, mentioned previously, resulted in the piecemeal distribution of urban land, oversized housing plots, excessively wide roads and large areas of neglected open space. Nevertheless this low density development within the city boundaries houses less than 50% of the Capital's population.

Since 1970 the Government all but stopped the distribution of housing plots in the Capital. This restriction on urban land availability nevertheless execerbated the problem because of the continuing migratory flows and a growing housing deficit which in turn resulted in high rents, overcrowding, unauthorized housing and squatter settlements.

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(1) 1973 Population Census. Department of Statistics Khartoum.

The distribution of housing land was not combined with the provision of an adequate infrastructure except in 1st catagory income areas which housed senior government officials and the foreign community. The proportion of 1st catagory income housing is less than 4.6% of the total. In the other sections, services tend to be delayed for two or three years after the allocation of plots and the infrastructure remains incomplete until well after the completion and occupation of the houses.

2.5.2. State subsidies for housing.

Larger state housing subsidies are generally available for government officials. These may take the form of:

1. Houses constructed by the state for senior officials and subsequently let at nominal rents.

2. Large government loans (up to 90% of construction costs) for officials to build their own houses on serviced plots in urban areas, offered at nominal sums.

3. Cash monthly housing allowances for other officals.

1. State constructed houses: Since colonial times, the Sudanese government has provided houses to accommodate senior staff. Space and construction standards differ according to the employment catagory of the official and the prevailing living standards of the town in which the houses are erected. According to Mazari[1] during the 1960's, L.S. 4,000,000 was made available to different government departments to house their senior officials. The proporation according to departments is given in the following table:

(1) Mazari, S.A. "Housing in Towns" Sudanese Government Town Planning Department Report. Khartoum, September 1965.

Table 16 Public Investment in State-built Houses in 1960(s)

Public Unit	L.S. thousands Sudanese Pounds
Ministry of Health	1500
Ministry of Interior	2249
Ministry of Judiciary	0093
Mechanical Transport Department	0100
Post & Telegraph Department	0015
Total	3957

Source: MAZARI; S.A., (Capital's Chief Townplanner 1960(s))
"Housing in Towns"
An official document prepared in September 1965.

These funds were used to employ private contractors to construct some 1,740 houses in the period 1960-1970. Houses are let at nominal rents with additional charges for electricity, water and telephone services. Transfer to other towns is to houses of similar standard.

2. Government Loans

Because the construction of a housing stock has proved woefully inadequate, other forms of housing assistance are made available to government officials. Massive loans were granted and accounted for 75% of all government financial resources for housing during the period 1960-1970[1]. The justification for this financial outlay was that since the government officials were in permanent employment with a guaranteed income, the loans represented a secure investment. Private banks took a similar attitude that only highly paid government officials were capable of repaying capital and interest over a short period.

For the highly-paid officials the Housing Bank had purchased imported building materials at cost, whereas the rest of the population who were responsible for the construction of their own houses had to purchase building materials at full retail price with 100%-200% on-costs. As mentioned previously, the infrastructure is properly provided in 1st catagory income areas with paved roads and landscaping as well as a full sewage disposal system.

(1) Guarda op.cit. page 52.

3. Housing allowances

Housing allowances are given as monthly cash payments to government officials who are not provided with either state built houses or housing loans. Initially only officials of the Ministry of the Interior were eligible, but they were subsequently awarded to all government departments. The allowances do not necessarily augment the housing stock, but are more often regarded as an additional salary payment.

2.5.3. Low cost housing construction

In an attempt to improve housing conditions for the low income groups, the National Housing Authority was established in 1960. The Authority suggested that the government should undertake responsibility for mass housing schemes and bulk purchase of building materials. This proposal was not supported by the government, though an experimental project was agreed to build 1,000 houses in Khartoum North for L.S. 1,000,000. The houses constructed were of two types; a small two roomed house and a slightly large 3 roomed house. These houses were allocated to families in the 3rd income catagory, particularly for large families, on a mortgage loan system. The total of 1,000 houses was clearly insufficient to house the 40,000 people who desparately needed houses in Khartoum during this period. Nevertheless, no further government housing schemes were proposed until 1970(1) and the low income groups in the Capital were left to their own devices to secure housing land.

2.5.4. Government public utilities subsidies

In addition to the housing scheme described above, the government subsidised the urban infrastructure costs. These included the construction of roads, bridges as well as mains services. Responsibility for these facilities is shared by the local municipalities and the Central Electricity and Water Corporation. Payment of bills is not well organised, particularly bearing in mind that the C.E.W.C. is not intended to depend upon public subsidies.

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(1) In the early 1970's, some government departments including the Police and National Railways built some low-cost housing for their employees, but the total did not exceed 400 houses.

2.5.5. Evaluation of government improvement schemes.

The general criticism of government policy is that the distribution of residential land for separate income groups was carried out piecemeal; without the preparation of an adequate outline plan for the Three-towns.

According to Khmed[1], 1,740 rental houses were built by the state for government officials during the period 1960-1970. In addition 1,000 houses available on mortgage were built for lower income skilled manual workers in Khartoum North and 63,300 undeveloped plots were disposed on leasehold to various income groups, only 23,300 of which were within full serviced residential development areas.

Table 16 Growth in the Capital Housing stock 1960-1970

	Houses
State-built good housing for highly-paid officials	1,740
State-built low-cost housing for the workers	1,000
Open residential plots distributed 63,300 of these number of houses built by lessees	23,300
Total of houses added to the Housing-Stock	26,040

(1) Source: A.E.K. AHMED
Sudan Urban Housing Policies
M.Phil. Thesis, University of Edinburgh 1972

The number of houses added to the housing stock during this period amounted to no more than 26,040 units. According to El Agib[2], by the end of 1966 the low-cost housing stocks only met 1.25% of the actual housing needs, and he estimated that the housing deficit in central Sudan alone was more than 60,000 units. In 1968, The Department of Statistics[3] indicated that 124,000 units were needed for all urban areas.

(1) Ahmed, A.E.K. "Sudan Urban Housing Policies". M.Phil. Thesis. University of Edinburgh 1972.

(2) El Agib, A.A. "The Housing Problem Dimensions and Solutions". Round Table Conference, Khartoum, March 1967.

(3) Housing and Population Survey 1968. Department of Statistics, Khartoum.

Demographic data after 1970 indicates that natural growth in the major cities, combined with a continuous migratory flow from rural areas, has caused a housing crisis beyond the economic control of the present government.

Houses available on mortgage, despite relatively low interest rates and long term repayment plans, still remain beyond the means of the majority of low income groups.

According to Balula[(1)], only 1,200 houses had been built within the government housing purchase scheme between 1953-1967 in the Three Towns area.

The New Housing Policy approved by the Central Government in June 1976[(2)], recorded a housing deficit in the Three Towns Capital of 46,000 plots[(3)], indicating a need to accommodate some 230,000 people. This data does not take into account housing obsolescence or the growth in squatter settlements,which now account for 29% of the Capital's total population according to Guarda[(4)].

Quite apart from basic housing needs, little account has been taken of the demand for community facilities. Infrastructure systems are rarely provided and in the prevailaing socio-climatic conditions of the Sudan, much family living takes place out-of-doors, accentuating the demand for community space.

The housing policies which concentrated on the provision of housing for highly-paid government officials can be further criticised in absorbing 29% of capital expenditure and investment during the 1960-1970 period, yet at the same time only meeting 1% of total housing needs in physical terms. Though the houses were occupied by government officials on relatively high salaries, economic rents were not charged. It is suggested that if the capital investment of some L.S. 4,000,000 should have been channelled into non-profit housing associations which could have met a much larger housing requirement.

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(1) Balula, A.E. "Financing Housing in the Three Towns". Paper delivered to the Round Table Conference. Khartoum, March 1967.

(2) The Author was a representative on the National Committee established in 1974.

(3) The Capital houses 43% of the total urban population (see page 20)

(4) Guarda, R.E. op.cit. page 27.

Table 18 Increase in Urban Housing Deficit

		Housing Units
1. Workers houses met 1.65% of Central Sudan's needs 1966 Total urban needs (Central Sudan = 60%)		100,000
2. 1968 Total urban needs		124,000
3. Officials' housing (1,740) met 1.1% of urban needs, 1970 Total urban needs		158,000
4. Capital's needs by 1976 (46,000) Total urban needs (Capital = 42% of total) = Squatters (30% of Capital's total) = Obsolete housing stock (urban total) =	 110,000 14,000 56,000	
1976 Total urban needs	180,000	180,000

Source: worked out from different data given in 2.5.5.

Where government loans were granted for the construction of houses for government officials, up to 90% of construction costs were allowed. According to the Estate Bank(1), 64% of housing investment was chanelled into upper income groups accounting for 15% of the population and 36% of housing investment for the remainder of the urban population. Ahmed(2) suggests that if this total investment had been directed wholly towards the provision of partially serviced plots, something in the order of 10 times the total number of new dwellings could have been provided. In any event, the contrast in housing standards between the three main income groups in urban areas was very marked. There was no attempt to try and raise the overall housing standards of the population and the accompanying photographs serve to illustrate the difference in prevailing standards in the three income categories.

(1) Guarda, R.E. op.cit.

(2) Ahmed, A.E.K. op. cit.

The first illustration shows a three-storey unit in a category 1 income area, with private garden. The second illustration shows housing in a category 2 income area with serviced plots but with large expanses of neglected open spaces.

2nd Class Housing

Housing in the third income category shows a marked contrast to the preceding two photographs, though it accounts, nevertheless, for 60% of the urban housing in the Three Towns Capital. These plots have no infrastructure provision whatsoever. The lack of an overall development plan has aggravated the situation.

3rd Class Housing

2.6. Underlying Causes of the urban housing problem:

The main causes may be summarised:

1. A lack of understanding at government level of housing needs.
2. Low priorities and levels of finance in the housing industry.
3. Lack of a housing policy in the context of national development.

2.6.1. Government attitudes towards housing

A general official attitude towards housing has been merely the obligation to provide either unserviced plots at one level or house structures at another. Concern with the standards of the total urban environment has beennon-existent.

This basic lack of understanding has extended to the non provision of infrastructure services including water and power supply, sewage disposal, garbage collection, surface water drainage or an adequate highway system. Community and social services have also not been considered, extending to the provision of adequate schools, medical posts, markets, religious buildings, hospitals, public transportation, security and recreational facilities. Where infrastructure is provided it applies to only a minority of high income groups which themselves become proportionately smaller with the increase in the number of squatters and other low income groups.

2.6.2. Inadequate housing finance

Sudanese Government economists tend not to regard housing investment as a productive sector. Present policy favours investment in sectors which achieve a quick turnover of capital with low capital input. As in many developing countries, such a policy mitigates against public housing investment on any large scale. The ten year economic and social development plan 1961-1971 states:

> "It would be virtually impossible for the Government to allocate a substantial part of its scarce resources to modern house building at a time when so many other types of investments will have to be carried out".

The economists responsible for the Ten Year Plan[1] ignore the possibility that the housing industry could be regarded as a key industry in a developing country and with adequate government support, would act as a catalyst for other industrial developments providing expanded employment opportunities and economic development.

The government investment in housing has been described in the preceding chapter. The inadequacy of this policy has been fully discussed. Government investment in infrastructure is not fully recorded but evidence suggests that it was quite as meagre as housing investment itself.

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(1) Ten Year Economic and Social Development Plan 1960/61-1970/71. Ministry of Finance and Economics. Republic of the Sudan. Khartoum 1962.

If one compares Sudanese Government investment in housing with housing investment in other developing countries, it is apparent that The Sudan fails to meet the criteria set down by The United Nations housing division, which stated that minimum investment resources for the housing sector should be not less than 5% of the total G.D.P. (Gross Domestic Product) of any developing country. The Sudanese investment in the period 1960-1970, accounted for approximately 1.5% of the G.D.P.

The following table gives a graphic comparison of housing investment in other developing countries.

Table 19 Comparision of Sudanese Public Housing Investments with those of some Developing Countries during the 1960(s).

Country	Housing Investment Rates to G.D.P.s %
Panama	4.2
Venezuela	3.2
Sierra Leone	3.1
Singapore	3.0
Chile	2.7
Kenya	2.3
Philippines	2.2
El Salvadore	2.1
Tunisia	2.1
Malaysia	1.8
Thailand	1.7
SUDAN	1.5

Source: U.N. "World Economic Survey" 1969-70 p.55.

The table indicates that none of the developing countries has invested the minimum 5% suggested by the United Nations. Nevertheless, The Sudan appears bottom of the investment table.

Private Housing Investment

In addition to the low level of public investment in housing, there has been a notable absence of private investment. No government measures were taken to sponsor private housing investment.

Had tax concessions and long term credits been made available to the private sector to develop the building industry, a much better housing production might have been forthcoming. Private investment instead tended to be channelled into the more lucrative fields of manufacturing industry and commerce. The non-availability of private housing loans or commercial mortgage schemes exacerbated the situation. No building societies as such exist and what private sector loans were available through banks, these only applied to high income categories.

Most housing built was constructed on a self-help, self-build basis utilising family savings for the purchase of building materials. Even so, it was not uncommon for low income families to sell part of their plot in order to finance the construction of their house.[1]

The lack of public or private finance was, therefore, the primary cause of the housing crisis. The criticism that can be levelled against government policy during this time was that the small amount of public finance available was not directed towards low income housing, but rather towards subsidising housing for highly paid government officials.

2.6.3. Lack of an integrated housing policy in The national development plan.

A normal part of any effective national development plan may be considered to be the effective provision of adequate housing land, construction materials and housing finance and expertise. Furthermore an effective programme of construction might be considered on essential component of this policy. Even in other developing countries, such as Brazil, a housing policy for low income groups has been consulted, albeit belatedly as an essential part of government policy. The establishment of the national housing bank of Brazil (BNH) in 1968, has ensured a large output of housing, though linked with physical and social planning difficulties. In The Sudan, no such organisation exists.

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(1) Balula, A.E. op.cit.

It is suggested here that if a national housing policy were instituted, this would encourage private investment in this sector, although it has to be admitted that in other developing countries, such as Latin America, private investment has tended to be directed towards upper income housing. Whatever might have happened in the Sudan in this context, it is incontravertible to say that the establishment of a major housing programme acts, in itself, as a major employment market. The growth of employment in housing construction could have had a beneficial effect in supporting or establishing associated industries.

Since the Sudan became independent of British colonial rule on January 1st 1956, the country has moved through a period of political instability, with rapid changes of successive governments, which themselves lasted for one to three years. For this reason it must be admitted it is difficult to see how any effective socio-economic policy, let alone housing policy could have been established. The great ideological differences between political parties accentuated these difficulties.

Apart from political instability the main obstacle to housing and planning development is a total lack of recognition of the need for comprehensive physical planning ranging from national and regional level to the planning of rural areas and villages. What physical planning structure did exist, only applied piecemeal within the distinct boundaries of each major town. The allocation and zoning of land for housing needs was considered separately for each town by the Central Town Planning Committee in Khartoum.

There is no mechanism to allow for the evaluation revision and up-dating of physical plans and no overall development policy or progamme of priorities. In common with other developing countries, there is a tendency on the part of local authorities to select land for housing on the periphey of urban areas, and once selected, the proposals are sent to the Central Town Planning Committee for approval. The Central Town Planning Committee, without the framework of an outline physical plan, only checks the relationship of the proposed new extension of the urban area with adjacent developed areas, and urban growth proceeds in a haphazard and uncontrolled way.

The Report of the Royal Commission to East Africa[1] says:

> "Piecemeal measures, such as the provision of a limited amount of good housing, not only fail to solve the problem of improving the conditions, but may even make it more difficult by encouraging an increase in the urban population."

The report suggests the need for a comprehensive approach to the problem....

> "An overall urban policy, which takes all factors into account, for example the availability of land, population and financial resources, should be formed as soon as possible."

Despite these recommendations prior to Independence, no such policy was established.

The main obstacles to the establishment of an overall housing policy may be summarised as follows:

1) The modern concept of town planning was only established in the Sudan comparatively recently (1962). The number of technically qualified nationals in this field is still extremely low with approximately twenty qualified physical planners in the housing section of the Ministry of Local Government, which is responsible for physical planning policy throughout the Sudan.

2) There is an accute lack of financial support for all technical divisions in government departments, and in particular in the fields of housing and town planning.

3) What town plans have been prepared only apply to the largest cities. No planning framework has been prepared for the development of rural areas.

4) Present regulations do little to support any physical planning proposals. Contradictory regulations exist for the provision of land and services, industrial investment, and building regulations. Regulations do not apply to the Central Department of Water and Electricity or The Department of Water Provision, both of whom may acquire urban land without prior approval of the Central Town Planning Committee.

5) There are no trained personnel in Social and Community Development.

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(1) The Report of the Royal Commission to East Africa (1953-1955) "Urbanization and Housing" pp.223-232. H.M.S.O. London 1955.

6) There is a lack of co-ordination between the few specialized departments which do exist. For instance within the Ministry of Local Government there is no central planning policy between the low-cost housing section, the town planning section or the land distribution section. The survey department, urban land registration department and the infrastructure services department exist outside the framework and control of the Ministry of Local Government. Responsibility for infrastructure provision is shared between The Central Department of Water and Electricity, The Ministry of Construction and Public Works, The Department of Water provision and the local municipalities. The Central Town Planning Committee is responsible for approving development in housing and agricultural areas.

In other developing countries help has been sought from the physical planning and housing organisations within the United Nations and it is suggested here that international technical expertise should be sought more enthusiastically by the Sudanese Government. It is essential that some form of comprehensive physical planning procedure is developed as quickly as possible both for urban and rural areas; and which takes cognisance of the social, economic and geographical features of each region. The haphazard planning policies which did apply resulted in excessive horizontal expansion of the Three Towns Capital described in The Government paper, New Housing Policy 1975:

> "The areas of housing plots distributed in the city of Khartoum during the Ten Year Plan period and the public and private investment used to develop these areas would have been quite enough to house the whole Khartoum population up to 1986. This would have been quite possible, if the oversized housing plots and wide roads were controlled according to the limited available natural resources."

The masterplan for the development of Greater Khartoum, which the Sudanese Government commissioned the Italian MEFIT Group to prepare in 1975, is still awaited.

2.6.4. Technical expertise in housing construction

In general, there was no technical expertise available in government departments to ensure that houses were built to adequate standards of safety. Whereas standards were applied to building materials and housing layouts, only design drawings were monitored and there was no attempt to inspect houses during or on completion of construction. Changes were invariably made after approval of design drawings, particularly with regard to the choice of building materials in lower-income housing. Standards of thermal comfort were worsened and open pit latrines replaced a waterborne sewage disposal system. Structure safety was not ensured and resulted in the collapse of large numbers of houses, where skilled building labour was not employed. The lack of skilled labour was, ironically, responsible for higher building costs because of ineffcency. Foundations were excessively large or else inadequate, requiring remedial work. Housing for families in the 3rd and 4th income categories was built using unskilled labour and without the use of architects or engineers. No codes of practice were issued, particularly for the use of imported building materials.

A Building Research Unit was established in 1970 at the University of Khartoum, in an attempt to improve building standards and techniques. It still operates within a low budget and has, to date, had minimal influence.

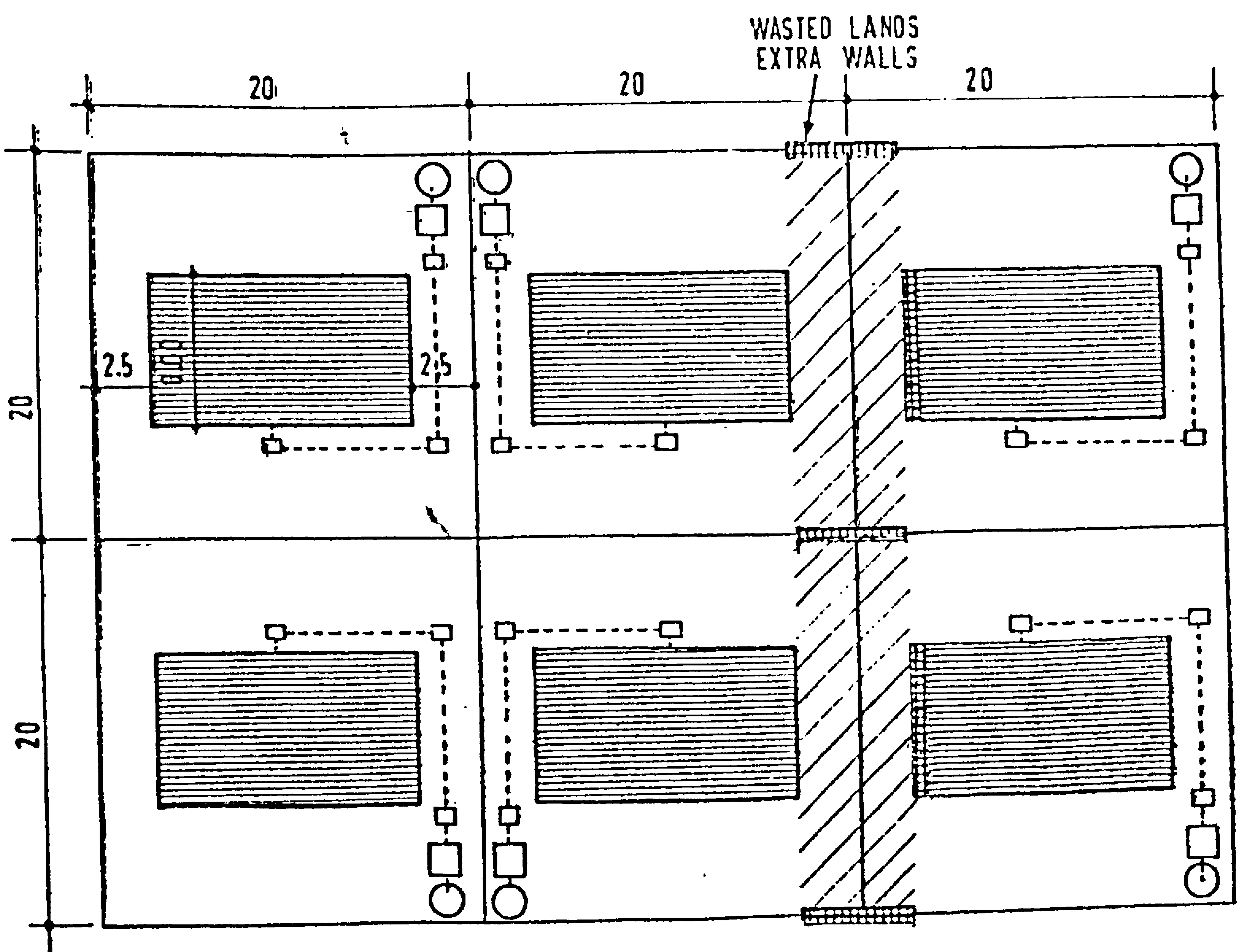
2.6.5. Government control of building standards

Apart from the lack of adequate building regulations and controls, building materials are not subject to specific dimensions and weights. Because of the increasing market demand for building materials there is a tendency for materials to be supplied substandard in both qualitative and quantitative terms. Government architects are forced to accept lower standards if only to ensure completion of contracts within reasonable programmes.

There is no price control system, a situation further exacerbated by the lack of wholesale organisations. Local building materials are subject to seasonal supply variations. Imported materials are via Port Sudan and the rail link to Khartoum. During the 3 months rainy season this rail link is often impassable due to flooding; with a consequent increase in the cost of delivered materials.

2.6.6. Role of the municipal building regulations

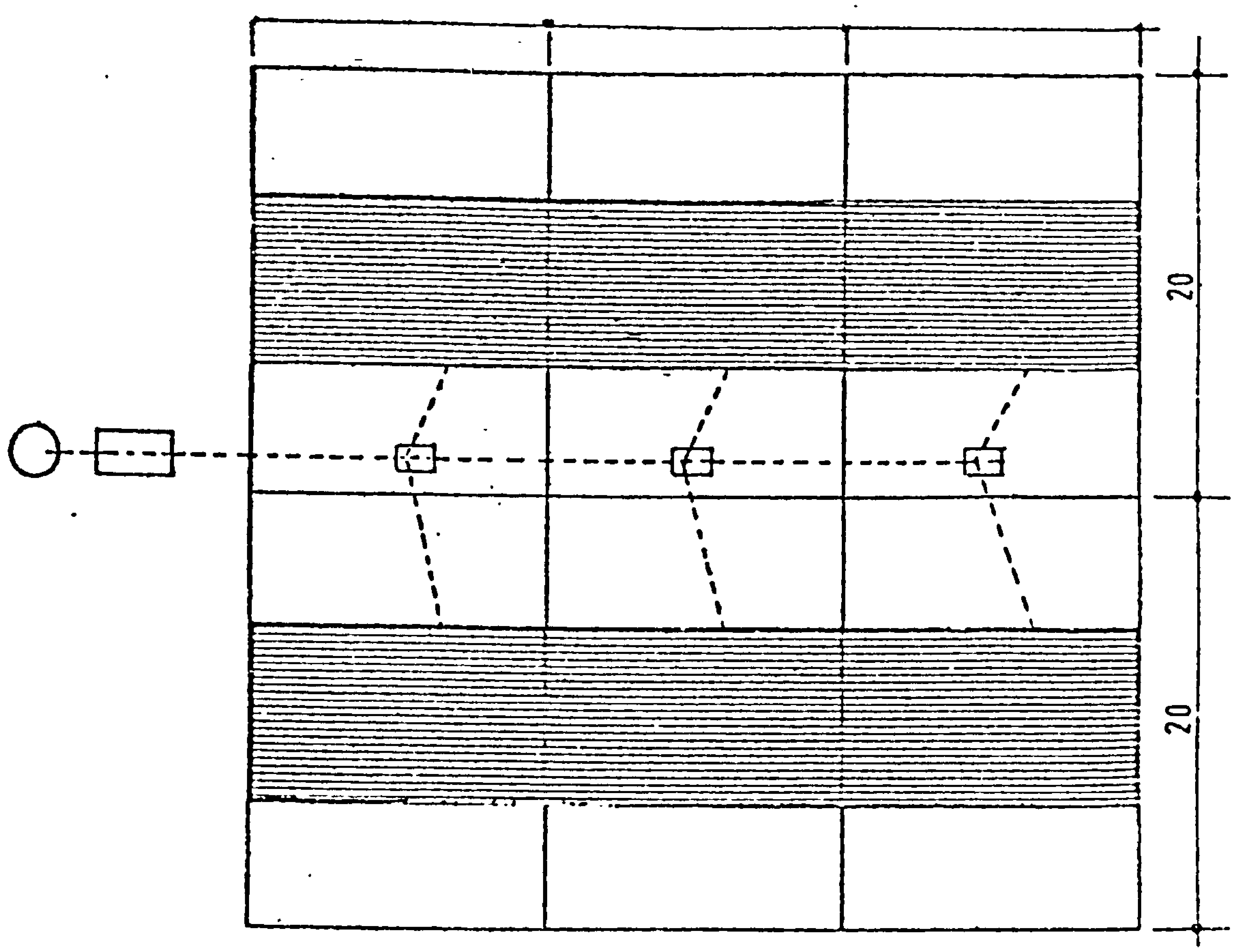
Local municipalities in the Three Towns Capital, in establishing building regulations and housing standards, paid little regard to the economic framework. Houses in the Third income group category are supposed to be constructed of first class red brick, with roofing material of either corrugated iron sheet or zinc. In practice, this rarely happens. All houses are supposed to be detached with a minimum distance of 2.5 metres between structures. The minimum plot size is set at 300m^2. The cost of meeting these requirements is excessive and worsened by the additional infrastructure costs caused by long frontages. All underground services must have separate connections to the mains system and shared systems between adjacent houses are prohibited. The accompanying advisory plan indicates the lack of realism on the part of municipal authorities. Each house has a separate sewage disposal system.



LAYOUT ACCORDING TO EXISTING BYE-LAWS

Source: HAMDI,M. Dept. of Architecture University of Khartoum 1971

The following sketch shows a similar group of six houses utilising a more economic site layout. This proposal utilises far less site area as well as economizing an infrastructure layout; though the area of each house is not reduced in any way.



Source: HAMDI, M.... op.cit.

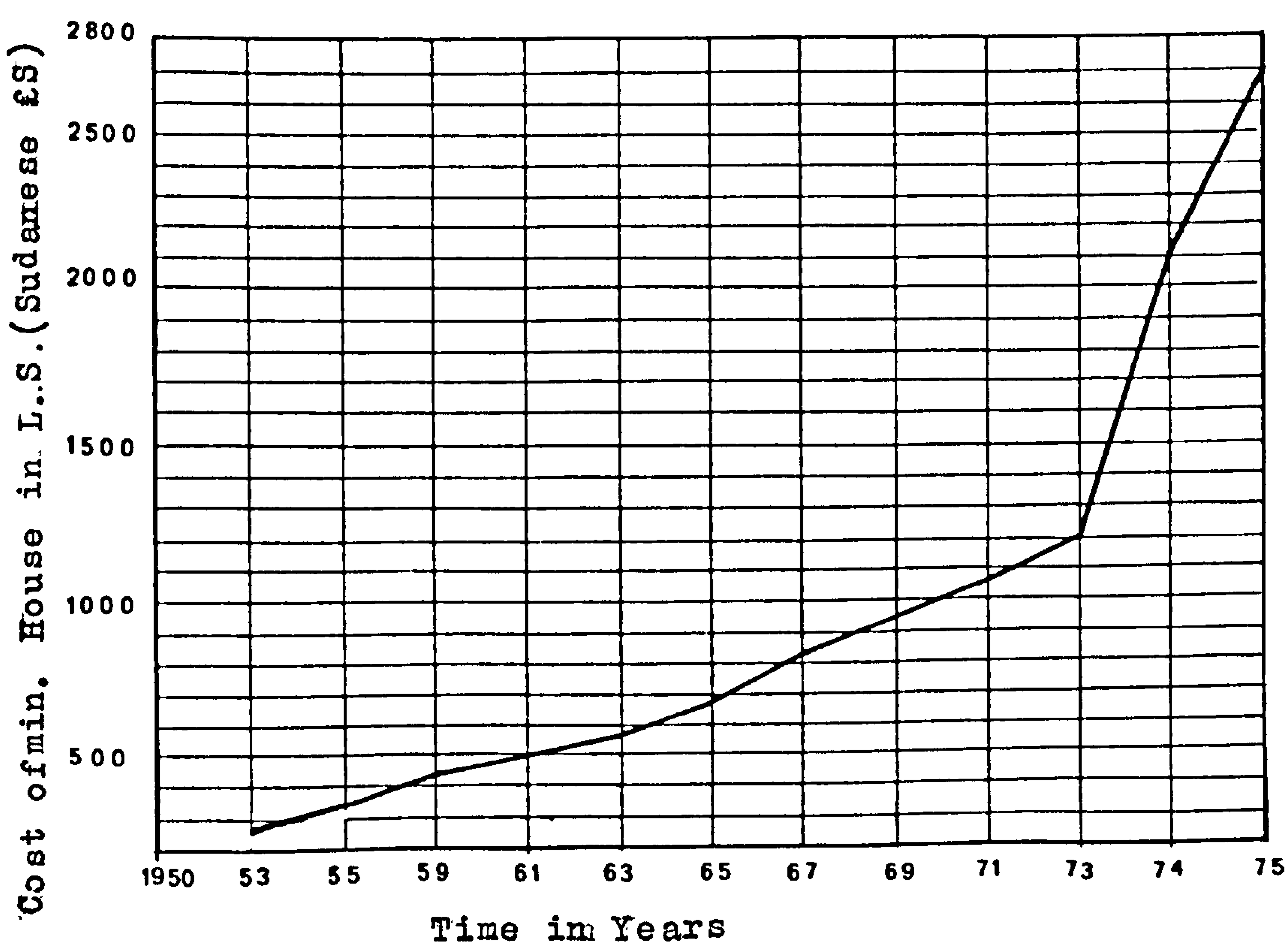
The result of the imposition of these high standards is that few houses in that income category get built with official approval. The table below shows the increase in costs in housing of this type between 1953-1973 and the equivalent increase in earning capacity.

Table 20 Increase in the Cost of the Minimum House (2 roomed house without land cost) in Government Schemes 1953-73

Year	Cost of Minimum House in L.S. (Sudanese pounds)	Tenant's Monthly average income
1953	250	25
1955	330	28
1959	410	30
1961	490	33
1963	557	37
1965	680	45
1967	820	55
1969	950	61
1971	1050	69
1973	1200	80
1974	2100	100
1975	2700	108

Source: HAMID, A. (Director of National Housing Authority) Khartoum 1973

The table shows a continuous and widening gap between the average tenant's income and the cost of a minimum standard house. If the minimum standard house costs an average of two man-working years, it was costing him almost seven man-working years in 1973. The graph below illustrates the rise in the cost of minimum standard housing between 1950-1975.



According to The Omduman Household Budget Survey [1], only 35% of urban households and only 15% of urban employees would be able to purchase the cheapest conventional dwellings during the 1961-1971 Ten Year Plan.

2.7. Summary

It is clear that the efforts of the Sudanese Government since independence in 1956, had been far from effective in solving the urban housing problem. Lack of public and private resources has been a major contributory factor, but the real fault lies in the lack of any well-directed policy.

The lack of co-ordination and the division of responsibilities between a multiplicity of government and municipal departments has made any national housing development programme of little relevance. There has been a tendency towards piecemeal solutions and planning by expediency. The lack of a co-ordinated policy has led to a number of planning problems:

1) Oversized plots which are not distributed according to immediate family needs and future expansion, but merely according to economic ability.

2) Absence of space standards in housing, according to social traditions or economic ability.

3) Lack of technical guidance and control, resulting in Thermal discomfort and health hazards.

4) Rigid time limits imposed on householders to complete houses to the required minimum constructional standards, regardless of their economic ability to pay.

5) Inadequate marketing system which prevents a low income family from being eligible for a residential plot within less than ten years of permanent residence.

All these factors, combined with uncontrolled and continuous migration to the urban areas, lack of infrastructure construction and excessive horizontal expansion accelerated the process of urban decay. The concentration of all financial investment in

(1) Omdurman Household Budget Survey. Republic of the Sudan. Dept. of Statistics, Khartoum 1965.

in industrial, commercial, educational, health and community development in the Capital only served to encourage mass rural emigration.

The acute shortages of modern building materials, skilled labour, technical knowledge and management served to prevent a co-ordinated housing programme. Imposition of unrealistic building regulations, disposal of oversized plots increased not only building costs, but also infrastructure costs and created development at uneconomic densities. Overall housing costs accelerated beyond the means of the lower income groups in urban areas.

There was no government initiative in providing for the housing needs of low income groups, but rather ~~rather~~ resources and technical effort was chanelled towards the provision of housing for a minority of relatively well paid government employees. The taxation system did little to encourage private investment in low income housing. Only 1% of total housing needs were met through government investment during the Ten Year Plan (1960-1970). It is suggested that even the minimum investment of government during this period should have been devoted to the provision of residential plots for low income groups than the construction of an extremely small number of houses. 40,000 unserviced plots were distributed during the Ten Year Plan but according to Ahmed(1), this was totally inadequate to serve the demographic needs.

The urban housing deficit beyond 1970 was estimated to be 136,160(2). This official deficit, encouraged the spread of squatter settlements within and on the periphery of the Three-Towns Capital. The diagram below illustrates the relative ratios of land occupation, a situation made more serious in the following compartive table of the housing deficit in other developing countries.

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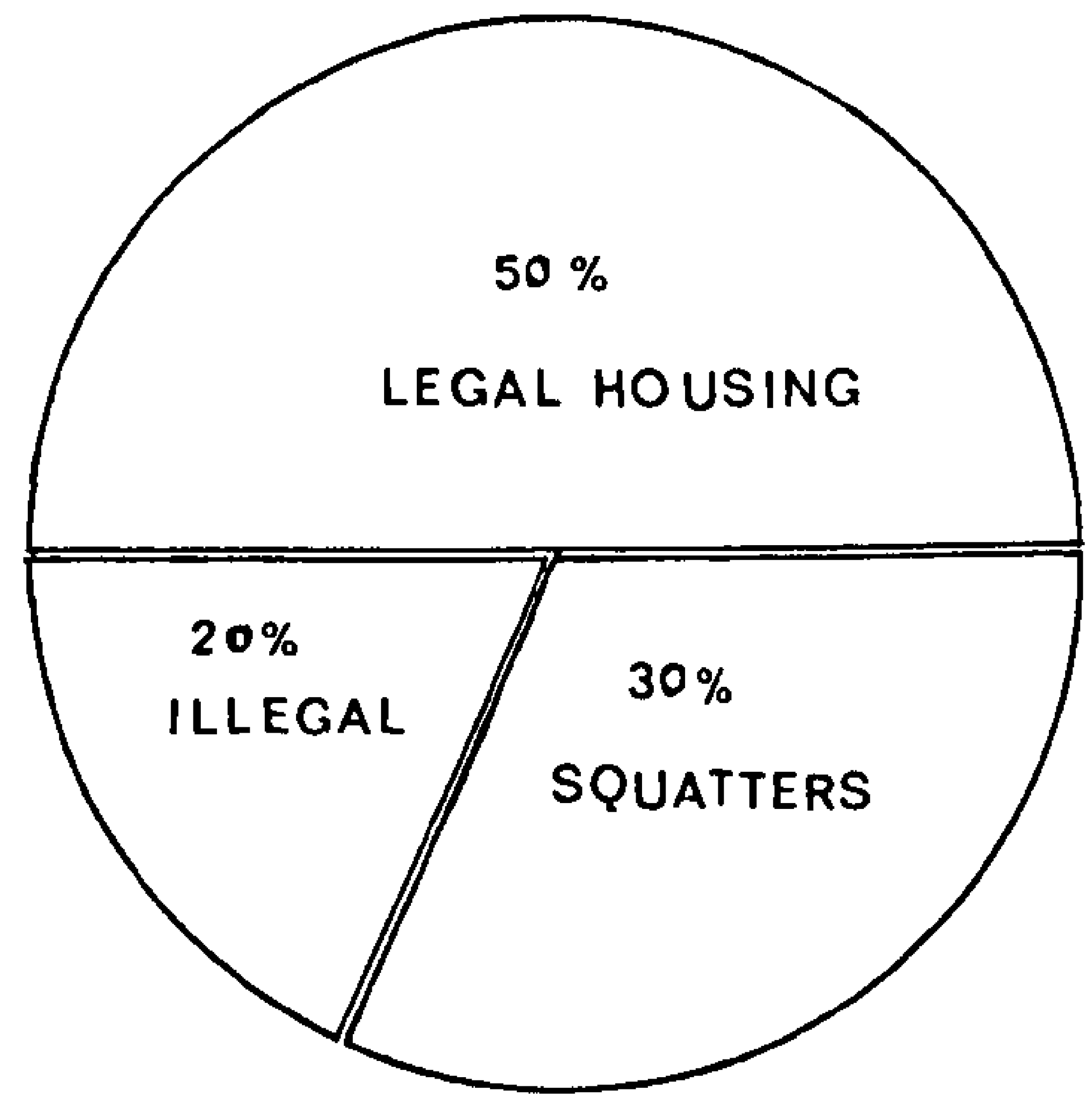
(1) Ahmed, A.K.M. Op.cit.

(2) "Household Sample Survey" Dept. of Statistics, Government of the Sudan 1970.



Relative Ratios of Land occupation in Khartoum

Table 21 Sudanese Capital's Housing Deficit Compared with some developing countries.

Country	% of squatting and illegal housing
Three-Towns Capital - SUDAN	50%
Bogota - Colombia	50%
Managua	50%
Mexico City	46%
Ankara - Turkey	45%
Brasilia	41%
Calcutta - India	33%
Caracas - Venezuela	30%
Lima - Peru	25%
Santiago - Chile	25%
Manila - Philippines	20%
Singapore	15%
Kingston - Jamaica	12%

Source: Figures collected from A/D August 1963, EKISTICS 272 Jan. 1976 and Charles Abrama - Man's struggle for shelter.

Note: Squatter settlements are differentiated from illegal housing in that squatters settle in peripheral undeveloped areas where land ownership is uncertain - whereas illegal housing takes place usually in the villages within the urban area on land already in defined ownership. The owners of small plots sell a section of that plot to another family who erect a house without the permission and control of the local authorities.

Although some of the figures above are likely to be distorted since they are official statistics which probably underestimate the true size of illegal and squatter settlements, it is clear that the situation in the Sudan is considerably worse than in many other countries. The initial Sudanese government reaction to the squatter settlements was antagonistic. As soon as squatter settlements formed they were destroyed by bulldozing them to the ground. Like many squatter settlements throughout the world this only resulted in the inhabitants forming alternative settlements elsewhere in the urban areas.

Squatting and illegal housing became inevitable since the lowest income groups had no other means of establishing residence in urban areas. It is suggested that official recognition of such settlements must be inevitable and that improved conditions can be achieved only through such recognition. The provision of serviced plots would encourage low income groups to invest what resources they have in the construction of permanent houses to adequate standards on a self-help, self-build basis.

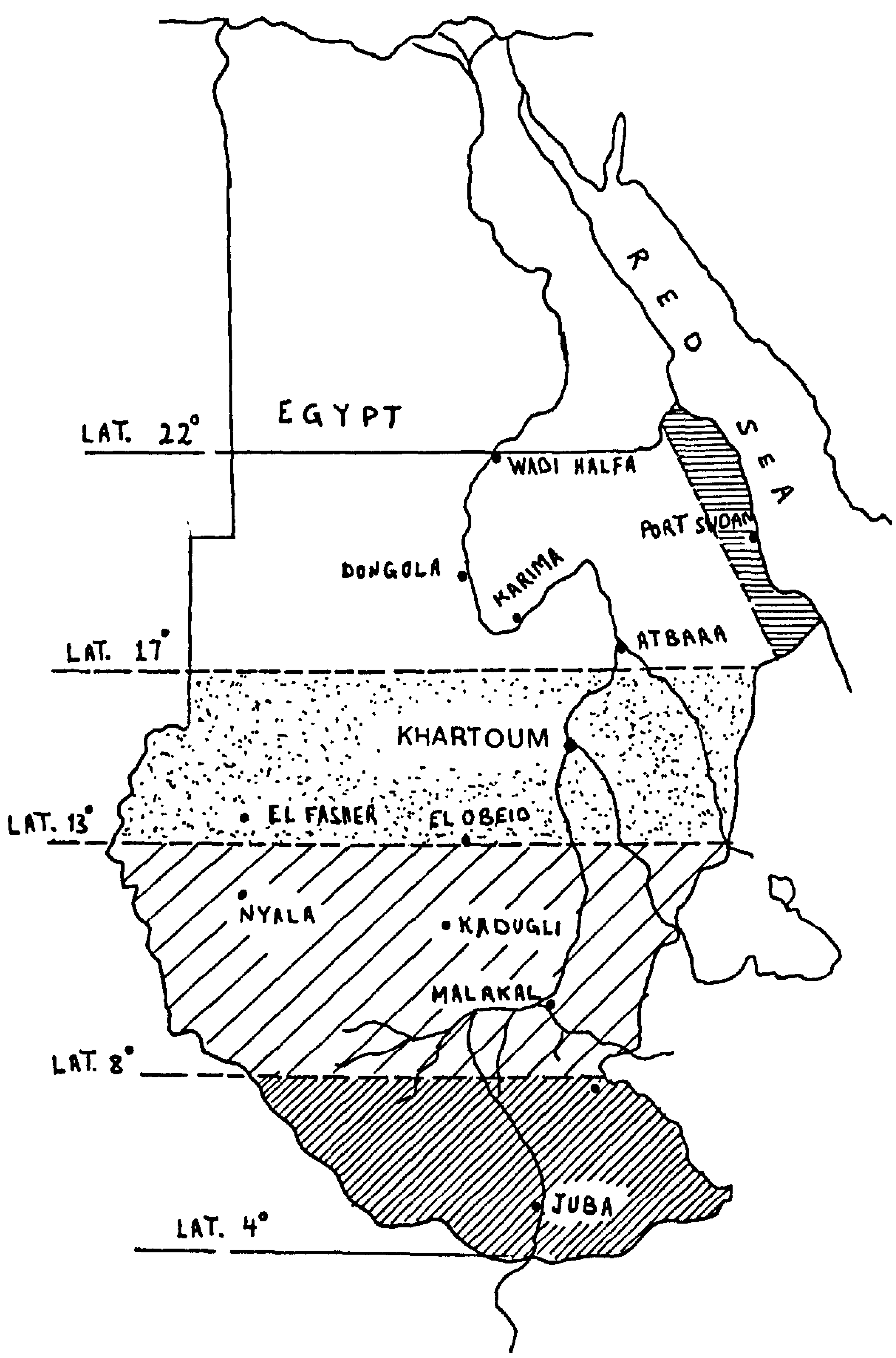
The following section discusses the climatic and social influences on Sudanese housing design which in turn forms a framework to indicate possible housing solutions for the dilemma outlined above.

CHAPTER 3

THERMAL AND TECHNICAL STUDIES

3.1. Climatic Divisions of the Sudan

The Sudan, broadly speaking, is a vast plain lying in the tropics between latitude 4^{O}N and 22^{O}N. Apart from the 'Sud' swamps in the South, there are no inland lakes or water surfaces large enough to produce local climatic conditions.



Climate Divisions of the Sudan

The country can be divided into five climatic zones (Sudan Meteorological Services, Khartoum 1973).

1. The Arid-desert zone between Latitude 17° - 22°N. This includes the whole Northern Province and has the typical desert features.

2. The Arid-Semi-desert zone between Lat. 13° - 17° N. This includes Khartoum Province, the plains of Kordufan, Upper Nile and the northern parts of the Blue Nile Province.

3. The Sub-humid Tropical zone ; comprising Western Darfour, some areas in Equatoria and Bahr El Gazal provinces where the elevation is more than 500 metres above sea level. This region is situated between Lat. 8° – 13°N.

4. The Humid tropical zone : situated between Lat. 4° - 8°N and containing the area along the southern border of the country in the Equatoria province.

5. The Red Sea coastal zone in the north east of the country.

These climatic zones cannot be separated by rigid lines as the characteristics of one zone merge gradually into the other.

A short summary of the basic climatic features of each zone is given below.

3.1.1. The Arid-Desert Zone

The region comprises the whole Northern Province and the northern parts of Darfour province. The plain is lifeless except along the banks of the Nile. It displays the typical desert conditions of scanty rainfall and extreme temperatures, and is characteristic of very poor pampas with very little or no vegetation. In winter it is often bitterly cold and strong dry winds sweep across the open plains at a temperature well near zero centigrade, while on summer days it is hotter than at sea level.

Clouds are rare, sunshine is abundant throughout the year and, the summer temperatures are among the highest known on the earth. However, the clear dry air also results in the rapid loss of heat from the bare ground after sunset, and the cool nights are refreshing. At night the rocks and sand lose their heat almost as rapidly as they acquired it, and this cooling process is further enhanced by the stillness of the air. The Relative Humidity is low throughout the year, helping to make the high temperature more tolerable.

TEMPERATURE in this region is very extreme. At Wadi Halfa the maximum temperature ever recorded is 52.5^{o}C; usual summer temperatures are around 49^{o}C. The average minimum on a winter January night is about 4^{o}C but temperatures of 1^{o}C are fairly common. Naturally, the winter nights are colder further north, the lowest January minimum of 2^{o}C being recorded at El Sheikh Fadl, at the border between The Sudan and Egypt.(1)

RAIN or even cloud cover is seldom seen, the mean annual rainfall over the whole area being less than 25mm, and practically nil in the north west border with Libya. If the air is sufficiently cooled when rising over mountains, by cyclonic or convectional movement, there may be occasional violent rain storms when as much as 40mm can fall in a single storm in regions which have been without rain for years. The wadis may overflow and cause much damage, but also renew the underground water-supplies.

RELATIVE HUMIDITY is very low due to the fact that trade winds travelling over vast plains of bare land become warmer and therefore drier. In addition, as it descends the air is warmed by compression on reaching denser strata, and because it is not receiving any moisture, its relative humidity decreases. The Summer relative humidity mean rarely exceeds 20%.

Prevailing WINDS throughout the year are northerly, very hot in summer and very cold in winter. Summer "Haboobs" associated with afternoon showers may occur occasionally in the southern region. The winter is characterised by strong winds blowing sand on most mornings and the occasional arrival of cold fronts from the northern Saharais followed by cold polar air causing moderate to

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(1) KUBA, G.K. "Climate of the Sudan" National Building Research Station, Khartoum September 1968.

severe dust-storms. The arrival of a cold front can cause considerable precipitation in the far north. The transitional period is short with small seasonal fluctuations.

3.1.2. The Arid-Semi Desert Zone

This region comprises the whole Khartoum province, most of the Upper Nile and the northern parts of the Blue Nile province. The region is associated with a certain type of desert landscape and sparse vegetation. The basic characteristics of this hot-dry region are the predominance of clear skies and high diurnal range of temperature associated with a low relative humidity. For example, Khartoum has a mean diurnal range of $14^{o}C$.[1] Hot-dry summer persists for approximately two-thirds of the year and during the other third moderate winter conditions prevail.

The early summer is dry and hot and with the rainfall in the late summer there is high humidity and a constant temperature. The highest temperatures occur in May and June, producing uncomfortable conditions which persist until the arrival of the rainy season. The rain is preceded by strong Southerly winds and sand-storms. Winter is the most favourable season with generally moderate temperatures, cool nights and low humidity.

Throughout the year skies are clear with few clouds because of the low humidity of the air. Towards the end of the hot period, dust suspended in the air may create a white haze, which produces a diffuse light and a painful glare. The lack of cloud cover results in a fairly rapid cooling action towards the evening and accounts for the high diurnal range of temperature. The range of temperature is usually modified during the short rainy season or during the occurence of severe dust-storms known locally as "Haboobs". These dust-storms are very common in summer when the atmosphere is subject to a daily variation of dust content which, significantly, is higher in the afternoon.

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(1) Summary of Meteorological and rainfall Observations Khartoum Station 1967.

Unlike the desert, the sand is stable, anchored by sparse vegetation nurtured by the limited rainfall. The brown and red barren ground changes rapidly and dramatically with the rain. The landscape becomes green and fertile within a few days and plants grow quickly. In the cooler period vegetation covers the ground, but diminishes as the temperature rises. The soil is damp during the rains but it dries out quickly and there is a risk of soil erosion during summer monsoons.

Khartoum province, the subject of the present study, lies in this region and a detailed account of its climate is discussed subsequently.

3.1.3. The Sub-Humid Tropical Zone

In this region temperature and humidity are fairly high nearly all the year round. Rainfall is abundant, ranging from 500mm in the north to 1000mm in the south(1) and the wet season varies accordingly.

There are considerable variations in the altitude of the country. The valleys of the Blue Nile and the White Nile, being only a few hundred feet above the sea, have less rain but much higher temperature than the uplands and they are heavily forested in many parts. In this central belt the rains last longer than in the north; at Kadugli from May to September, at Malakal from April to October. The temperature is lower during the rains due to the evaporation and the presence of clouds, but rises again in the dry season. During the rainy season, the rivers, Bahr El Gazal, Bahr El Arab, Sobat and many smaller streams which dry in summer, are swollen by flood water and much of the area south of Malakal becomes a great lake.

Air temperature in the shade reaches a mean maximum during the day of between 28°C and 35°C, but occasionally, especially in the dray season, it may far exceed these levels. Temperatures as high as 43°C may occur, especially in the northern area but usually the temperature falls appreciably at night when the mean minimum varies between 21°C and 27°C. Both the diurnal and annual

(1) Climate of the Sudan. Sudan Meteorological Service. Khartoum. Undated Note.

ranges of temperature are narrow.[1]

RELATIVE HUMIDITY remains high compared with the previous regions, and is usually about 50% for most of the wet season but may vary from 40 to 70%. The dry winter season is of longer duration here than in the southern area and during this period humidity is fairly low. Vapour pressure is steady in the region of 2000 to 3000 N/m.

Sky conditions are fairly cloudy throughout the year. Cloud cover varies between 50 and 80%. In summer skies are bright with a Luminance of 7000 cd/m or even more when it is thinly overcast. When heavily overcast, the sky is dull, 850 cd/m or less.

WIND velocities are generally low and calm periods are frequent. Strong winds usually occur during rain squalls, but cold fronts are relatively rare. Dust-storms may occur in the northern region.

The predominant wind directions are north-east in summer and south-west in the wet season.

3.1.4. The Humid Tropical Zone

This region comprises the whole Equatorial province in the southern part of the Sudan and has a typical equatorial climate, chiefly characterized by a very abundant rainfuall. The rainy season, which extends over nearly the whole year, is coupled with high relative humidity and a small range of temperature. The trees grow rapidly and luxuriantly. The temperature never falls below 21°C at night, and usually remains between 24°C and 31°C throughout the twenty-four hours. The air is almost always heavy with moisture and as a result solar radiation is considerably reduced.

Very violent thunderstorms are frequent. The mean annual rainfall exceeds 1500mm along the edges of the White Nile delta and decreases northward to about 1250mm in Juba and 1000mm in

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(1) KUBA, G.K. op.cit.

Akobo.[1] The higher land on both sides of the White Nile probably has a heavier rainfall. June, July and August are the wettest months.

There is very little seasonal change throughout the year, the only variation being periods with more or less rain and the occurence of gusty winds and electric storms.

AIR TEMPERATURE in the shade reaches a mean maximum during the day of between 24^{o} - $28^{o}C$ and at night the mean minimum varies between 18^{o} - $24^{o}C$ with quite narrow diurnal and annual ranges.[1] Solar radiation is partly reflected and partly scattered by the cloud blanket or the high vapour content of the atmosphere: the radiation reaching the ground is therefore diffuse, but strong, and can cause painful sky glare. Cloud and vapour content also prevents or reduces outgoing radiation from the earth to the night sky, so the accumulated heat is not readily dissipated.

RELATIVE HUMIDITY is very high and the vapour pressure is steady in the region of 2500 to 3000 N/m. Precipitation is high throughout the year, generally becoming more intense for several consecutive months in the wet season. Annual rainfall can vary from 2000 to 3800 mm and in the wettest month may exceed 350 mm. During severe storms rain may fall at the rate of 80 mm/hr. for short periods.

Southerly WINDS prevail nearly all the year. The northern wind which arrives in December, prevails until mid-February. Having collected heat from the land on its movement from the north, it is a hot dry wind and brings about a decrease in relative humidity, producing a reasonably comfortable climate in spite of a rise in temperature.

Vegetation in this region grows quickly due to frequent rains and high temperatures and is difficult to control.

3.1.5. The Red Sea Coastal Zone

This region comprises the coastal belt of the west bank of the Red Sea in the north-east part of the Sudan. It is situated in the Saharan zone, but due to the presence of the Red Sea its climate is subject to special variations. The conditions of Port Sudan,

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(1) KUBA, G.K. op.cit.

the capital of this region, and those of Khartoum, compared in terms of mean temperature and rainfall, it may be said that conditions in both places are similar. However, because of the coastal position of Port Sudan and the incidence of breezes from the Red Sea, the yearly mean relative humidity is 63% compared with only 30% in Khartoum, although the yearly mean rainfall of 164 mm at Khartoum is higher than the yearly mean rainfall at Port Sudan (110).[1] The incidence and relation between air temperature and relative humidity at Port Sudan is more in line with conditions in hot-humid areas, though theoretically it is situated in the Saharan region.

The Red Sea coast is distinguished by its high humidity and small range of temperature as compared with the rest of the Sahara. Temperatures range between 24-36^{o}C as the annual average and are coupled with high relative humidity almost throughout the year. At the time when maximum temperatures are recorded, in July and August the average Relative Humidity is low, but the diurnal values are dependent upon the wind direction. Slight sea-breezes may raise the humidity within hours. The mean relative humidity is 49% in summer and 72% in winter.[2]

Light rainfall occurs throughout the year, with the maximum amount falling in October - December. The mean annual rainfall is 120mm, most of which falls during the winter months when the hot moist wind from the Red Sea meets the cooler hills inland. There is copious dew at night caused by the cooling of the warm moisture-laden air; the water deposited often equals a heavy shower of rain.

Throughout the region, AIR TEMPERATURE in the shade reaches a day time mean maximum between 34^{o}C and 36^{o}C. At Suakin the mean temperature in August is 35^{o}C, in January 24^{o}C, the daily range of temperature averages 11^{o}C in summer and only 5^{o}C in winter. August is the hottest month and February the coolest.

This area is famous for the summer dust-storms known as "Hababai", caused by the southerly wind bursting through the gaps in hills. In spite of the lower Relative Humidity the worst season

(1) Miles Danby "Design of Buildings in Hot-dry Climates" Build International (6) 1973 p.56

(2) KUBA, G.K. ibid.

is the summer. During the Winter there are reasonably low temperatures although the relative humidity is still high, and the refreshing northern wind and reduced solar radiation make conditions pleasant and bearable.

The following is a record of the mean Air Temperature and the mean Rainfall of Port Sudan, the capital of this Region:

MEAN TEMPERATURE ($^{\circ}$C)

Alt.(ft)	J	F	M	A	M	J	J	A	S	O	N	D	Year	Range
18	24	24.5	25.5	26.6	30.2	33.1	34.6	35.5	34	30.8	28.5	25	29.8	11.5

MEAN RAINFALL (mm)

Alt.(ft)	J	F	M	A	M	J	J	A	S	O	N	D	Year
18	5	3	3	3	4	0	11	6	0	14	52	26	127

Source: Summary of Meteorological and Rainfall Observations......op.cit.

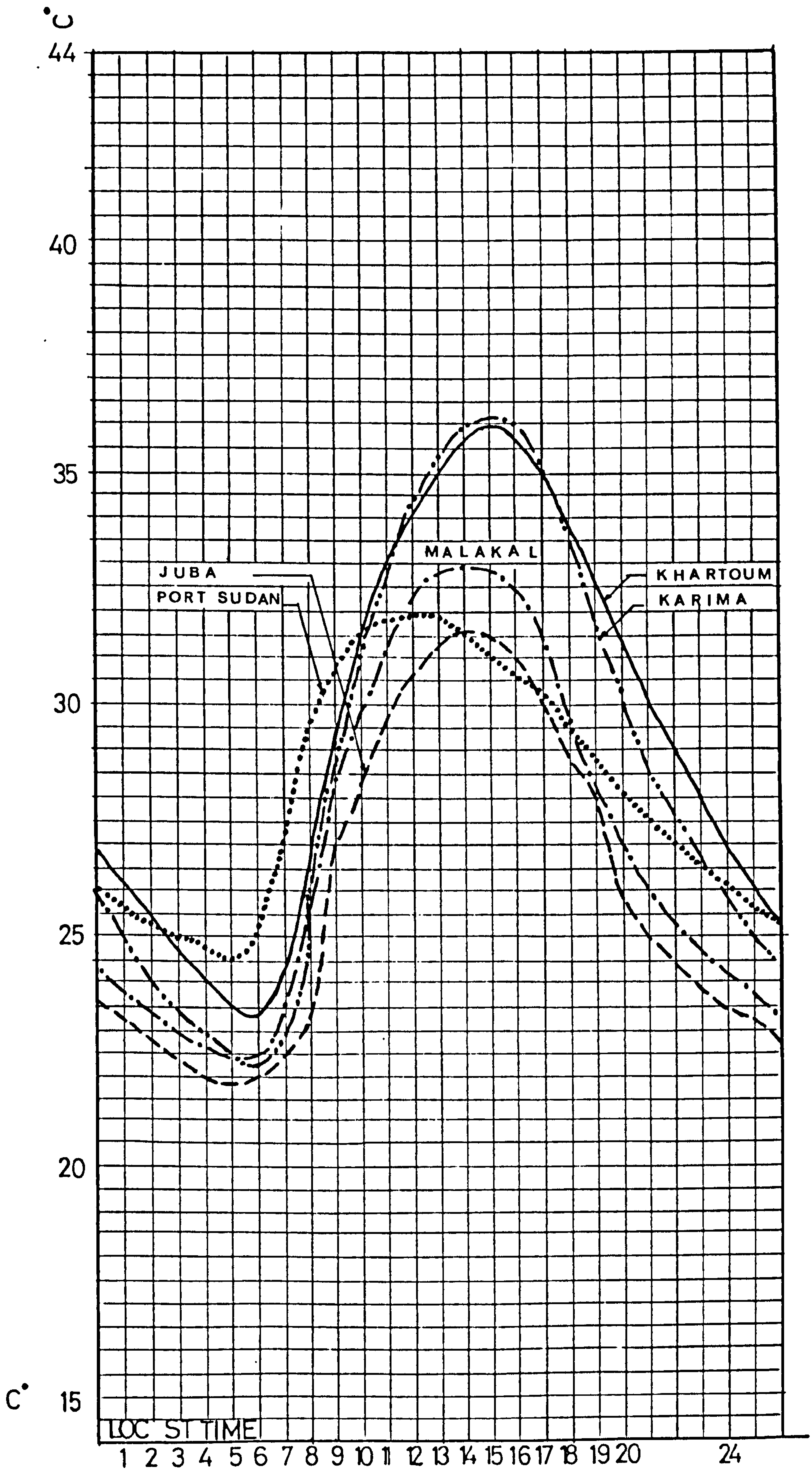
3.1.6. Graphic Summary of the Climatic Features in the Five Zones

Since the climatic features of any geographical region are better understood when they are graphically represented, the graphical summary shows the Sudan's five climatic zones. The graphs are drawn according to the weather norms of one town in each zone.

The first graph represents the Hourly Mean Temperature of the Five zones : (next page)

From the graph it is clear that Karima and Khartoum are the hottest towns in the country with mean temperatures of about 36°C. Malakal and Juba have the lowest hourly mean temperatures, obviously due to the longer duration of the wet season and to the presence of considerable cloud cover which reduces the amount of solar radiation.

Port Sudan, although it lies in the Saharan region, experiences considerable reduction in its hourly mean temperature due to the presence of Red Sea breezes.


°C
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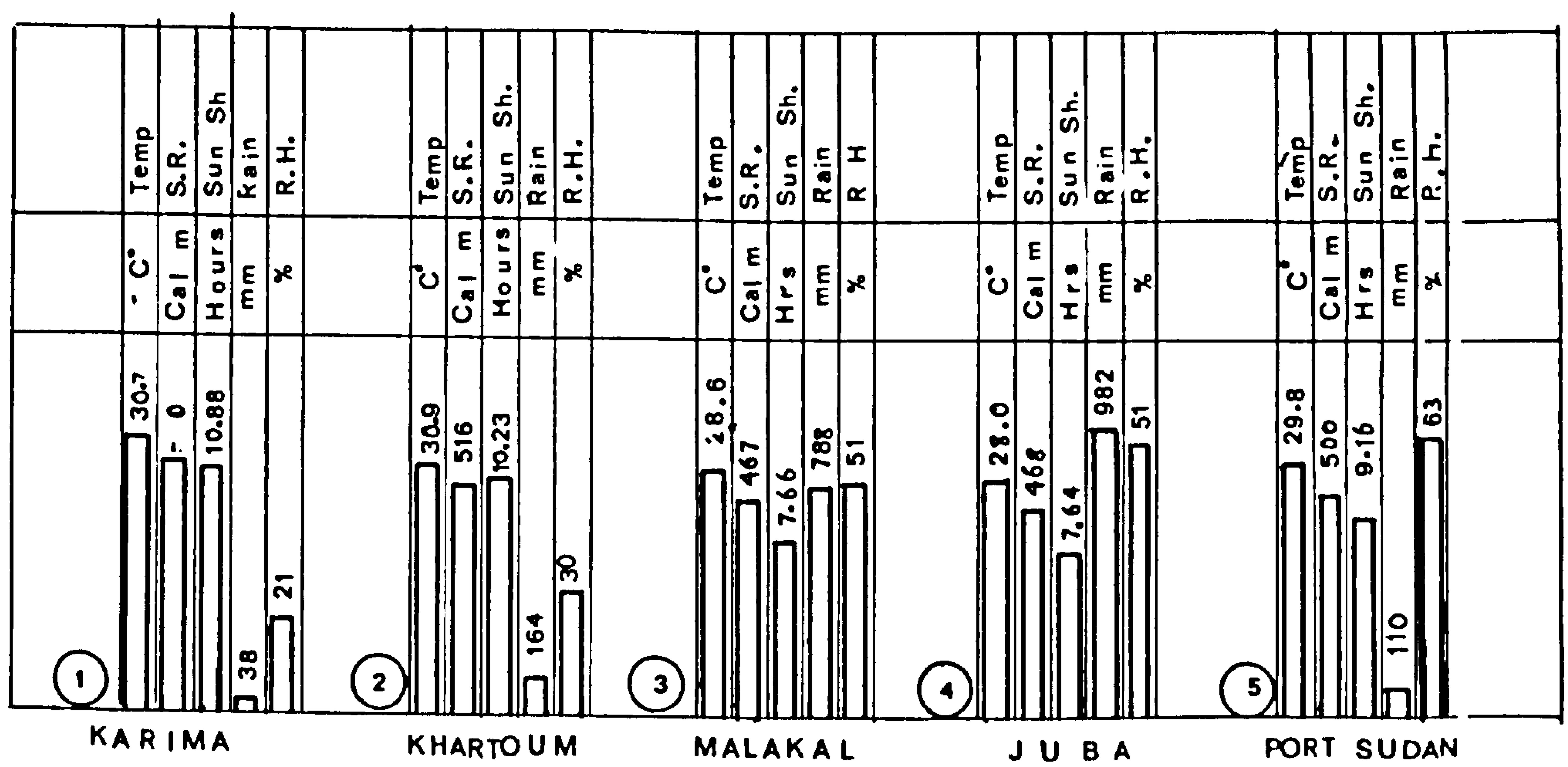
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 24

The next graph shows a summary of the Yearly Mean Records of Temperature, Solar Radiation, Sunshine, Rainfall and Relative Humidity for the five zones :



Source: drawn from records supplied by the Sudan Meteorological Station. Khartoum.

Again it is clear that, Karima and Khartoum receive the minimum amount of rainfall while the two southern capitals Malakal and Juba receive the maximum rainfall. The Relative Humidity graph shows that Karima and Khartoum are very dry throughout the year while Malakal, Juba and Port Sudan show a considerable amount of humidity.

The last graph gives a complete picture of Rainfall, Relative Humidity, Sunshine hours, Monthly mean Temperatures and Solar Radiation in the five zones. It comprises graphic summaries of each region arranged above each other to give coherence and to show the influences of different climatic effects upon each other.

CLIMATICAL NORMS FOR THE FIVE CHARACTERISTIC PART OF THE SUDAN

Source: Drawn from records supplied by the Sudan Meteorological Station, Khartoum

From the graph the decreasing amplitude of temperature diagrams going from north to south and the alteration in rainfall and relative humidity become obvious justifying the subdivision of the country into zones. There are some fluctuations in the solar radiation diagrams where they deviate from the temperature lines, especially in the southern zones where the total rainfall is high and the number of cloudy days consequently increased. This discrepancy, stated in the Khartoum Meteorological Station reports, arises because the data covers only a period of three years for the southern zones, while for the other areas mean figures ranging over 30 years were used.

3.2. The Climate of Khartoum Province

Khartoum, the capital and biggest urban centre of the Sudan, located at latitude 15-36°N and longitude 32-33°E, lies in the middle of the arid sub-desert climatic zone described above. This area can be said to have two main seasons[(1)]:

1. A summer (April - October) which is hot and dry at first (April-June), becoming slightly humid and a little cooler later (July-October).

2. A winter (November - March) which is described as a season of generally cool and pleasant weather. The relative humidity is, however, uncomfortably low. There are occasional warm spells of varying duration. Less frequently, in December-February, the area is affected by cold air arriving from the Sahara desert in the North west.

Meteorological averages for the Khartoum area are given in the following table:

(1) Climate of the Sudan. Sudan Meteorological Service, Khartoum. Undated note.

Table 22

Item	Summer-dry (April-June)	Summer-wet (July-Oct.)	Winter (Nov.-March)
Mean Daily Max.temp. °F	103.6	95.5	93.7
Mean Daily Min.temp. °F	73.6	73.0	60.6
Mean Daily Range °F	30.0	22.5	33.1
Mean Relative humidity	30%	62%	31%

Source: Climate of the Sudan. Khartoum. Undated Note.

From the table it is clear that Khartoum has the same typical features of hot dry climate with high diurnal range of temperature and very low relative humidity. A mean relative humidity range of 30% clearly reflects the prevailing water deficiency arising from the high evaporation rate relative to precipitation. It will be seen, however, that the severest weather conditions, from the thermal point of view, are likely to occur during the early part of summer (April-June) when the highest daily maximum temperatures, the largest diurnal temperature fluctuations, the longest sunshine hours and the greatest intensities of solar radiation are to be found.

In this region winter does not pose a problem. With a mean daily minimum temperature of 60.6°F the short winter does not necessitate the heating of buildings.

3.2.1. Air Temperature

The following table gives the Khartoum Mean Temperature:

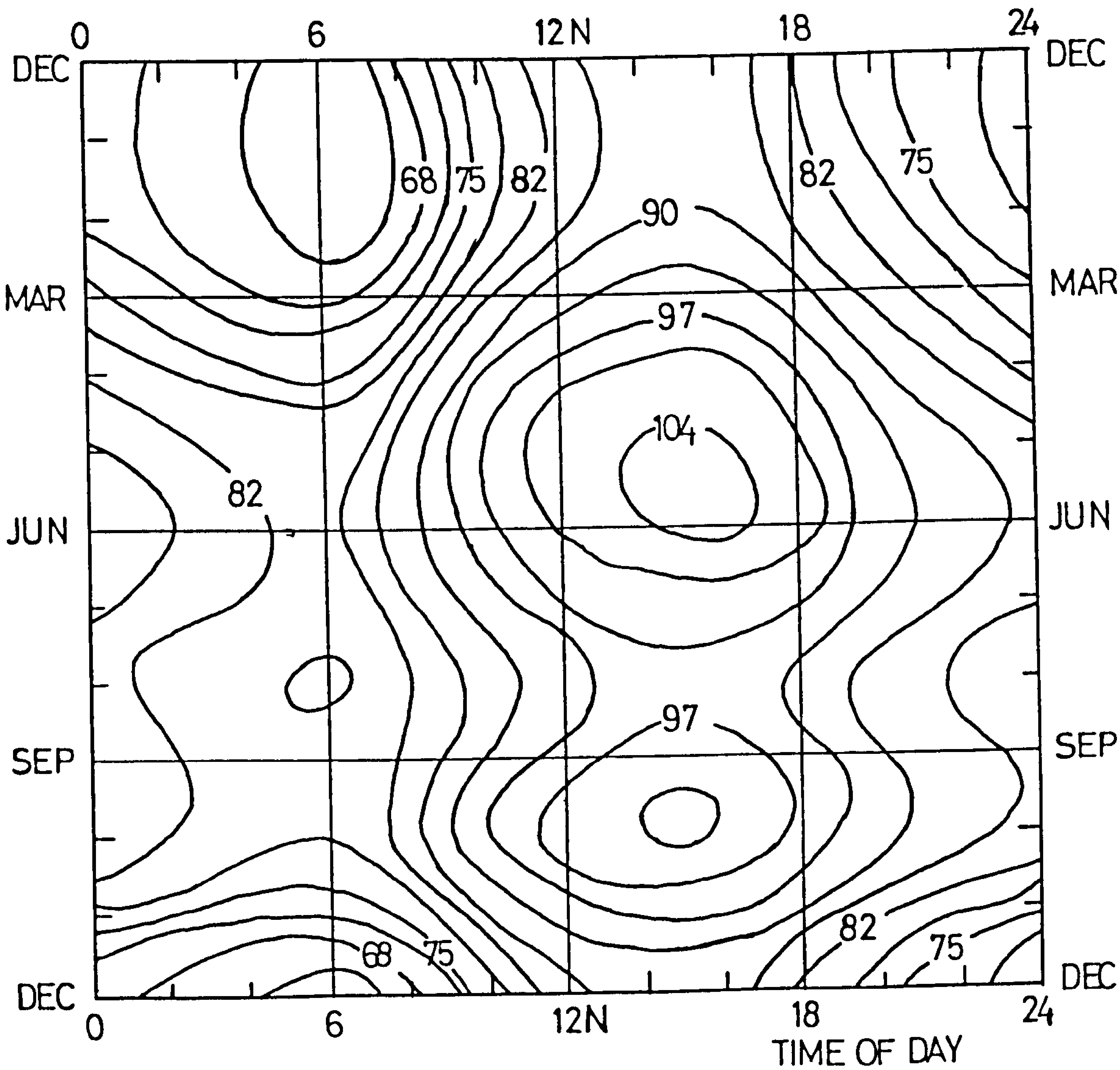
Table 23: Khartoum Mean Temperature in °F

Alt.ft.	J	F	M	A	M	J	J	A	S	O	N	D	Range
1,280	70.3	73.4	79.2	86.0	91.7	91.4	88.5	86.5	88.2	87.4	80.2	72.1	21.1

Source: Summary of Meterological Observations. Khartoum Station 1967.

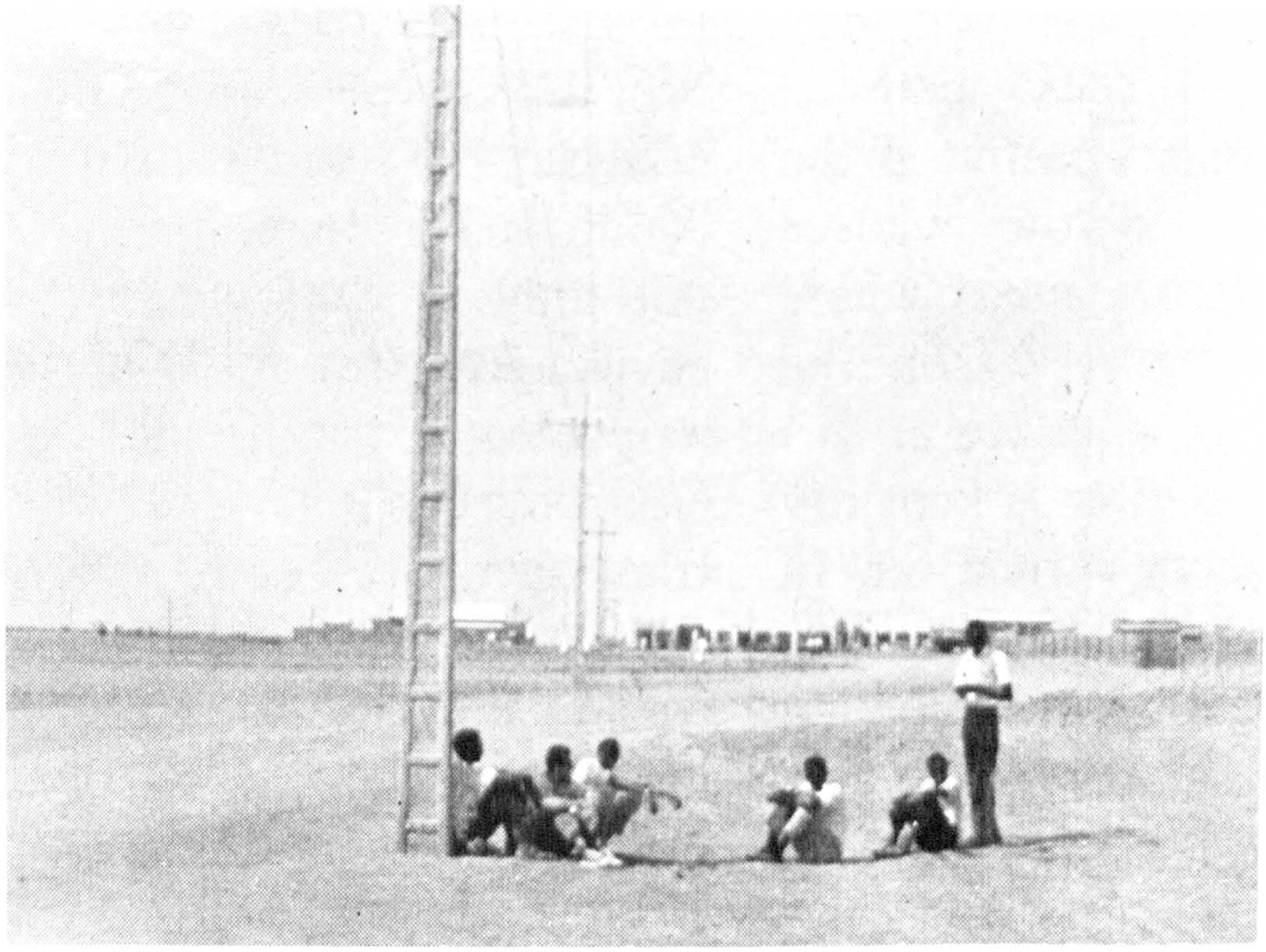
The mean temperature record shows a high diurnal range due to the lack of cloud cover which results in a fairly rapid cooling action towards the evening. In March the temperature rises fast and April, May and June comprise the hot season. During this period the unobstructed solar rays heat the land surface up to about 103°F at midday, whilst at night loss of this heat by long-wave radiation cools the surface to 73°F or below.

The inspection of the Isopleths of Khartoum temperatures (°F) given below shows that the highest daily maximum values of air



Isopleths of Khartoum Temperatures (C°)

temperatures are reached in late April, May and early June. Records of hourly air temperatures for Khartoum, for the years 1971-1973, show that temperatures up to 112°F are reached in the early afternoon.



Even the shade of an electric post is appreciated under midday summer temperature in Khartoum.

The highest daily totals of solar radiation occur at the same time of the year, though days with highest totals of solar radiation do not necessarily have the highest air temperature maxima. Daily totals of 2210 Btu/ft^2 (600 cal/cm^2) according to Bhalotra,Y.[(1)] are not uncommon (about 30 days a year), with the highest daily total recorded for the three years at about 2390 Btu/ft.^{2}

Spells of warm days within similar high temperatures and solar radiation totals sometimes occur. One such day (24th May 1973) seems to be typical enough to represent the severe summer conditions. The following table gives the actual temperatures of such a day:

(1) Bhalotra, Y.P.R. "Meteorology of Sudan"
Memoir No.6 Sudan Meteorological Service, KHARTOUM 1973.

Table 24 Hourly Temperature of MAY

Hours of the day	1	2	3	4	5	6	7	8	9	10	11	12
Recorded Temp. ^{o}F	87	85	86	84	83	82	83	91	97	101	105	108

Hours of the day	13	14	15	16	17	18	19	20	21	22	23	24
Recorded Temp. ^{o}F	109	111	111	109	109	106	105	96	94	94	94	93

Source: Sudan Meteorological Service, Memoir No.6. Khartoum 1973

From the above, it is clear that the maximum air temperature for the day, occurring at 2.00 p.m. local time, was 111^{o}F, the minimum 82^{o}F occurring at 6.00 a.m. local time. The total solar radiation for the day (falling on a horizontal surface) was 2215 Btu/ft. 12.00 hours of sunshine were recorded. A comparison between the maximum air temperature of 111^{o}F and the minimum of the day 82^{o}F shows that a diurnal range of 29^{o}F occurs.

In this hottest month of the year, May, the sun crosses the zenith and as there are as yet no clouds to screen it occasionally, the heat is intense and the mean temperature of the month may go over 90^{o}F.

The monthly mean temperature of the greater proportion of the year (March - November) is hot with temperatures over 80^{o}F. Only in the cool season (December - February) is the monthly mean temperature expected to be below 80^{o}F. However, at this season, nights are distinctly chilly with the average maxima in the neighbourhood of 4^{o}C (39^{o}F), which usually occurs in January, the coldest month.

In the wet-summer season (July - October) due to the very occasional but heavy rainfalls the day-to-day variations of temperature are very small. The mean monthly temperature ranges from 88.5^{o}F to 86.5^{o}F.

3.2.2. Solar Radiation

In Khartoum province area skies throughout the year are clear, cloudless, and of a deep blue hue. For this reason the direct and reflected sunlight from the bare, light-coloured ground causes serious visual discomfort and glare, especially in the afternoons. Even in the rainy season when occasional clouds absorb a considerable amount of the incident solar radiation, this radiation is still high.

In summer, intensive direct solar radiation may go up to 700 or 800 k cal/m.h. on the horizontal surface, and is further augmented by radiation reflected from the barren, light-coloured terrain. However, the absence of clouds in the atmosphere permits easy release of the heat stored during the day-time in the form of long-wave radiation towards the cold night sky. Diffused radiation may only be present during the afternoon dust haze periods. The effect of this high level of solar radiation in summer is to raise the day-time temperatures so high that the rapid cooling at night may sometimes cause light materials to crack and break up. In order to compensate for such factors when preparing a building design it is important to know the actual figures for total solar radiation and at what times the crucial variations are likely to occur.

Sid Ahmed A. Ibrahim of the Faculty of Engineering, University of Khartoum, recorded the daily totals of solar radiation for Khartoum Area. He took the records for the 24th of May, usually the hottest day of the year. The surfaces chosen were a horizontal surface, and vertical surfaces facing east, west, north and south. This selection was made in line with the tradition of flat roofed buildings in the hot-dry climate of Khartoum, and the traditional siting of buildings, along cardinal axis, to catch the predominantly north-south wind for cross-ventilation.

The following table gives the hourly values of direct (I_D), diffused (I_d), and total (I_T) radiation falling on a horizontal surface and vertical surfaces facing east, west, north and south for Khartoum on the 24th of May :

Table 25 Khartoum Hourly Values of Solar Radiation

Time	Horizantal			East			West			North			South		
	I_D	I_d	I_T	I_D	I_d	I_T	I_D	I_d	I_T	I_D	I_d	I_T	I_D	I_d	I_T
6 a.m.	8	8	16	73	18	21	0	4	4	25	7	32	0	8	8
7 a.m.	72	20	92	180	47	227	0	13	13	52	21	73	0	17	14
8 a.m.	137	29	166	198	59	257	0	21	21	48	30	78	0	21	21
9 a.m.	197	31	228	180	58	238	0	25	25	38	32	70	0	25	25
10 a.m.	245	33	278	138	53	191	0	29	29	29	37	63	0	29	29
11 a.m.	278	34	312	76	45	121	0	32	32	25	35	60	0	32	32
Noon	292	34	326	0	37	37	0	34	34	25	37	63	0	34	34
1 p.m.	278	34	312	0	32	32	76	45	121	25	35	60	0	32	32
2 p.m.	245	33	278	0	29	29	138	53	191	29	34	63	0	29	29
3 p.m.	197	31	228	0	25	25	180	58	238	38	32	70	0	25	25
4 p.m.	137	29	166	0	21	21	198	59	257	48	30	78	0	21	21
5 p.m.	72	20	92	0	13	13	180	47	227	52	51	73	0	14	14
6 p.m.	8	8	16	0	4	4	73	18	91	25	7	32	0	8	8

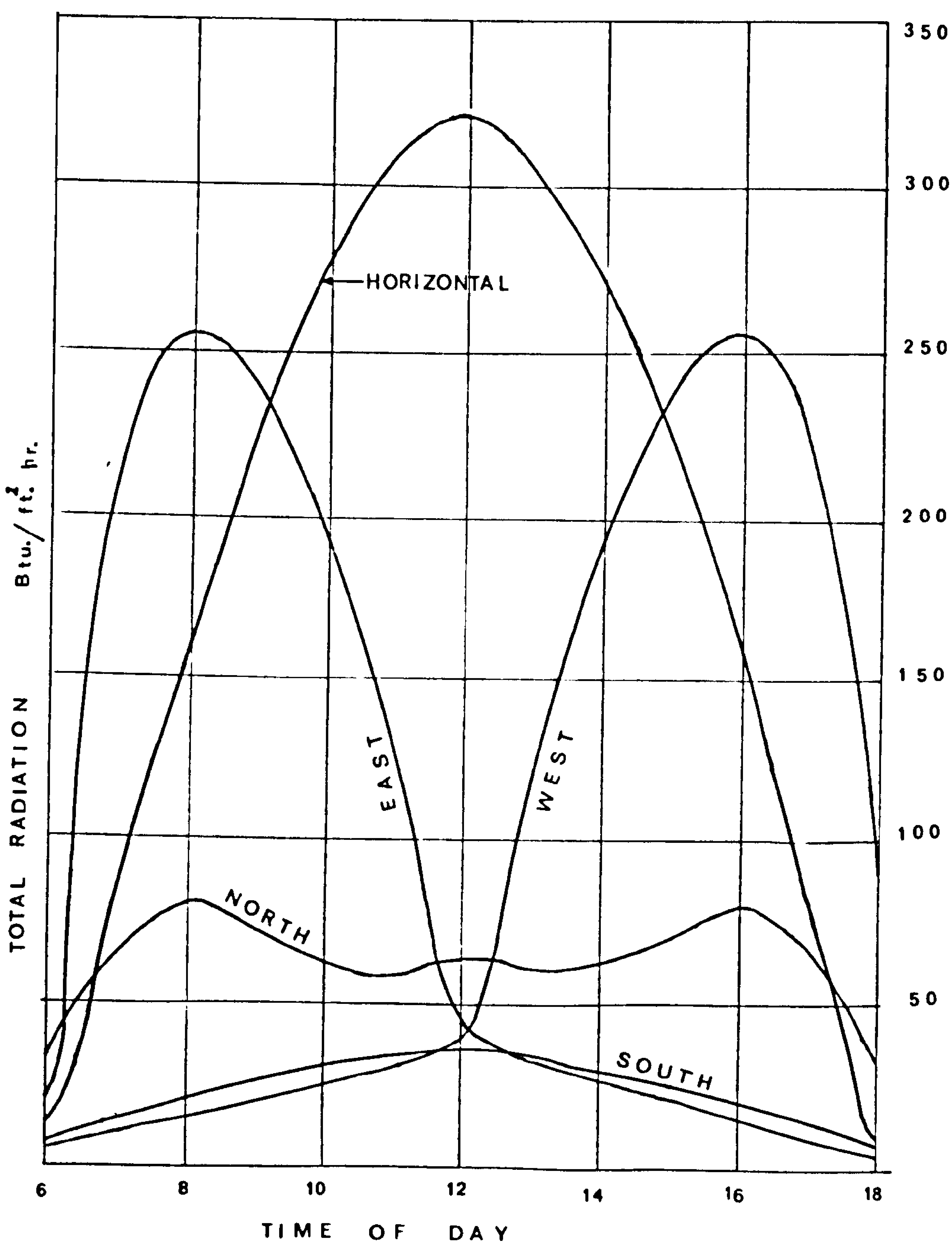
Source: Sid. Ahmed A. Ibrahim, Faculty of Eng. University of Khartoum.

From the table it is clear that the horizontal surfaces (roofs and bare ground) receive the maximum totals of solar radiation, which can be up to 326 Btu/ft.^{2}h. at midday, during the period 10 a.m. to 3 p.m. when the air temperature is at its maximum level. Next to horizontal surfaces, high levels of solar radiation may, if no design precautions are taken, penetrate the buildings from the WEST side, especially in late afternoons from 2 p.m. to 5 p.m., when a maximum of 257 Btu/ft.^{2}h. can be reached. The East sides of the buildings cause minor problems between 8 and 9 a.m. when a maximum of 257 Btu/ft.^{2}hr. occurs.

From the table it is also clear that the South vertical elevations of buildings receive no solar radiation at all throughout the summer season, and this is why the people in this area traditionally open their windows on the southern side. It is also worth noting that the prevailing breeze during the summer season comes from a southerly direction. The northern aspect also receives very little direct solar radiation throughout the summer.

The following is the Khartoum picture of the total solar radiation falling on different surfaces, represented in a graph.

Total Solar Radiation falling on a horizontal surface and vertical surfaces facing East, West, North & South at Khartoum.



3.2.3. Khartoum Rainfall

As has been mentioned previously, skies in Khartoum are a clear, dark blue for over two-thirds of the year; but June brings a decided change. South-west winds set in, bringing abundant cloud, the mark of the rainy season. Although falls of rain are isolated and last only for a few hours, they are of a tropical nature and fall in very heavy showers between noon and midnight; they are generally accompanied by thunder and sometimes by tornadoes.

Usually the rainfall increases very rapidly from the northern part of Khartoum province southwards. For example the yearly mean rainfall in Shendy, at the northern part of Khartoum province, is 76mm while the mean rainfall in El Masseid in the south is over 235mm.

The following table gives the Mean Rainfall of Khartoum:

Table 26 Mean Rainfall in Khartoum (in mm)

Town	J	F	M	A	M	J	J	A	S	O	N	D	Year
Khartoum	0	0	0	3	5	9	43	70	30	4	0	0	164

Source: Meteorological Department Records. Khartoum, Sudan.

From the above figures, the rainy season lasts from June to September with August as the wettest month, when the monthly mean rainfall may go over 70 mm. The Meteorological Department records taken since 1931 onwards show an average of 2.5 days with rainfall in August exceeding 10mm. The maximum recorded daily precipitation for the month is always above 30 mm.

The annual mean rainfall is approximately 164 mm. At least three fifths of the annual rainfall is associated with thunderstorms which are generally of short duration. Precipitation during storms tends to be severe and intensities of 80 mm per hour for a 15 minutes storm have been recorded.

The rains last till September and on rare occasions there has been about 5mm rainfall in October. The rainfall is least in the northern part of Khartoum province, but even the northern frontier of the province generally receives about 45mm at Shendy. At the end of the rains, the temperature rises again as the sky clears. By the end of November the north - east winds are well established and give relief from the high temperatures.

3.2.4 Relative Humidity

In Khartoum Relative Humidity is very low due to the fact that more than nine months of the year are hot-dry and the clear skies which prevail for most of the year result in a large diurnal range of temperature. Generally, evaporation from the soil surface and from vegetations exceeds the annual precipitation and for this reason there is a water deficiency for most of the year.

However, due to the presence of the River Nile and the few rains in the wet season a maximum relative humidity range of 50% may be reached in Khartoum. The maximum amount of rainfall and therefore the highest mean relative humidity occur in August. Relative humidity varies from only 10% in the northern part of Khartoum province to 50% in the southern part; with an average range of 30% for the whole province. The vapour pressure is normally between 750 and 1500 N/m^2.[1]

Continuous physical work in the sun is too difficult at midday in May, the hottest month of the year when the wet bulb temperature in Khartoum may reach 24.5°C (84°F).

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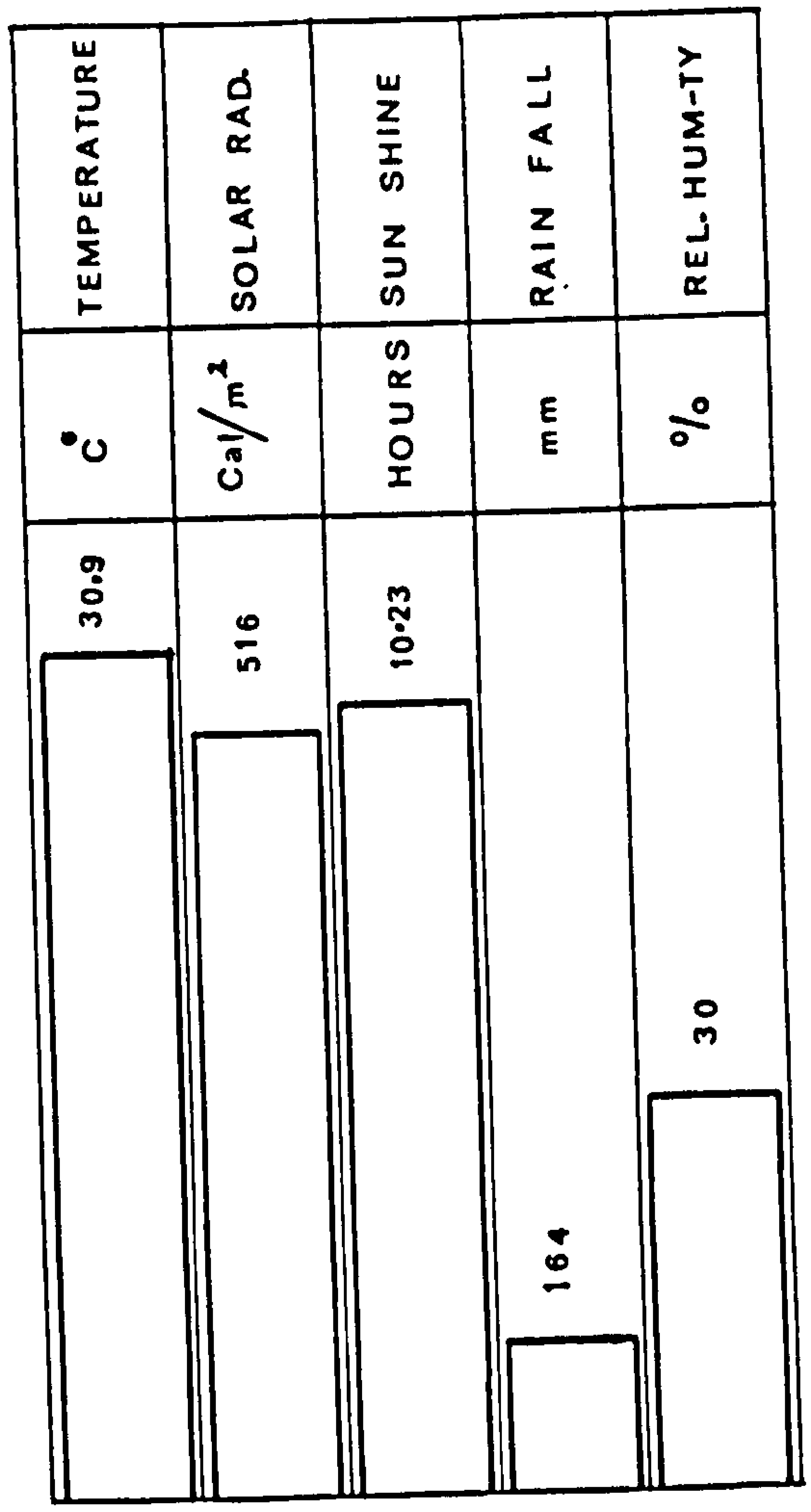
(1) Summary of Meteorological Observations Khartoum Station 1967

KHARTOUM YEARLY MEAN



3.2.5. Wind Speeds in Khartoum

The pattern of wind occurrence in the hot arid climate of the Central part of the Sudan is changed by the presence of the River Nile. A notable change in the pressure gradient occurs at the Nile Valley. Eastward of the Nile the iso bars are close, circling round the low-pressure centre, while over the Sahara at the northern part of Khartoum province there is an extensive region of small pressure change. The summer midday winds are unpleasant, though of low speed, but they are welcome at night, when the high day temperatures subside.

The mean hourly values of wind speed at Khartoum for May, the hottest summer month, are recorded in the following table:

Table 27 Mean Hourly Wind Speed for a Typical May Month, at Khartoum.

Hour of the day	1	2	3	4	5	6	7	8	9	10	11	12
Wind speed M.P.H.	8.1	8.5	8.2	8.0	8.4	7.8	7.9	9.4	11.6	11.7	11.0	9.6

Hour of the day	13	14	15	16	17	18	19	20	21	22	23	24
Wind speed M.P.H.	8.8	8.2	8.0	7.7	7.5	7.1	6.5	6.3	6.8	7.2	8.0	8.7

Source: Meteorological Dept. Khartoum. Undated Note.

From the above figures it is clear that the lowest speeds occur a few hours before midnight, while the highest occur just before noon. The most frequent speeds lie between 8 and 9 M.P.H., with the mean of all values at 8.4 M.P.H., which can be assumed to represent the average free wind condition.

However, wind speed in Khartoum varies not only with time, but also with height and degree of obstruction, so that the free wind speed would have to be modified to approximate conditions in built-up areas.

According to Professor Page[(1)] the free wind speed must be modified for built-up areas as follows:

(i) 1/3 of the wind speed when considering the first few storeys of buildings in central parts of towns,

(ii) 2/3 of the free wind speed for buildings in suburban areas, and for the middle stories of buildings in central parts of towns,

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(1) Page, J.K. "A technical note on the calculation of temperatures in concrete roof slabs" RILEM symposium on concrete and reinforced concrete in hot countries. Haifa, 1960.

If a value of 2/3 of the free wind speed is assumed for Khartoum because of its low building density, then considering a free wind speed of 8.4 M.P.H. a design value, for built-up areas, would be in the order of 5.5 M.P.H. which is too small to help reduce the excessive heating of the atmosphere.

However, the Province of Khartoum is susceptible to the severe sand storms ("haboobs"). They are usually associated with thunderstorm condtions and are caused by downdraughts from cumulonimbus cells which lift large quantities of surface dust into the atmosphere. For a haboob to develop fully, rain must not fall in any quantity or the dust will be washed out of the atmosphere thus precluding the raising of further dust from the wetted surface. Haboobs are particularly prevalent during the months May to July, that is before the onset of the rainy season. They usually break-up in the late afternoons in the east-west direction.

Due to these heavy dust sand storms, the usual open drainage channels of Khartoum become filled with fine sand and need to be cleaned out every year before the heavy rains start. In addition, fine sand deposited on the road surface by the wind is washed into the drainage system by storm-water, blocking inlets and piped lengths.

3.3. Solar Radiation in the Central Part of the Sudan

In this region clear skies and lack of clouds mean that direct radiation is the main source of solar energy. A high convective heat exchange takes place in summer, when the maximum air temperature in the shade may reach 50°C and more, and diurnal range in temperature may reach 17-23°C. Radiation heat exchange between the outer surfaces of buildings and the outdoor environment takes place in the form of:-

1. Direct short-wave radiation from the sun.

2. Diffused short-wave radiation from the skyvault.

3. Reflected short-wave radiation from the sunlit ground around the buildings.

4. Long-wave radiation from nearby heated objects.

5. Outgoing long-wave radiation from the outer surfaces of the buildings to the sky and surroundings in a reverse action when the atmosphere gets cool in the evening. (1)

Because of the clear sky conditions and low relative humidity, the solar energy reaches the ground with very high intensities compared with most other geographical regions. The high values of incoming short-wave radiation, plus high values of air temperature, result in extremely high heat gains on the outer surfaces of the buildings. To reduce these heat gains by high short-wave radiation, any building should be surrounded by surfaces of low reflectivity such as wet, bare ground and green fields, which the lack of water supply makes difficult and expensive in this region.

Long-wave radiation from heated grounds and objects:-

Surfaces and objects exposed to direct sunlight gain more heat than the surrounding air temperature by about 14-25^{o}C which is usually higher than the surface temperature of the vertical surfaces of the buildings. These sunlit heated grounds and objects give more heat by long-wave radiation to the surfaces of the buildings.

The amount of solar heat absorbed by a building depends on:-

(i) The orientation of the building

(ii) The shape of the building

(iii) Surface absorption

(iv) Kind of shape

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(1) Victor Olgyay "Design with Climate" page 33. Princeton University Press. U.S.A.

The largest amount of solar heat is received by horizontal surfaces and usually the increase of horizontal surfaces results in an increased heat load.[1] The roof of any room receives only 26% less than the total heat gained by all the other four walls, so that unshaded roofs need special attention, and the asymmetrical distribution of solar radiation must be used to produce the smallest irradiated vertical areas facing the maximum solar heat input.

3.4 Building Orientation

Under conditions of excessive heat in a hot arid climate, the daily atmospheric changes and high summer diurnal range of temperature affect the general health of the people and their efficiency at work, so it is important that the orientation and shaping of any building should help to minimize heat gain.

The orientation of buildings is affected by a number of factors, e.g. wind speed and direction, the visual requirements of sunlight, reduction of external noise and the requirements of privacy; but the main criteria for orientation in hot dry regions is the control of solar heat gain through different facades of the building at various times of the year.

To achieve the correct orientation of any building a graph of the daily values of the total short-wave radiation may be used reaching differently orientated vertical surfaces at different times of the year at the proposed location of the building, together with orientation charts. In addition, the optimum orientation for a given site must give maximum radiation in the low temperature period while simultaneously reducing insulation to a minimum in the high temperature period.

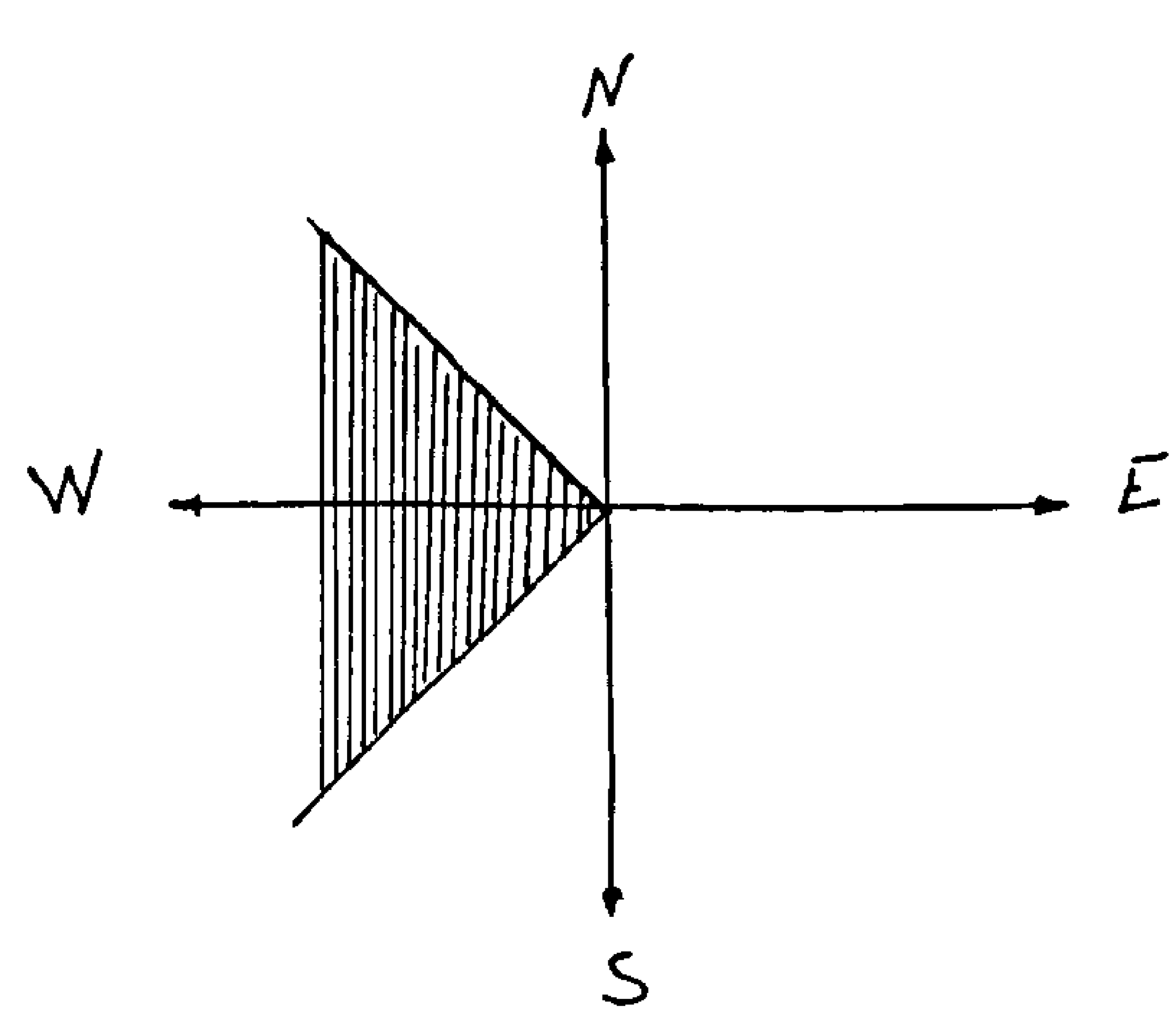
It is clear that the walls facing west and south-west receive higher values of solar radiation than thos facing east and south-east, while south and north sides receive lower values of total

(1) See the figures given by Sid Ahmed A. Ibrahim .p.74.. op.cit,

short-wave radiation; the south and north orientations are ideal. The orientation of any building cannot, of course, be resolved on solar considerations alone. So it is important to give orientation tables in terms of ranges rather than in terms of optimum values. Moreover, since any building has several facades, the merits and shortcomings of orientation must be taken into account.

In selecting suitable building orientation in hot dry regions, reduction of the internal daytime temperatures must be a main objective, and thus minimization of solar heating is a primary concern. As the significance of orientation with respect to the sun depends greatly on the external colour of the walls and the size and shading conditions of the windows, the walls should be whitewashed or nearly white, and the windows small and well shaded. When this is done, the whole problem of orientation is much reduced, as additional thermal insulation can compensate for slight variations in the temperature elevation of the external surfaces. Usually a north-south orientation is preferable to east-west; and because consideration of wind orientation is unnecessary from the point of view of daytime conditions, since windows are kept closed at this time, it is advisable to give a slight deviation from a north-south direction to improve the ventilation during the evening and night. However as dust accompanies the winds in this climate it is preferable to locate the entrances on the leeside of the buildings. The direction of the evening and night winds, although not a major factor, is of greater importance.

From the figures given by Sid Ahmed, A. Ibrahim, it is clear that to protect the building from direct solar radiation in summer, walls between north-west and south-west must be avoided:-



because the shading of the windows facing east and west is not so easy to achieve as that of the north and south windows. Therefore it is preferable that the frontage of the walls facing east and west should be shorter than those facing north and south.

With the development of techniques for measuring radiation and the accumulation of data, the approach to orientation has beem made on a quantitative basis. These measurements have become the foundation for a number of solar-orientation theories.

Making calculations on sum intensities, Felix Marboutin[(1)] reached the following conclusions:-

1. For best living conditions (warmth in winter, coolness in summer) principal facades of buildings should face south.

2. Facades facing south-east and south-west offer the advantage of insulation, but they are colder in winter and warmer in summer than facades facing south.

3. East and west exposures are warmer in summer and colder in winter than are south, south-east and south-west exposures.

Gaston Bardet[(2)] devised an orientation chart based on Marboutin's theory. He finds south to be the preferred orientation, allowing variations up to 30^{o} to the south-east and south-west.

Ludwig Hilberseimer [(3)] concludes that east and west orientations are the least advantageous; that south-east and south-west are reasonably satisfactory and that south is the most advantageous. When south-east and south-west orientations are combined in a single dwelling unit, however, they are to be preferred to a due south orientation.

Due to the importance of the right orientation in minimizing the solar gain in buildings, especially in our hot-dry climate, a detailed study to find the optimum orientation in Khartoum province is set out later.

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(1) Marboutin, Felix "L'Actinometre et L'Orientation des Rues et des Facades". La Technique Sanitaire et Munincipale. March 1931 p.60-67.

(2) Bardet, Gaston "Le Factor Soleil en Urbanisme". Techniques et Architecture No.7-8 July/August 1945 p.202-6.

(3) Hilberseimer, Ludwig The New City. Principles of Planning. P. Theobald, Chicago 1944.

3.5. Treatment of Walls

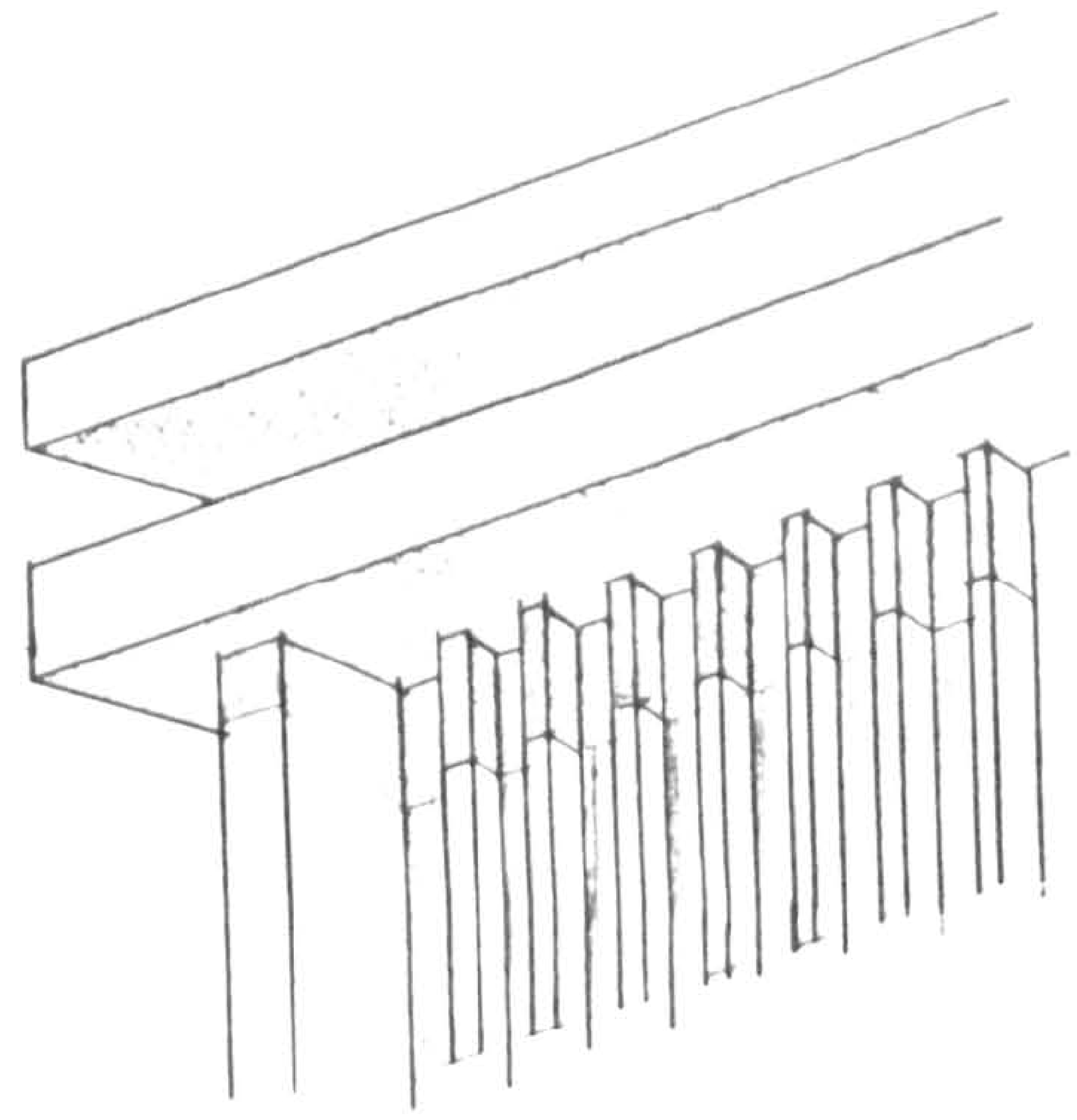
Before sunrise, both the outdoor air and the external surfaces of the building envelope are at their minimum temperatures. After the sunrise the outdoor air temperature increases, reaching its maximum in the early afternoon (2-3 p.m.).

The rise in the outdoor air temperature causes heat flow to the external surfaces of the building envelope, while at the same time solar radiation from the sky and reflected heat from neighbouring surfaces affects the surfaces of the building. Part of it will be reflected, the remainder will be absorbed by the surfaces depending on their shape and colour. In consequence the surface temperature of these surfaces will be greater than the outdoor air temperature and at this point the heat will be transferred to the interior (i.e. cooler) part of the building. When the external air temperature reaches its maximum and starts to cool, the process is reversed and heat from the walls starts to go outwards in the form of long-wave radiation.

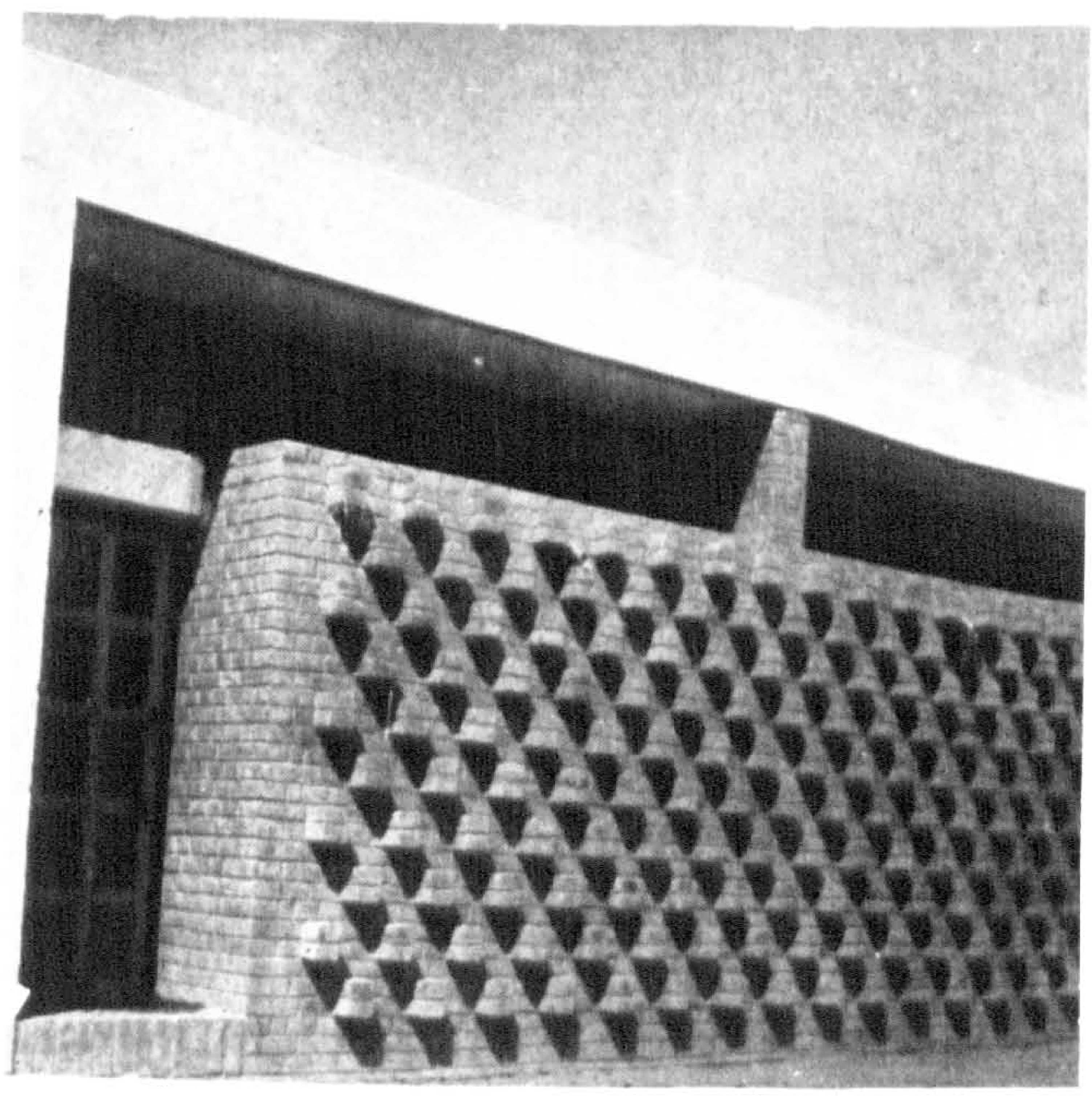
In view of this process, it is clear that walls must be designed in such a way as to reduce the solar radiation reaching their outer surfaces in summer, yet allowing them to respond to the heating effect of the sun in winter.

The colour treatment of the outer surfaces of the wall is crucial; as the wall, unlike the roofs, receives both short-wave radiation from the sun and the sky, and long-wave radiation from sunlit heated ground and surrounding objects, their colour and treatment must protect them from both forms of radiation.

Corrugated treatments of the surface area of the exposed part of the wall increase the out-going long-wave radiation from the wall to the sky.



Partial shading of the walls by allowing alternating recessed sections in the construction of the wall will prevent part of the direct rays of the sun from reaching the walls in summer, while allowing low altitude sun to reach the walls in winter.



Low-cost housing in Chandigarh, India
Architect P. Jeanneret.

Trees, strategically situated, can also provide an effective shading of the walls.

3.5.1. Wall Protection

Complete protection of the walls can be achieved by the use of sun-breakers or sun screens to block the direct rays before they reach the surface of the wall. However, care should be taken to avoid excessive storage of heat in the screen itself because this will be radiated to the main wall during the evening. For this reason light coloured timber and various metals have certain advantages over thick concrete slabs.

<u>Wall Protection by Anti-Sun Screens :</u>

Walls can also be protected from direct sun rays by means of anti-sun screens fixed on the external part of the wall. Two main types of screen are used:-

1. Fixed screens, solid, slatted, louvred or perforated

2. Screens with adjustable louvres.

Portable screens allow rapid cooling of the main wall; adjustable screens reduce the rate of the out-going long-wave radiation from the surface of the wall to the sky; fixed screens are usually used in walls without openings.

The efficiency of the screen depends on:-

1. The thermal resistance and capacity of materials used for its construction.

2. The reflectivity of the external surface of the screen and the emissivity of its internal surface.

3. The direction and speed of the wind affecting the wall to be protected.

4. In case of external louvred screens, the form, relative position and orientation of the louvres. (1)

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(1) Victor Olgyay "Design with Climate" .... op.cit.

Thermal resistance of the screens depends on the materials used, so insulating materials or timber are the best. It is preferable to use light-coloured finishes for the external surfaces of the screen and a low emissivity finish for the internal surface. The efficiency of the screen increases with the velocity of the wind, so in lower ground floors, where the wind speed is lower a different type of wall protection may be used.

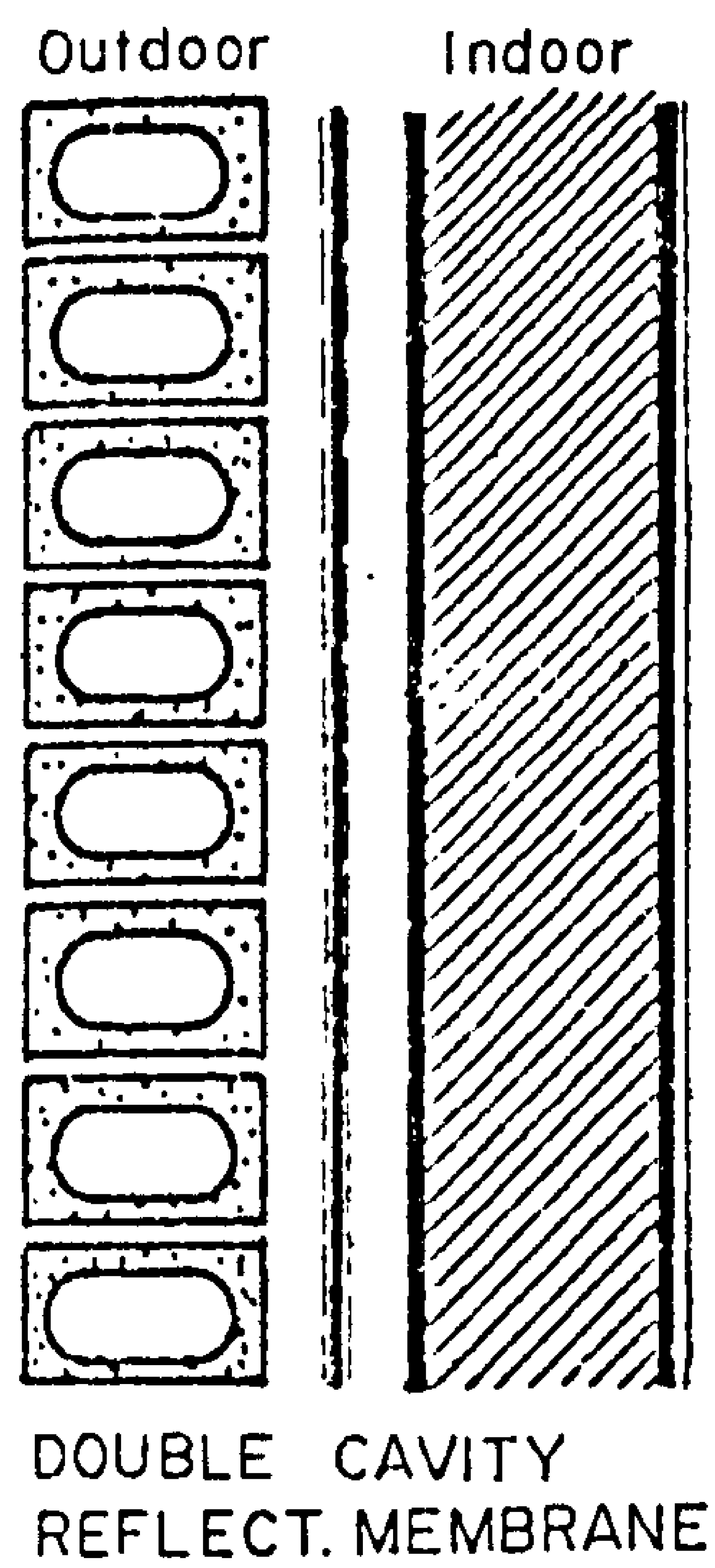
3.5.2. Cavity walls

Many experiments have been conducted in hot dry climates with a view to protecting the outer walls of buildings from direct solar radiation, especially by the use of cavity walls consisting of two outer and inner leaves separated by an air cavity. It has been found that the external leaf of the wall is subject to a very rapid temperature rise, causing accelerated heat exchange by radiation across the cavity to the inner leaf of the wall. In addition rapid cooling takes place towards evening and so a reflective membrance must be used to reduce the heat transfer across the cavity. The maximum temperature of the leaf of the cavity wall is always 2-3^{o}C higher than solid walls under sunlit conditions, and due to this difference in temperature, heat transfers by radiation to the inner leaf. As a result the indoor surface temperature becomes 2^{o}C hotter than the solid walls 2-3 hours after the outside temperature reaches its maximum. This throws some doubt on the use of the usual cavity walls. The ventilation of the cavity wall gives no better results and the openings in the cavity may cause problems with vermin and insects.[1]

The most recent improvement to cavity walls is a double leaf construction in which the outer leaf has low absorptivity for solar and long-wave radiation and high resistance to inward flow of heat, plus low heat storage capacity; in addition the inner leaf has rapid cooling ability and large heat storage capacity.

(1) Source: Miles Danby, Design of Buildings in Hot-dry Climates Build.International (6) 1973 page 63.

The outer leaf is composed of lightweight hollow bricks and the inner leaf of a heavyweight brick wall:



Source: Miles Danby, Design of Buildings in Hot-dry climates Build International (6) 1973 page 63.

To reduce the passage of heat into the inner cold leaf, heat exchange by long-wave radiation and convection is prevented by a membrane of aluminium coated bituminous paper and the cavity is sealed to prevent dust desposits forming on the aluminium foil. The external surface of the wall must have low absorptivity and be painted white with several coats of white lime-wash to give lower surface temperatures.

3.6. Roof Construction

In a hot region the roof is the main element of heat absorption and usually receives most of the incidental solar energy. It plays a major role in the heat balance of the building as a whole, so great care must be taken in its design. The heat entering the building from the roof alone is much greater than that entering through all four walls, and in the case of rigid concrete roof slabs excessive sunshine heating may force them to expand and cause structural failure.

There are two categories of roofs:-

(a) solid homogeneous or composite heavyweight roofs
(b) lightweight roofs of one or two layers. (1)

The determining factors of the thermal characteristics of solid roofs are their external colour, thermal resistance and heat capacity.

In the case of double roofs their thermal performance depends on:-

1. The materials and colour of the external roof
2. The ventilation conditions in the intermediate space
3. The thermal resistance of the two layers

The air between the two layers acts as an insulator, but must be ventilated by special openings, fillings or mechanical means to prevent excessive heating of the ceiling.

The external surface of the roof is subject to the largest temperature fluctuations, depending on its type and on its external colour, which has great influence on both the external surface temperature and the ceiling temperature.

The nature and the colour of the external surface of the roof determine:-

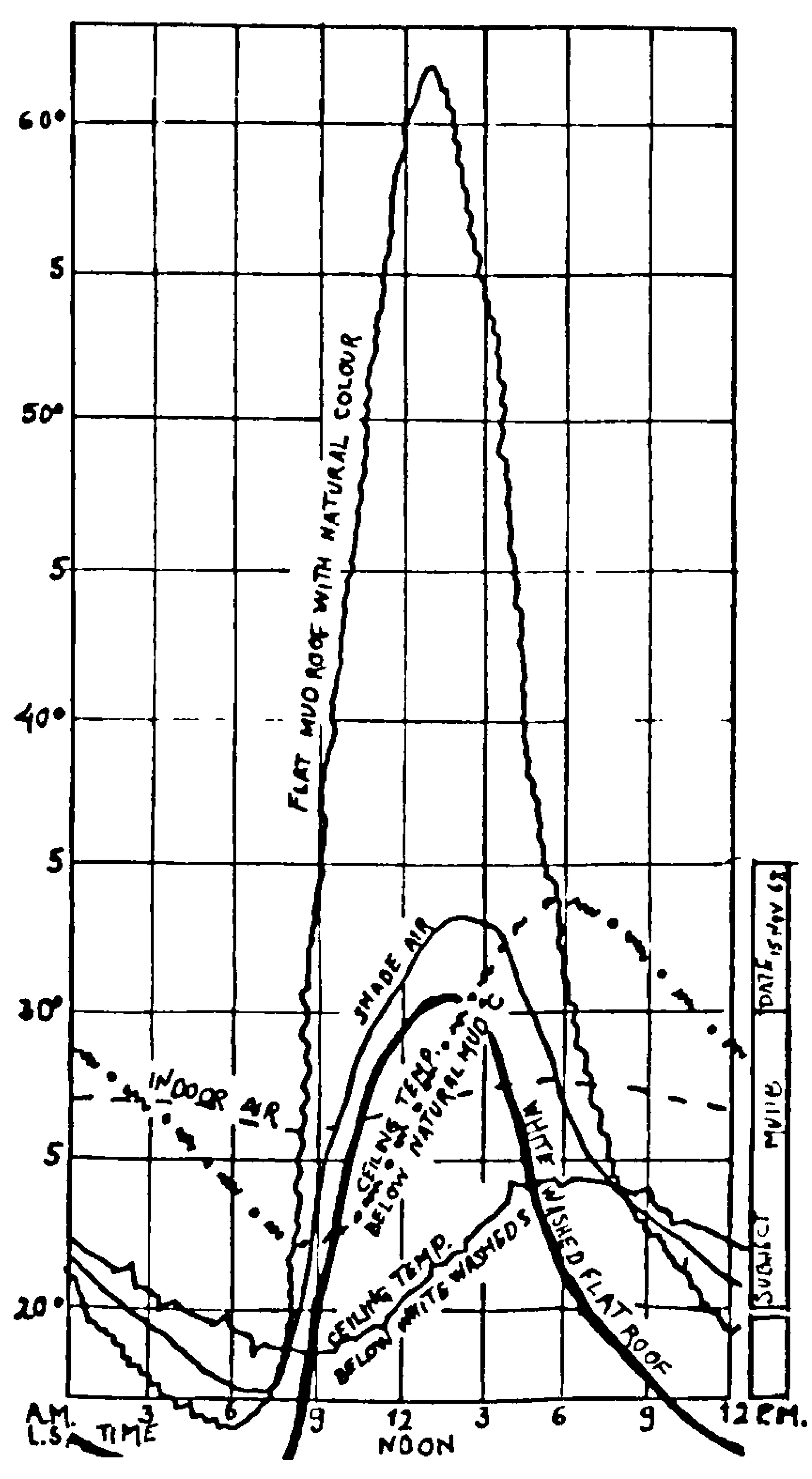
1. The amount of solar radiation absorbed in the roof structure during the day.
2. The amount of long-wave radiative heat loss at night.

(1) Givoni, "Man, Climate and Architecture" page 138.

3.6.1. The effect of roof whitewashing

Throughout the hot-dry regions, it has been traditional practice for people to cover the outer surfaces of their homes by several coats of whitewash which significantly reduces heat transmission through the roof by reflecting about 90% of received solar radiation.

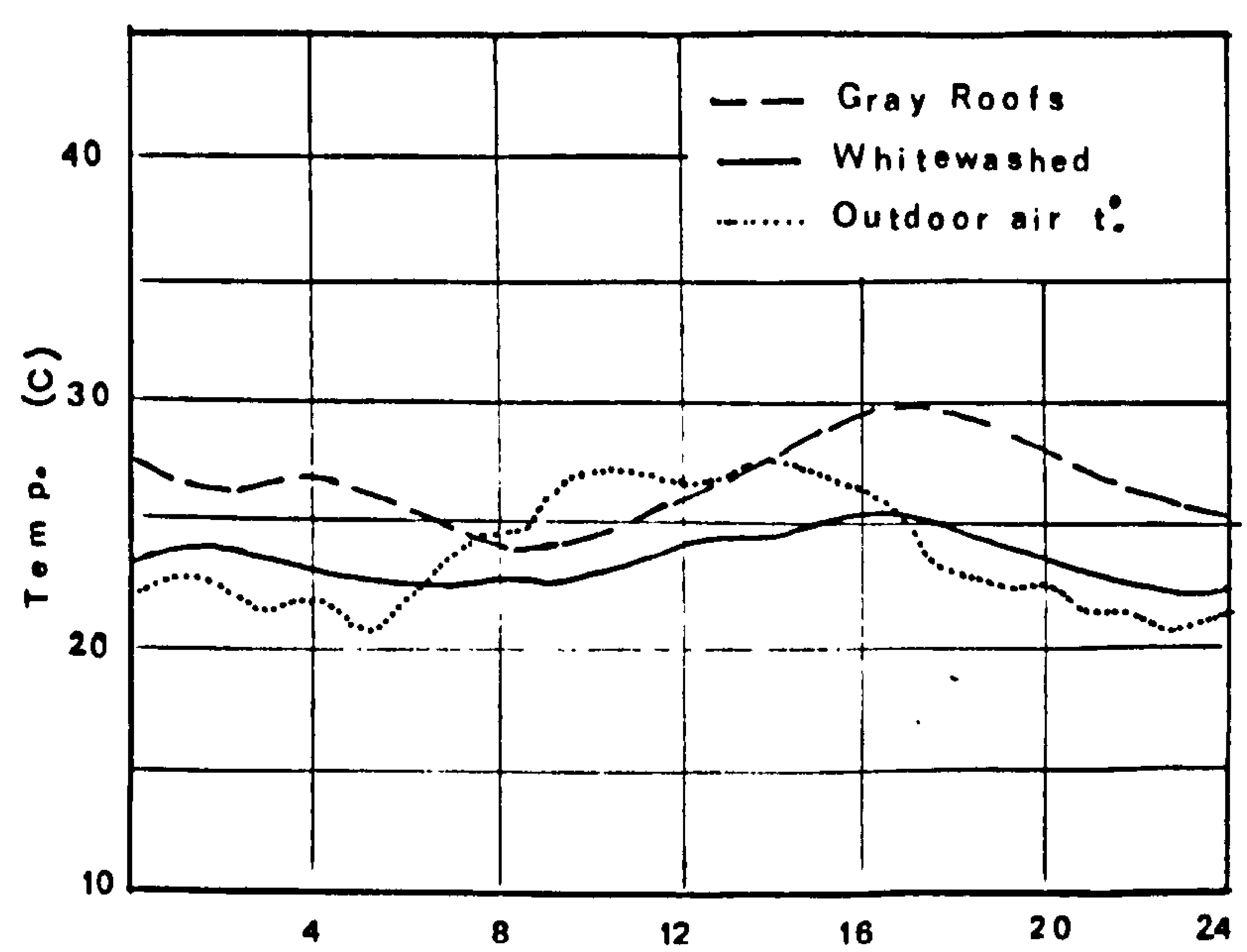
The effect of lime whitewash on mud roofs is considerable as can be shown by an experiemnt in which half of the mud roof is coated with whitewash and the other half left without wash.(1) When the surface temperatures of each part was taken at noon, when the air temperature was 55°C, it was found that the surface temperature of the natural mud roof was 63°C whilst the surface temperature of the washed part was 31°C.



(1) Source: Miles Denby. Design of Buildings in Hot-dry Climates Ibid...... page 64.

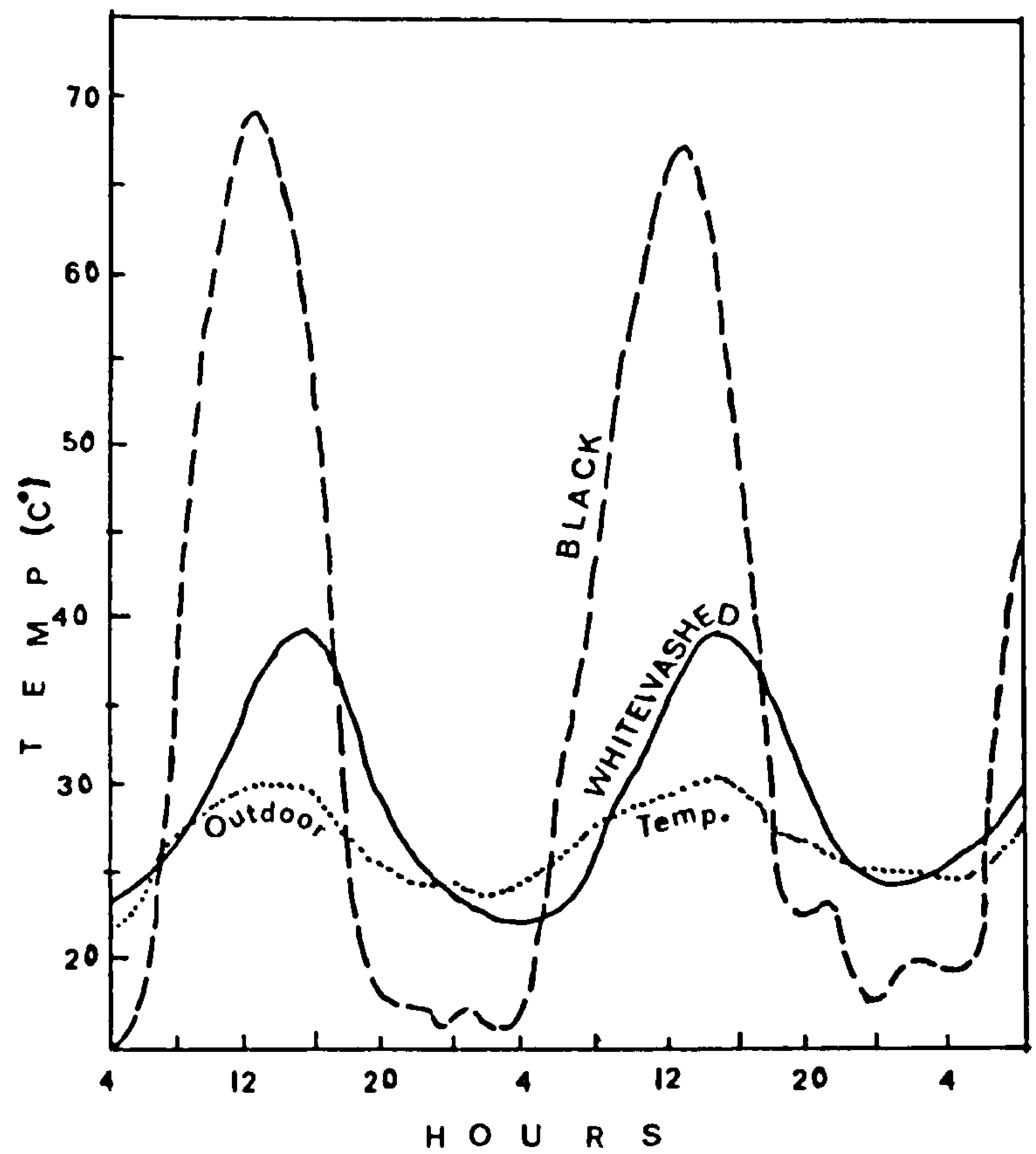
The indoor temperature of the building was also affected by the white lime wash. The maximum ceiling temperature below the natural mud was found to be 34°C, while below the whitewashed area it was only 24°C, in fact very near to the noraml room temperature.

Many other experiments have been done in different parts of the tropics to investigate the effect of external roof colour in reducing indoor surface and air temperatures. It has been found that in summer, in dark roofs the surface temperature usually rises to 32°C above the maximum air temperature, whilst in the whitewashed roofs surface temperature exceeds the maximum air temperature by only 1°C. The average surface temperature of the whitewashed roofs is appreciably lower than the ambient outdoor level:



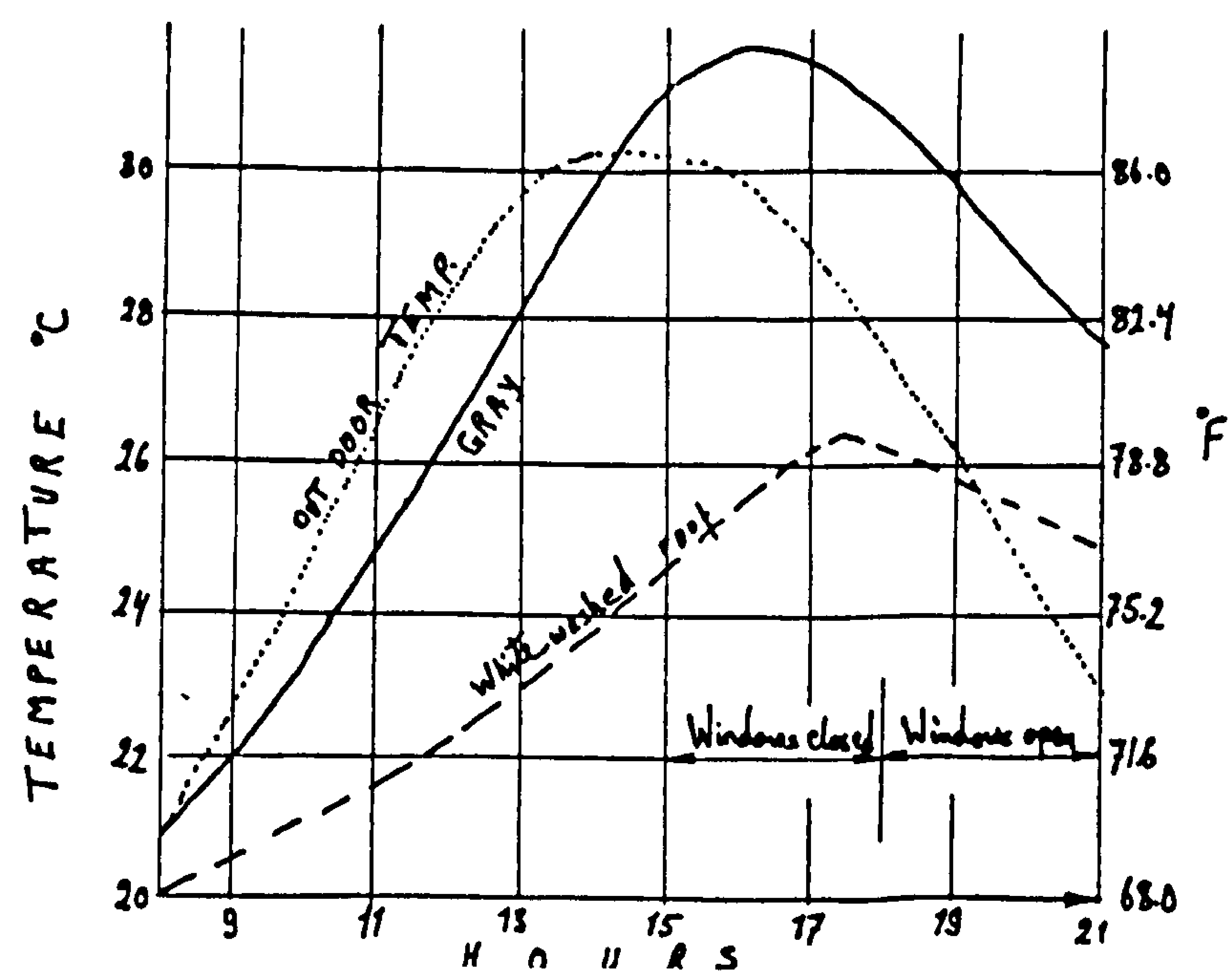
Source: Givoni, Man,Climate and Architecture ..... op.cit p.147.

The effect of the external colour on ceiling temperature is related to the thermal resistance and heat capacity of the roof structure. When the thickness, thermal resistance and capacity of the roof increase, the difference in maximum ceiling temperatures caused by the external colour will reduce.



Source: Givoni, B. .... op.cit. page 141.

This graph shows the great differences between the ceiling temperatures of black and whitewashed roofs, whilst the lower graph shows that the temperatures of ceilings under grey roofs are higher than those of the upper layer of the roof and indicates a heat flow from the roof into the building:



Source: Givoni, B. .... Ibid. page 142.

The ceiling temperatures in buildings with whitewashed roofs are usually below those of the upper layer of the roof and so here the roof acts as a cooling element for the building because the average external surface temperature of the whitewashed roof is lower than the average external air temperature.

The effect of ventilation on the temperatures of both the upper and the outer surfaces of a pitched roof is a reduction of only $\frac{1}{2}$°C.(1) Both natural and mechanical ventilation of the attic have a very limited effect on heat reduction.

In single-layer lightweight roofs consisting of corrugated asbestos sheets without double ceiling, the thermal effect depends on the colour and the external finish of the sheets. When the colour of the sheets is white, heating by solar radiation is almost non-existent, whilst long-wave radiation to the sky is fully utilized. The average indoor temperature may therefore be below the external average, which is satisfactory provided that the whitewashing can be frequently renewed.

3.6.2. Roof Protection

Many different methods have been used to protect roofs from direct solar radiation, but the main method used is still that of whitening the outer surfaces to promote reflection. There are difficulties inherent in this because as the roof surface accumulates dust its reflectivity gradually declines as dust absorbs solar radiation almost as much as a black surface. In certain areas the white coat is washed away annually by rains. Frequent renewal of the whitewash becomes necessary and though this is a relatively inexpensive job, it is often inconvenient and tends to be neglected, particularly as the roof is usually out of sight.

Being only a surface treatment, whitewashing has little direct influence on the inherent thermal properties of the construction, that is, its thermal resistance or heat capacity. Far from being constant, the role played by the white external colour in regulating internal surface temperatures diminishes as the heat capacity and

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(1) Givoni, B. .... op.cit.

thermal resistance increase, though its influence is still significant.

Generally, to enjoy the comfort of an interior cooled by external whitewashing one has to endure discomfort arising from its adverse impact on the external thermal and luminous environments. The rooms are protected only at the expense of the courtyard and the street, which suffer a high level of radiant heat from the external surfaces and an uncomfortable amount of glare.

3.6.3. Roof Protection by Reed Panels instead of Whitewashing

An experiment has recently been carried out in the University of Khartoum[(1)] to investigate the effect of reed panels on bamboo framework in protecting roofs from direct solar radiation. In the Sudan the reed panel is locally produced and its cost is low and fairly standard. A 2.70 by 0.90m panel costs £S 0.300 (about 36p) - the unit price varies inversely with the amount purchased. It is lightweight, light coloured (short-wave reflectively about 0.50), rigid enough to be supported at 1.00-1.50, intervals, and is easily fixed to the supporting structure. Panels are secured to the bamboo structure by thin wires. In the experiment two thirds of the roof were shaded by the reed panels whilst one third was left unshaded. When the surface temperatures were recorded, the ceiling temperature below the exposed part of the slab was seen to rise rapidly from a minimum of 31.5°C at 7.00 a.m. to a maximum of 44.7°C at 4.30 p.m., whilst the ceiling temperature below the reed panels shaded part was found to be always lower than below the exposed part of the slab by 5.1°C.

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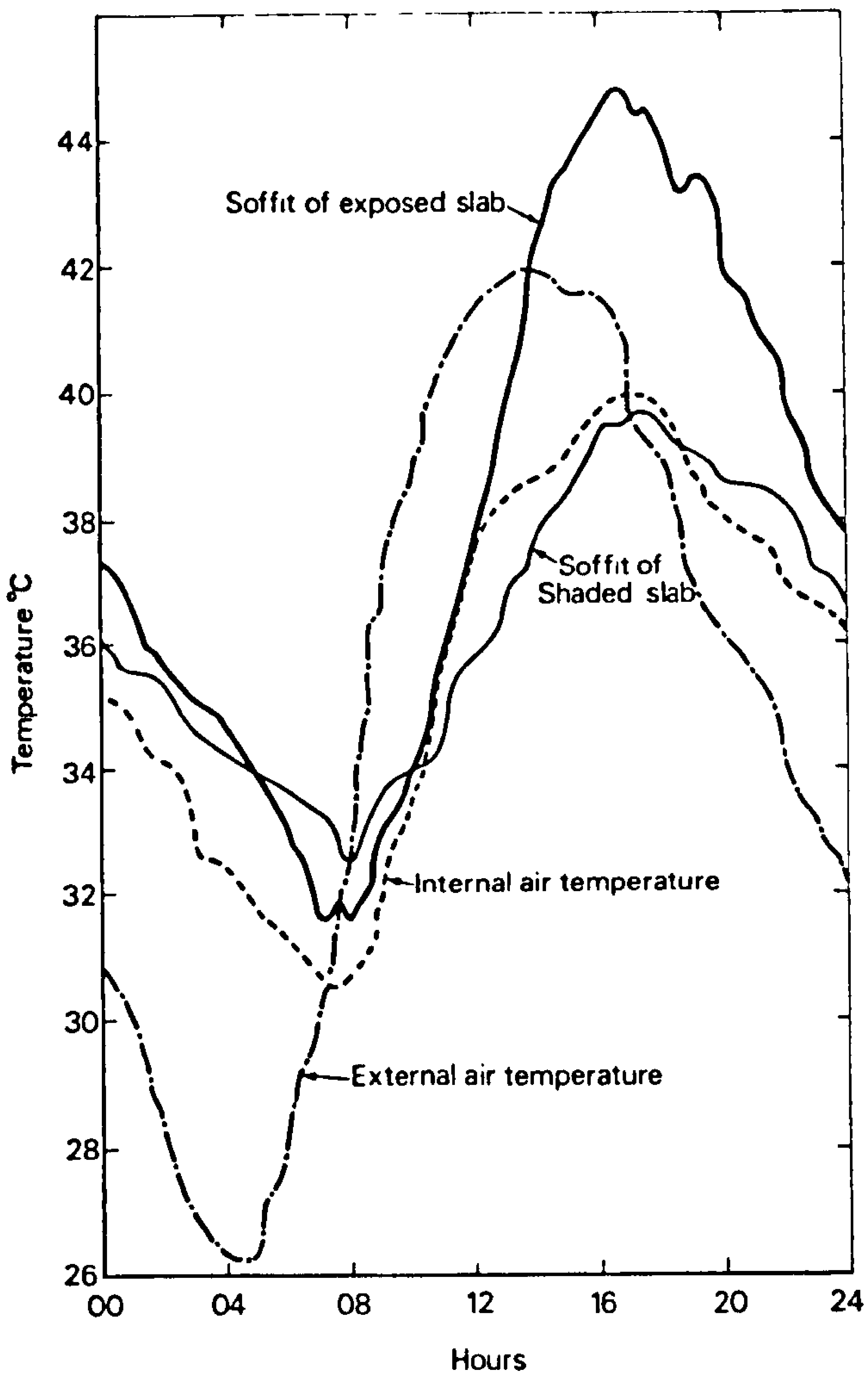
(1) Source: Adil.M. Ahmed. Thermal Performance of Concrete Roofs and Reed Shading Panels. Overseas Building Notes, No.164 Oct. 1975.



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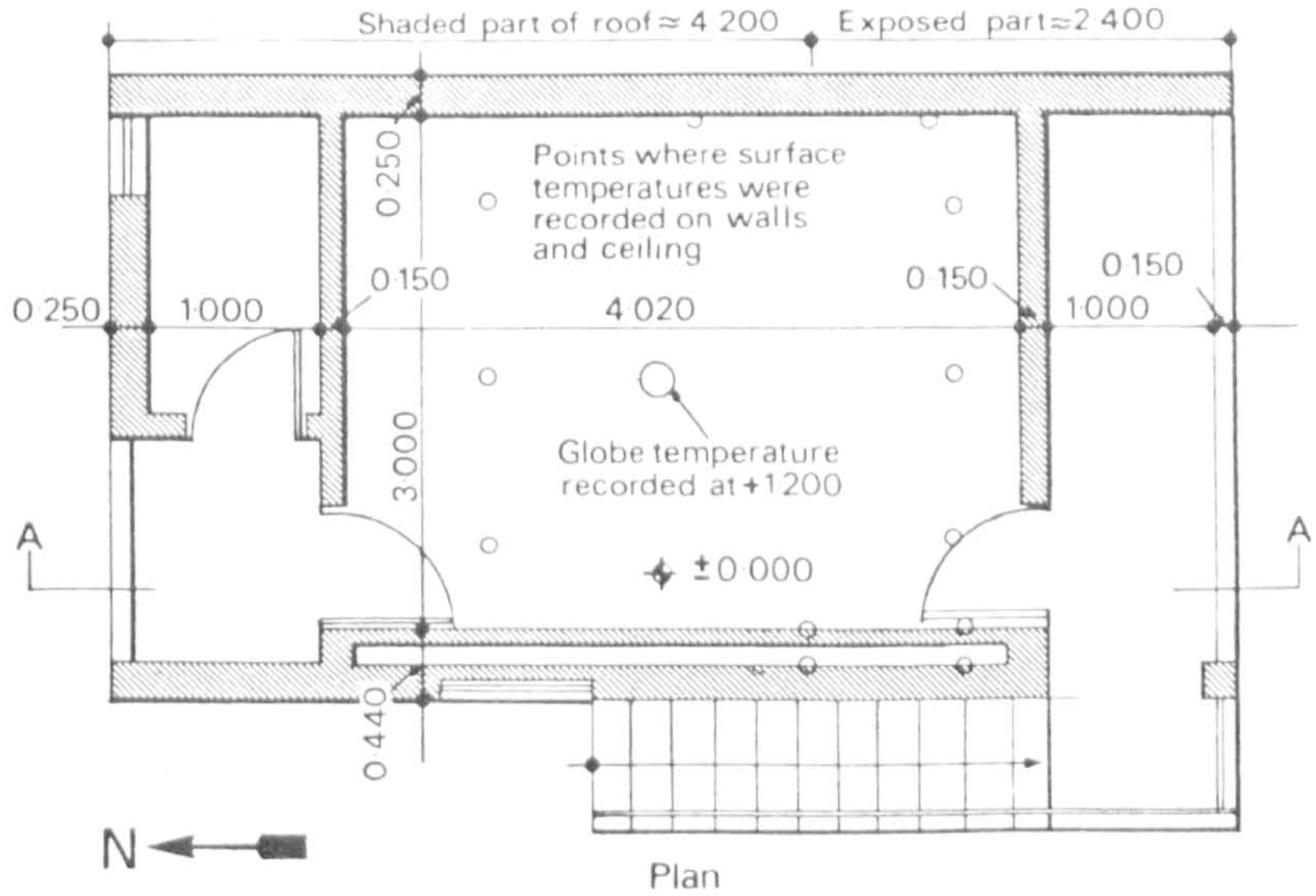
Source: ADIL, M. AHMED, Overseas Building Notes No.164 Oct.1975

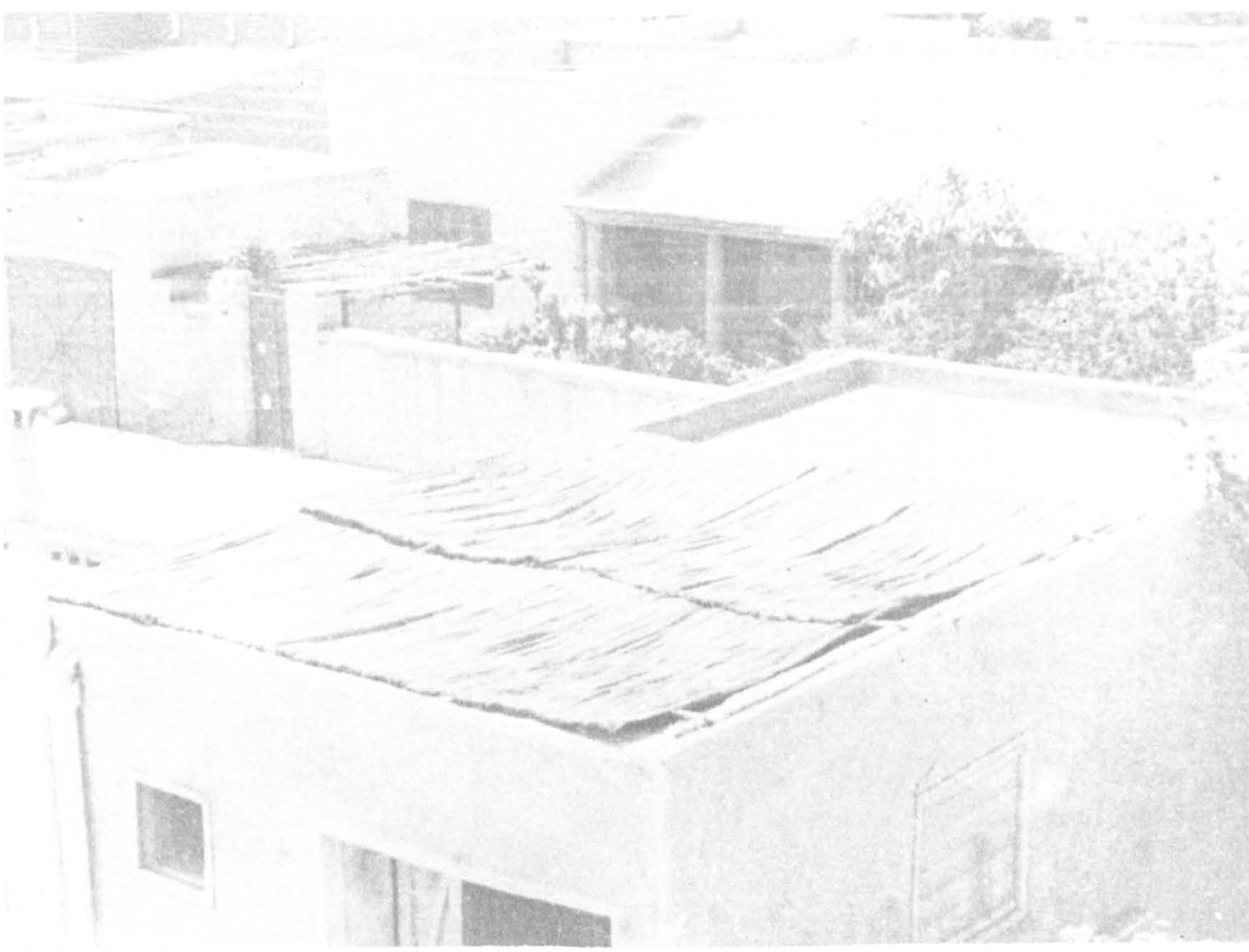
3.6.4. The use of Insulating Materials in Roofs

If a heavyweight layer is provided with an external layer of efficient insulating material, itself protected by a waterproof light-coloured, heat flow during the day from external to internal layers is restricted by the insulation and only a small proportion of the potential heat is absorbed in the element. Even this heat can later be removed by ventilating the interior during the evening and night, thus maintaining relatively cool conditions throughout the day.

Insulating materials may be used to minimize heat losses in winter, but the use of a thick layer of insulating materials may retard the rate of cooling of the roof after a hot day, and reduce the warming effect of the sunshine in winter.

Ceiling Temperatures under the exposed and shaded parts of the slab.





Two-thirds of the roof covered by Reed Panels

Source: Adil M. Ahmed ...... op.cit.

3.6.5. Cooling the Roofs by Evaporation

Sometimes cooling is used to prevent heat-ng of flat roofs, using either stationary water pools above the roof or by spraying. This method may reduce the roof temperature by 30°C by water spraying and 25°C by water pools.(1)

A combination of a white water-resistant external surface and water-spraying may reduce the external surface temperature below the outdoor level, but such methods are very costly in the Sudan with its restricted water supplies, and water ponds may also provide a breeding ground for mosquitoes.

3.6.6. Influence of Ceiling Height on Indoor Thermal Conditions

Reduction of ceiling height without adversely affecting the indoor comfort of houses is desirable because:-

(i) It permits economy in materials, walls, partitions and labour.

(ii) It may facilitate the design of full-height elements and so lower the cost of elements and their erection.

(iii) In multi-storey buildings the number of storeys can be increased by lowering the ceiling height and so reducing the cost per dwelling unit.

However, it is important to determine whether or not the reduction of ceiling height will affect the ventilation conditions or the thermal comfort of the building.

Systematic studies of this problem were undertaken in Australia, England, India, South Africa and U.S.A.

In Australia at a ceiling temperature of 35°C a 1.2 metre reduction in height resulted in a reduction load increased by only 2 k cal/h (which is 2% increase in the overall cooling requirements of the body).(2)

In India an experimental study has been carried out with 4 experimental units of different heights. The result showed that

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(1) Sutton, G.E. "Roof Spray for reduction in transmitted solar radiation". Heating, Piping and Air Conditioning 1950, 22 pp.112-118

(2) D.H.K. Lee "Physiological Objectives in Hot Weather Housing". H.H.F.A. Washington 1953.

raising the ceiling height above 2.7m had no significant thermal advantage, irrespective of ventilation conditions and seasonal variations.[1]

In South Africa the experiments of thermal analysis of different ceiling heights showed that:-

a) Adequate overhead clearance is the standing position or 2.3m.

b) Persons accustomed to higher ceilings will undergo an initial period of psychological discomfort after which they become adjusted to the new environment.

c) Natural lighting by windows is not affected by the height of the ceiling.

d) Lowering the ceiling does not affect ventilation conditions. (2)

In England, Crowdan[3] made a comparision of temperature and air change measurements in rooms identical in all aspects except ceiling heights, which were set at 2.40m, and 2.10m respectively. The tests took place in winter. Observations were made on the subjective responses of occupants and in addition an opinion survey was taken in apartments with lower ceiling height (2.25m) than is usual in England (2.40m). The conclusion was that there is no adverse effect, either climatologically or psychologically, in a reduction from 2.40m to 2.24 or even 2.10m. 90% of the occupants of the lower-ceilinged apartments told the interviewers, that the height seemed appropriate to them, and a large majority did not notice that the height was lower than usual.

From all the above studies it can be concluded, that in hot regions rooms with lower celings (2.50m) are not thermally inferior to higher ceilinged rooms (up to 3.30m).

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(1) C.L. GUPIA and K.R. ARO. An experimental study for determining adequate ceiling heights of residential buildings in hot-arid regions. N.B.O. J. India, October 1959.

(2) S.R. RICHARDS, Minimum Ceiling Height in South Africa. Bull.No.15, Nat.Build.Res.Inst. Pretoria January 1957.

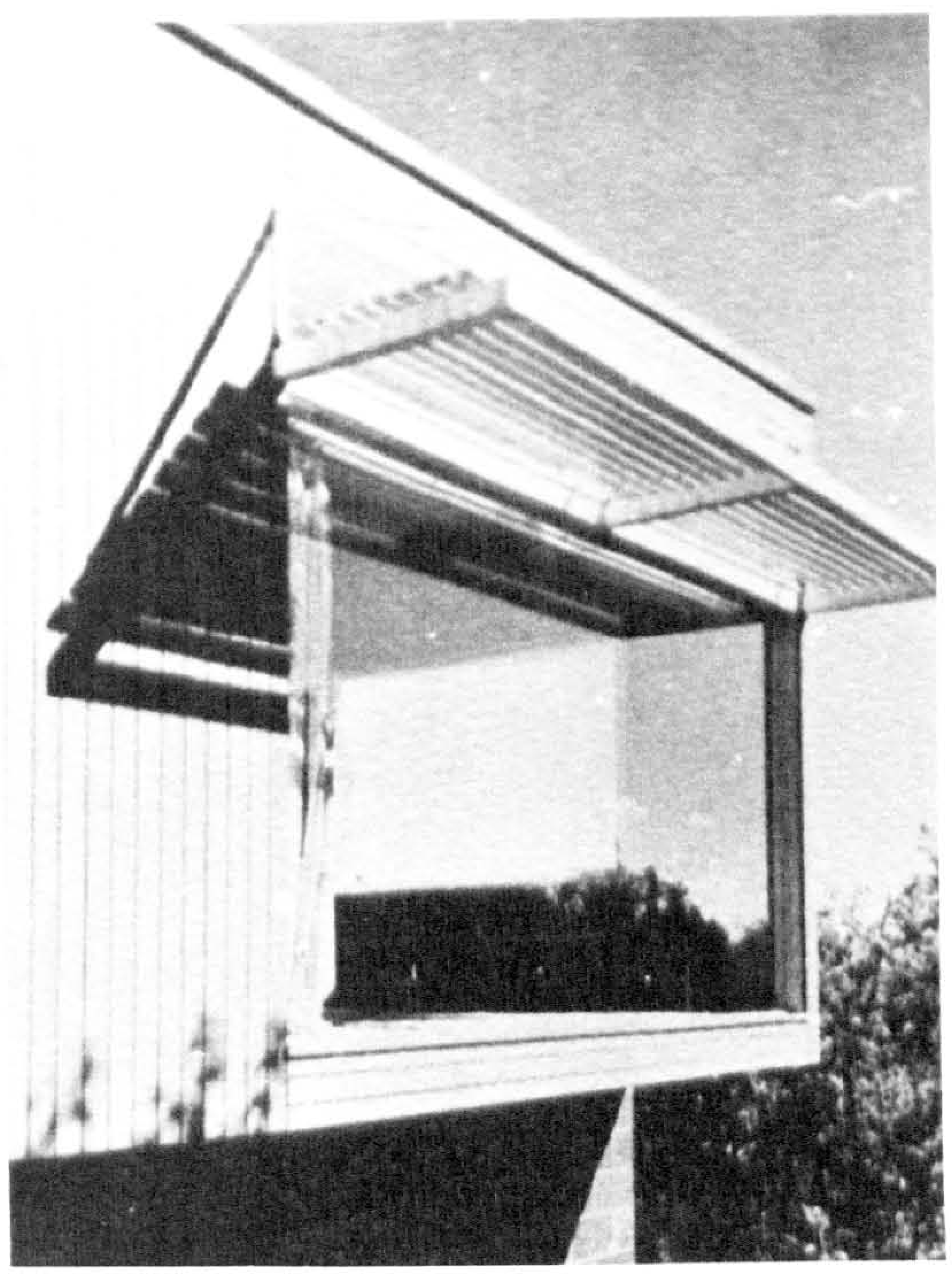
(3) G.P. CROWDAN, The height of rooms in dwellings in relation to health and comfort. J. Ray. San.Inst. March 1951.

3.7. Natural Shading of Buildings

In a region with such severe hot climatic conditions, it is always preferable to protect buildings by natural shading systems rather than mechanical solutions which generally have certain disadvantages as well as being very expensive.

Different means are available to provide a good level of shading but they all have to be considered right from the first stage of the design:-

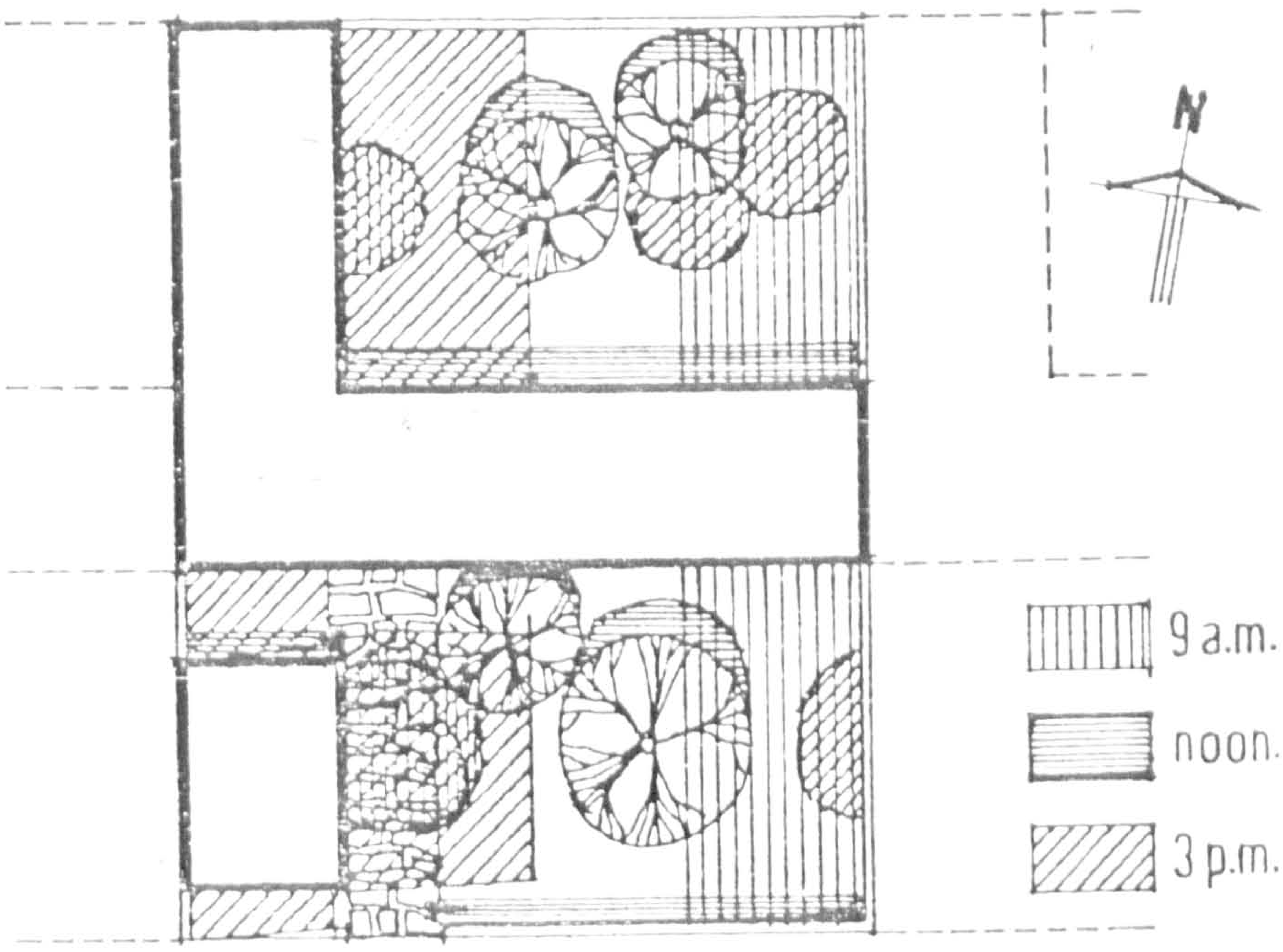
1. Natural shading may be achieved by using horizontal elements:-

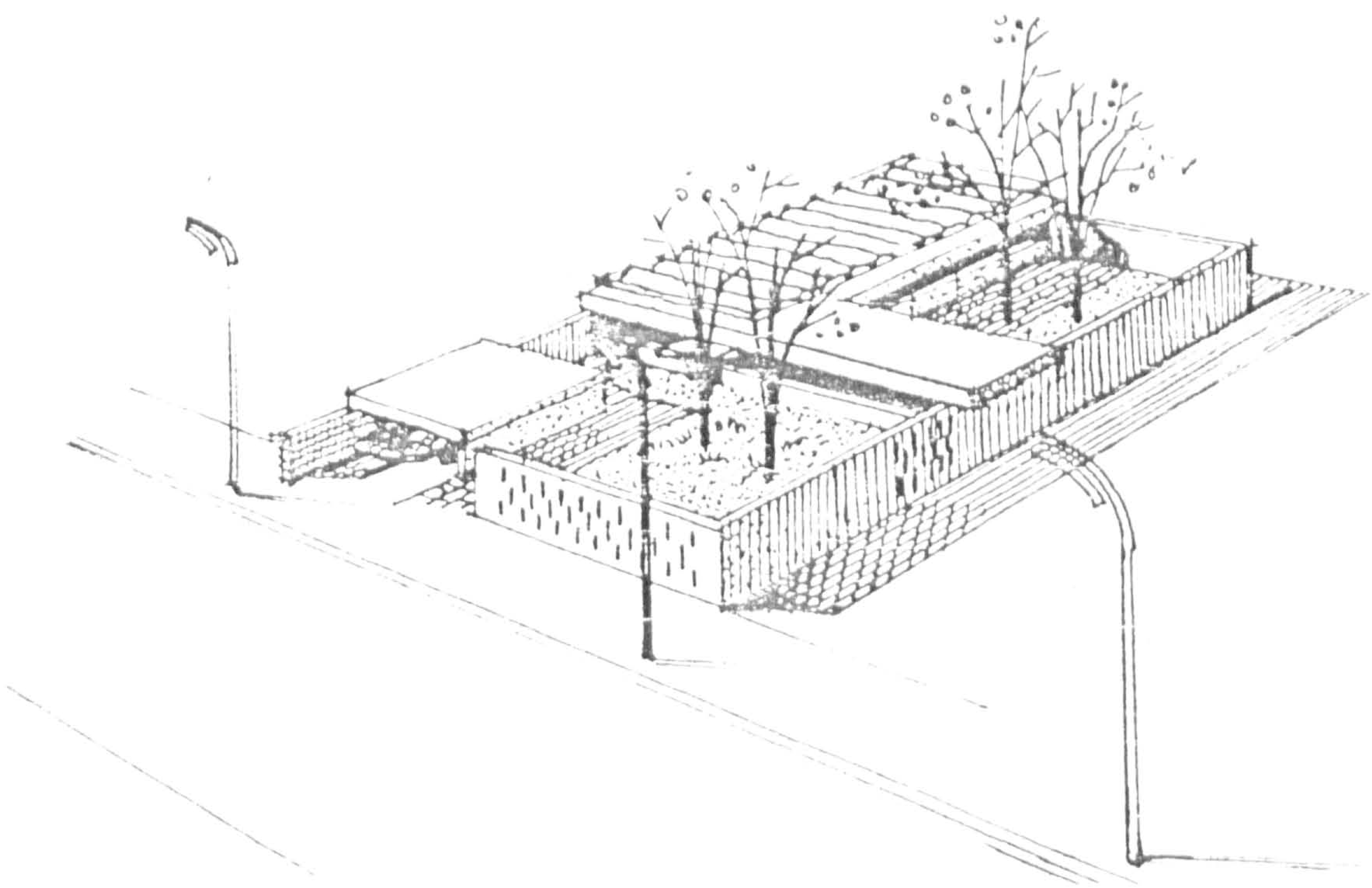


The Architects Collaborative Martin House

Lexington Mass.

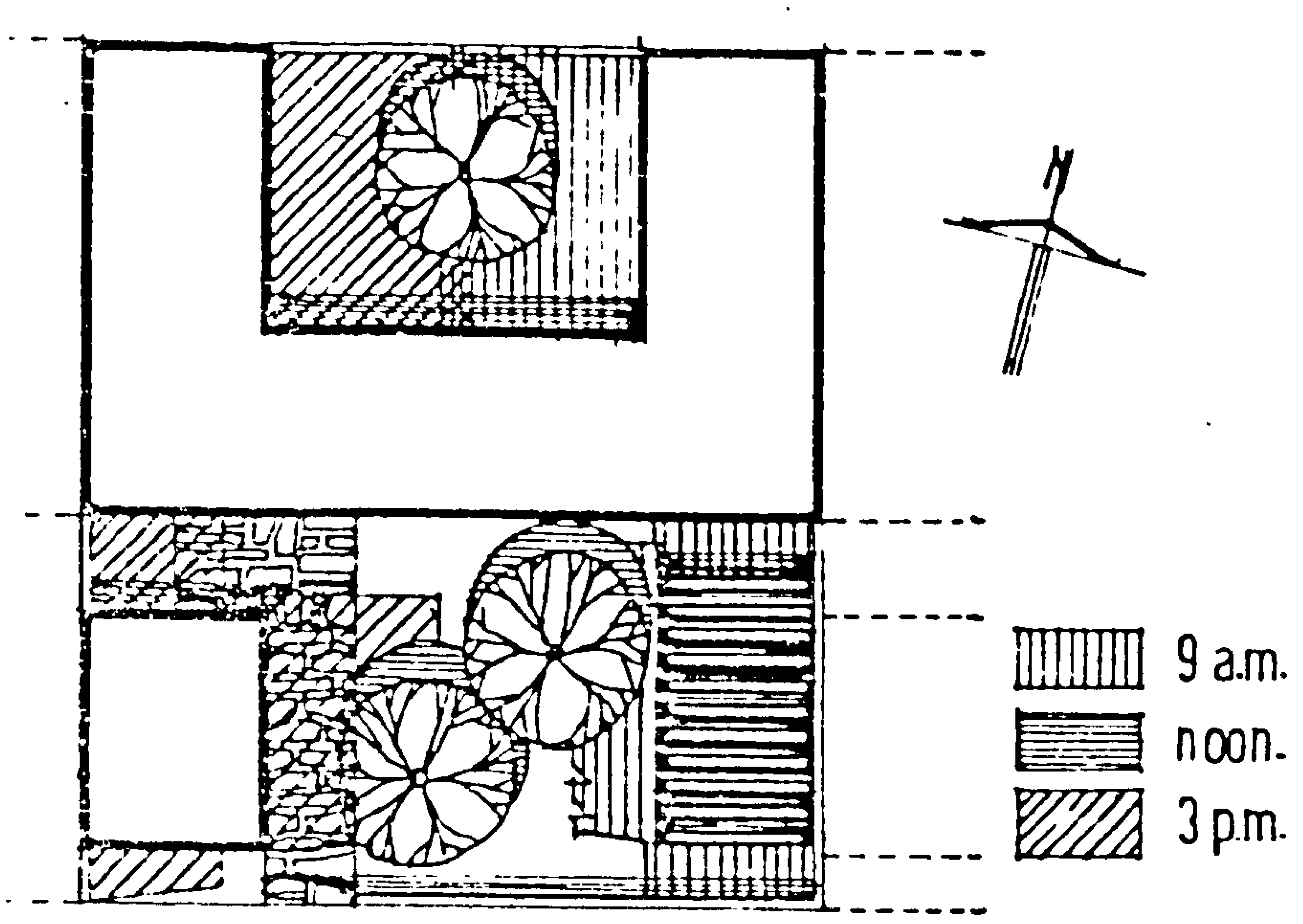
2. Natural shading may also be achieved by using alternative forms of layout, e.g. L and U shapes which will increase the number of walls and so increase the shade in different parts of the building:

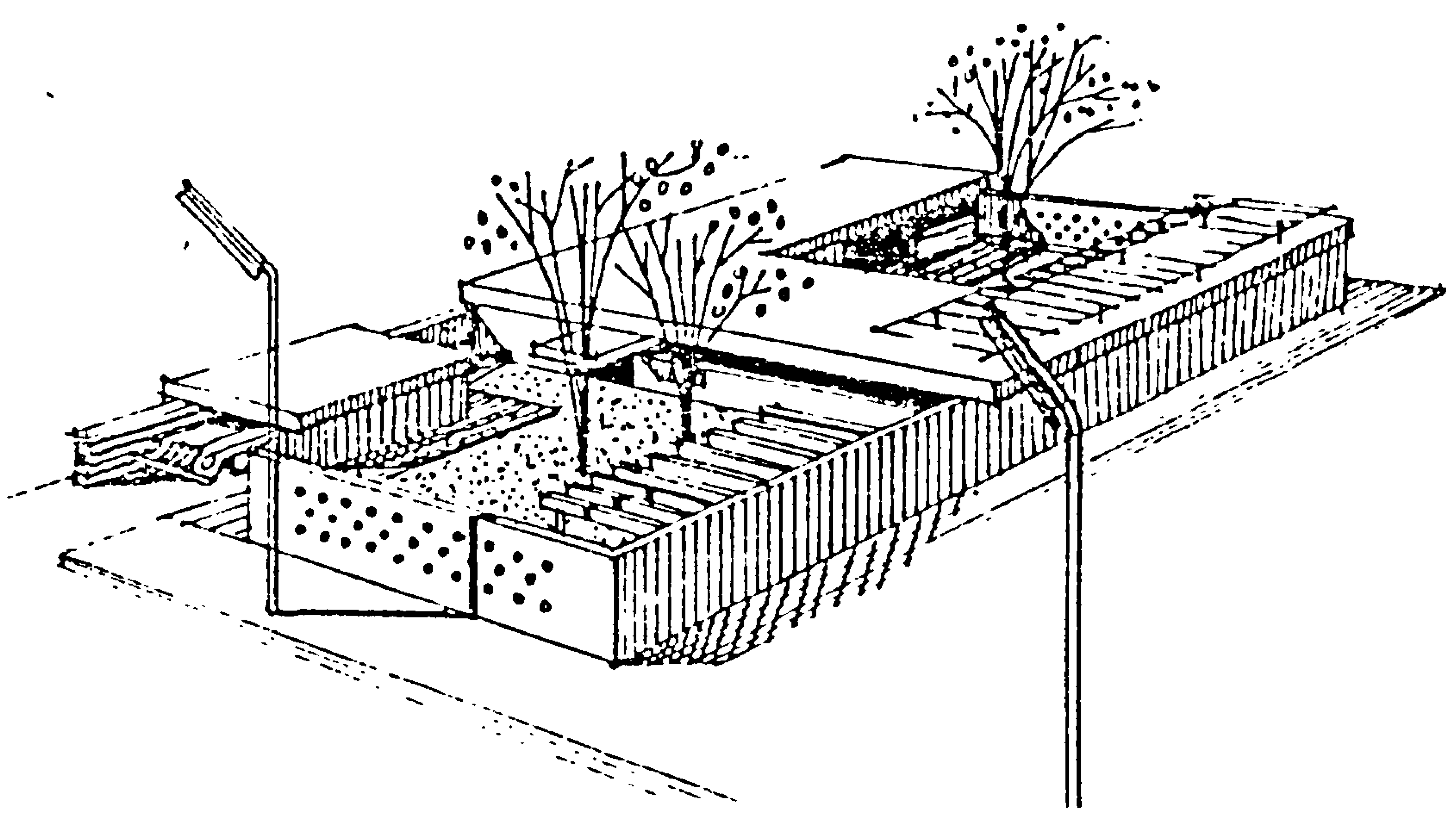




Source: S. HASSAN
The Climatical Influences on Architectural Design in Hot Dry Regions. Ph.D. Thesis. Sheffield University 1965.

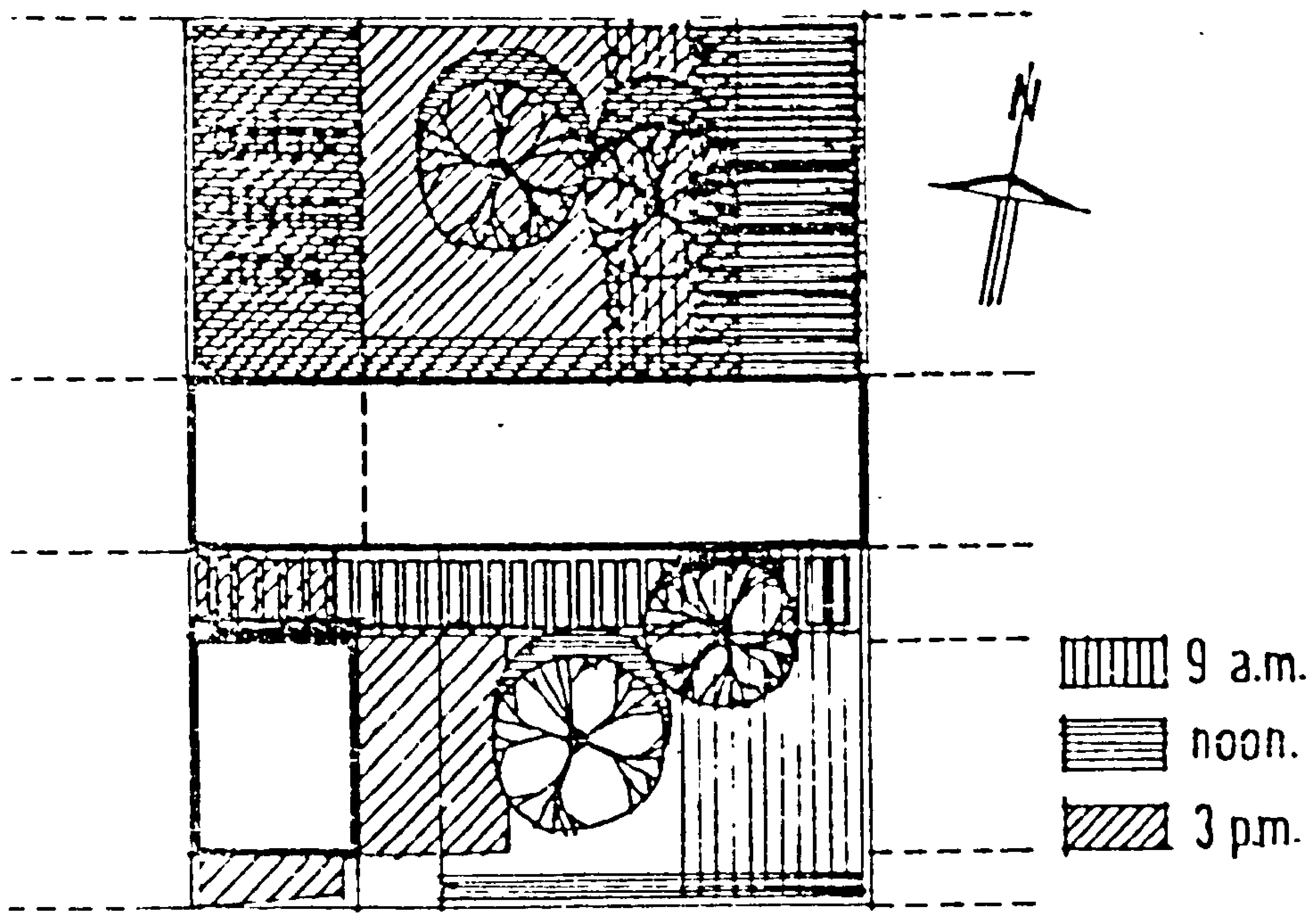
3. U-shape layout of buildings gives a good quality of shade around the whole building:-

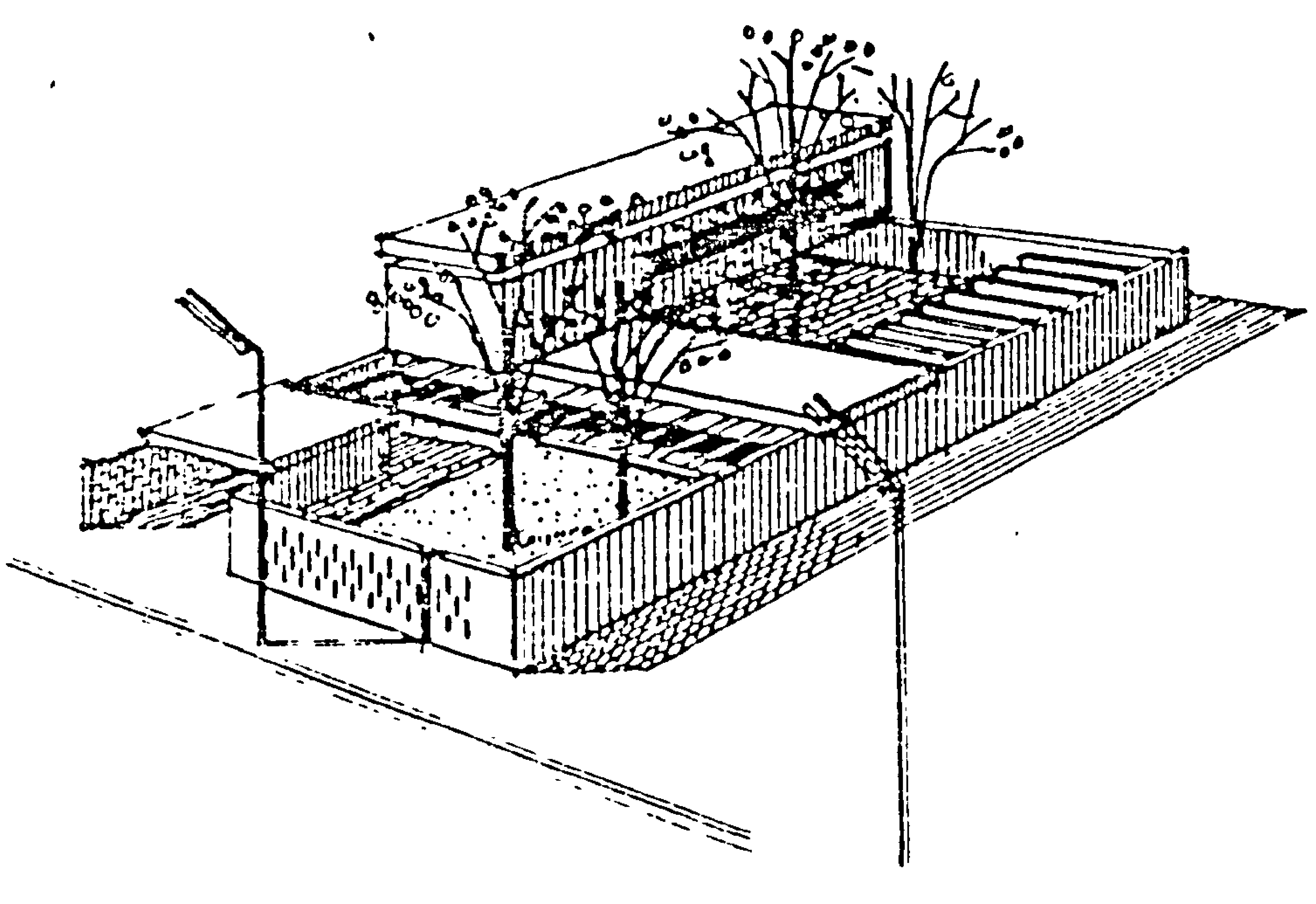




Source: S. HASSAN .... op.cit.

4. Shading may also be achieved by raising some parts of the building above the level of the ground.

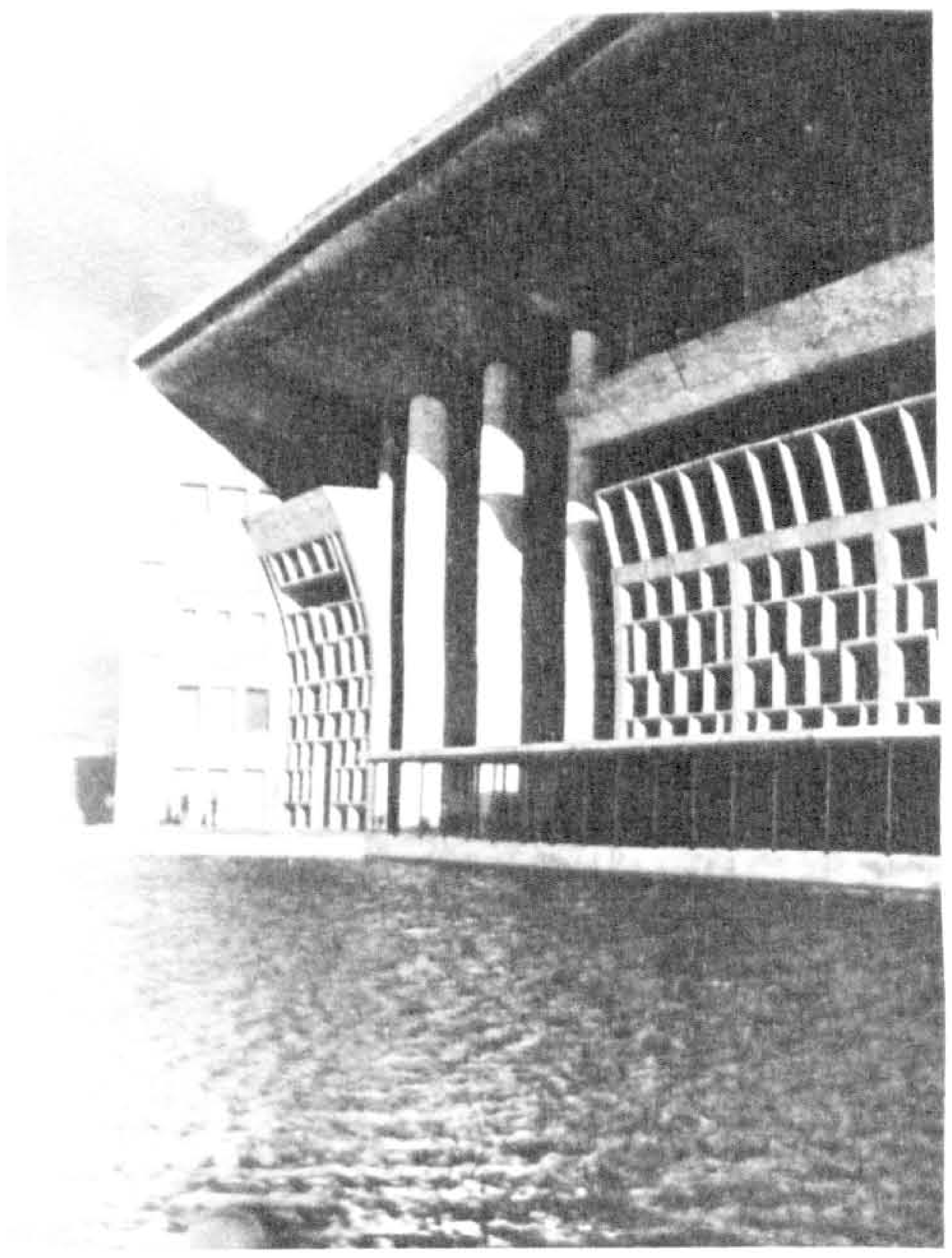




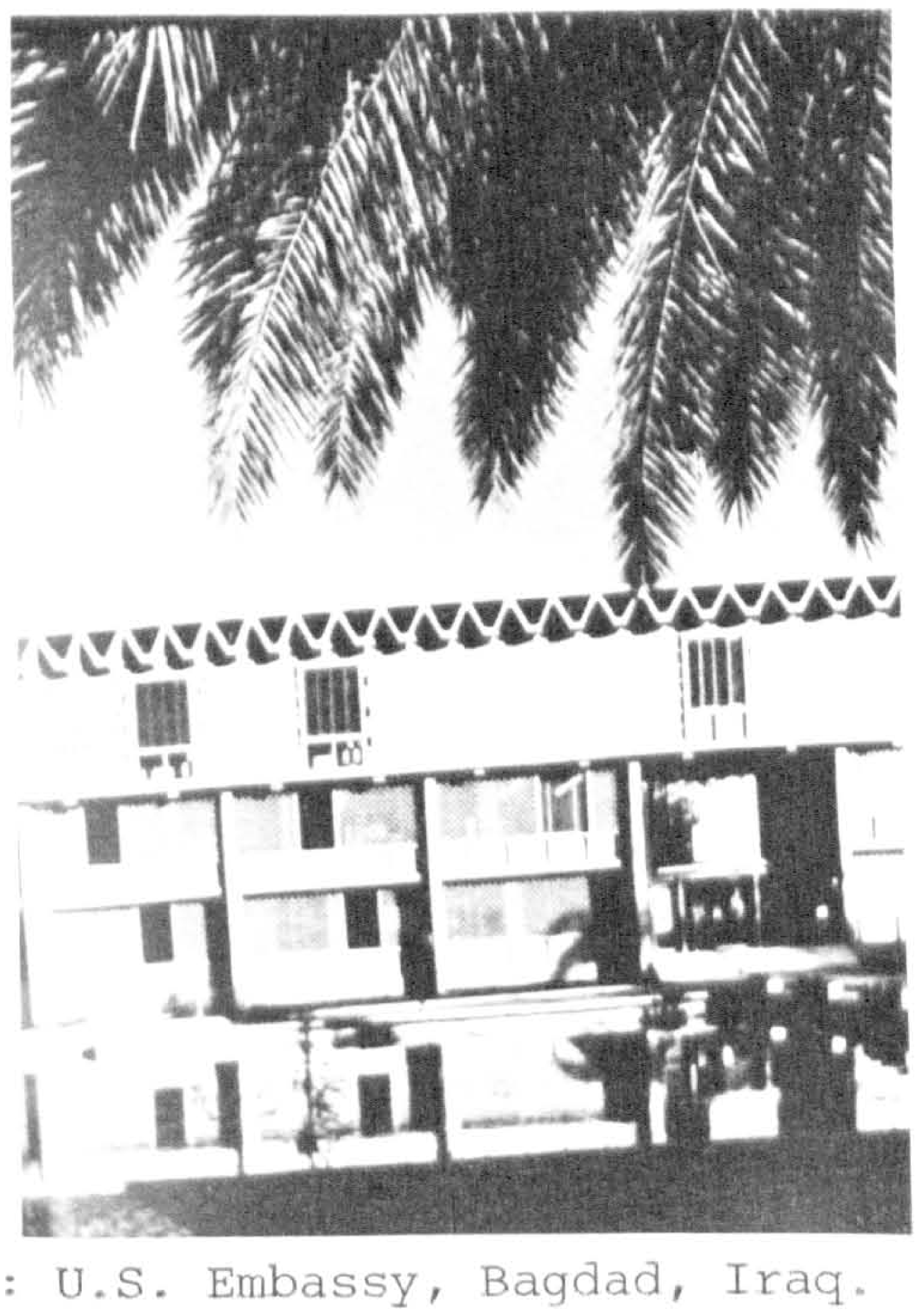
Source: S. HASSAN .... op.cit.

5. The close spacing of the buildings gives maximum natural shading and creates small living spaces between the buildings. This is the oldest traditional method used in the region and is still the best solution.

6. Water ponds and plantations in the surrounding areas give a good natural shading and protect the buildings from direct solar radiation.



Le Corbusier : Palace of Justice, Chandigarh, India.



Jose Luis Sert : U.S. Embassy, Bagdad, Iraq.

Trees, beside their shade, absorb through their leaves large amounts of solar heat before it reaches the ground (temperature at mid-day under the trees is $3^{\circ}C$ lower than under shaded environments). Trees also reduce the effect of dust and the acoustical reverberation time in the courtyards.

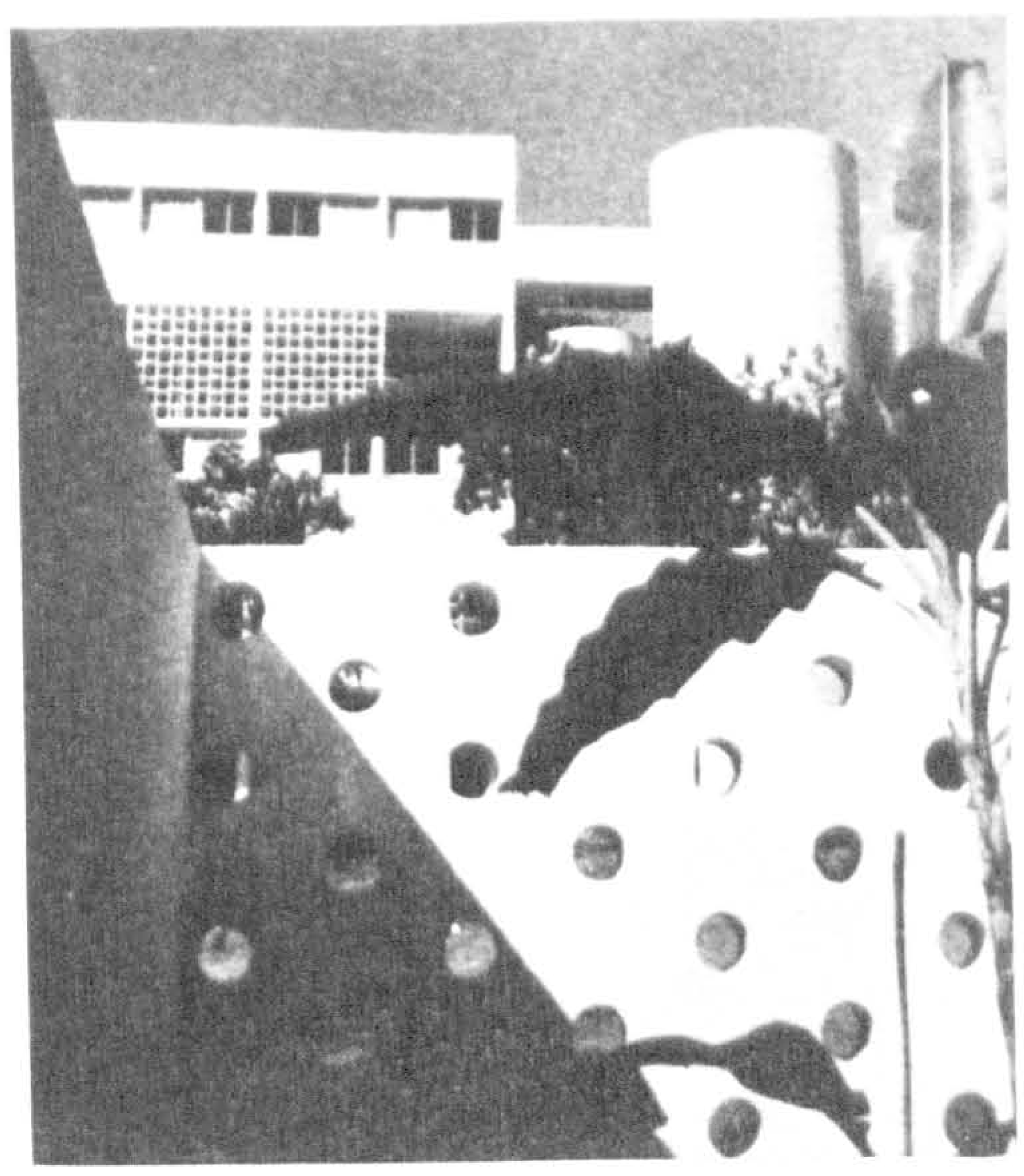
The walls enclosing the space around the building may also help the thermal behaviour of the building, taking the following points into consideration:-

(a) They must be of a pale colour (pure white causes glare).

(b) They can be effectively shaded by strategically situated trees or creepers.

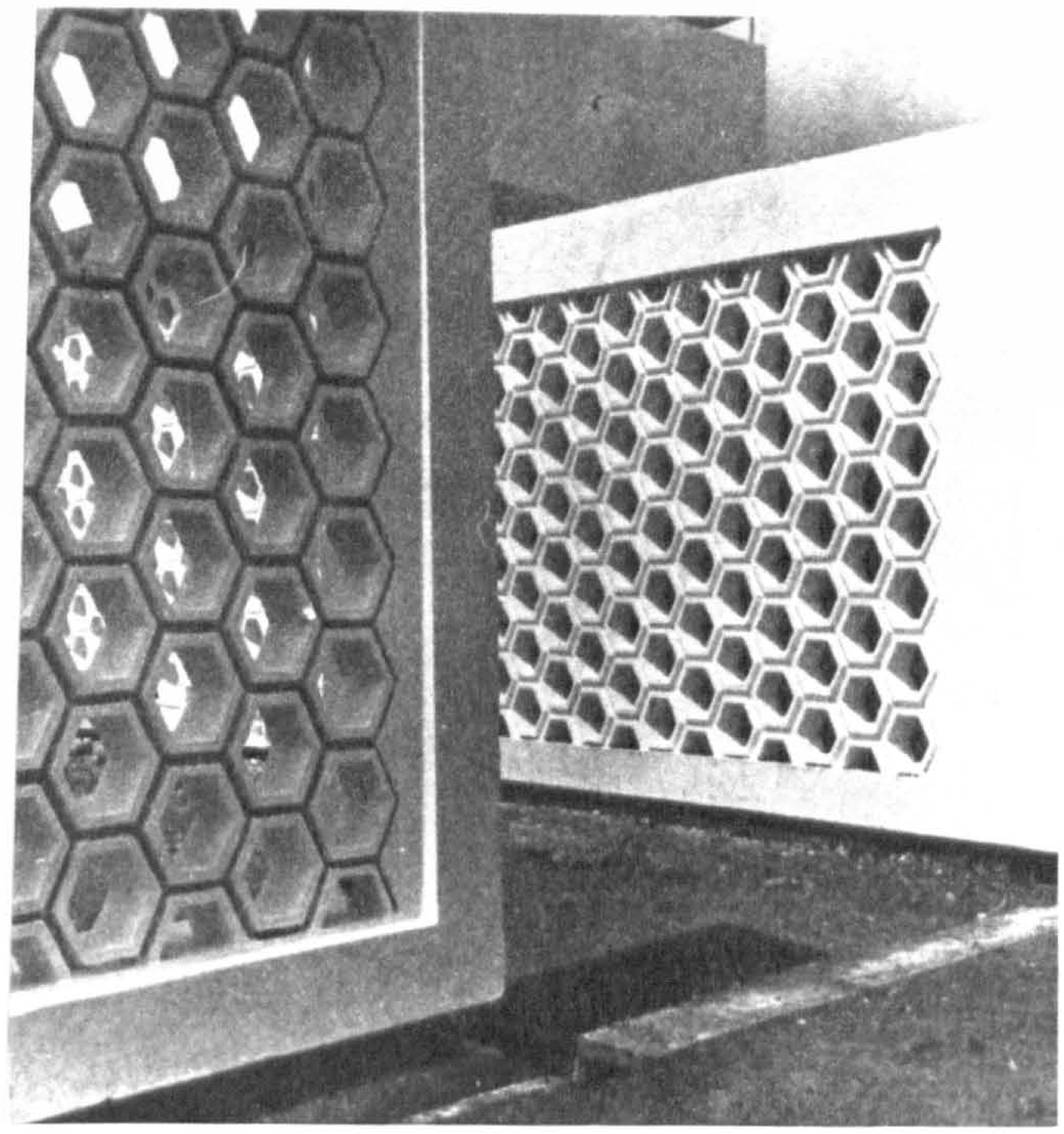
(c) Their surfaces can be self-shaded by using corrugated or uneven finishes. This roughness in the walls will increase the rate of convective heat loss and so improve the heat balance of the wall and thus of the surroundings.

(d) Holes may be used in these walls to reduce glare and facilitate air movement.



A Leonso Eduardo Reidy

Residential Group in Pedregulho, Rio de Janeiro, Brazil.



Source: Miles Danby: Grammar of Architectural Design ..... op.cit.

3.7.1. Shading effects of Trees and Vegetation

The old custom of surrounding homes with shady trees has deeper roots than the simple desire to enjoy the varied beauties of nature. Besides satisfying the instinctive need for protection, trees also contribute much to the immediate physical environment they reduce air-borne sounds with great efficiency if densely planted; the viscous surface of leaves catches dust and filters the air; vegetation usually secures visual privacy and reduces annoying glare effects.

However, trees are particularly beneficial in their thermal effects. It is well known that the ground itself, when exposed to the direct rays of the sun, gets very hot during the course of the day and, like a concrete roof slab, continues to radiate heat during the night. The natural cover of the terrain tends to moderate extreme temperatures and stabilize conditions through the reflective qualities of various surfaces, e.g. plant and grassy covers reduce temperatures by absorption of insulation, and cool by evaporation. This reduction can amount to 1,500 Btu/sq.ft./season. It is generally found that temperatures over grass surfaces on sunny summer days are about 10° - 14°C cooler than those of exposed soil, and temperature under a tree at mid-day was observed to be 5°C lower than the unshaded environment.(1)

Conversely, city environments and man-made surfaces tend to elevate temperatures, as the materials used are usually of an absorptive character. For example, the temperature in a city may well be 124°F whilst the air temperature is 98°F.

Furthermore, trees provide generous shade at the right seasons. This makes deciduous trees especially valuable when placed close to buildings.

Vines are another of nature's automatic heat-control devices, cooling by evaporation and providing shade. This combination makes them valuable for sunny walls in such hot weather.

Both vines and trees should be selected for their appearance as well as shading performance. The type of tree to be used in a given location is very important and two things should be borne in mind: the shade and character of the tree itself, both in winter and summer, and the shape of its shadow for a natural shading device.

Water ponds in the courtyards of a building also moderate high air temperatures, especially in summer. Water, having a higher specific heat than land, is normally warmer by comparison in winter and cooler in summer, and cooler during the day and warmer at night. Accordingly, the proximity of bodies of water moderates extreme temperature variations, and in winter raises the minima whilst in summer lowering the heat peaks.

The following photographs of a model of a house shaded by three trees shows how trees moderate its micro-climate by casting their shadows during the consecutive hours of a summer day from dawn to dusk.

In early morning the sun relieves the coolness of daybreak. After 8 a.m. the east side gets protection from the single tree at the south-east corner. At noon an overhang shields the building. In the early afternoon the tree on the south-west corner protects the west side. For complete shade coverage there is another tree to the west. This is placed at a greater distance from the house, as the setting sun lengthens the shadows. The hedge to the west is intended to catch the last low-angle evening rays.

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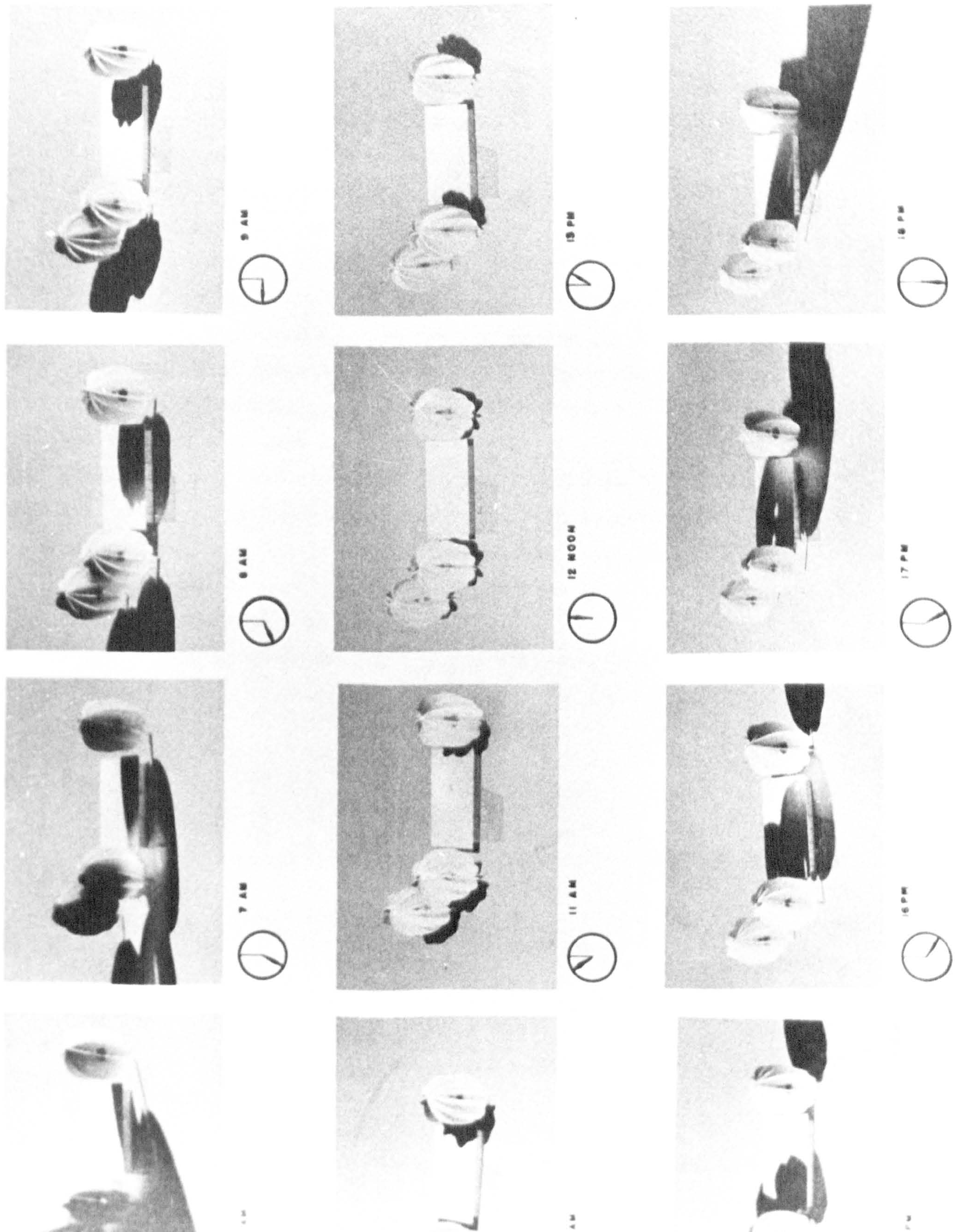
(1) Victor Olgyay, Design with Climate .... op.cit.


7 AM
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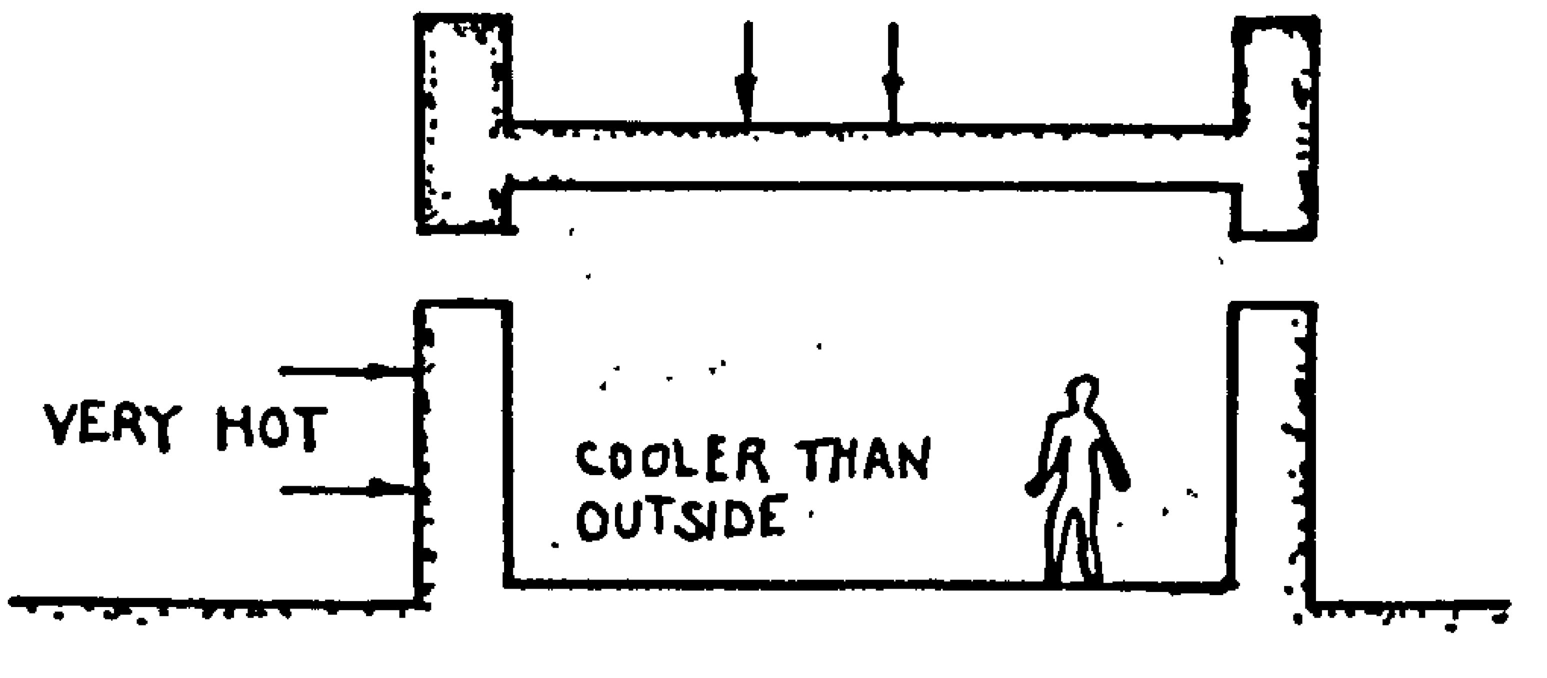
3.8. Ventilation of Buildings

3.8.1. Natural Ventilation of Buildings

Because of economic factors in the Sudan, it is essential to maximize the natural ventilation of buildings wherever possible. In the housing sector very few buildings have mechanical ventilation and natural ventilation is the rule. Traditionally, it has been found that when a room is ventilated throughout the day, the indoor air temperature follows closely the outdoor air temperature and remains high after the outdoor air temperature drops. When the same room is not ventilated during the hot period of the day, the indoor air and surface temperatures are 10-11°C lower than the maximum outdoor air temperatures. The mean indoor surface temperature of the unventilated room is about 4°C lower than that of the ventilated room. Later in the day, when the ventilation is brought into use, the indoor air temperature falls rapidly in sympathy with the outdoor air temperature. It is therefore a common practice in this region to close windows when it starts to get warm in the morning and not open them until late afternoon.(1)

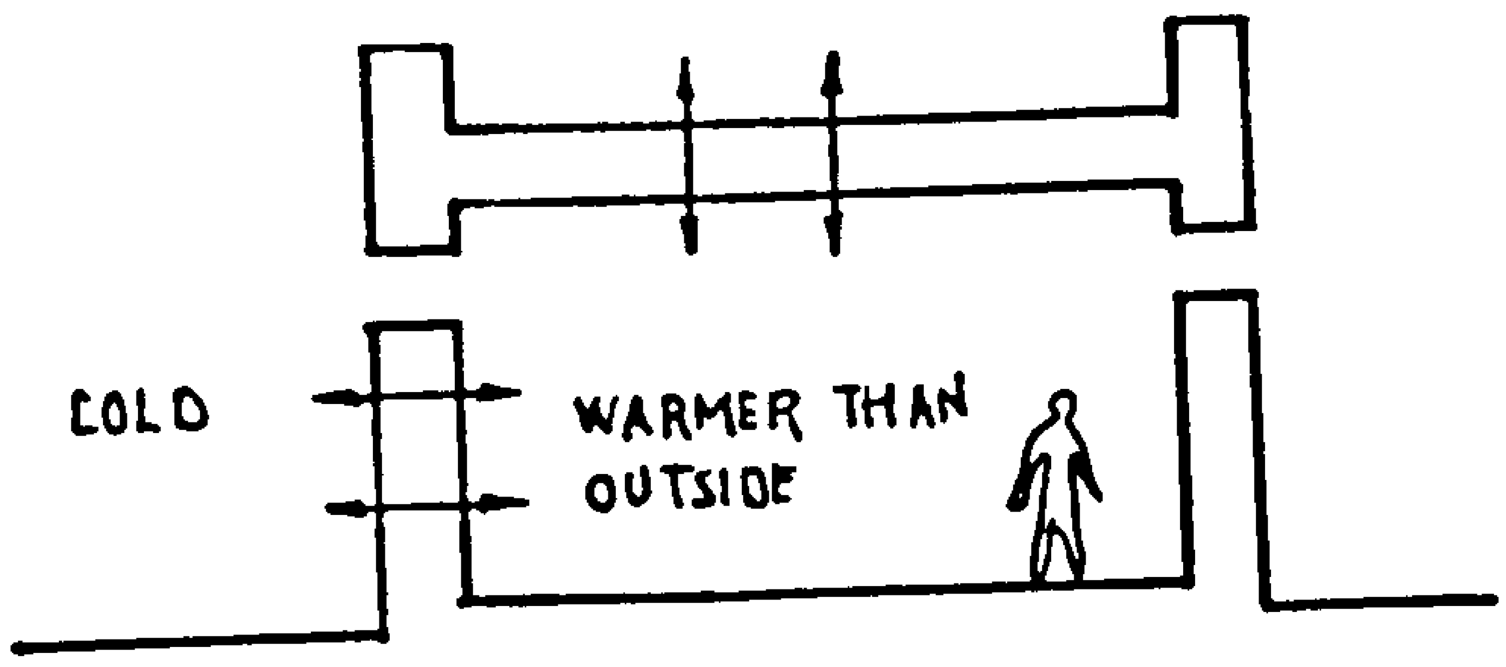
Fig.I - Room unventilated during the hottest period of the day:-



Room unventilated during the hottest period of the day.

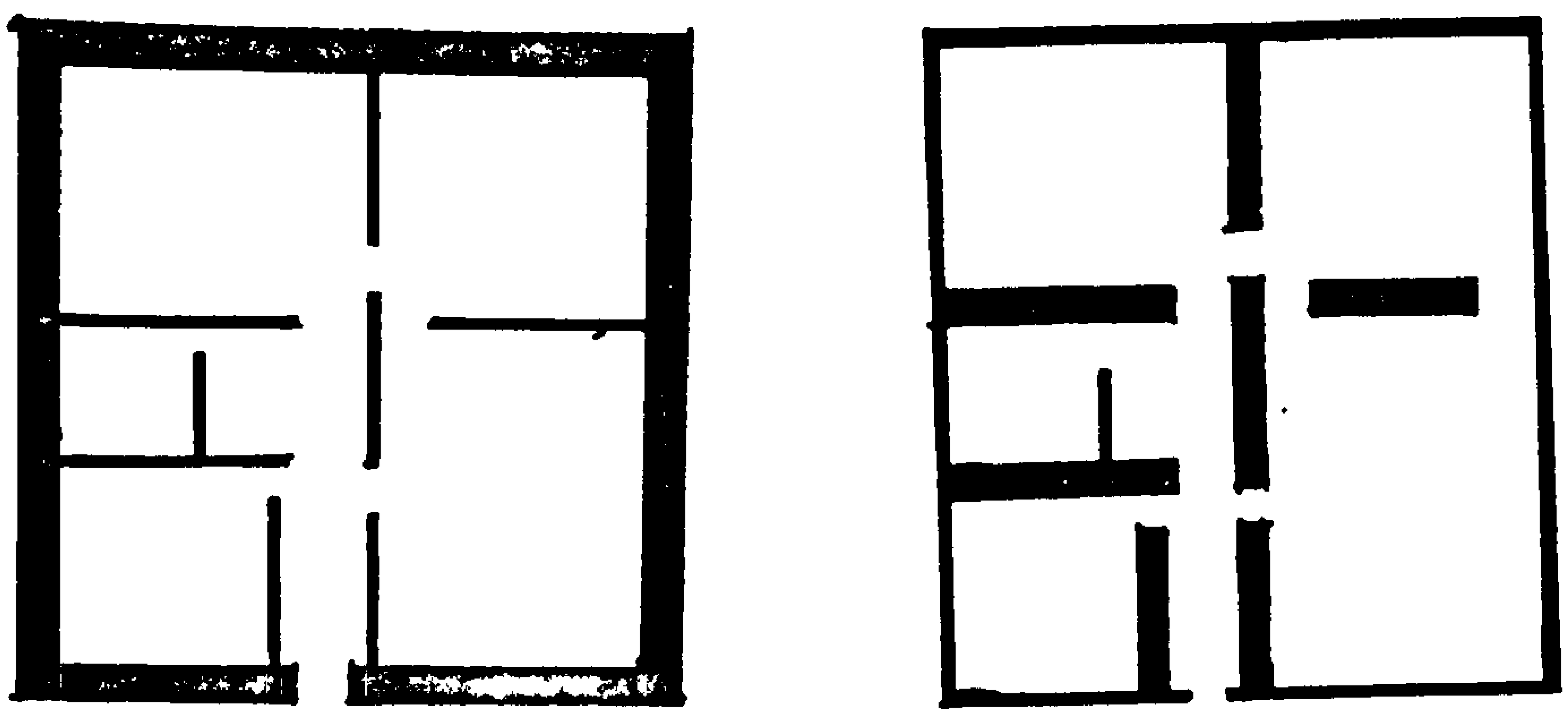
(1) Source: Miles Danby, Build.International (6) 1973 ... op.cit.

Fig. II - Room ventilated throughout the day:-



Usually the number of people inside a house at any one time is quite small, so there is no need for ventilation during the day, and large gatherings are traditionally held out of doors under the shade of verandas, canopies and trees. However, night ventilation is very importance and openings should be positioned to facilitate a through passage of cool air. A heavyweight structure usually retains a level of coolness for the following day and helps to keep the interior cool, provided the openings are closed during the hottest part of the day.

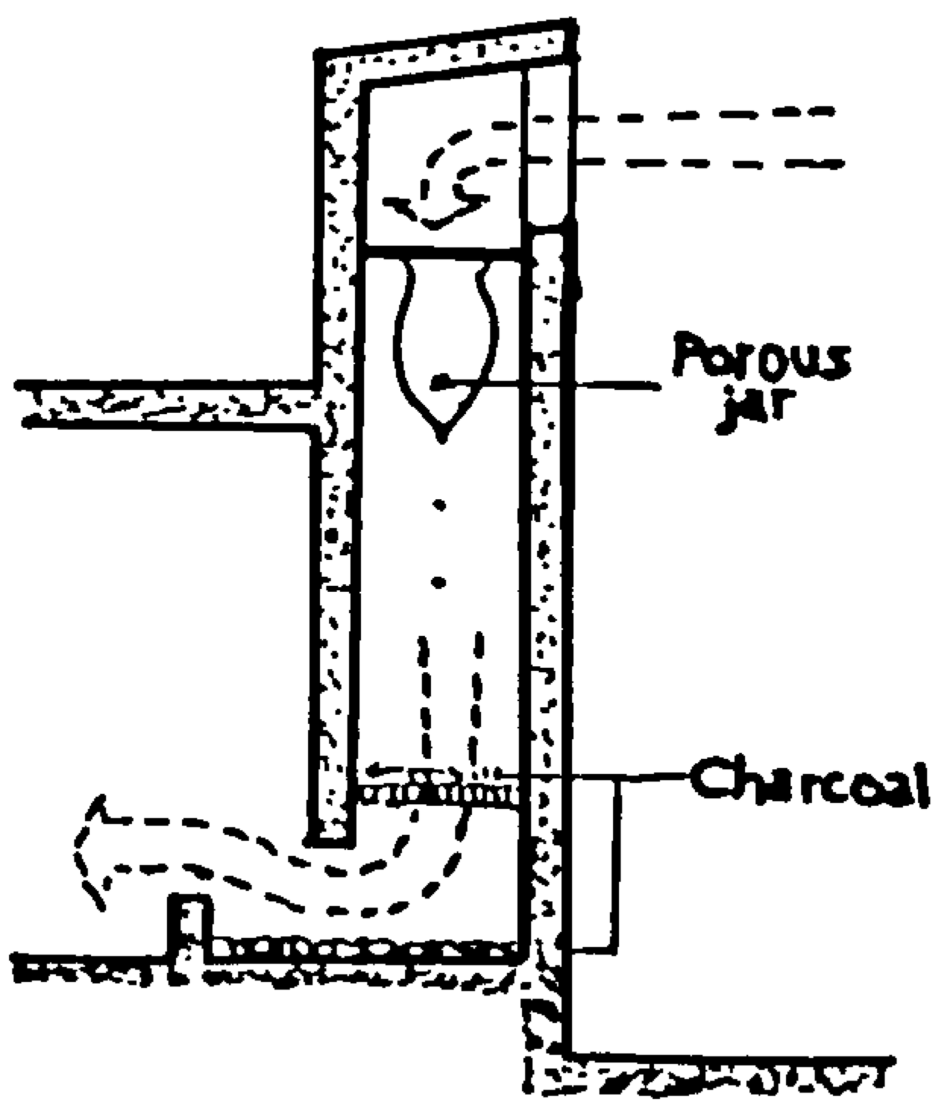
The suitability of heavyweight structures for the climate of the Sudan is often taken for granted, but the mass is normally located in the outer shell. Actually, it seems that the mass might be more effective if it could be confined to the interior of the building where it would not be subject to the impact of solar radiation, allowing the cool internal temperature to be maintained for a longer time.



Source: Miles Danby ..... Build International .... op.cit.

Evaporative coolers:

Sometimes a traditional device for ducting cool air to the interior of the building is used. This consists of a chimney type structure with an opening designed to catch the prevailing dry winds which are then funnelled down a shaft in which a large porous pot full of water is suspended. The water slowly drops onto a grid on which charcoal is spread and the air passing over the porous pot and the charcoal absorbs the water vapour. Cooling takes place by evaporation and this produces cool air inside the building:-



Source: David Oakley. Tropical Houses .... op.cit.

There are many other traditional means of improving the micro-climate around the buildings, e.g. water gardens and fountains where water can be obtained in generous quantities. In Khartoum, houses with well established gardens maintained through irrigation from the Nile, have a micro-climate 2-3°C cooler than other residential areas with no or few gardens.

3.8.2. Mechanical Ventilation

The previous methods of natural ventilation may be sufficient in houses with small numbers of people, but when large numbers have to be assembled in the confined spaces of a building some form of mechanical ventilation becomes essential.

Ceiling fans are generally used, but air-conditioning is now becoming more common. This takes the form of a centralized system in which the conditioned air is distributed through the building by means of ducts; or as a central system in which chilled water is distributed through the building with individually controlled electrical blowers to each room; or as small self-contained units in individual offices and houses. However, the marked contrast between air-conditioned working environments and normal outside conditions is felt by those using the buildings, and the people in naturally ventilated or air-cooled offices find their working conditions more comfortable than those in air-conditioned ones. Other disadvantages are that with all types of air-conditioning the initial cost is high; running and maintenance costs are considerable, and particularly with individual air conditioners, there is a problem of noise. Desert air-coolers are now becoming more popular because both initial and running costs are much lower than those of air-conditioning systems. The air-cooler is a large electrical fan which blows air through a special absorbent filter made from wool fibre which is kept constantly wet with an electrically impelled spray. It is used in schools, offices and middle-class houses, but its disadvantages are that the apparatus is bulky because of the need to process a large volume of air and its fans create a certain amount of noise. As the Government is opposed to the import of expensive and sophisticated air-conditioning systems, they are now locally manufactured with the import only of pumps, switch controls etc.

3.9. Control of Solar Radiation

3.9.1. Heat Penetration through Glazed Windows

One of the characteristics of modern architecture all over the world is the wide spread use of glazing in building facades. However its use in very hot-dry climates has led to an overheating problem within the buildings. In some large cities the recent introduction of modern insulating materials in conjunction with those of high heat capacity has allowed window openings to be made larger whilst still maintaining the thermal conditions that are obtained in traditional buildings. Architects have begun to use movable or adjustable insulated panels for shading instead of ordinary shutters, trying at the same time to reduce the heat flow across large openings to the desired level by using insulation of an appropriate thickness. Nevertheless, mechanical cooling is still used to provide comfortable thermal conditions.

Windows have a profound effect on indoor thermal conditions and this is a special problem in hot climates. Heat gained through a sunlit glass area is significantly greater than through an equal area of ordinary wall, and its effect is felt almost immediately. This applies even when windows are shaded against solar radiation and closed against air flow from outside. Large openings are not necessary even at night, as good cross-ventilation can be achieved with small windows provided that they are correctly placed: efficiency of ventilation is not proportional to size of aperture.[1]

The windows should be designed and arranged so that approximately equal areas are open on the windward and leeward sides of the building, and so that the air stream is directed to the area and level of occupation. This is particularly important in bedrooms, where two horizontal strips of windows, placed in different walls, provide the most adequate arrangement; one should be at the height of the beds and the other below the ceiling, and this will bring about

(1) Givoni, B. and Hoffman. "Effect of window orientation on indoor air temperature". Architectural Science Review Vol.9 No.3 Sept. 1966.

air motion in the room by thermal force during windless hours. The flow at night is inward at the lower level and outward through the upper openings. The horizontal strips generally give a better distribution of air flow in the occupied zone than vertical ones.

It is also preferable to locate windows in such a way as to direct the main air flow along the interior surfaces in order to minimize the rate of heat extraction from the mass of structure. However, where higher levels of daylight are needed, the window size should be the smallest which can provide the necessary illumination, and measures such as the use of light internal colours should be used to maximize the illuminating effect of the penetrating radiation.

The Thermal Effect of Windows

It is well known that the thermal effect of a glazed wall section is dependent on the spectral properties of the glass. When falling on a transparent or translucent surface, radiant energy is divided into three components: one part is reflected and has no thermal effect on the material; a further component is absorbed by the material and is dissipated by convection and long-wave radiation; the third component is directly transmitted through the material. The relative properties of the three components are determined by the angle of incidence with the surface and the spectral properties of the glass. From the combined viewpoints of illumination and heating, the principal distinctions between types of transparent materials are their different relative transmittance and ranges of transmitted wave-lengths.

As already stated, the quantitative thermal effects of windows on the indoor environment depend on the size of the windows relative to the space which is heated by the penetrating radiation. However, other factors influence the effect of windows such as ventilation conditions, thickness, and the thermophysical properties of the materials.

The thermal effect of window size depends mainly on shading conditions. When the windows are openable and shaded, the increase in their size brings indoor temperatures closer to outdoor levels because of the higher ventilation rate and the low thermal resistance of glass. When windows are not shaded, increase in size causes higher solar heat gain and thus elevates indoor temperatures. The amount of the increase depends on orientation and season.

3.9.2. Solar Protection by Sun-Devices & Sun-Breakers

In order to minimize heat penetration of buildings architects began to use heat-intercepting glass, which permits the use of large window-walls with a lower level of heat penetration than that experienced with ordinary glass. Heat-intercepting glass intercepts over 40% of the radiant energy but nevertheless, a large amount of heat still penetrates, raising the indoor temperature considerably. For this reason architects have looked for solutions through the use of shading devices.

The concept of shading devices is fundamentally sound because it is based on the interception and reflection of energy before it strikes the building. Shading devices are especially efficient because by shaping them according to the changing seasonal sun-path, both summer shading and winter heat gain can be achieved. The sun-breaker can also express a strong spatial character, add new elements to the architectural vocabulary and introduce regional flavour. The materials used can offer rich possibilities for visual expression by elaborating the surface, utilizing the play of light and shadow or adding to the spatial composition by employing rhythm, light, colour and texture.

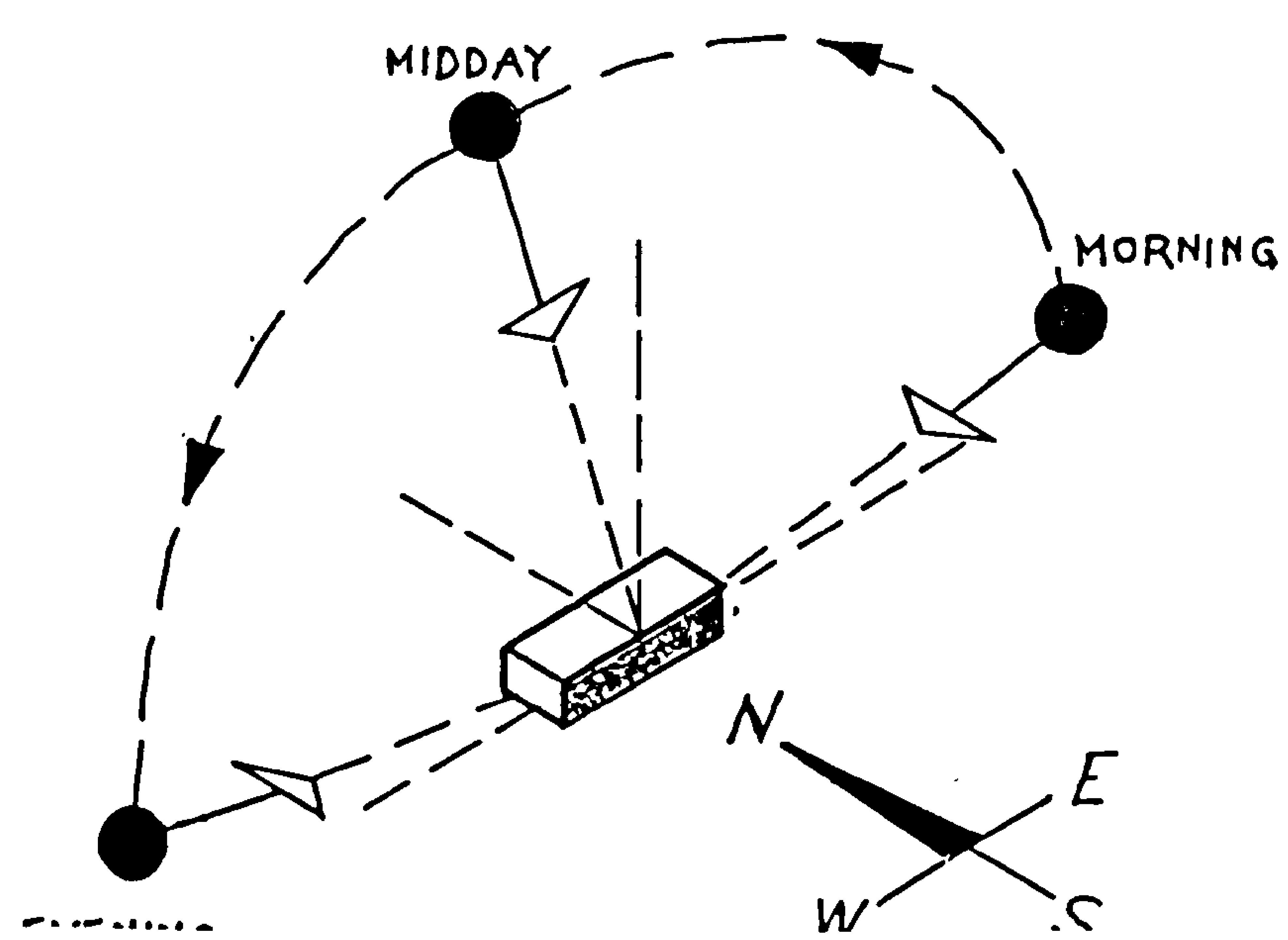
Shading the glass affects the quantity of incident radiation and hence modifies both the heat flow to the interior and the indoor temperatures. The extent of modification depends on the position of the shading with respect to the glass, whether external or internal. When shading intercepts radiation outside the glass, part is reflected outwards, part reflected inwards and the remainder is absorbed raising the tempereature of the shade. As a result only a small fraction of the incident radiation penetrates externally shaded glazed areas.

When the shading is internal, solar radiation is transmitted through the glass before interception. The radiation absorbed into the shading material is re-released to the interior and almost all this heat remains within the space as the opaqueness of the glass prevents long-wave radiative heat dissipation. The effectiveness of internal shading is therefore determined by its reflectivity (colour), and on the whole it is much less effective than that of external shades. Shading devices may be fixed, adjustable or retractable and of various architectural shapes and geometrical configurations. Internal shading devices include venetian blinds, roller blinds and curtains. External shading devices include shutters, awnings, overhangs and a variety of louvres: vertical, horizontal and a combination of both (egg-crate). Shading suitable between double glazing includes venetian blinds, pleated paper and roller shades, which are usually adjustable or retractable from the inside.

Shading devices may perform a variety of functions: controlling heat gain either constantly or selectively (eliminating the sun in overheated periods, admitting it in underheated periods). They may affect daylight, glare, view and ventilation. The relative importance of these factors varies under different climatic conditions and in various situations.

Before any shading device can be effectively applied, however, the direction and angle of elevation of the sun must be determined. This is established by the latitude, the time of the year and the time of the day.

The sun's rays are most difficult to exclude from a building when they are at a low angle, i.e. in the morning and evening when the sun is shining from the east and west respectively.

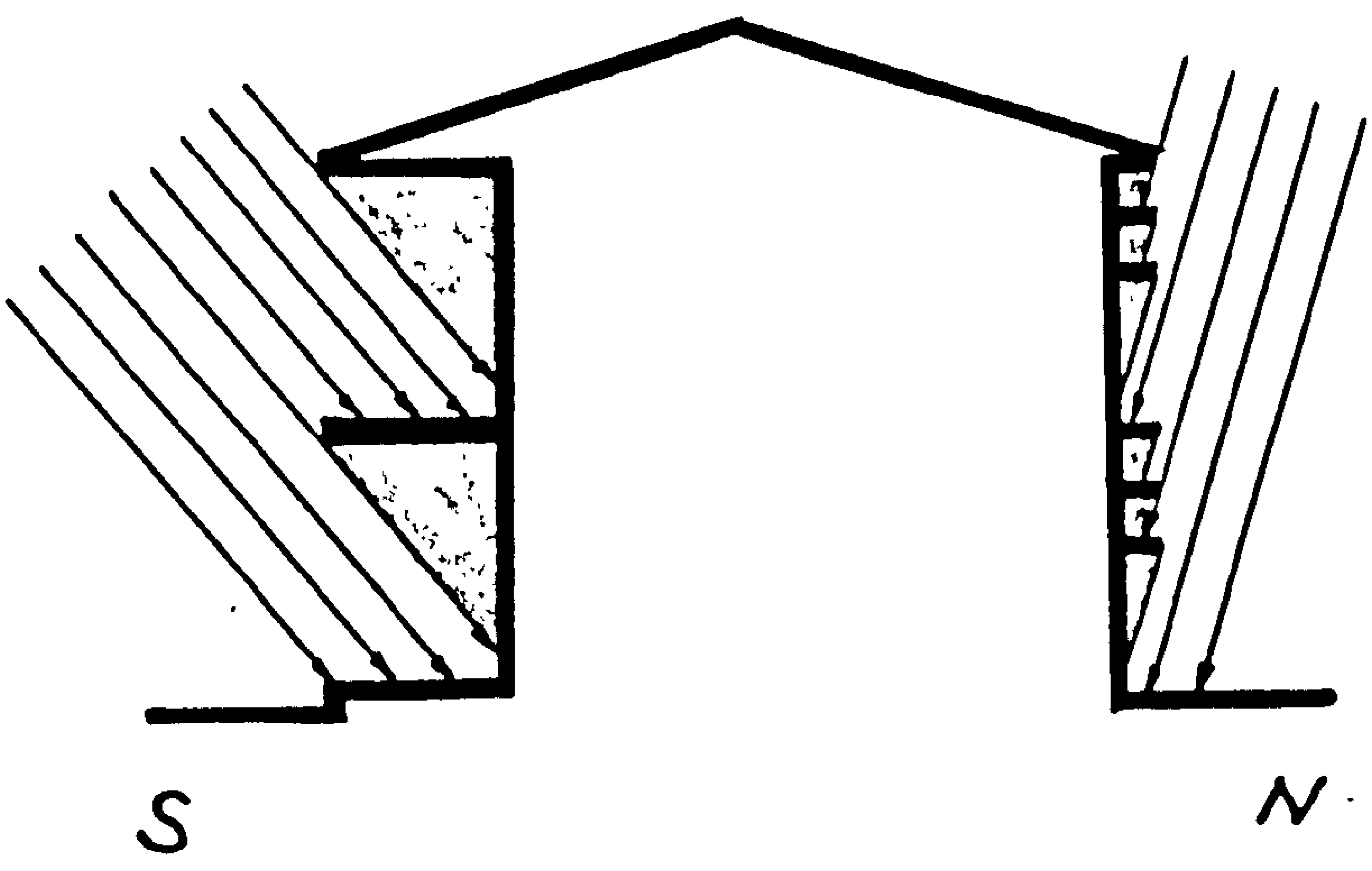


Source: Miles Danby, Grammar of Arch.Design .. op.cit.

It is therefore best to eliminate all doors and windows from the east and west elevations and in the Sudan it is customary to restrict window and door openings to the north and south elevations of the buildings. The sun can still penetrate into the building but at a much steeper angle than if they were on the east and west elevations and because of the angle it is easier to arrange a shading device.

The simplest method of all is to provide a roof overhang. This will give shade for both the walls and the openings of a single-storey building. As a general rule it is better to make the overhang at least half the height of the wall. Obviously this becomes impracticable for any building of two or more storeys, so a method commonly used is to extend the roof slab to form overhanging balconies which shade the floor below.

Roof overhang and balconies can be useful in forming open but covered corridors which give access to various rooms of the building.



Source: Miles Danby ...... op.cit.

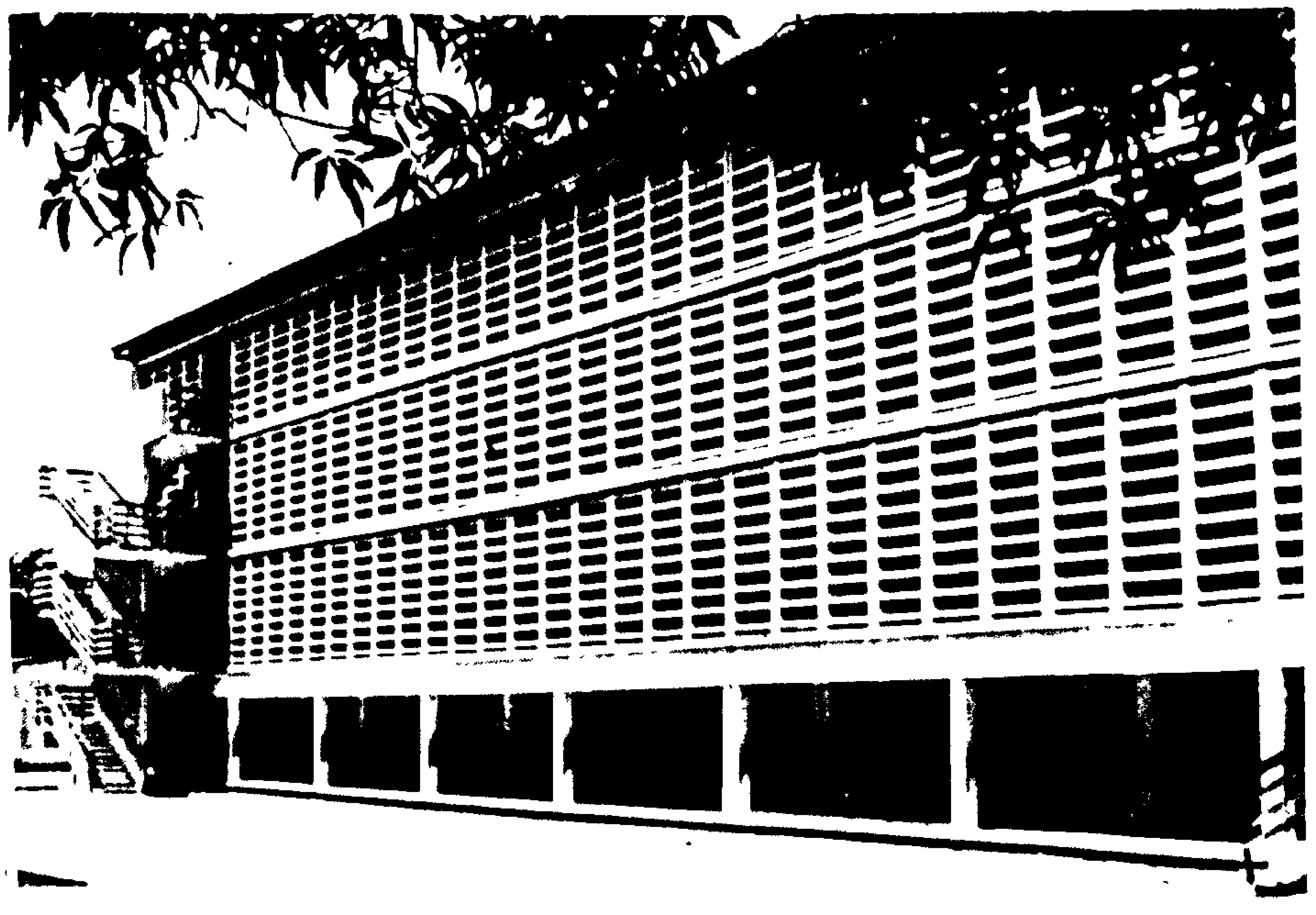
Corridors are not usually necessary on both sides of a building, so other methods of shading can be considered for the opposite side.

The shading devices which have been used in recent times have different compositions, and a wide variety of screens are available. This diversity is not incidental because the character of the screen design reflects its particular function.

3.9.3. Fixed Shading Devices

Fixed shading devices cannot be adjusted according to the variations of sun position or functional requirements which may vary from season to season and even at different hours of the day. The relationship between the geometrical configuration of a given shading at a given orientation and the annual and diurnal patterns of the sun determine the effectiveness of that device as a sun screen. It is possible to test the actual thermal performance of a fixed shading device by constructing a model and testing it under artificial or natural irradiation conditions.

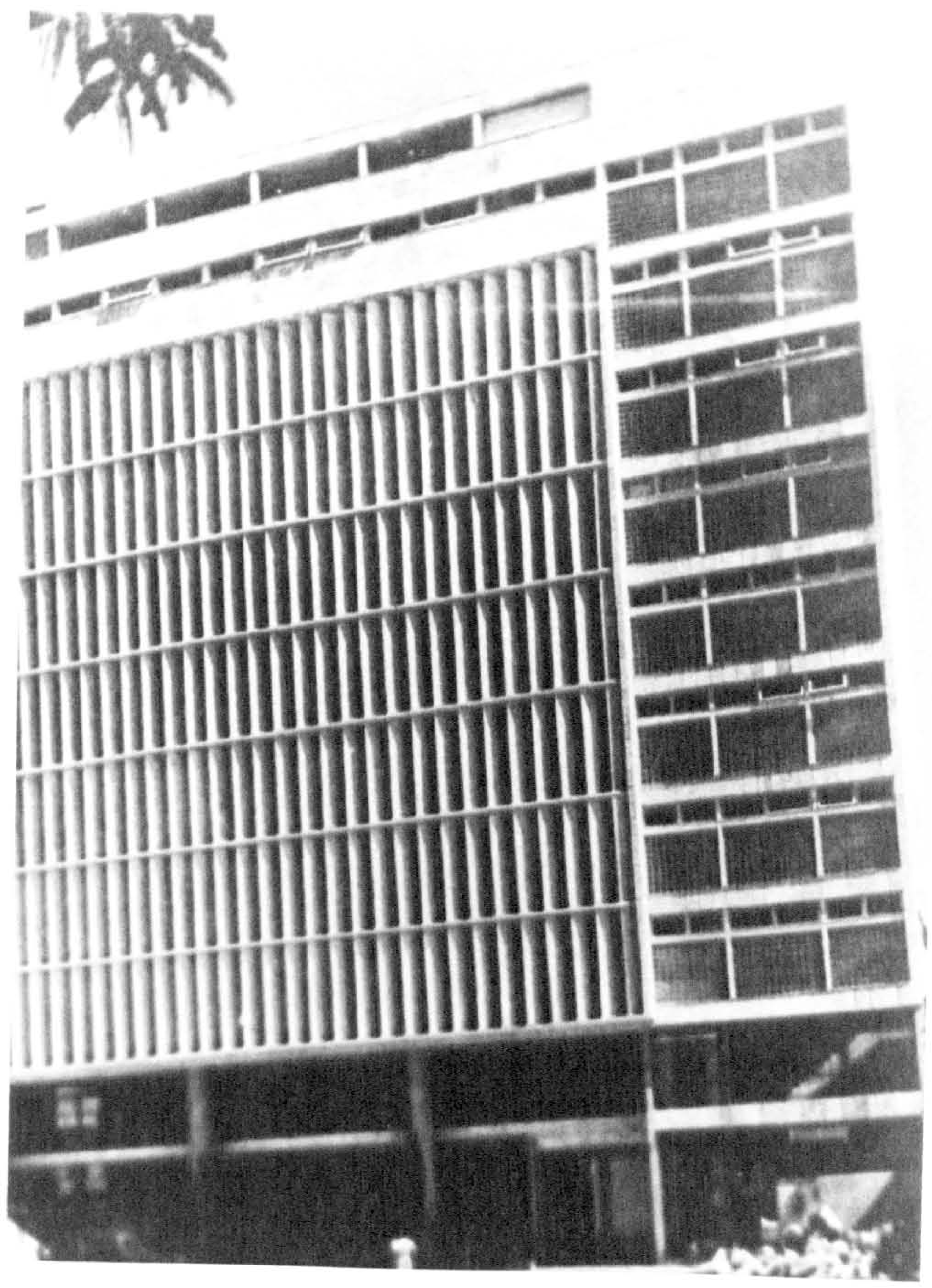
Fixed shading devices may be horizontal:



School in Lagos, Nigeria

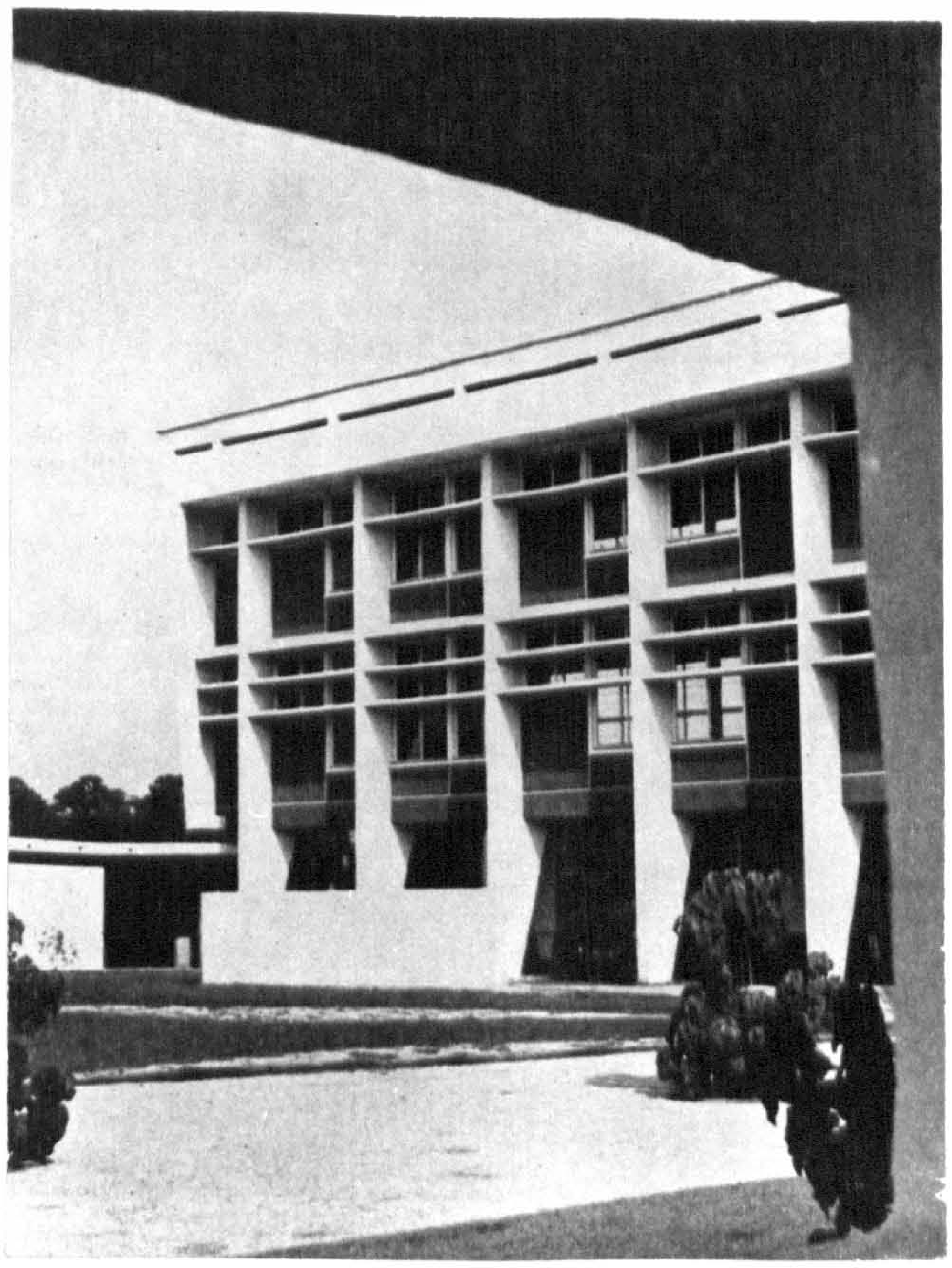
Architect: Fry, Drew and Partners.

Some orientations need vertical fixed shading members with fixed fins which may dominate the whole appearance of the elevation:

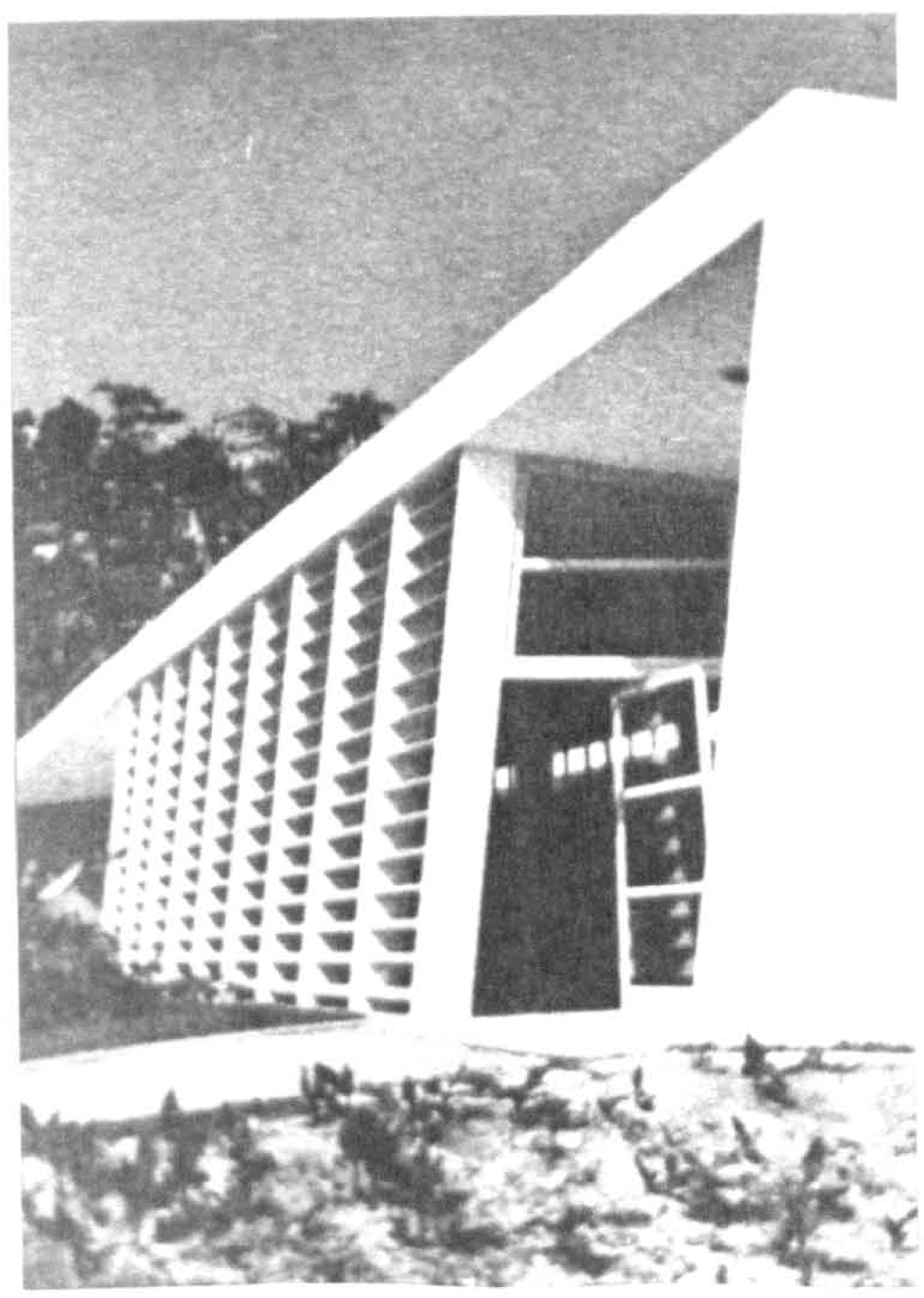


M.M.M. Roberto
I.R.B. Building Rio de Janeiro, Brazil

Fixed shading devices may be a combination of both vertical and horizontal devices (egg-crate):

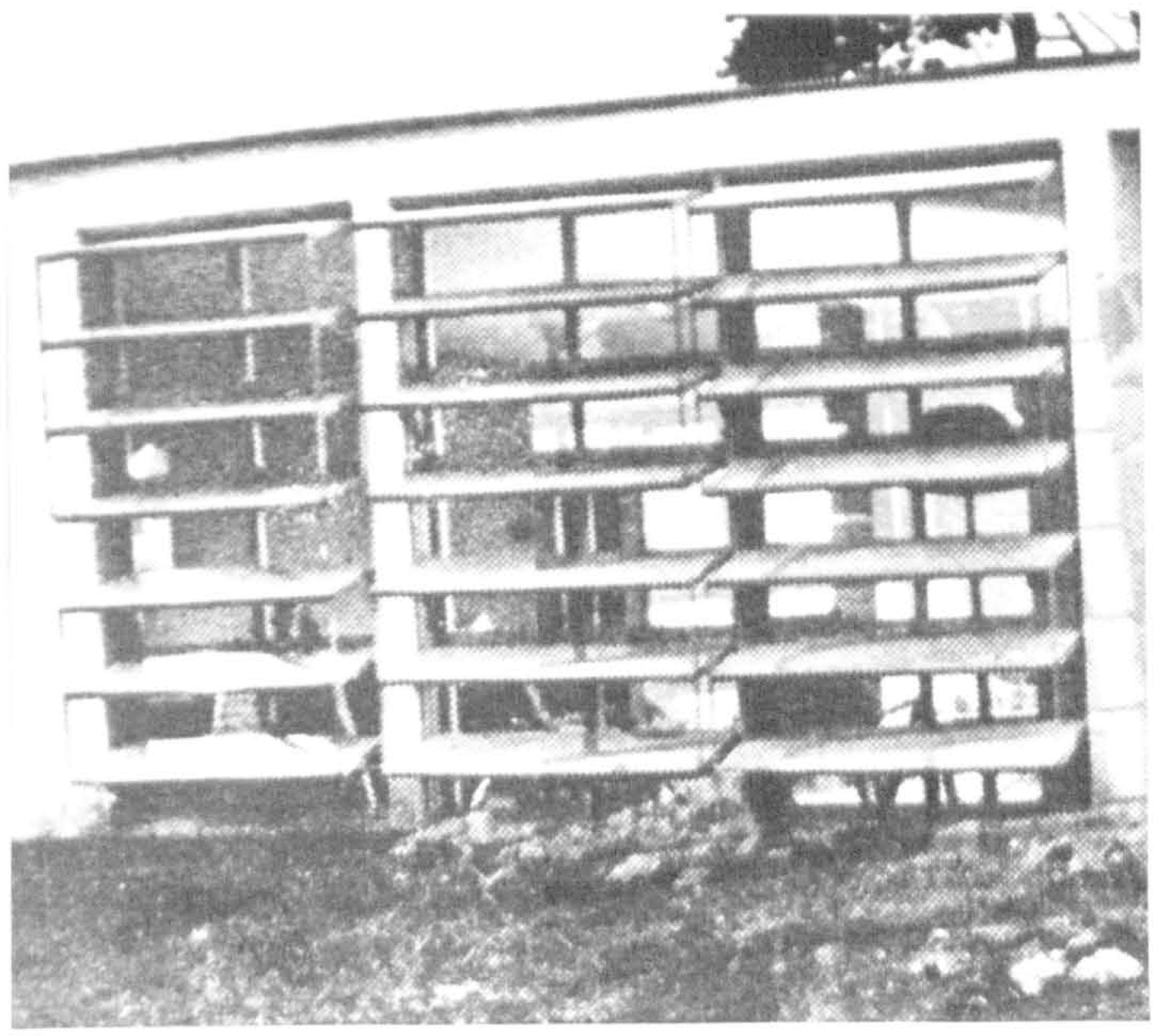


The 'egg-crate' sun-breakers are of many different types, but the most common type is the combination of fixed and movable 'egg-crates':

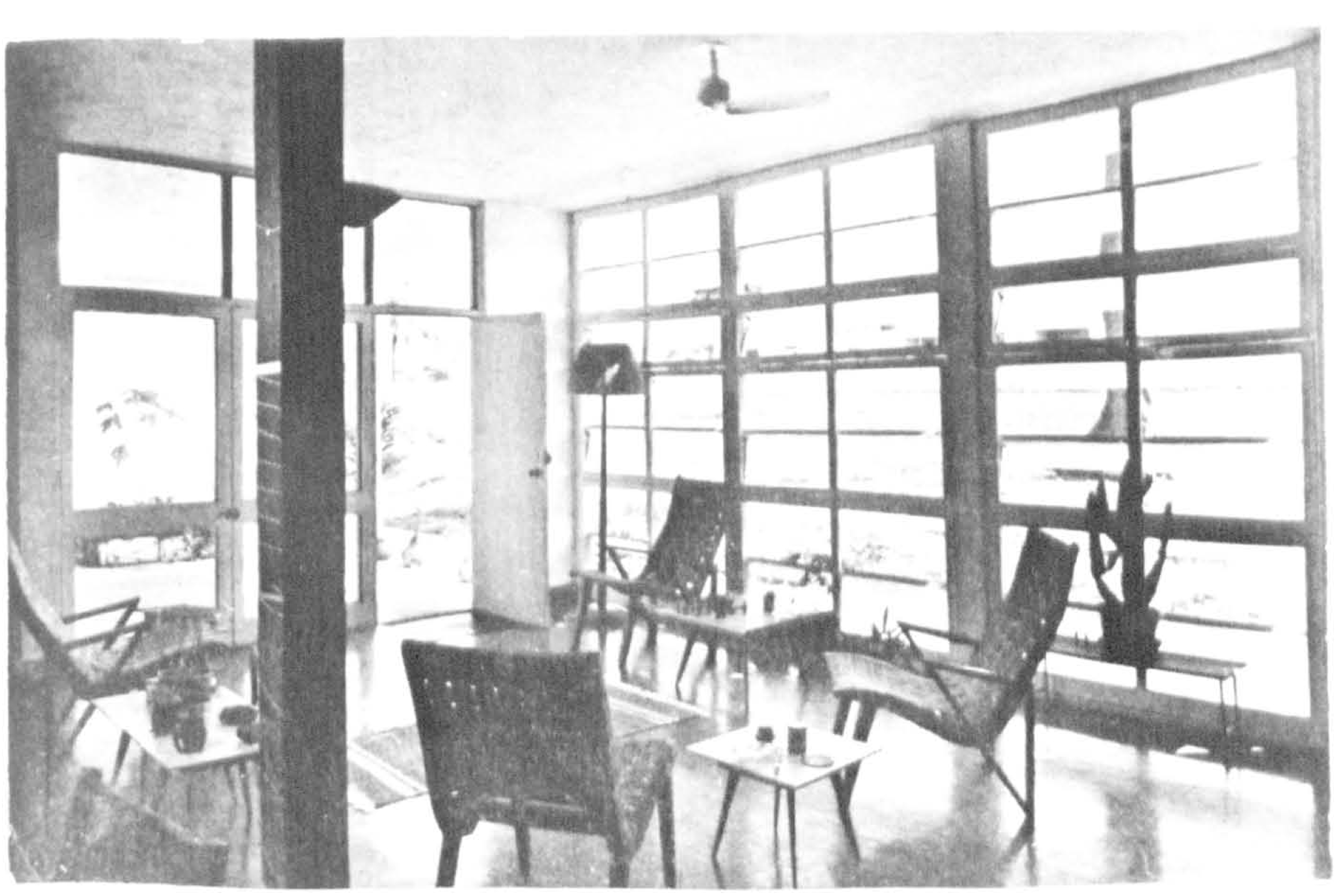


Supermarket, Pedregulbo Neighbourhood
Architect: Affrnso Reidy

Considerable use has been made of louvre sun-breakers. The louvres can be made of various materials such as concrete, wood, or glass or a metal such as aluminium. They can be fixed or adjustable, large or small in scale:



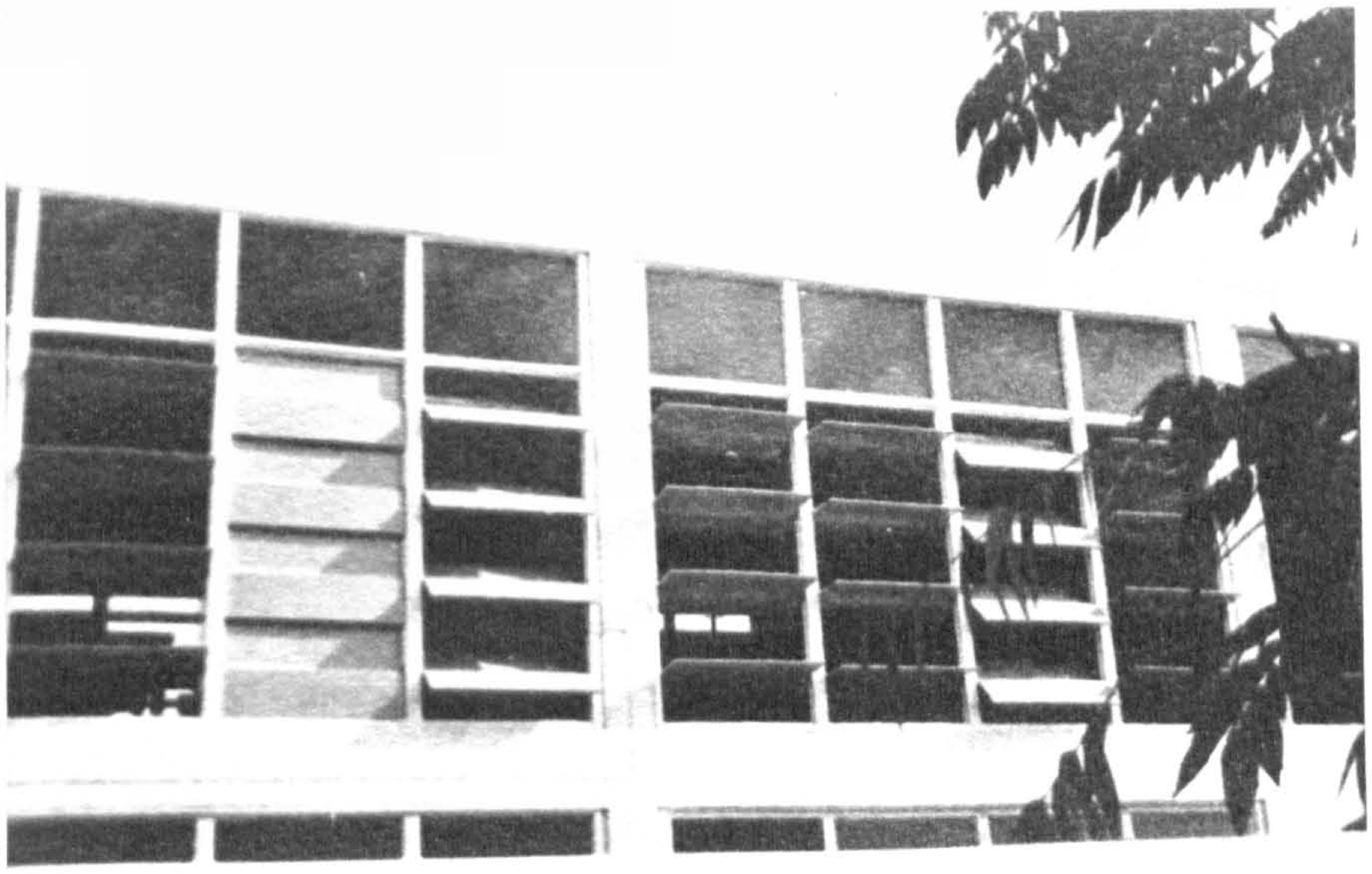
1. External View



2. Interior

House at Kumasi College, Gana

Architect: James Cabitt, Scott and Partners.



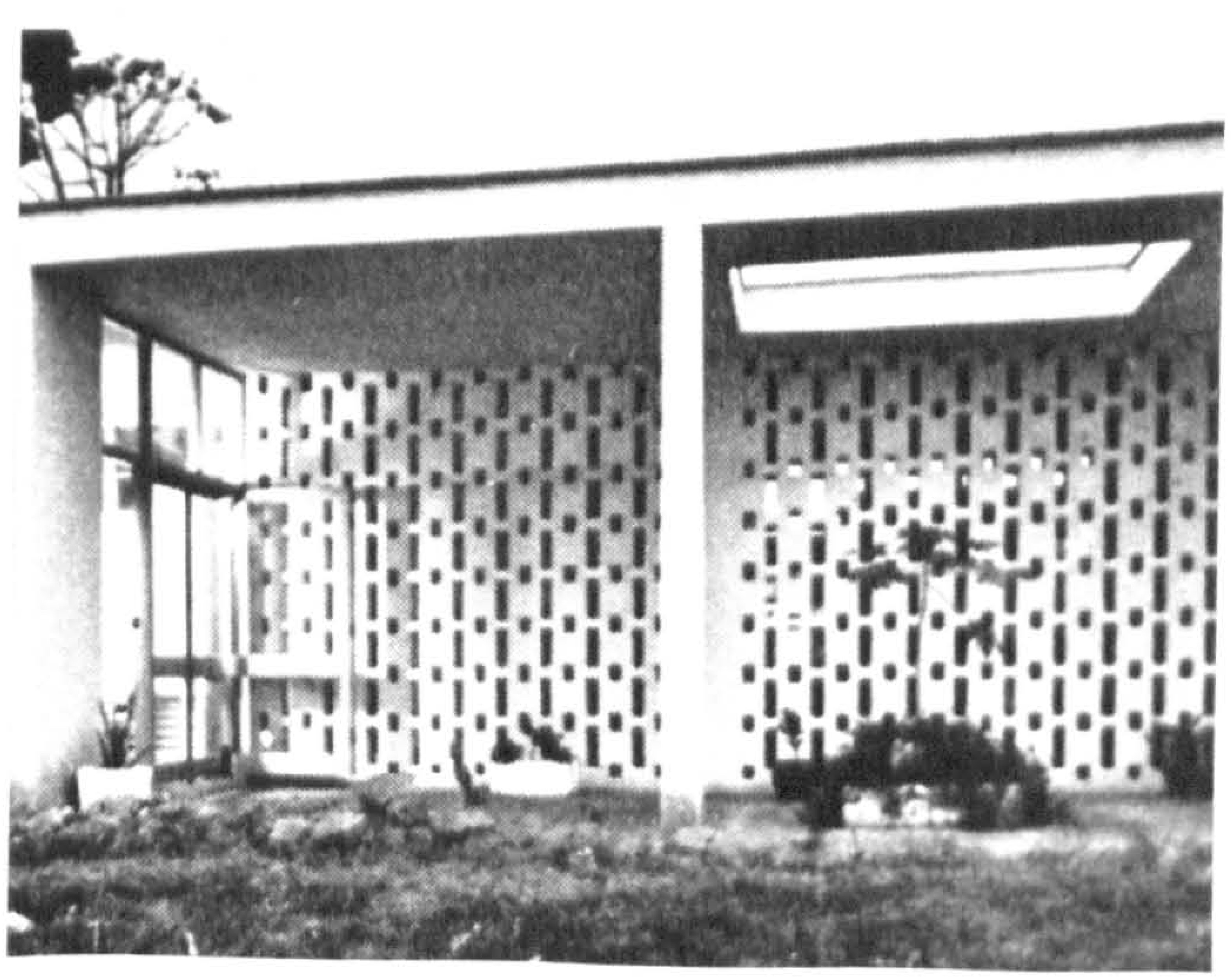
Adjustable Louvres

To be as effective as wider louvres, narrow louvres must be set closer together. They can be set at an angle one above the other in a vertical frame or extended out from the building horizontally in a frame.

3.9.4. Shading the Windows by Hollow Blocks

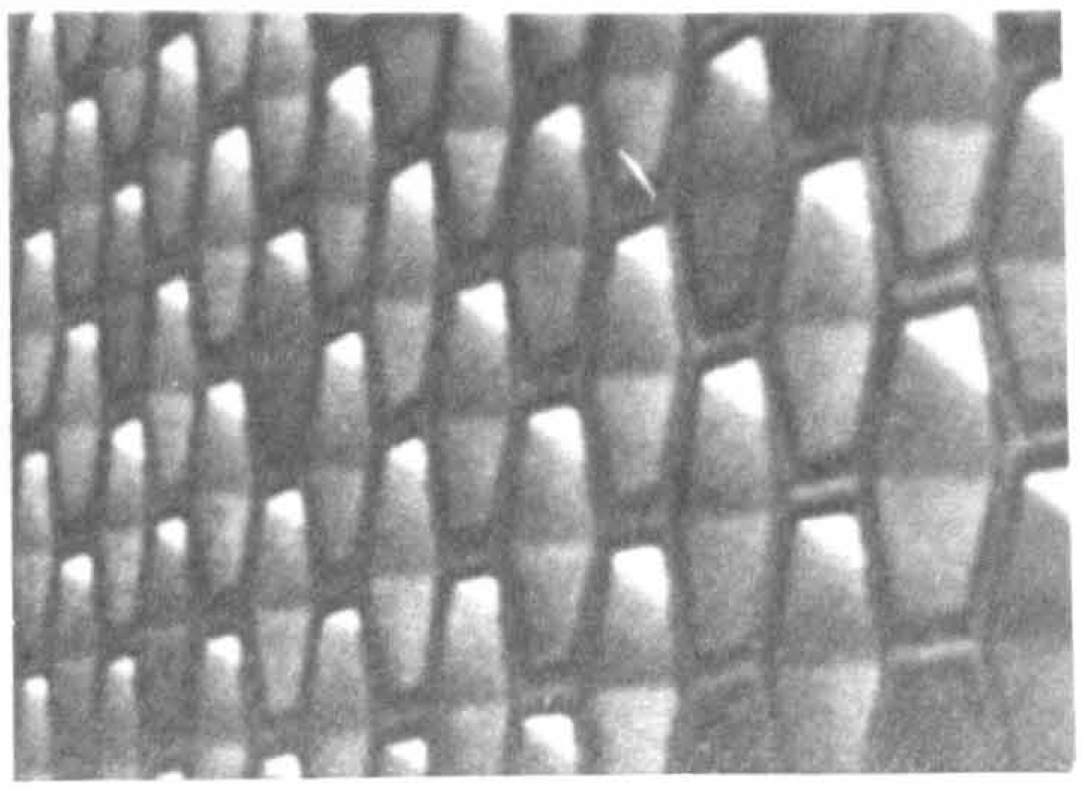
Sometimes whole window openings are shaded by hollow blocks of different shapes and patterns.

Some patterns allow air movement and provide shade with varying degrees of privacy:



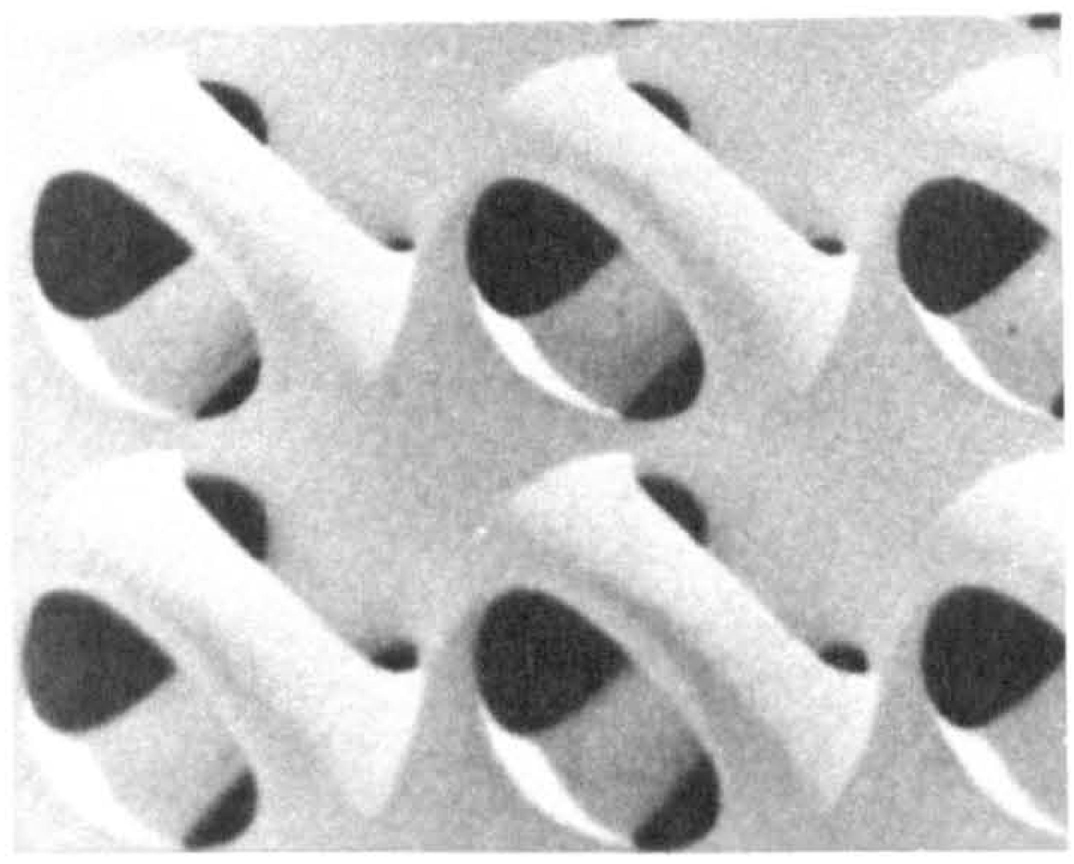
House at Comasi College ...... op.cit.

Patterns might be geometrical:



V. Olgyay
Design with Climate
op.cit.

or use the fluid ploy of the light by ingenious spatial constructions:



V. Olgyay .... Ibid

The widespread use of sun-shading devices has led to large modern buildings built in hot tropical countries having a certain characteristic appearance. Their motifs vary, but are dictated by the sun, whose strength and angles varying according to orientation and location have led to various regional patterns.

Finally it must be remembered that thick heavy concrete sun-breakers, because they are made of a dense material with a high thermal capacity absorb a lot of heat which is then radiated for a long time after the heat source is removed. Exterior devices made of dull finished materials may conduct heat into a structure on windless hot days; conversely on windy, cold days they may act as a cooling radiator and carry heat away from the walls. This can be avoided if the devices are insulated from the building i.e., connected to it only at necessary points, leaving an open space in between. This open slat also serves as an escape hatch for banked-up warm air.

3.9.5. Summary of Shading Device Methods

In order to incorporate shading devices as a design feature, it is necessary to define the times - hours and seasons - and then to define the direction - orientation and altitude - where shading is needed:-

1. Data should be collected for the daily temperature changes throughout the whole year. Average daily temperatures should be used with hourly or two-hourly data for each month of the year. The temperatures which fall over the bottom line of the comfort zone (75°C) will define the over-heated period. This can be tabulated on a chart where the hourly and monthly divisions serve as ordinates.

2. To determine the positions which make shading necessary:(1) The over-heated period is then transferred to sun-path diagrams which will show the position of the sun and whether shading is desirable at a given time.

3. To determine the type and position of a shading device for the over-heated period, plot the projection of a device onto the sky-vault by a protractor to find the shading mask, which can be used in any situation.

The sun projection effect for glass surfaces depends on several factors:-

A. The reflective capacity of the applied material and its colour coating; white and light colours are particularly effective.

B. The location of the shade protection which influences the radiation and convection heat impacts. The effectiveness of shading devices increases 35% by using external shade protection instead of internal.

C. The specific arrangement of the applied shading method. Shading devices can be put in order of their shading coefficients as follows: venetian blind, insulating curtain, outside shade screen, outside metal blind, coating on glass surface, trees, outside fixed shading device and outside movable shading device.

From the general practice of using shading devices in the tropics it is clear that on southern, south-east and south-west aspects horizontal shading devices are more effective than vertical ones, and in all orientations from east through south to west, horizontal shading is more effective than a vertical one. Horizontal windows are more suitable for east and west elevations than vertical ones.

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(1) The exact solar angle must be known, otherwise shading devices may fail to shade the interior during the hottest period of the day.

The architect dealing with this problem must take the following recommendations into consideration:

1. External devices are more efficient than interior ones.

2. The differences in efficiency between external and internal devices increases as the colour darkens.

3. For internal devices, the efficiency increases as the colour lightens.

4. For external devices, the efficiency increases as the colour darkens.

5. With efficient shading, such as external shutters, it is possible to eliminate more than 90% of the heating effect of solar radiation.

6. With inefficient shading, such as dark-coloured internal devices, most of the solar, radiation impinging on the window may be expected to enter the building.

7. Dark shading devices on the leeward of the building have a much smaller heating effect as the air passing over them flows away from the building.

8. Design should allow free flow of air over all the surfaces whilst allowing this air to be carried away from the outside of the building whenever possible.

9. Constructional difficulties, such as moisture movement of timber, corrosion, warping, expansion and contraction of materials must be taken into consideration.

10. Besides satisfying the thermal requirements the device must meet the requirements of daylighting, natural ventilation, reflected solar radiation, weather protection, maintenance consideration and aesthetic appearance.

Economy of Shading Devices

Economy in shading devices can be achieved by comparing the cost of air-conditioning an unshaded building with that of a shaded one, adding to the latter the cost of the shading device. This will produce a realistic assessment of costs of such a device. For design purposes this process can be reversed. By calculating the amount of heat entering a building and the cost of the air-conditioning necessary to counterbalance it, one can determine how much can be expended on a shading device to produce a break even situation.

The horizontal shading device protects southern orientations efficiently, whilst the other types work well toward east and west, where the more expensive movable types might be utilized.

It is evident that properly designed shading devices might not only pay their way, but save in cost. Different orientations have different heat impacts, and the counterbalance of these will affect the cost of either mechanical cooling or of a shading device.

Careful architectural planning, while considering cost of mechanical cooling and shading devices, will include:-

1. The arrangement of the whole building layout and particularly the orientation of the elevations.

2. The size and distribution of window and door openings.

3. The appropriate design of shading devices.

3.10. Thermal Comfort Conditions

During the last 50 years a large number of experiments have been carried out in different parts of the world to study the influence of thermal environment on man's performance and the majority have concluded that it is generally lowered when he is exposed to heat stress. Pepler and Warner(1) (1968), showed that mental performance is reduced when the ambient temperature is a few degrees centigrade higher than is comfortable.

In order to create comfortable working and living conditions in tropical countries it would be easy to recommend air conditioning systems of varying degrees of sophistication, but such systems would generally prove too expensive to be practicable. It is conceivable that within the next 50 or 100 years a large proportion of the tropical population will live and work in artificially cooled buildings; but the immediate problem is how to produce comfortable conditions by simple and inexpensive means. Building design must take account of basic thermal principles in order to devise unexpensive ways of reducing heat stress. Unfortunately

(1) Pepler, R.D. and Warner, R.E. "Temperature and learning: An experimental study" Amer.Soc.Heat.Refr.Air cond.Eng.Trans. journal. Volume 74.II. 1968.

tropical countries still lack expertise in this field; this applies in the Sudan where in big cities such as Khartoum, for instance, the buildings are still constructed with no regard to the basic thermal comfort rules.

Before discussing thermal comfort conditions with specific reference to tropical countries, one must look at the topic generally and see to what extent the established comfort criteria, which have been developed in the temperate climates, can be used for man in the tropics.

When the thermal balance between the body and its environment is upset, through inadequate heat loss or by heat gain from the environment a condition of thermal stress is said to exist. This is frequently met with in warm climates, and has been shown[I] to lead, not only to subjective sensations of discomfort, but also to a reduction in mental and physical efficiency, and in very extreme cases can constitute a hazard to health.

Therefore, thermal comfort for any individual is usually defined as that condition of mind which expresses satisfaction with the thermal environment.[II] Normally, this means that the person does not know whether he would prefer a warmer or a cooler environment.

However, people vary in their thermal requirements and if a group of people is subject to the same room climate they will not normally react to it in the same way. The aim is, therefore, to create optimum thermal comfort for the group i.e., a condition in which the highest possible percentage of the group are thermally comfortable.

The important variables which influence the human thermal balance and hence the state of comfort, are:

(1) air temperature,
(2) relative air velocity,
(3) mean radiant temperature, and
(4) relative humidity

(I) Givoni, B. and Bim, Y. "Effect of the thermal environment and psychological factors upon subjects response and performance of mental work" Ergonomics, Vol.5, No.I, 1962.

(II) Ashrae : "Thermal comfort conditions" Amer.Soc.Heat.Refr. Air cond. Eng. Standard 55-66, New York 1966.

The air temperature and the relative air velocity are both important for the convective heat loss from the body; the mean radiant temperature (which determines the radiant heat loss) and the relative humidity in the ambient air are important for diffusion of water vapour through the skin and for the evaporation of sweat from its surface.

The problem lies in finding the combination of these factors which will provide optimal thermal comfort for man. For the temperate climates comfort criteria are fairly well established, based on many studies during recent years; for example, the work of Ṙohles, F.H. and Johnson, Amer. Soc. Heat. Refr. Air cond. Eng. Trans. No.78,I 1972 and the work done by the Technical University of Denmark. The 'comfort equation' has been devised, which incorporates all combinations of the four variables involved and can be represented in a series of 'comfort diagrams' which provide the information in a form that can readily be applied in practice.

It is now important to ascertain whether these results can be applied to the situation found in tropical countries. To answer this question many studies have been carried out in different parts of the tropics with a view to comparing tropical comfort conditions with the 'comfort equation' of the temperate zones.

Comparison between Tropical Thermal Comfort and the Temperate Comfort Equation

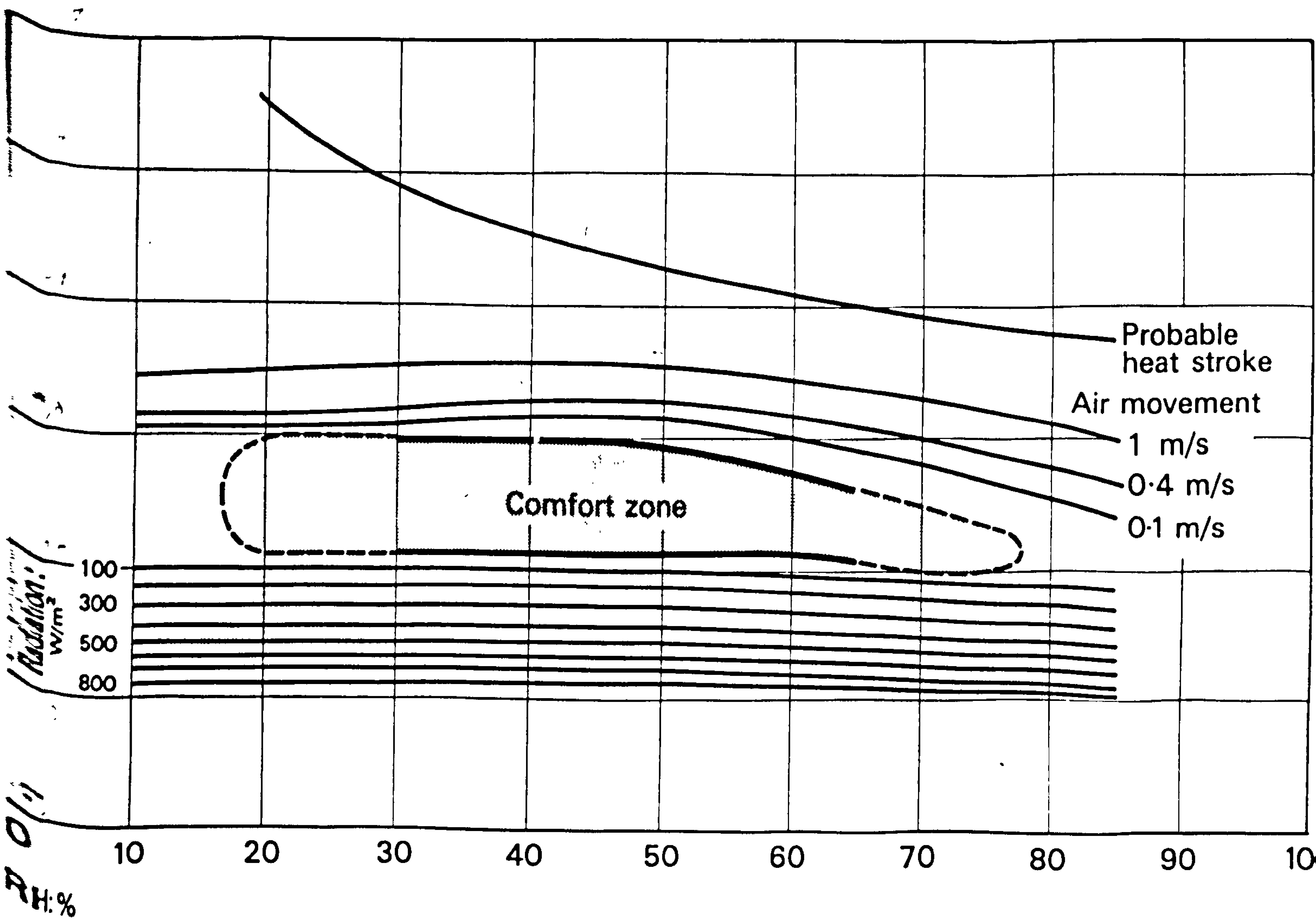
Table

Location	Year	Author	R.H. %	REL.VEL. m/sec	Preferred Field st.	amb.temp. °C Comfort eq.	Difference
Calcutta	1952	Rao	70	0.1	26	26	0
Singapore	1953	Ellis	80	0.4	27	27.5	-0.5
Nigeria	1955	Ambler	70	0.1	26	26	0
Singapore	1959	Webb	80	0.4	28.5	27.5	+1
N.Austral.	1963	Wyndham	80	0.1	26	26	0
N.Guinea	1967	Ballantyre & Barned	80	0.1	26	26	0

Source: P.O. Fanger "Improvement of Human Comfort" Technical University of Denmark No.402.

The previous table seems to show a remarkable agreement between the requirements of the inhabitants of the two zones and it would appear that the comfort criteria for temperate climates can also be applied to tropical countries. However, for tropical regions a lower clo-value must be considered due to the lighter clothing which is worn.

To give more accurate results for tropical regions V. Olgyay constructed his bioclimatic chart for thermal comfort, in which the comfort zone is defined in terms of DBT and R.H. In this chart he also showed how the comfort zone may be pushed up by the presence of air movements and lowered by radiation:-



According to Olgyay the optimum thermal comfort zone lies between 30 and 65% Relative Humidity and 21^{o} and $30^{o}C$ DBT air temperature. The comfort air velocity may be in the range of 0.1 M/Sec to 0.4 M/Sec. and the solar radiation must be less than 100 W/m .

3.10.1. Principles for Building Thermal Comfort Design in Tropical Countries.

It is sometimes claimed that there should be no attempt to change building principles which are widely used in the tropics, since local people often have hundreds of years of experience in how to build houses most suited for their climate. This may very well be true in some cases, but in many others the most elementary physical principles are violated, resulting in an indoor climate that is unnecessarily hot.

From studies undertaken throughout the tropical world, there is general agreement that the following thermal principles should be followed in order to produce a satisfactory indoor climate:

General Principles

- Light colours of roof and exterior walls.
- Insulation of roof and walls.
- The long axis of the house lying eat/west.
- Screening of windows from the sun.
- Less windows on east and none on west sides.

In Hot-Dry Climates

- House closeable during day. Through-ventilation during night.
- High heat capacity of roofs and walls.

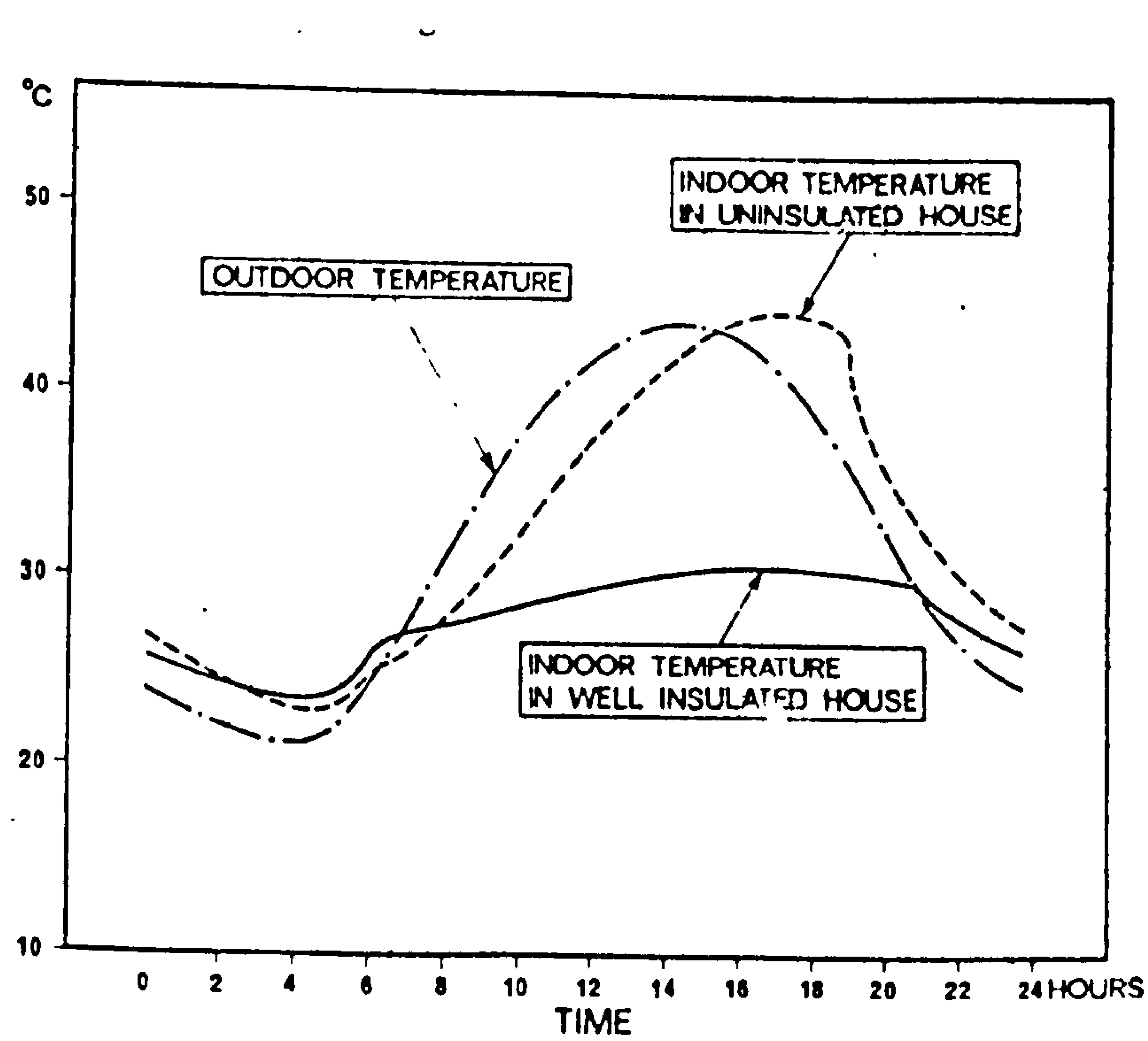
In Warm-Wet Climates

- Through ventilation during day and night by means of large openings and by suitable orientation of the house in relation to the prevailing wind.

These are the general principles for building thermal comfort design in the tropics. However, in hot-dry climates insulation seems to be essential. It should be placed in the outside of the house and heat capacity of roof and walls must be large, so that closed houses are only warmed up slowly during the day.

Many experiments have been done to prove the importance of insulation in buildings in areas such as the central part of the Sudan. For example, P.O. Fanger[1] carried out the following experiment:

He conducted experiments on the indoor temperature in a normal house with heavy walls in a hot-dry climate. In one case the house was uninsulated and in the other case well insulated on the outside with mineral wool or corresponding natural materials, for example, a thatched roof. The house was closed during the day and open for through-ventilation during the night. The uninsulated house had walls and roof of concrete (12cm), while the well insulated house was provided with an outside layer of mineral wood (10cm). Otherwise the two houses were identical.



(1) P.O. Fanger Laboratory of Heating and Air conditioning, Technical University of Denmark. Building 402, 2800 Lyngby, Denmark.

The outside air temperature was at a maximum of 45°C in the afternoon and a minimum of 21°C in the early morning. The indoor temperature in the uninsulated house was very high during most of the day, up to 45°C; while in the insulated house it was kept at a quite comfortable level, lower than 30°C both during day and night. The diagram shows quite dramatically the impact of heat insulation in these conditions.

The majority of the population in the Sudan are poor and cannot afford to isulate their houses with mineral wool or other sophisticated materials but the effectiveness of insulation is beyond doubt and priority should be given to devise cheap and simple materials for this purpose. The application of many of these thermal comfort principles need not be expensive - some in fact need not cost a penny. It is merely a question of using existing knowledge and techniques. For example, the picture below shows a number of simple mud dwelling houses from the central part of the Sudan which ignore most of the accepted thermal comfort principles.

A typical view of Khartoum's 4th class residential areas.

The houses are built of sun-dried clay. The insulation is insufficient. There is no overhang to screen the walls from the direct sun's radiation, and the red-brown colour of the external walls gives a sun absorption rate which is two or three times greater than if the walls were white. The openings of the houses are too small to ensure sufficient through-ventilation during the night. When it is realised that 80% of existing Sudanese housing stock is built in after this pattern, it becomes clear that the people are suffering from acute thermal discomfort because they lack elementary technical knowledge. Therefore, careful and comprehensive studies of the local conditions are essential if acceptable thermal comfort is to be achieved.

3.10.2. Hygiene Comfort

To produce an acceptable standard of hygiene a building must offer fresh air through-ventilation, good water supply, good light and dry vermin-proof shelter in the wet season.

For good through-ventilation houses must be well sited to catch the prevailing breeze with a well designed system of apertures to facilitate cross-ventilation. To achieve good ventilation, rooms should face the breeze as nearly as possible, be of the correct shape and contain doors and windows of an appropriate size and correctly placed. As hot air usually rises to the upper parts of the rooms, it is important that there should be ventilation fairly near the ceiling. The positioning of windows and doors should be designed to encourage a circulation of air but to exclude sun and rain.

Ventilation between blocks of houses must be efficient. A few substantial air gaps (about one room thick) in rows of terraced houses are more effective than small gaps between individual houses.

Due to the lack of a proper sewerage system in the majority of the housing occupied by low income groups in the Sudan traditional pit latrines are still widely used. These must be placed where they are least likely to foul the air.

3.10.3. Design of Naturally Cooled Buildings

With the proper use of climatical analyses and bearing in mind their implication for design, it is possible for an architect to produce a naturally cooled building.

Fundamental to this is likely to be the use of heavyweight/ insulated roofs and walls to reduce the overall internal temperatures. Among materials suitable for this purpose are high heat capacity concrete walls externally insulated by rockwood or expanded plastics and covered by waterproofing materials. The required thickness of the materials may be calculated depending upon the outdoor maximum and minimum temperatures. The roofing should be of a similar composite construction, and the internal partitions of high heat capacity. All external surfaces should be as near to white as possible.

Windows may be large but should be protected by movable insulated shutters; apart from small apertures for illumination, both windows and shutters must be closed during the day.

It is advisable to provide an internal or semi-internal courtyard with access to the rooms of the house through large openings, insulated in the same way as the windows. By opening the windows and these apertures during the evening, the interior can be cooled rapidly from several sides. The roof should slope down towards the courtyard, and be surrounded by a parapet at the upper edges. Although the temperature of the whitewashed roof will be close to that of the outdoor air during the day, long-wave radiation reduces this below the outdoor level at night. Thus air in contact with the roof will be cooled at night, and channelled by the slope into the courtyard and then into the rooms. Heat gain from the warmer external air is restricted by the parapet which reflects most of it into the open air.[1]

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(1) Givoni, B. "Naturally cooled Buildings for hot desert climate". Proceedings 4th International Congress of Biometeorology. New Brunswick, U.S.A. August 1966.

With this type of design it is possible to obtain reasonably comfortable conditions with usual summer maximum temperatures, but when temperatures are very high, especially in summer, further cooling in the evening and night may be achieved by more efficient use of the cold air in contact with the roof.

3.11. Grammar of Climatical Analysis

Walter Gropius, considering regional expression, writes:

> ".... true regional character cannot be found through a sentimental or imitative approach by incorporating either old emblems or the newest local fashions which disappear as fast as they appear. But if you take the basic difference imposed on arhitectural design by the climatic conditions diversity of expression can result if the architect will use the utterly contrasting indoor-outdoor relations as focus for design conception." (1)

Le Corbusier, about regional climates, said:

> ".... The symphony of climate has not been understood. The sun differs along the curvature of the meridian, its intensity varies on the crust of the earth according to its incidence. In this play many conditions are created which await adequate solutions. It is at this point that an authentic regionalism has its rightful place." (2)

From these quotations it is clear that the regional analysis focusing on the importance of climatology in residential design is the first step and that bioclimatic evaluations of local weather data supplied by meteorological stations must be the starting point for any architectural design aiming at environmental climate balance.

Prevailinq climatic conditions can then easily be plotted on the chart, and will show that corrective measures are needed to restore comfort conditions. Many of these measures may be achieved by natural means, that is, by adapting architectural design to

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(1) Gropius, Walter. Scope of Total Architecture. Harper and Brothers. N.York 1955.

(2) Le Corbusier,"Building an Entire New City in India, Chandigarh" Architectural Forum. Sept.1953 pp.142-149.

utilize climatic elements.

When the bioclimatic needs of a given site are thoroughly understood, it is possible to estimate the balance of natural forces that can be attained in a building. The desirable elements - sun radiation for cold periods, shade for hot times, ventilation for humid times - can be considered in relation to specific needs.

However, during the underheated winter periods, all possible techniques should be called into play to maximize heat preservation by offsetting radiation and reducing heat loss. Similarly at overheated times in summer, channels of inward radiation should be stopped, out-going radiation possibilities improved, and peak heat loads moderated by emissive means.

Environmental Design in Architecture

It is desirable to work with, not against, the force of nature to create better living conditions and a structure which in a given environmental setting reduces undesirable stresses, and at the same time utilizes all natural resources favourable to human comfort, may be called "climate balanced". Even under the exceptional environmental circumstances of the hot-dry areas of the Sudan, it is possible to use natural means to achieve a house of great comfort and at a lower cost than one using mechanical conditioning. In an ideal structure in an ideal location it might be possible to create an indoor environment always within the comfort range. However, in a hot-dry climate, especially in summer, the natural stresses are too large to be fully solved by natural means, because the compensating forces are limited and are sometimes blocked by the interaction of the building components. The task facing those conducting research in this field is to make the greatest possible use of all the natural means available in order to produce a more healthy and comfortable house, and to achieve a saving in cost by keeping the use of mechanical aids for climate control to a minimum. Because of its disadvantages and very high initial and running costs, mechanical conditioning should only be called upon after all available natural means have been explored.

3.11.1. Climatic Design Within the Urban Context

In recent years, architects have begun to apply new housing layouts especially in towns, with new and improved building materials and techniques imported from western countries. The trend is away from traditional practices and towards lasting ways of building which are also cheaper to maintain. Increasing cement production is leading to the introduction of industrialised building systems. Unfortunately this development has brought with it the temptation to copy blindly the practices which have proved successful in some highly-developed countries without giving consideration to Sudan's particular climatic, traditional and social conditions, and it seems doubtful whether they can be successfully applied under these conditions or whether they will prove widely acceptable. Consequently, there is an urgent need to find a new method of producing low-cost housing which will suit Sudan's environment and social structure.

The following criteria must be borne in mind when new schemes for housing are being considered:

a) Residential areas should be situated close together to reduce walking distances.

b) The layout of housing areas can form a pattern, similar to an egg-crate shading device, maintaining coolness in the courtyards.

c) The walls of houses and gardens can provide shade to out-door living areas.

d) Unit dwellings or groups should create patio-like areas: concentration is desirable.

e) Town structures should combat the heat with a shaded and dense layout.

f) Public spaces must be closely connected to residential areas.

g) Paved surfaces should be avoided wherever possible as they absorb heat and transfer it to the buildings; pools of water are beneficial.

h) As vegatation is generally sparse, concentrations of plant and grass-covered areas in the manner of an "oasis" is desirable.

i) Vegetation is desirable both as a radiation absorbent surface and for its evaporative and shade-giving properties.

j) The compact "patio" house type is preferred: adjoining houses and group arrangements (all continuous on E-W axis), of large total volume are advantageous. High massive building is preferable.

k) Heat loss, rather than gain, must be the objective. Therefore closed building arrangments around green areas are preferable: this utilizes evaporative cooling effects and radiation losses at night. Lythosphere arrangements are applicable, i.e. subterranean utilization. High ceilings are not necessary.

l) Outdoor or roof sleeping possibilities should be considered. Inward looking layout can benefit from cool air pool effects. Single floor and a convenient plan resulting in economy of movement avoids heat gain.

m) Heat-producing areas (e.g. kitchen etc.) should be separated from other areas of the house. Non-inhabited spaces should be placed on the west side to absorb sun impact.

n) Compact shapes of forms and volumes are preferable, with the longest dimensions on E-W axix. Volume effect is important. Building forms should have minimum solar projection.

o) Deep room arrangements can be used as a cooling contrast to intense outdoor heat. Use of low emissivity "cool" colours reduces heat reflection on interior surfaces. Connection with patio areas has cooling effect on adjacent spaces.

p) Relatively small openings reduce intense radiation. Windows should be shielded from direct radiation, and set high to protect from ground radiation. Openings should be light-closing as protection against high diurnal heat. External shades are preferred. Openings should be located on south, north and, to a lesser degree, on east sides.

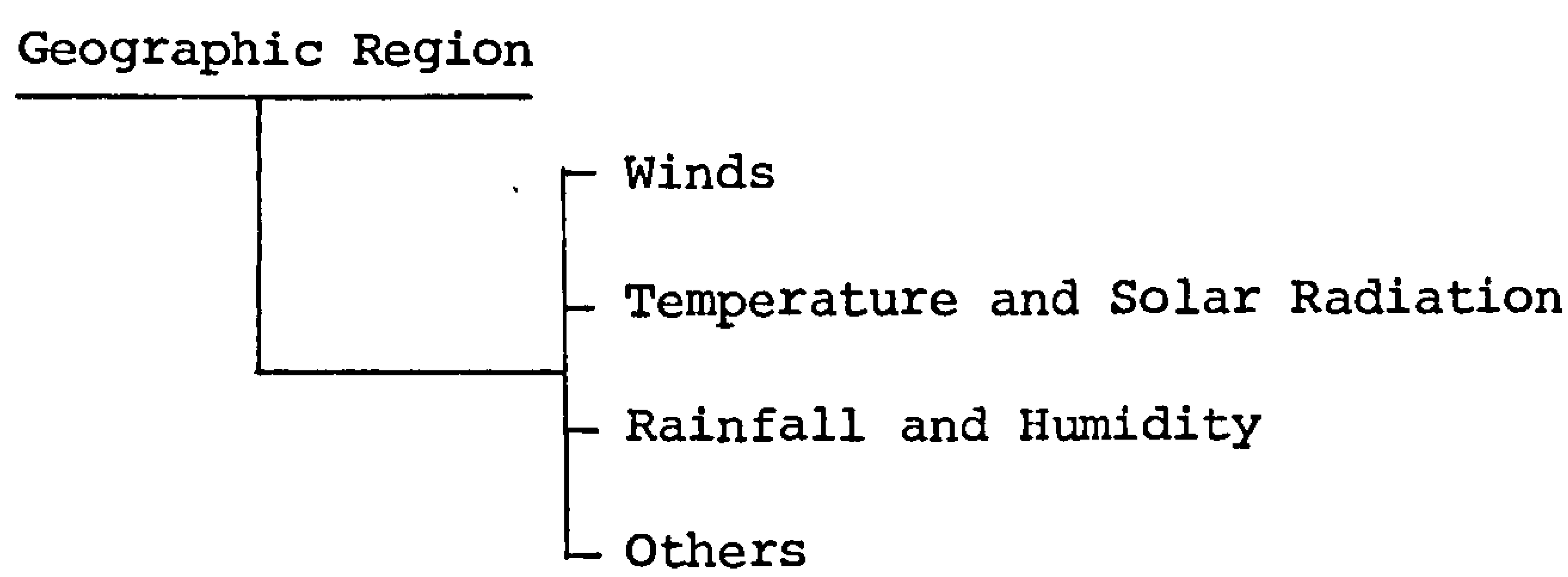
q) Walls of daytime living areas should be of heat-storing materials, walls of rooms intended for night use of materials with light heat capacity. East and west walls should preferably be shaded.

r) High reflective qualities are desirable for both thermal and solar radiation.

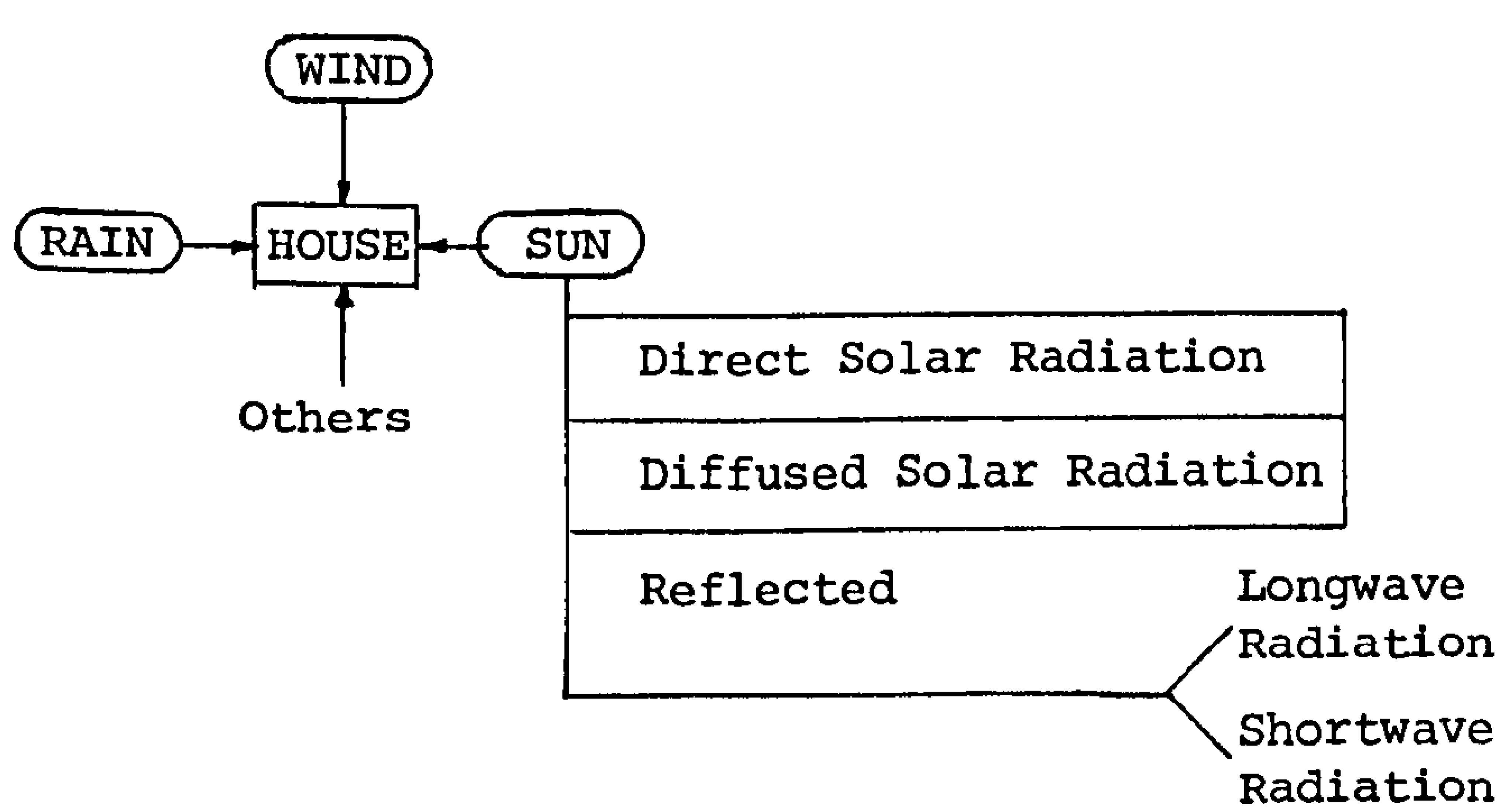
s) Roof of heat storage insulation is the best because it uses the flywheel effect of out-going radiation for daily heat balance. However, a shaded ventilated roof is also applicable, primarily over night-use rooms.

3.12. ComputerAnalyses on Building Orientation for Khartoum Province

Factors affecting the internal house climate are:-



In a sketch diagram, the natural components affecting the internal environment of the houses can be illustrated as follows:-



It is the concern of the building science specialists to analyse the details of these different components and suggest methods to provide the ideal indoor thermal comfort.

In the Sudan, of the above mentioned factors, the winds and the rare periods of rainfall do not cause insoluble problems. The severe heat of the sun, which prevails for more than ten months a year is a major problem especially in Khartoum Province where the heat conditions not only affect the indoor climate and therefore the living conditions of the people, but is also a potential danger to health. In addition the extreme heat causes many normally used building materials to crack.

Of all the natural means available to the designer to reduce heat imput to a building and thus improve living conditions, the most important is optimum orientation.

3.12.1. Housing Orientation

Housing orientation is governed by the following factors:-

1) View in different directions.
2) Position of the building in relation to nearby roads.
3) Topography of the site.
4) Location of sources of noise.
5) Privacy needs.
6) Most important, the nature of the climate.

The nature of climate in the Sudan means that the most important factor is solar radiation gain. From points made previously it is clear that the heat gained by any house depends on the surface colour of its outer walls. In the sub-heading "Wall Treatment" (page 85) it was concluded that if the outer walls are light in colour, they may reflect more than 90% of the solar heat falling on them.

In the Sudan, the overwhelming majority of the housing stock is dark in its outer colouring; this is due both to lack of economic means and lack of technical knowledge. The Sudanese low income groups (85% of total population) can only afford to plaster the outer walls of their houses with dark mud, which absorbs a great deal of solar energy, and so it is essential to improve living conditions by maximum use of natural means, such as orientation. Unfortunately at the moment there are no rules or municipal laws to guide people or advise them on the orientation of their houses. As a result all the houses in the Central Sudan are orientated in the traditional North-South direction according to the flow of the summer winds; solar radiation is not taken into account.

3.12.2. Computer Programme : Introduction

Solar radiation reaching the earth's surface is classified as direct and diffuse radiation. The direct radiation lies in the solar beam while the diffuse radiation reaches the surface after scattering in the atmosphere. The energy received per second per square metre of a surface is termed the irradiance and has units of Wm^{-2}.

The most common method of finding the optimum orientation is to rotate the vertical sides of the building in different directions and calculate the irradiances falling in every given direction. The amounts of total solar radiation received by all the sides from every given direction are then plotted in a graph and compared to find the best orientation inviting minimum solar energy.

Carrying out such calculations manually is inefficient. For this purpose perhaps the computer program SUN 3 offers the best solution. Compared with tabulated design data conventionally used to predict peak summer conditions, SUN 3 computer program has the advantage of giving realistic values for irradiance for any time of year by varying the atmospheric turbidity and water content. It is also chosen because it gives quick and perfect calculations of total solar energy.

The main aim of the computer analysis[1] is to select the

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(1) BS 28 August 1976. Dept. of Building Science, Faculty of Arch.Studies. University of Sheffield.

optimum housing orientation for Khartoum Province in summer months, by rotating the houses in intervals of every 15^{o} from the north.

Wall openings affect the thermal behaviour of houses and complicate the problem, because many factors such as their position, size, height, protection, reflection, absorption and transmission of solar energy have to be taken into account. Small rectangular box houses with no openings were used to find the total solar energy per square metre falling on their solid sides at different orientations.

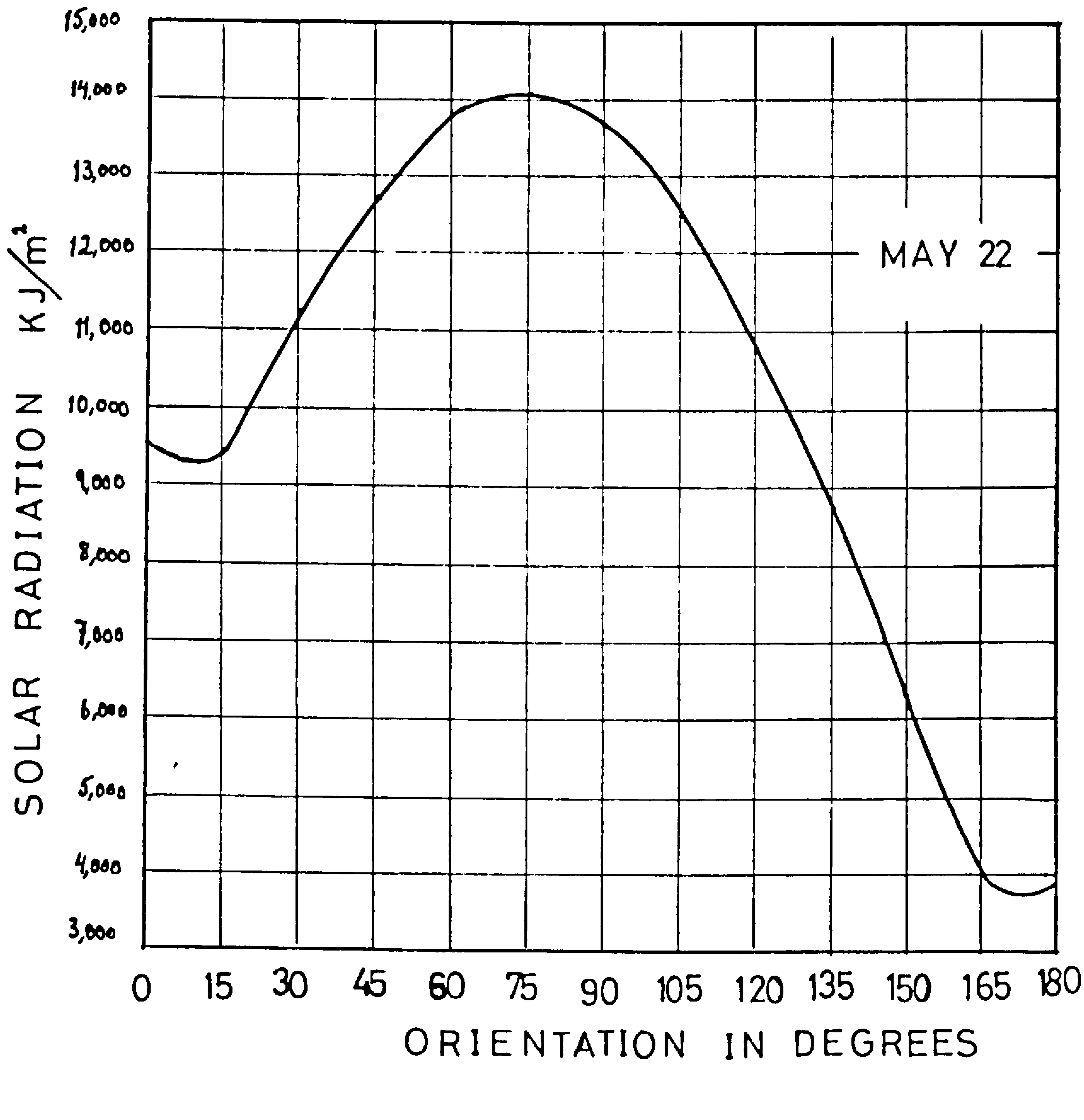
Appropriate data for Khartoum Province was fed into the program and run for the hottest summer months, May, June and July.

The results of computer figures of direct, diffuse, ground reflected and total solar radiation falling on the house during this period are given at the end of this Chapter.

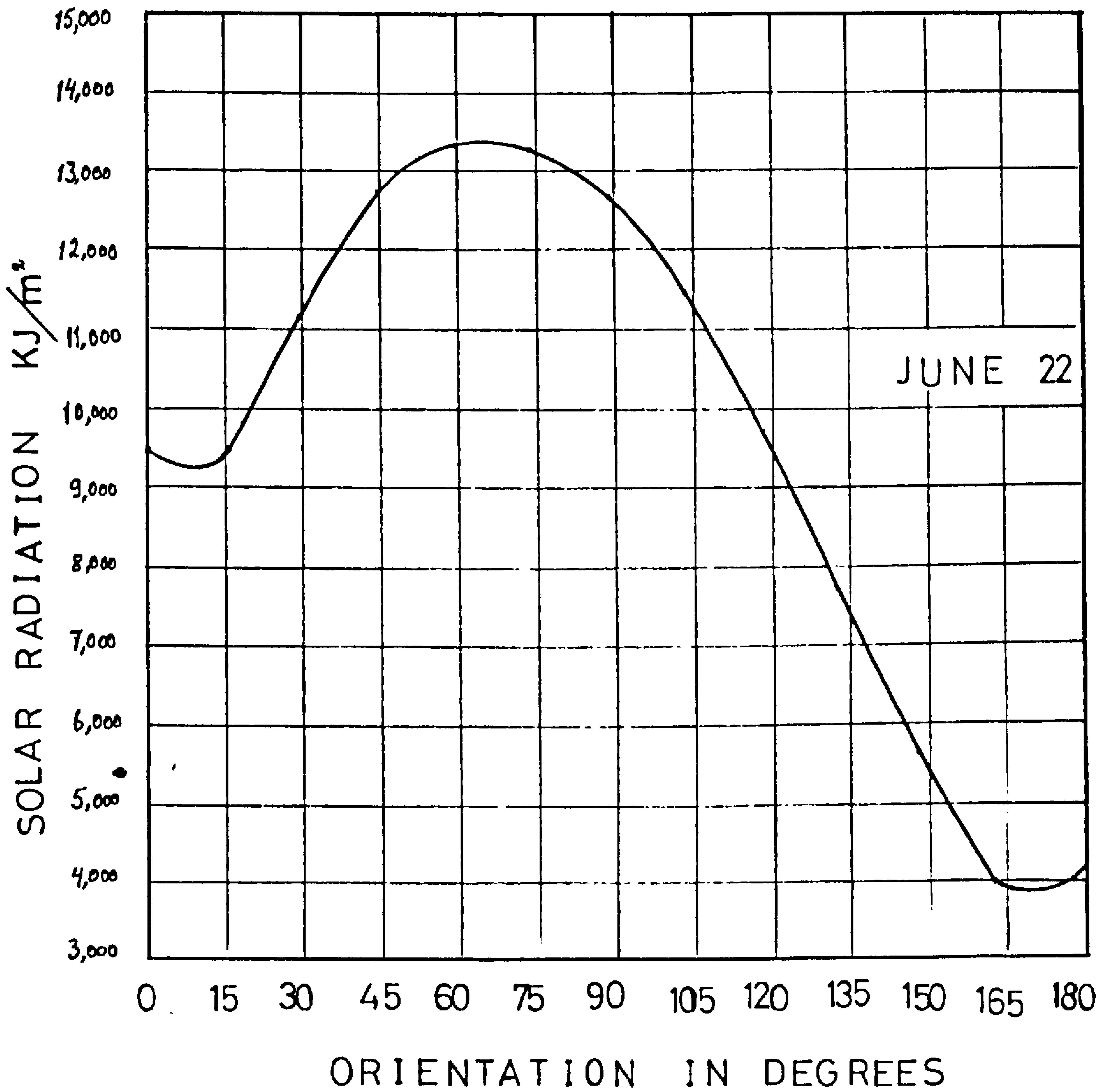
3.12.3. Analyses and Results

The program gave the amounts of direct, diffuse, ground reflected and total solar radiation per square metre falling on a vertical plane at intervals of every 15^{o} from the north for the three summer months May 22, June 22, and July 22 respectively. The information obtained is presented in graphical form.

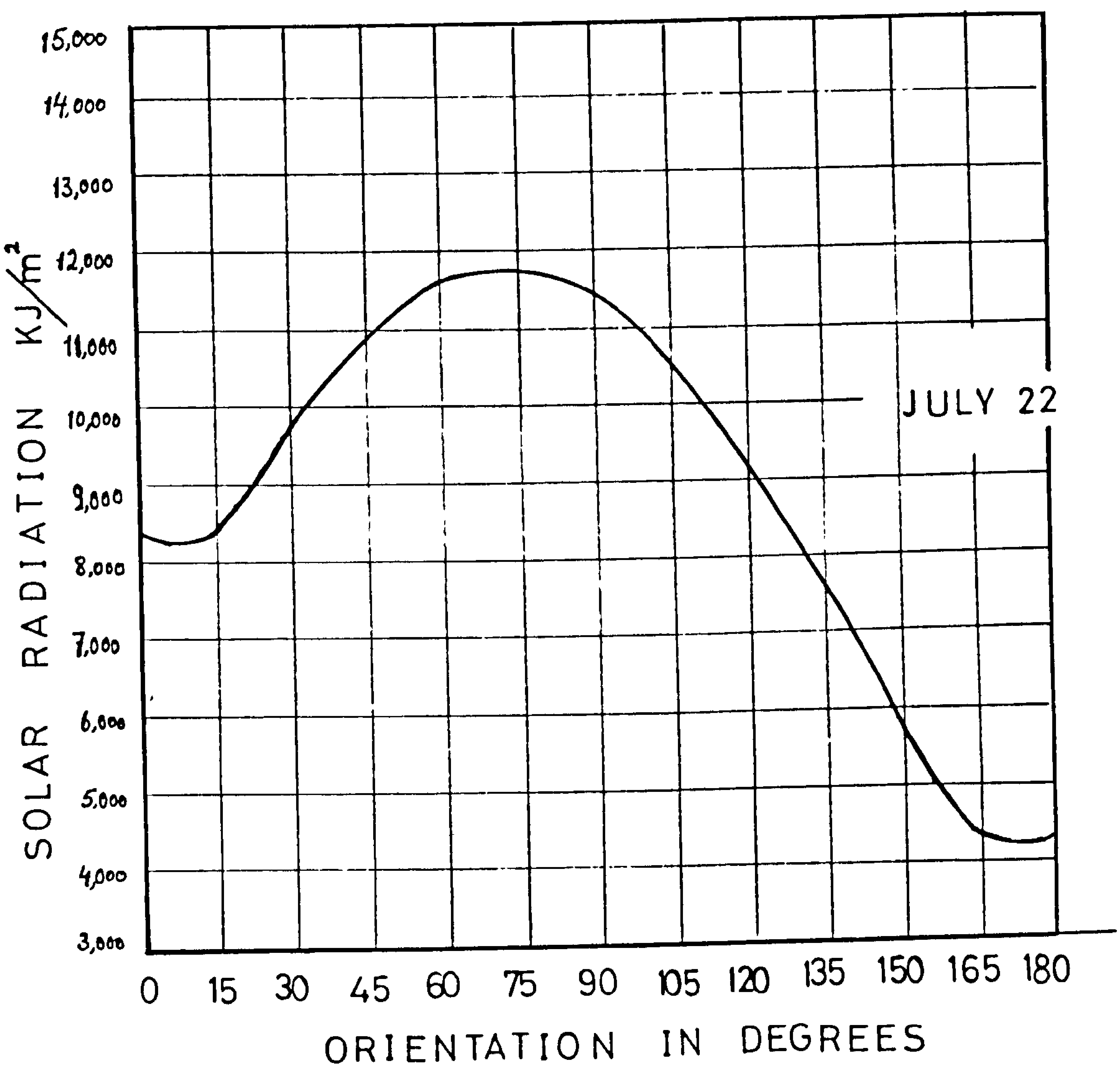
Graph of Solar Radiation per sq.metre falling on a vertical plane rotated at 15° orientations in MAY 22nd, for Khartoum.



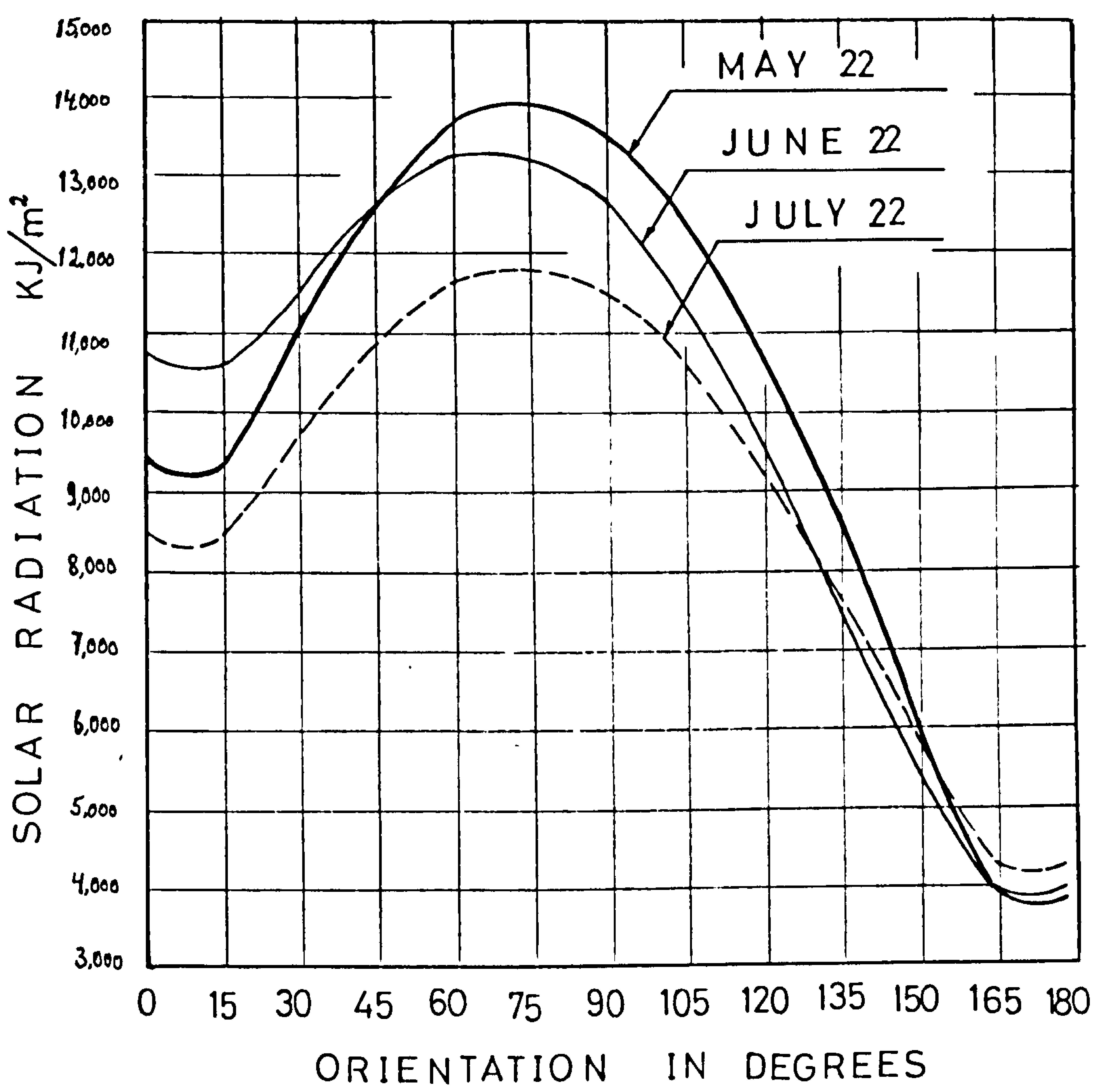
Graph of Solar Radiation per sq.metre falling on a vertical plane rotated at 15° orientations in JUNE 22nd, for Khartoum.



Graph of Solar Radiation per sq.metre falling on a vertical plane rotated at 15° orientations in JULY 22nd, for Khartoum.



For comparison, the values of total solar radiation falling in each month have been plotted on a single graph to give a complete picture of the incidence of solar radiation on vertical planes at the hottest times of the year.



Total Solar Radiation per sq.metre falling on a vertical plane at 15° orientations for summer months May, June and July in Khartoum.

By combining the graphs it becomes clear that, of the three months, MAY is the month of highest solar impact. It is also clear that in Khartoum the SOUTHERN orientation receives the minimum amount of solar energy in summer, even less than the northern orientation. Bearing in mind that the winter sun enters the houses from the south, then it is obvious that the SOUTHERN orientation has advantages throughout the year.

However, one cannot make a total judgement based only on the total amount of solar energy absorbed by vertical planes, because every building absorbs solar irradience both by its vertical sides and its horizontal or inclined roofs. Graphs therefore need to be prepared which take account of this. These graphs again aim to give the picture of total solar energy absorbed by all the sides of the houses at different orientations for each of the three summer months. The calculations from which the graphs were drawn are set out below. Note that since the amount of total solar energy received by the horizontal roofs is constant in any given orientation, it is not taken into consideration in the comparison.

Calculations of total solar energy per square metre falling on all the sides of rectangular box house:

It is established that, if the solar energy falling on any given vertical side (a) of a building is known, then the energy falling on all the other cordinal sides (b, c, d) etc., can be calculated by the following formula:

$$\begin{aligned} &\phi_1 & & & &= a \\ &\phi_1 &+ 90^\circ &= \phi_2 & &= b \\ &\phi_2 &+ 90^\circ &= \phi_3 & &= c \\ &\phi_3 &+ 90^\circ &= \phi_4 & &= d \end{aligned}$$

Adding the energy falling on:

$$a + b + c + d = R$$

gives the total solar energy falling on all the sides.

From the computer figures given for Khartoum province on page I, Index, the total solar energy falling on all the sides of a rectangular box house per 1 square metre is calculated as follows:-

Total solar energy per sq.metre falling on all the 4 cordinal sides of a box house in Khartoum at MAY 22nd:-

$$\phi_1 = 0^\circ = 9{,}540 \text{ KJ/M}$$
$$\phi_1 + 90^\circ = \phi_2 = 90^\circ = 13{,}701 \text{ KJ/M}$$
$$\phi_2 + 90^\circ = \phi_3 = 180^\circ = 3{,}909 \text{ KJ/M}$$
$$\phi_3 + 90^\circ = \phi_4 = 270^\circ = 13{,}701 \text{ KJ/M}$$

Total solar energy at 0° orientation = $R\downarrow$ = 40,851 KJ/M

Solar Energy per sq.m. at diff.orientation in Khartoum MAY 22nd

Table 29

	Orientation	Solar Energy
Total solar energy	at 15° per sq.metre	= 40,148 KJ/M
Total $R\downarrow$	30° "	= 42,333 "
Total $R\downarrow$	45° "	= 43,226 "
Total $R\downarrow$	ϕ 60° "	= 42,333 "
Total $R\downarrow$	ϕ 75° "	= 40,148 "
Total $R\downarrow$	ϕ 90° "	= 40,851 "
Total $R\downarrow$	ϕ 105° "	= 40,148 "
Total $R\downarrow$	ϕ 120° "	= 42,333 "
Total $R\downarrow$	ϕ 135° "	= 43,226 "
Total $R\downarrow$	ϕ 150° "	= 42,333 "
Total $R\downarrow$	ϕ 165° "	= 40,148 "
Total $R\downarrow$	ϕ 180° "	= 40,851 "

Table 30 Calculations of total solar energy per square metre falling on all the cordinal sides of a rectangular box house in Khartoum at JUNE 22nd

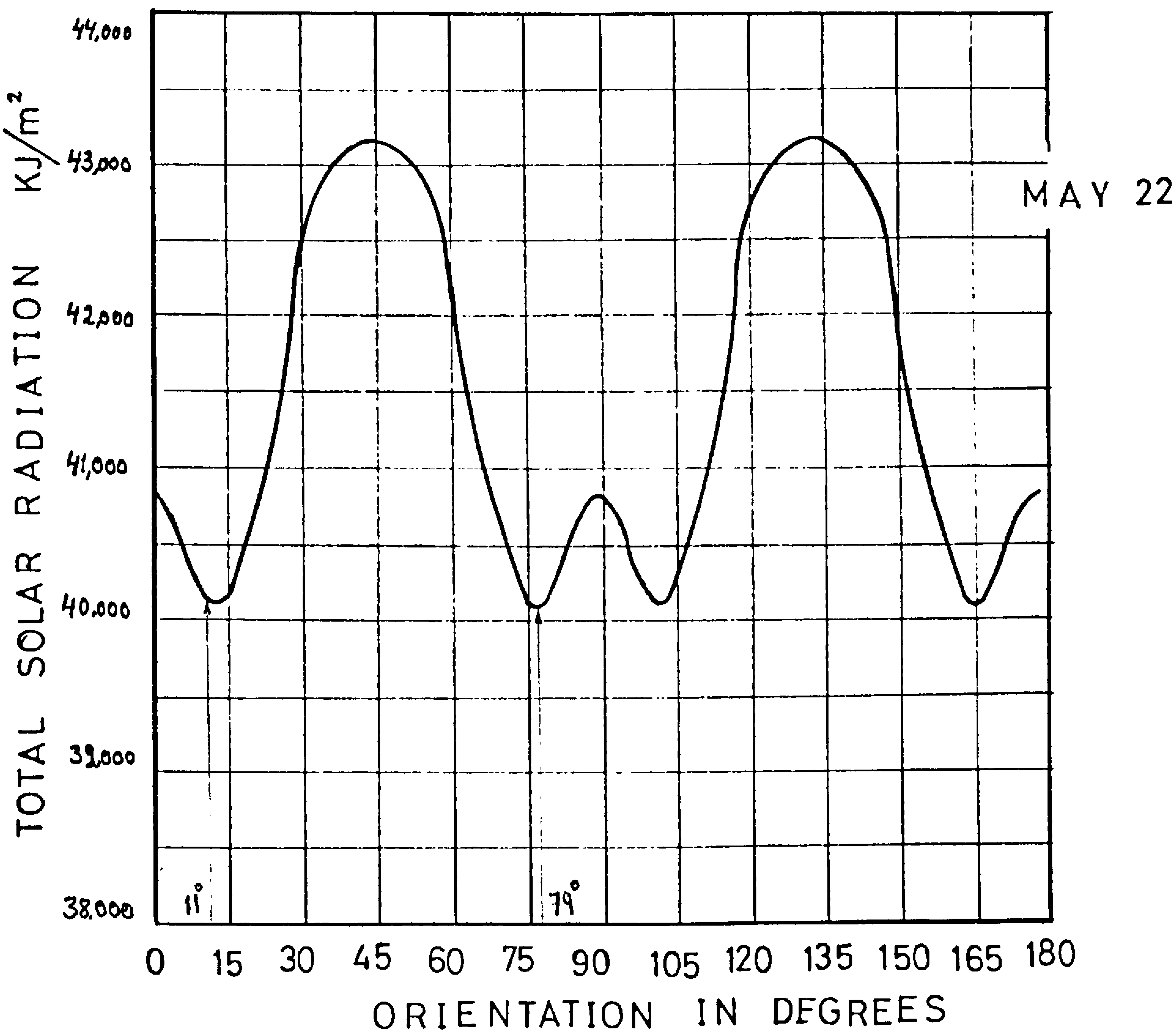
	Orientation	Total Solar Energy
Total $R\downarrow$	at ϕ 0°	= 40,599 KJ/M
Total $R\downarrow$	ϕ 15°	= 39,700 "
Total $R\downarrow$	ϕ 30°	= 40,438 "
Total $R\downarrow$	ϕ 45°	= 41,204 "
Total $R\downarrow$	ϕ 60°	= 40,438 "
Total $R\downarrow$	ϕ 75°	= 39,700 "
Total $R\downarrow$	ϕ 90°	= 40,599 "
Total $R\downarrow$	ϕ 105°	= 39,700 "
Total $R\downarrow$	ϕ 120°	= 40,438 "
Total $R\downarrow$	ϕ 135°	= 41,204 "
Total $R\downarrow$	ϕ 150°	= 40,438 "
Total $R\downarrow$	ϕ 165°	= 39,700 "
Total $R\downarrow$	ϕ 180°	= 40,599 "

Table 31 Calculation of total solar energy per square metre falling on all the cordinal sides of a rectangular box house in Khartoum for JULY 22nd.

	Orientation	Total Solar Energy
Total R↓	at Ø 0^{o}	= 36,223 KJ/M
Total R↓	Ø 15^{o}	= 35,718 "
Total R↓	Ø 30^{o}	= 37,245 "
Total R↓	Ø 45^{o}	= 37,846 "
Total R↓	Ø 60^{o}	= 37,245 "
Total R↓	Ø 75^{o}	= 35,718 "
Total R↓	Ø 90^{o}	= 36,223 "
Total R↓	Ø 105^{o}	= 35,718 "
Total R↓	Ø 120^{o}	= 37,245 "
Total R↓	Ø 135^{o}	= 37,846 "
Total R↓	Ø 150^{o}	= 37,245 "
Total R↓	Ø 165^{o}	= 35,718 "
Total R↓	Ø 180^{o}	= 36,223 "

The calculation set out above can be represented graphically as follows:-

Graph of Total Solar Radiation per square metre falling on all the cordinal sides of a box house at different orientations in Khartoum, at MAY 22nd.

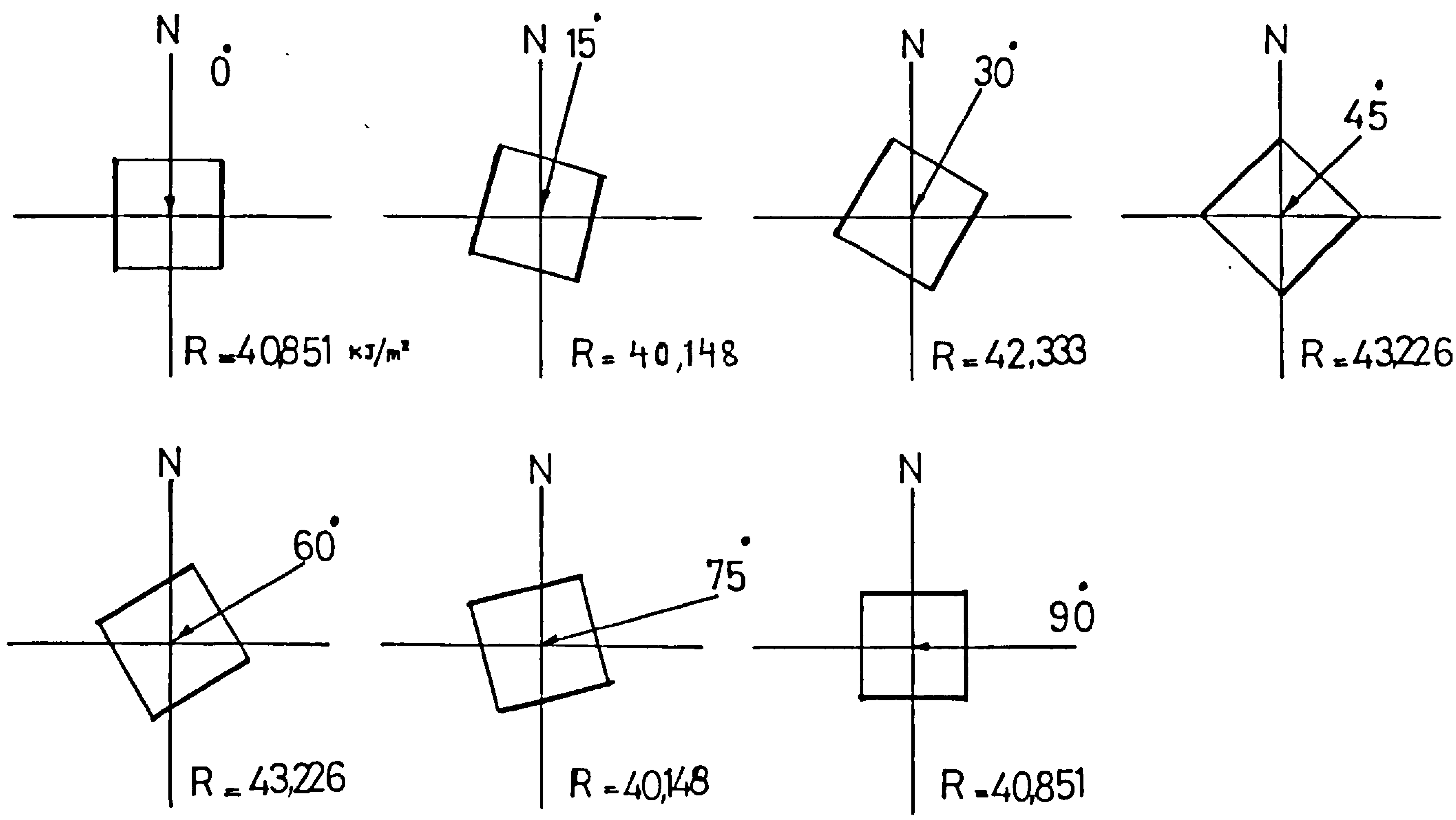


To facilitate comparisons, values of total solar energy per square metre received can also be plotted for different orientations.

Plotting of Total Solar Energy per square metre received by the houses at different orientations in Khartoum at

MAY 22nd

MAY 22



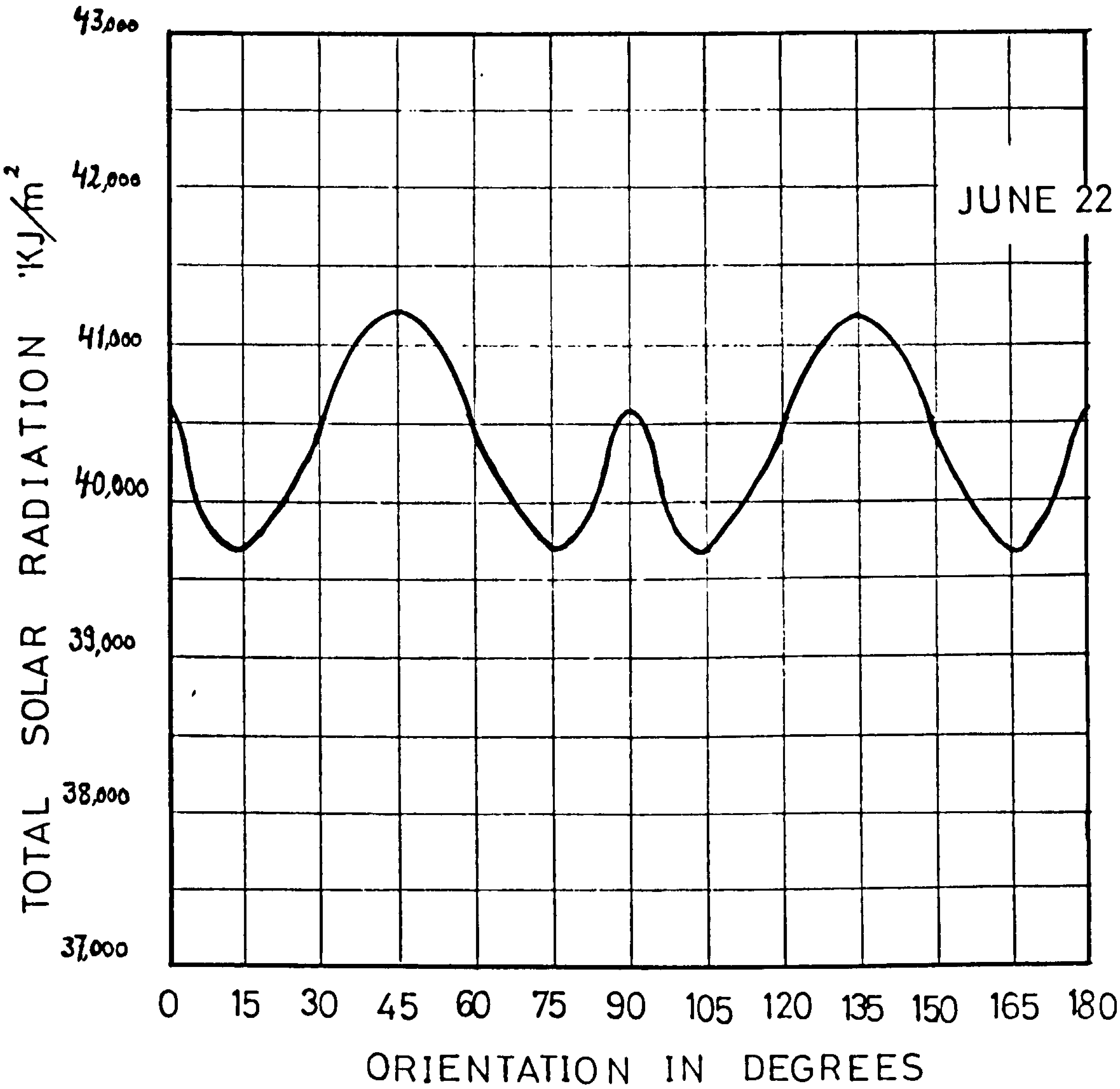
From the two graphs it is clear that:

1. Orientation 11° from the north gives the minimum amount of received solar radiation.
2. Next to the 11° from north comes the Sudanese traditional north-south orientation.
3. The north-west and south-west orienations give the maximum heat imput.
4. From the ventilation view point 11° from north orientation is no worse than the north-south orientation, since the traditional southerly winds can ensure cross ventilation.

5. Orientation 79° from north gives the same value of solar energy R↓ per square metre as the 11° from north orientation, but is has two disadvantages:-

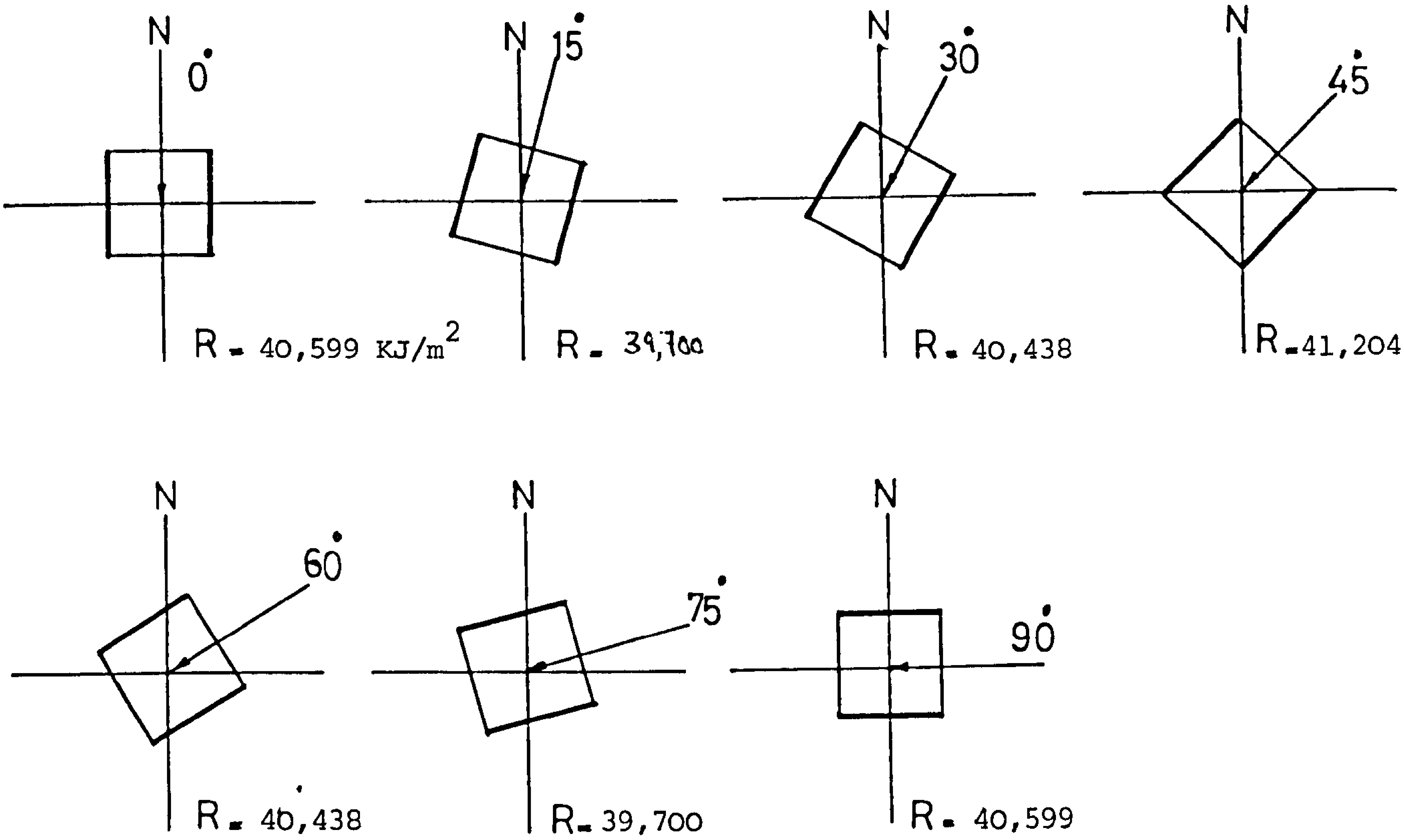
   (a) It does not allow easy cross ventilation
   (b) Openings allow the low sun rays from the east and west to penetrate the rooms and raise the temperature.

The June picture of received Solar Radiation per square metre is the same as May 22nd. It differs only in absolute values.

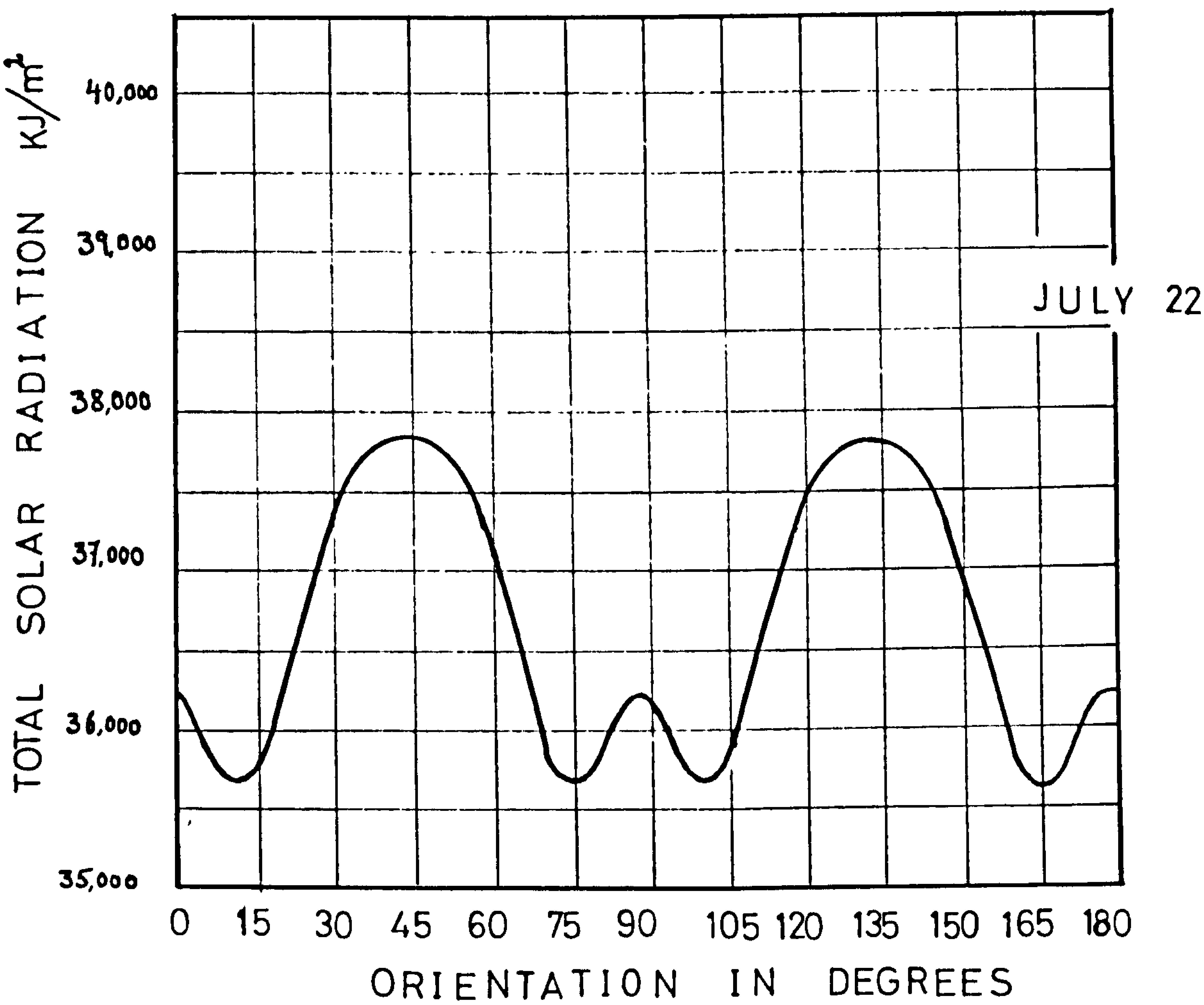


Plotting of Total Solar Energy R↓ per square metre received by the houses at different orientations in Khartoum in: JUNE 22nd

JUNE 22

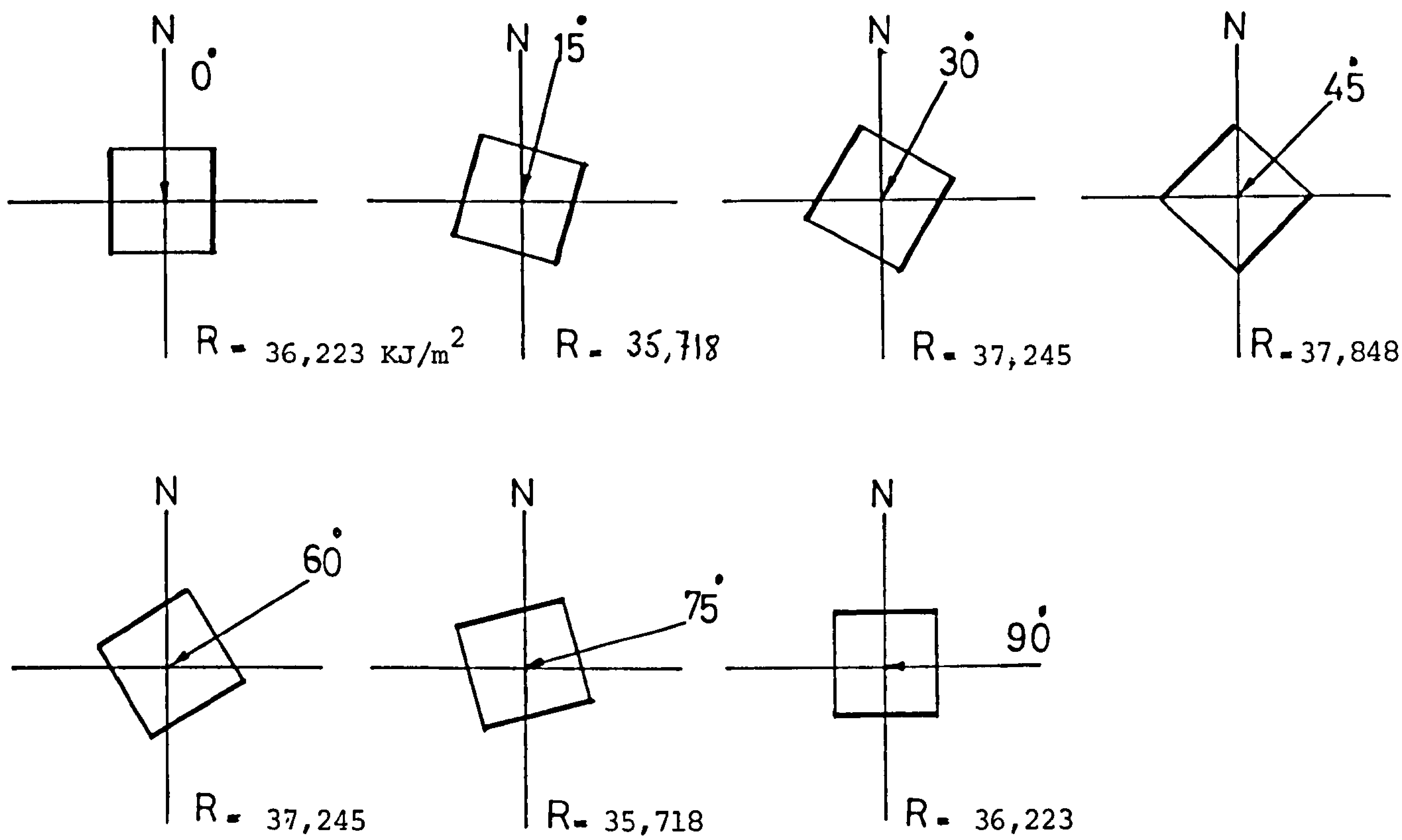


Graph of Total Solar Radiation per square metre falling on all the cordinal sides of a box house at different orientations in Khartoum at JULY 22nd.



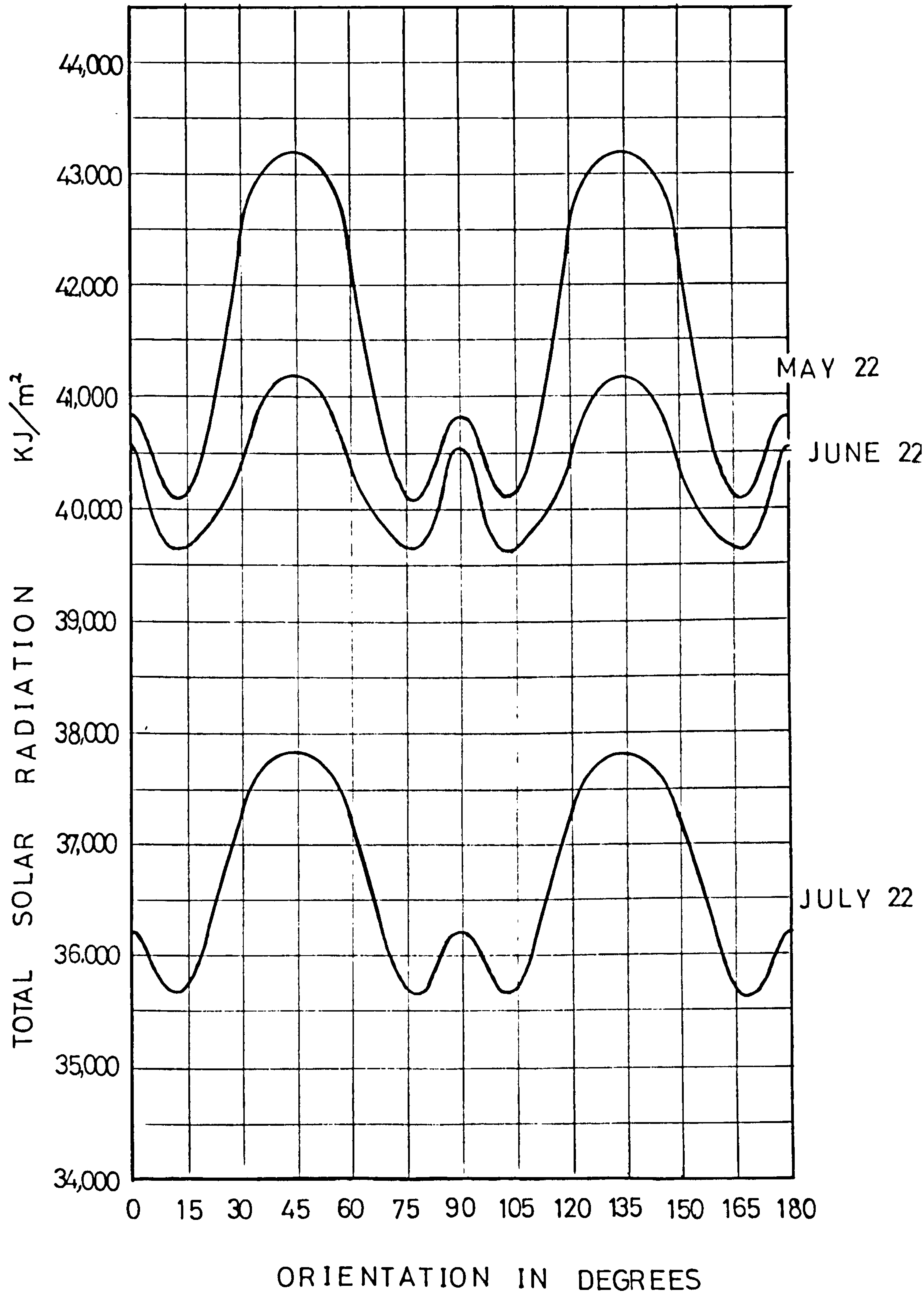
Plotting of Total Solar Energy per square metre received by the houses at different orientations in Khartoum in JULY 22nd.

JULY 22



A composite graph of the results obtained allows a comparison of conditions in May, June and July.

Graph pf Total Solar Energy per square metre absorbed by all the vertical sides of houses in summer months May, June and July in Khartoum.



The last graph clearly emphasizes that, of the three months studied, the maximum amount of solar absorption occurs in May. While July gives a maximum solar energy of 37,848 KJ/square metre, and June a maximum of 41,204 KJ/m^2, MAY gives a maximum of 43,226 KJ/m^2. In other words MAY readings exceed those in June by 2,022 KJ/m^2 and those in July by 5,378 KJ/m^2.

3.12.4. Results and Conclusions

1. Although there is a negligible difference in the absolute values of outdoor temperature in Khartoum (1) between May and June, there is a significant difference in the amount of total solar energy absorbed by buildings during the month of May. Therefore, houses must be orientated according to the total amount of solar energy $R\downarrow$ and not according to the absolute values of outdoor temperature.

2. Because of the high level of received radiation recorded in May, this month must be used as the indicator for design measures aimed at producing maximum indoor comforts.

3. The selection of the correct orientation gives the smallest amount of solar energy absorbed by vertical areas and thus minimizing heat gain to the interiors.

4. The figures of total values of solar energy and all the graphs drawn in this study indicate that the OPTIMUM ORIENTATION for Khartoum Province is to place the main face of the houses perpendicular to the AXIS 11^{o} FROM THE NORTH. This proves that the traditional north-south orientation is not the ideal one and it is clear that this relatively small rotation by 11^{o} would produce a substantial decrease in the amount of solar radiation absorbed by the house.

5. In MAY a difference of only 11^{o} from the traditional north -south axis gives a difference of:-

   40,851 - 40,120 = 731 KJ

   solar energy in every square metre, a fact of great significance when it is remembered that a difference of only 1^{o}C lower than the normal temperature is felt as a relief in the extreme heat.

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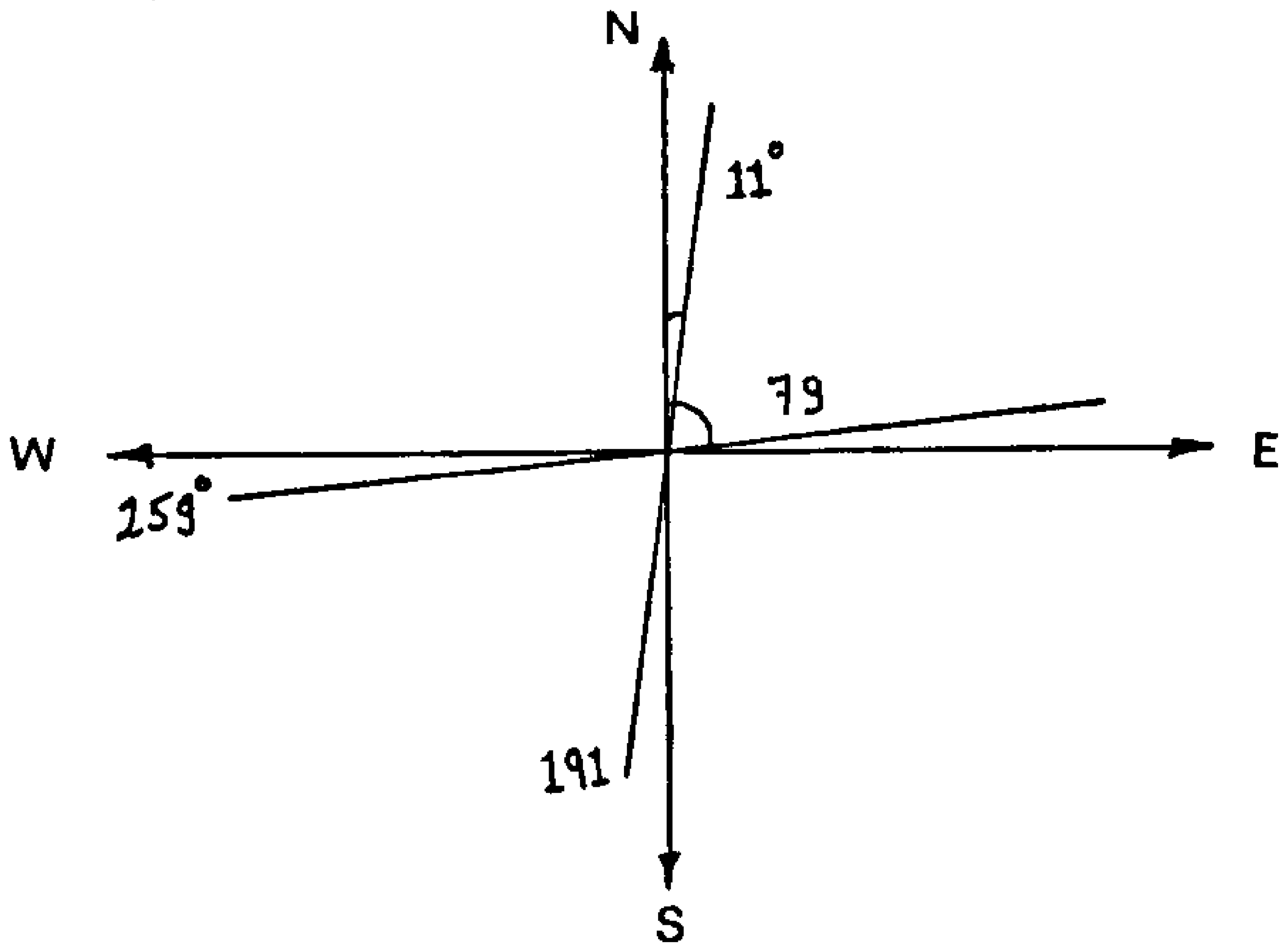
(1) see page 69 Chapter 3 "Climate of Khartoum Province".

6. From the graphs it can be said that, the best housing orientations for Khartoum are:

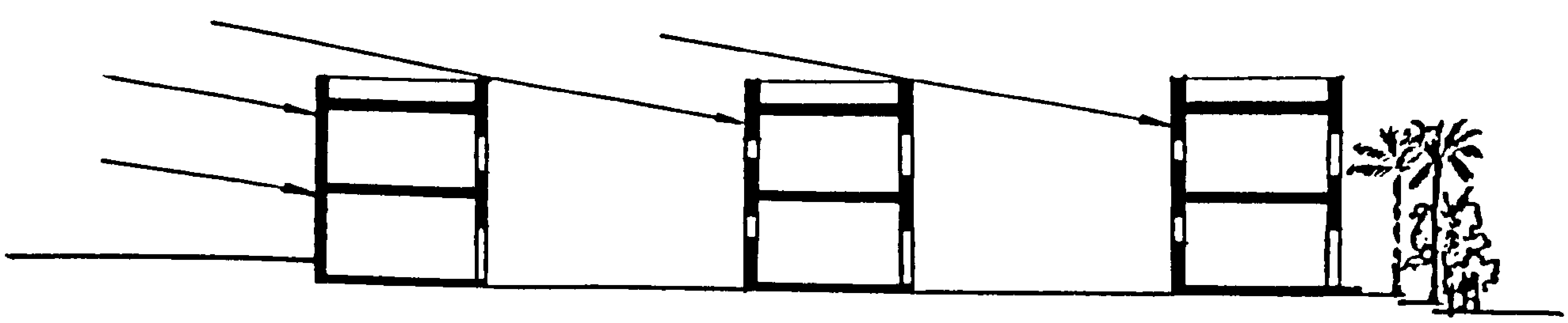
$11^{O}N$, $79^{O}N$, $191^{O}N$ and $259^{O}N$



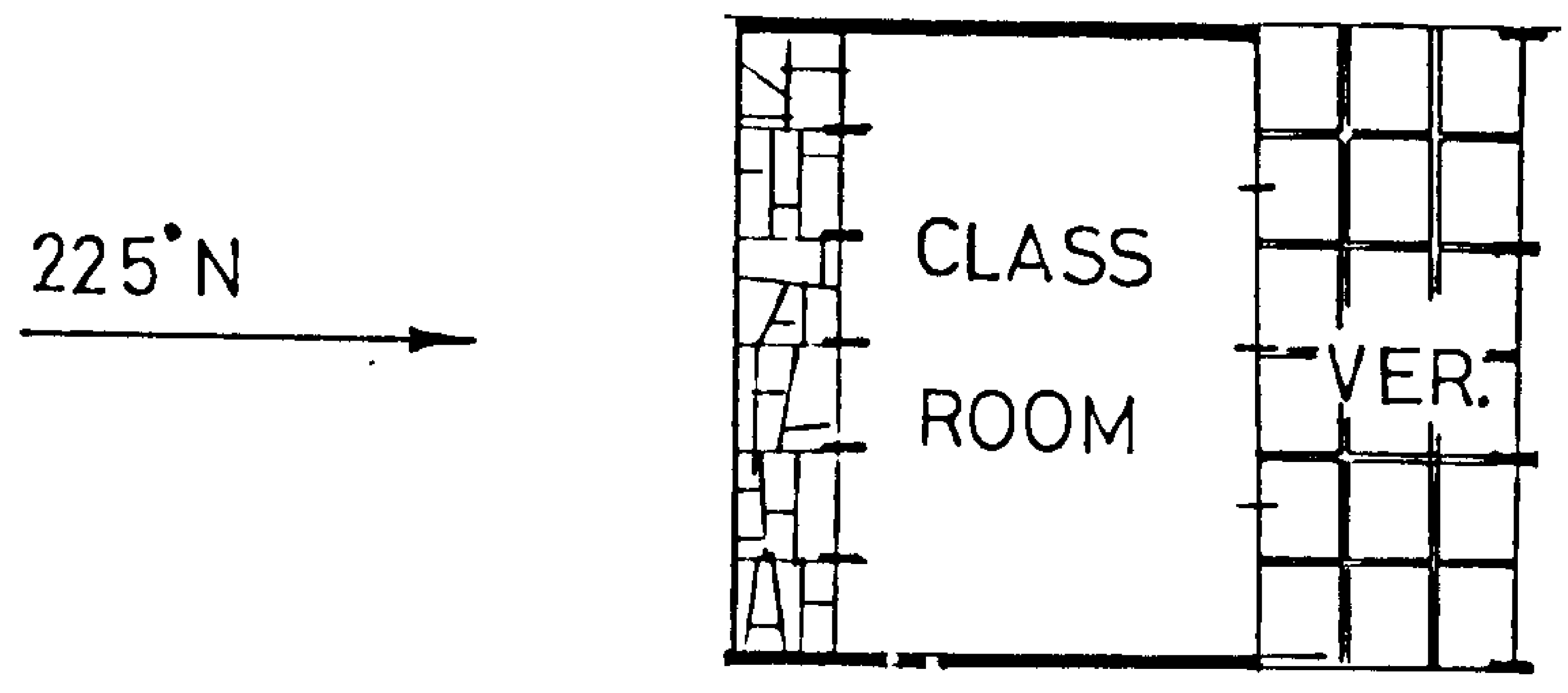
since all of them give a fixed minimum of solar energy per square metre, but out of these $11^{O}N$ and $191^{O}N$ are ideal since they are not exposed to the low sun rays from the east and west.

7. Orientations $11^{O}N$ and $191^{O}N$ are also especially suitable for Khartoum because they reduce the effect of the frequent summer dust storms which come from the east.

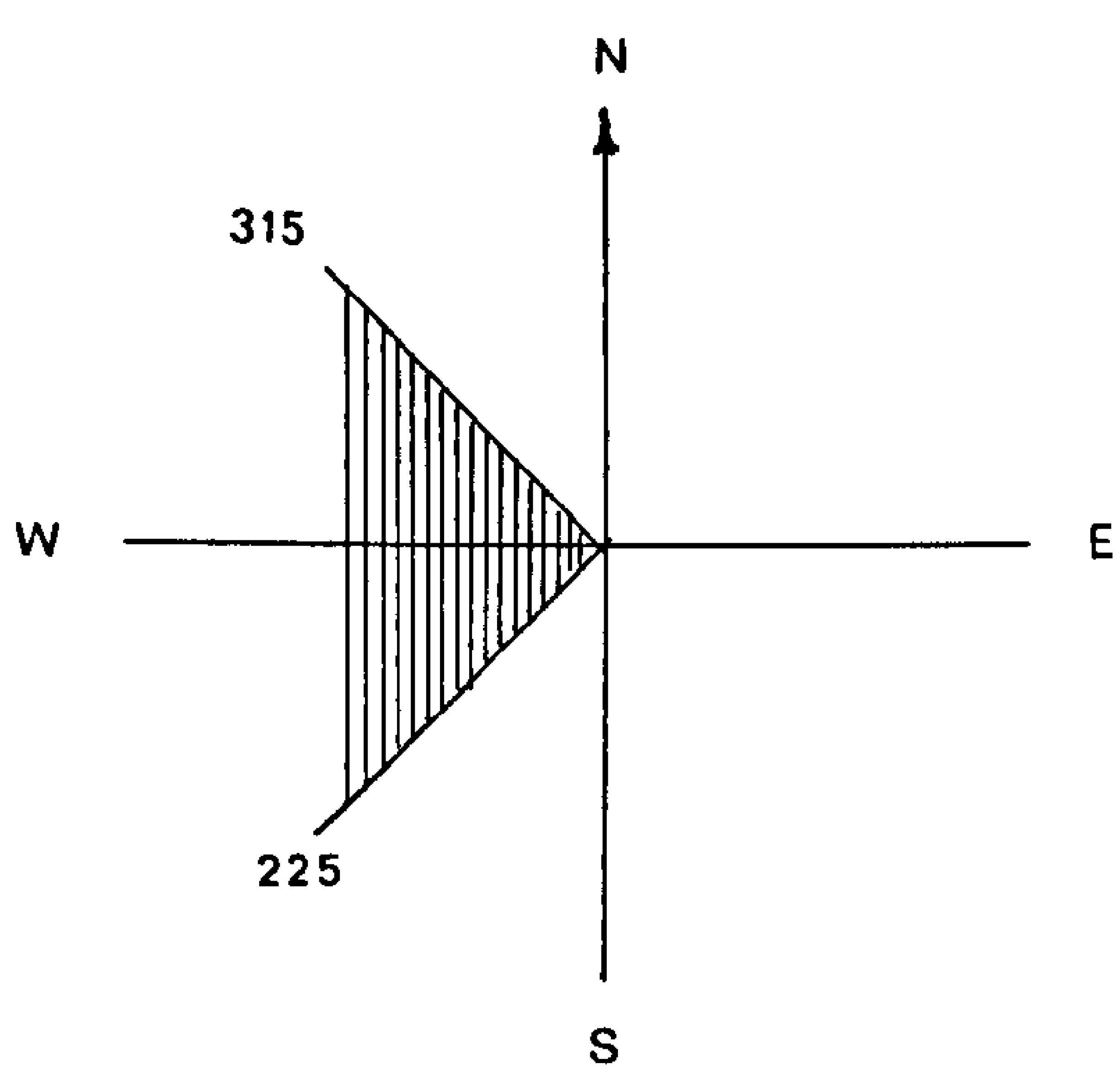
8. When dealing with the other two orientations i.e. $79^{O}N$ and $259^{O}N$, great care must be taken to protect these sides from the low sun rays from the east and west by trees, shading devices, sun-breakers or by special layout arrangements which will ensure that the openings are protected by neighbouring building. For example:-



9. The orientations $79^{O}N$ and $259^{O}N$ may be used for special buildings e.g., in elementary and preparatory schools which will have closed for the day before they can be affected by the late afternoon sun.



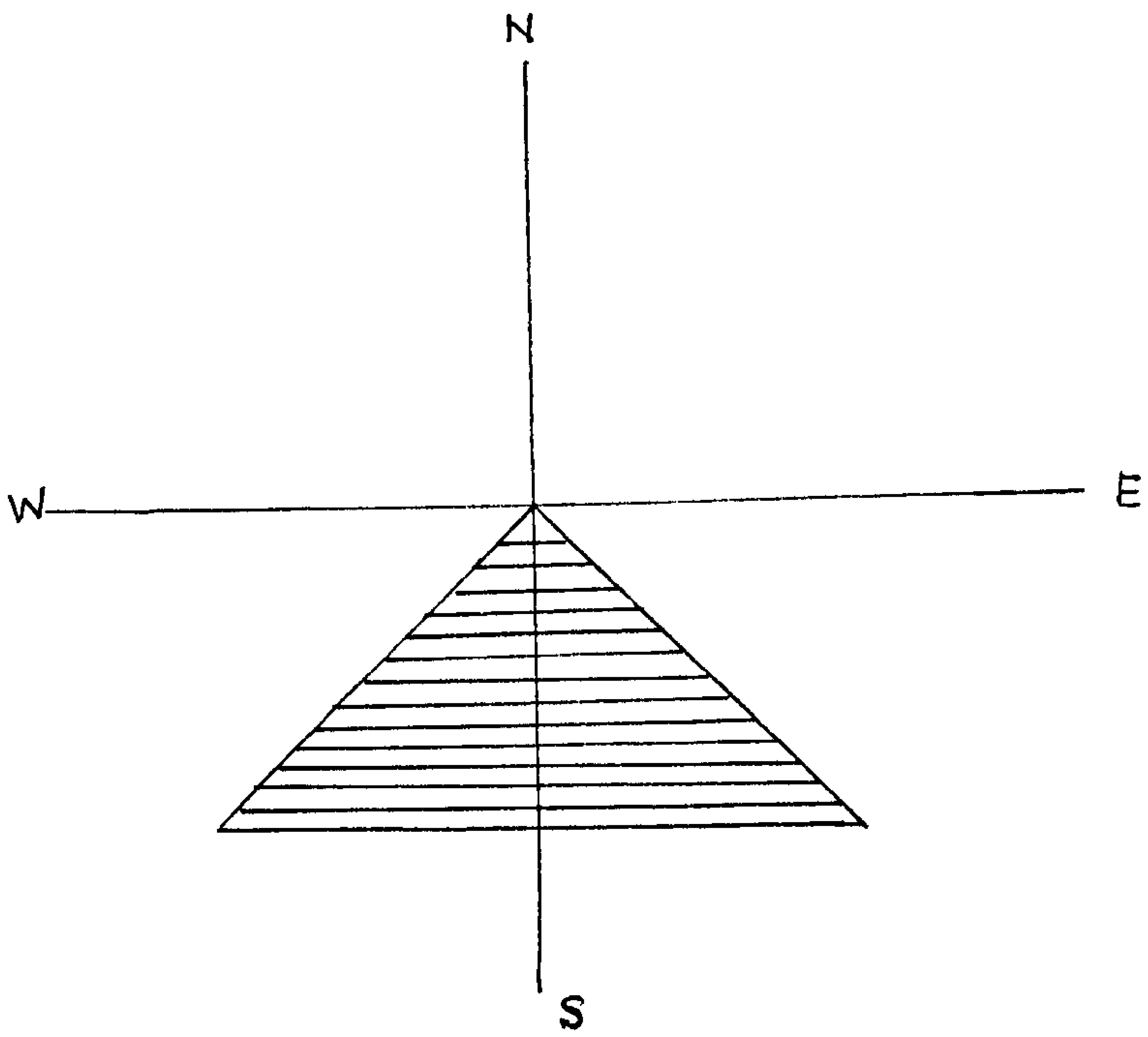
10. The orientations receiving maximum solar energy in Khartoum are 315^{o}N and 225^{o}N, i.e., north-west and south-west. Unshaded openings between these two orientations must be avoided.



11. Although a great difference in total solar energy input occurs if the houses are rotated for only few degrees, cross ventilation can be ensured with wide-range of orientations. According to B. GIVONI, (1) with a range of 90^{o} i.e., 45^{o} on each side from the wind direction, good ventilation can be ensured if outlets are provided on the other side. Therefore, it is not necessary to orientate the houses perpendicular to the wind direction. The ideal orientation is that position which invites minimum solar energy while at the same time ensuring good cross ventilation.

(1) B. GIVONI "Man Climate and Architecture" page 262.

12. Finally it can be concluded that in addition to the colour of the outer walls, shape of the building and extent of shape, HOUSING ORIENTATION is one of the most important factors in the control of solar energy absorption.



Range of good ventilation for Khartoum in summer.

CHAPTER 4

SOCIAL ASPECTS OF SUDANESE FAMILY NEEDS

4.1. Influence of Islam on the Sudanese Social Behaviour

Islam came to the Sudan in the seventh century by way of Egypt and since then it has completely shaped the lives of the Sudanese and their social behaviour. The overwhelming majority of the Sudanese are Muslims and in this central region the entire population is committed to Islam.

The basic idea of social life in Islam is that all Muslims are brothers and that every individual must share the tribulations or achievements of his brothers. The idealistic situation occurs when an individual puts his own desires second to the desires of his brother, and helps him with his own money or goods although he himself might be in need of them.

However, Islam has its own rules of social security which lays down that a minimum percentage is to be taken from the community's wealthier members and distributed annually among the poor.(1) Islam reminds every Muslim that he must never fully enjoy the luxuries of life while his relatives and neighbours are suffering. This extends to the belief that "the rich man who sleeps with his stomach full, while knowing that his neighbour is sleeping hungry, is a non believer" as it is reported in one of the sayings of the Prophet Mohammed, peace be upon him.

All Sudanese social customs in this region are derived from the Islamic laws. The way of life of the average family is derived from these long established Islamic and Sudanese social traditions. Almost all the members of every household in the major part of the Sudan, observe the rules of Islam.

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(1) It is not left to the rich to give charity when they wish. It is a legal obligation and if anyone is reluctant to give, the governer is authorized to take it by force and distribute it to the needy members of society. However, as it is a kind of worship, it is usually given freely.

4.2. Social Relations with those of close Kinship

Responsibility towards close relatives is the first priority in Sudanese relationships. Every individual Sudanese bears complete responsibility for his close relatives. If he is rich, his relatives have a complete right to demand a part of his surplus capital if they are faced with hardship.

Relations between close relatives are reinforced by Islam which commands every Muslim first to support and help his relatives, then his neighbours before going out to help the rest of the community.

4.2.1. Kinship Relations

The ties of close kinship are very strong throughout the Sudanese rural areas; life in the villages is based on kinship patterns, where many elementary families live in one big homestead.

The smallest residential unit in the villages is the household. The elementary family consists of the father, his wife or wives and their children, while the household consists of a person or group of persons living in a house or a section of a house and managing their domestic interests independently.

The most frequent type of household is the elementary family, sometimes enlarged by one or several persons, such as close male or female kin e.g., widowed mother-in-law, relative lodger. Sometimes a whole branch might join the household, such as families who have lost one of their own main elements, either the head of the family or the mother. These additional branches may sometimes constitute semi-independent units, when an adult woman is put in charge of a unit.

Joining a full-fledged elementary family can be achieved in two ways. The disintegrated family units may be absorbed completely by the elementary family; in this case they share in all the daily life and the meals of the members of the absorbing family, they participate in the common economic and domestic activities; a man alone joining such an elementary family lives with the head and the adult sons, a woman alone lives with the household mother and her adult daughters, and orphaned children live together and sleep together with the children of the household.

In the case of a widow and her children (household head's mother, sister or daughter), she may receive her own house within the homestead of the adopting family, where she lives with her own children and where she prepares her own meals.[1]

The reason behind the formation of such multi-family households is that it is too difficult for the disintegrated family units to support themselves independently, due to the conditions of economic hardship which prevail throughout the Sudanese rural areas. The responsibility of every Sudanese towards his close relatives encourages him to help them in case of hardship, treat them as members of his own family and share with them what he has.

The percentage of completely independent elementary families is almost negligible. The majority of rural families live in kinship groups, each consisting of many elementary families living together. These rural households not only support each other morally and financially, but almost every kinship group shares the same domestic facilities. The common diwan (guest reception room), the common courtyard, the common kitchen and even the comon latrine in some areas, are services normally shared by such a group.

In a survey carried out by the University of Khartoum[2] the social relations of Sudanese rural families were carefully studied. The survey produced the sketch plan:

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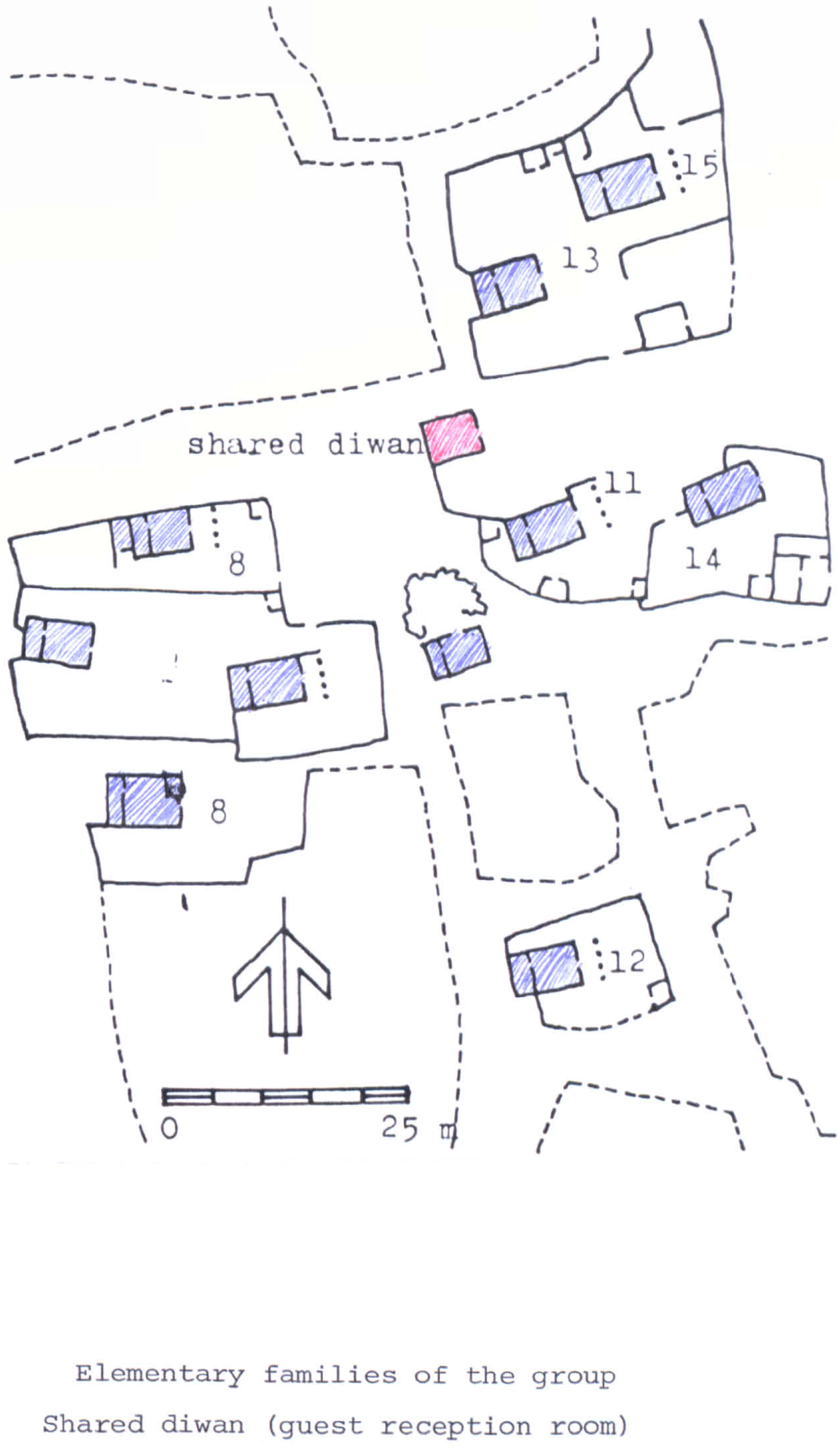
(1) Dr. G. BRAUSCH "Marriage Systems and Housing in Udeid El Bashagra" THE ARCHITECT University of Khartoum, Dept. of Architecture Magazine 1964.

(2) BASHAGRA AREA SETTLEMENTS 1964. "A Case Study of Village Development in Gezira Scheme" University of Khartoum 1964. Dept. of Social Anthropology and Sociology. Dept. of Architecture, Dept. of Rural Economy.

A kinship group sharing a common diwan



Source: Bashagra Area Settlements ..... op.cit.

which shows the grouping of the houses of many elementary families of an average kinship group around the common shared domestic facilities.

However, when the overcrowding in a big kinship becomes unbearable, that kinship group normally scatters in different peripheral parts of the village and it is then obviously not possible to organize common domestic services among its members.

4.2.2. Social Aspects in Suburban Areas

Social relations and kinship ties in suburban areas are weaker than those in rural areas, but they are still very strong compared with normal social behaviour in the cities. Households in suburban areas consist mainly of elementary families, but each kinship group lives in a certain area as close as possible to each other. However, they differ from the rural kinship pattern in that every elementary family lives in a completely self-contained house with separate domestic services. Each family finances its own domestic affairs independently.

In suburban areas kinship ties are still very strongly felt, but in a modified way. All the branches of a kinship live separately but they are very strongly tied to each other. An event happening to any branch, such as illness, difficulties or special occasions makes all the branches come together to face the event collectively and share its expenses, each according to his economic ability.

Although the families of a suburban kinship group live independently, they still share the common diwan (guest reception room) or diwans. Each family receives a small number of local guests in its own small reception room, but the common diwan is used by any one kinship family when receiving a big number of guests or when celebrating a special event.

Every suburban kinship group shares its own common interests and its members support each other both morally and financilly. In case of any hardship facing any branch, all the other members are obliged to help by contributing whatever they can afford. All the families of a kinship group may contribute monthly or give occasional financial help to a kinship member who is ill, unable to work or is suffering from other difficulties.

Often, the households' heads take their evening meal together in the shared diwan (built normally by the kinships' richest member), each bringing his food from his own house. All the members share in the reception if a large number of guests is invited to the common diwan by any kinship branch. Occasional guests coming from a long distance usually sleep in the common diwan for some days, where they are received and entertained by all the kinship members, each bringing his food daily to the guests. Other than guest reception, a suburban kinship group uses the common diwan for its own occasional meetings to discuss kinship affairs and problems.

Because of the close social relations enjoyed by the Sudanese, the common diwan is usually too small to accommodate the large number of occasional visitors who come to share with the kinship in some of its special events such as weddings, and funerals. For this reason, every kinship group contributes towards the cost of a large tent, light chairs, carpets, electric lamps etc., to be used by all the kinship families and their neighbours on such occasions. The tent is placed in front of the common diwan to create sufficient space for large numbers of visitors to be received in both of them. Kinship members pay nominal monthly instalments for maintenance of the tent and renewal of the other services.

4.2.3. Social Relations in Cities and Urban Areas

Urban Sudanese families consist of completely independent elementary families, each managing its domestic affairs and services separately. However, occiasionally a rural kinship member joins the family as a lodger if he comes to the city for business or study.

In the cities it is very rare to find all the families of a kinship group living together in one area. City housing plots are distributed by ballot and consequently people from different backgrounds find themselves living together. However, in spite of this, urban kinship families scattered in different parts of the same city often visit each other. They also bear great responsibility towards each other and share the problems of any kinship member.

Every urban family receives its guests in its own reception room. Visits normally take place in the afternoons when it is cool enough to receive a big number of guests in the open air in front of the reception room. In case of special events such as weddings and funerals, the family compound is too small to accommodate the large number of guests. For this reason urban families use the street in front of their compounds where big tents are erected to receive the guests. Unlike the suburban areas, here the tents, chairs, etc., are rented from specialist shops.

Kinship members in the city bear the main responsiblity towards each other in case of hardship facing any individual member. They share some expenses and take part in guest reception. Close neighbours in the city also offer each other mutual support.

4.2.4. Design Recommendations

- Sudanese social relations must be carefully analysed and understood because they are crucially important in determining realistic neighbourhood layouts and individual house designs.
- The possibility of providing shared facilities in every neighbourhood must be thoroughly explored.
- The houses must be grouped around semi-private spaces to be used by all the families for special events in order to encourage and strengthen social relations between urban families.
- It will be better, if these shared common areas can be multi-purpose, so that in addition to guest reception, they can be used for such purposes as recreation and children's playing areas.

4.3. Influence of Social Relations in Self-Help Housing Projects

The strong social relationships already described have many effects on the daily life of the Sudanese. In addition to the complete mutual help between the members of every kinship group, there is a strong feeling of community which connects the interests of whole villages and areas, because close ties of marriage connect many kinship groups. Detailed studies of all these social relations are out of the compass of this research, though they are obviously a very important factor when formulating house designs to satisfy the complex needs of Sudanese urban families. There are many desirable aspects to the long established social relations and traditions should be retained and improved.

One such long-standing tradition is the collective erection of houses. It is thought that it may have had its origins in agriculture.. Kinship groups are accustomed to help anyone of their members who was unable to carry out certain agricultural work, because of sickness or for other reasons, or because he lacked money to pay labourers. Such a man normally calls for help (Nafir) from his kinship members, neighbours, and friends. All of them come at the stated time and carry out the job collectively. The person who benefits from the help is not supposed to make payment. Such help is not restricted to agricultural work but could also be applied to such major tasks as house construction.

In rural areas houses are built without paid labour. All rural buildings were built by the (Nafir) system, where the house owner only provides the materials while the construction work is done for him free of charge by his kinship members, neighbours and friends. He in turn is always ready to give a hand to any friend requesting help with house erection. Since all rural housing is built from mud with wooden rafters for the roof, construction techniques are very simple and well known to all rural people.

In suburban areas also collective housing erection is a very long established tradition. The house owner provides the materials and calls his relatives and friends to help. The only paid worker is the master-builder, who must be employed as the house must be built by a trained professional, but the owner, his family and friends do all the labouring and unskilled work. Such collective construction normally takes place at the weekends and the afternoons, when the participants have returned from their normal jobs. In addition to materials and the master-builder, the owner also pays for special services such as electrical and sewer connections. However, if one of his friends or relatives is a professional in this field he may undertake this part of the work in his spare time without payment or at a cheap rate.

Even in urban areas and big cities low income groups undertake house constructions in the same way, but as their relatives and kinship members live outside the city, they normally invite them to work in holidays and weekends.

From the above it is evident that the tradition of self-help housing construction is well established in both rural and urban areas of the Sudan. The local population lacks certain technical expertise, but their acceptance, enthusiasm and experience of the system are very well established.

4.4. Status of Women in the Sudanese Community

The position of women in the Sudanese community is derived completely from the laws of the Islamic Religion. Islam considers men and women to be completely equal in their spiritual, political and economic rights but since the two sexes are different in nature, Islam encourages men to work outside the home to support the family and encourages the woman to stay within the house, to manage domestic affairs and look after the children. Islam considers looking after the children and bringing them up well as a most important task. The women is also expected to care for her husband and give him encouragement and support so that he has no domestic worries and, can give his energies fully to his job.

However, this does not mean that the woman is completely confined to her house though conditions of dress outside the house are imposed. She can go out to work if there is a pressing need or if the type of work needs to be done by women, (e.g., nursing or the teaching of girls).

Women have equal votes and equal political rights with men. They have the same economic rights and can run their own business or shop if they have the means to do so. However, Islam does not ask the woman to support the house or share in the living expenses. Her money is her own concern; on the other hand the husband is required by the law to feed, clothe and keep her in a house of a certain standard.

Because of these Islamic traditions, Sudanese women are valued and respected.

4.4.1. Seclusion of Women

As already mentioned, though the Islam does not strictly forbid the woman to go outside the house, it is considered better that she stays home to bring up the new generation. When at home it is not considered appropriate that she should receive male guests from outside the family alone. She may receive her relatives and female guests in her own room, but other male guests must be received in the guest room.

The Sudanese household head is consequently concerned to preserve the "seclusion" of his women folk and one of his first requirements is that the outer boundary walls of the house must not be too low and that the front door should not face the windows of the women's rooms. To some extent, the situation in the Sudan is similar to that described by AMOS RAPOPORT[1] when he spoke about female privacy in Latin American and North African countries:

> "The windows and roofs of these court houses are designed to prevent anyone from intruding into the intimacy of the house. For the same reason, house doors on opposite sides of the streets may not face each other. Privacy is protected not only by the blank walls, small openings, and other physical devices, but also by custom - few outsiders are ever invited in, and when they are, the women's portion of the house is strictly prohibited".

However, the Sudanese differ from this in that they are very socially orientated. They visit each other very frequently, and always invite their relatives, neighbours and friends to their houses. "Seclusion" of women in the Sudanese society is best described by SAAD ELDIN FAWZI[2] :-

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(1) AMOS RAPOPORT University College London "House Form and Culture" Prentice-Hall Inc. Englewood Cliffs N.J. 1965 p.65.

(2) SAAD ELDIN FAWZI "Social Aspects of Low-cost Housing in Northern Sudan". Khartoum 1954.

> "…. does not mean the division of the members of the same household into males and females, who, though residing together, have virtually separate lives. Seclusion is valid only for one sex in relation to the 'stranger' or 'outsider' of the opposite sex".

He then explained the 'outsider' used in this sense by saying:

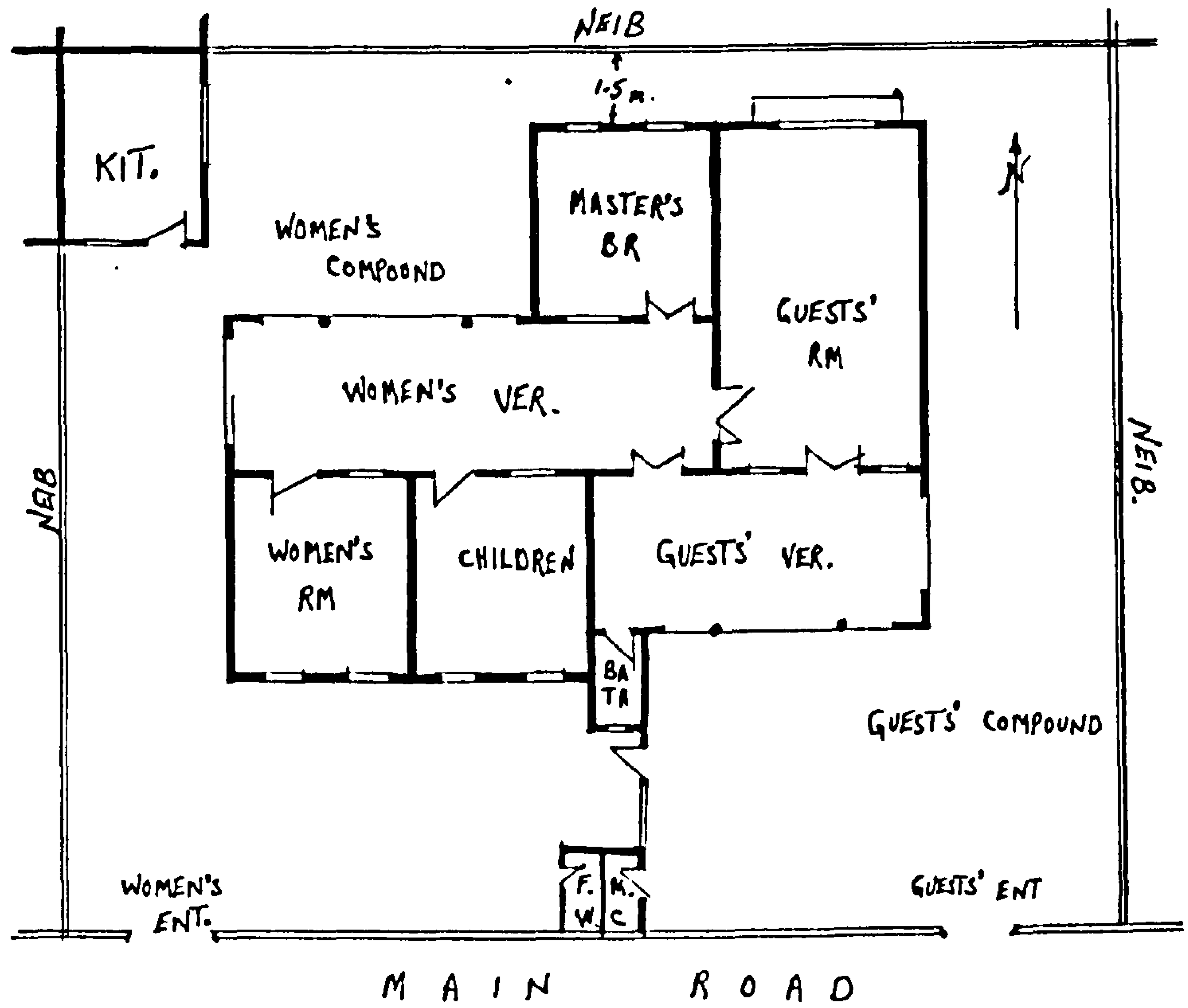
> "I might be on very good terms with my life-long neighbour, but I am still a stranger to his womenfolk and must be treated accordingly…."

Usually the man and his wife have their meals together and spend most of their free time at home with the children. When visitors arrive they are entertained by the whole family, or, depending on their type of relationship, they are taken to the 'guest room'.

4.4.2. Influence of Sudanese Social Traditions on House Design

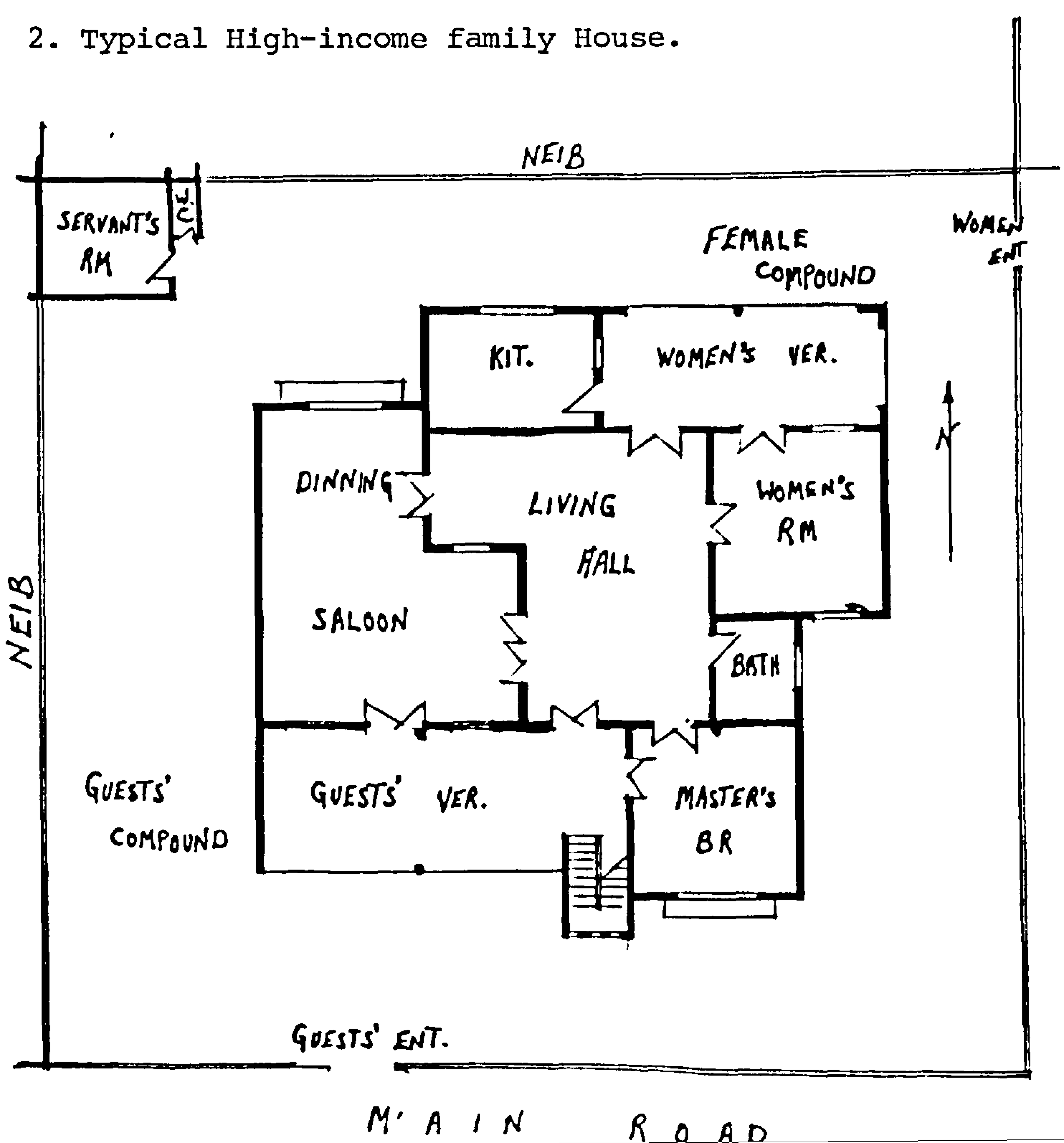
The long established patterns of social and family organisation naturally have considerable impact on house design. The desire for separation of the sexes, leads to the division of the house into two separate compounds for the purposes of everyday life. The requirements of prestige and social status have encouraged families to live predominantly in one of the compounds leaving the other almost entirely for guests. The result is that the family compound is usually very overcrowded, while the guests compound and rooms are usually less cluttered, well maintained but only occasionally used.

It therefore seems reasonable to suggest that guest rooms and compounds should be smaller in size. In general the guest room or 'saloon' in a Sudanese house is the biggest room (usually two rooms joined together); it is very well built and furnished and its overall cost might be more than one third of the total cost of the house. However, it is only used once or twice a week for a total of 5-10 hours, and in fact guests are seldom received inside the saloon. Because of the heat inside the rooms, guests are usually received in the guest compound or the verandah in front of the guest room. It therefore seems more appropriate to have a small guest room with a well landscaped guest compound. The following plans demonstrate how the need to preserve female privacy has led to two entrances, two compounds, separate w.c.'s and two sets of rooms.



1. Typical Middle-income family House in Khartoum

2. Typical High-income family House.



The desire to have large guests' and family courtyards has led to all houses in the Sudan being built as detached villa type dwellings. This is reinforced by Municipal laws which insist that the living rooms of two adjacent houses must be at least 2½ metres from the dividing shared wall. As a result the big cities in the Sudan are characterized by excessive horizontal expansion of low density housing, with long frontages of two rows of houses facing the road. This kind of development means that such services as electricity, telephone and sewerage are very costly, since the installations serve a relatively small number of people per square mile. The position could be improved if semi-detached or terraced houses could be made acceptable to both inhabitants and municipal authorities.

4.4.3. Outdoor Sleeping Arrangements

Because the night outdoor temperature in Central Sudan ranges between 15°-25°C for 10 months of the year, it is possible for people to sleep outdoors where they can take advantage of the fresh night air. Here again the question of privacy between the sexes has to be taken into account.(1) Children usually sleep with their parents in the inner family compound and separate arrangements are made for adult daughters; adult boys sleep in the guests' compound.

4.5. Household Structure

The Sudanese household usually begins with the elementary family phase, but all the elementary families very quickly enter the household phase, because the parents encourage their children to continue to stay with them after marriage, at least for one year.

(1) A detailed study about the Sudanese usage of outdoor areas will follow later.

Young married couples have the choice of living with either the husband's or the wife's parents. In either case, the household head builds within the enclosure of his homestead a small separate house for the young couple who will usually depend on the main kitchen of the household for at least one year, but after this they may have their own kitchen.

This custom means that there are often three or more families in the same house or in different parts of the same house, sharing the amenities, recognizing the same loyalties, and with each individual playing a certain role. This traditional pattern is still very strong and even in the cities it continues to exert considerable influence.

After the young bride has given birth to her first child, the young family may leave to go to a separate house, but various factors, such as the husband's inability to build or rent a house, or the bride's parents' attachment to their daughter and her child, may keep the family in the parental residence for years. However, the system leads very quickly to overcrowding and this causes some parts of the family to break away and set up their own homes.

4.5.1. Urbanization Influence on the Traditional Household Structure:

With the recent growth of urbanization, the traditional family household is gradually being superseded by individual family units and a new type of household is gradually emerging based on elementary families, i.e., husband, wife and their children.

Because of housing shortages in the major towns, and especially in the capital, many of the middle and low income families have begun to take in a lodger or a lodging family to share with them continuously increasing living expenses. Lodgers are taken whether the size of the house permits it or not leading to great overcrowding; this in turn raises the question of providing the degree of privacy required in Islamic society.

4.6. Household Life Cycle

The Sudanese household has four main phases of family development and housing requirement:-

(a) The pre-child phase : immediately after marriage to one or two years before the first child is born.

(b) The growing-family phase : family gradually growing as more children are born.

(c) The grown-up (or adult family) phase: when family reaches its ultimate growth and no more children are to be born.

(d) The household phase : when family enters into its household cycle. (1)

(a) The Pre-Child Phase

In the pre-child phase, as the husband's savings have usually been absorbed by the wedding ceremonies, the young couple are in no financial position to build a house. Renting a separate house is generally far beyond their means and so the majority share the parent's or in-laws' house, where they are provided with a room and a small separate compound for privacy, while sharing the household expenses. After the young family has its second or third child it will be obliged to find a separate house.

(b) The Growing Family Phase

The growing family phase starts with the increase in the number of children. Either the family will rent a house in the private market (which is expensive), or they may be fortunate enough to buy a piece of land. This involves more initial cost, i.e., cost of land, boundry walls and basic shelter, but has the advantage of greater security.

(c) Adult Family Phase

The grown-up or adult family phase occurs when the children grow up and the need for privacy between sexes demands more rooms and courtyards. If sufficient space has been allowed initially, such additions will be possible; otherwise overcrowing and lack of privacy will result, as adult children seldom leave home before marriage.

(d) The Household Phase

The Sudanese family has many ways of becoming 'a household', the most usual being that adult children get married and continue to stay in their parents' or in-laws' house.

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(1) ELIAS, E.O. "Space Standards in low-cost housing with reference to urban areas in Central Sudan". Ph.D. Thesis. University of Edinburgh, 1970.

> Alternatively, a family head may take responsibility for the elements of a disintegrated family unit, when a near relation dies, or when he remarries after his first wife dies. In all cases the household phase is associated with problems of overcrowding. Lack of space usually compels some of the household members to leave, but if there is sufficient space the married children may stay in the parent's home permanently and gradually take over as the parents decline into old age.

4.6.1. Design Recommendations

To find an optimum housing solution which satisfies all these phases, the above family-growth stages must be very carefully studied to ascertain the actual housing requirements they generate.

The design should make it possible for the young emerging family to share the house with parents or other acquaintances for some time without causing too much overcrowding or lack of privacy. However, both of these problems are likely to be most acutely felt during the household phase and at this stage families should be eligible for every available material and financial aid, including larger housing plots and extensive loans to be repaid over a long period.

4.7. Households and Neighbourhood Social Relationships

Islam which commands every individual to visit and help his relatives and neighbours made social relationships between the Sudanese very strong.

The strongest network exists in the villages where the extended kin families share the same interests. Each resident knows the whole village by name, visits them and receives them in his house very frequently.

Social ties in an urban population are weaker than those in the villages, but they are still very strong compared with western standards. In additon to frequent visits between neighbours, household of the same kinship, scattered in different parts of the city, pay regular visits to each other. Descent and marriage are two further threads which help to bind many households together into friendly neighbourhoods.

Urban families exchange casual visits between themselves without the need for invitations or special arrangements, especially in the afternoons, when it is pleasant and cool enough to sit in the outer compounds and the streets. Men receive their guests in front of the guest room, in the men's compound or in the street, in front of the main door. Women receive their female companions in the inner courtyard. The host and his guests exchange news while cold drinks and tea are served. Meals are served in the same way.

Urban families very frequently receive their rural relatives who come to the city for various purposes such as work, buying goods and spare parts or signing papers and documents in different governmental departments. These rural visitors normally divide their stay among their relatives in different parts of the city, where they sleep with them in turn, or settle in one place and pay short visits to the rest.

Male guests sleep in the outer compound in front of the guest room, while women guests sleep in the inner compound with the wife of the household. The Sudanese urban family spends most of its time in the open-air compounds, in front of the living rooms. Rooms are used only for two or three hours, at midday, when it is too hot to sit outside.[1]

Sudanese families are "society orientated" with strong feelings of community among the residents of each neighbourhood. This is especially noticeable in the evening after 5 p.m. when various social activities commence. Streets and open spaces are crowded with children playing or groups of men celebrating evening prayers. In streets and open spaces large tents may be found filled with people gathered for family occasions such as weddings, funerals, etc. Groups of women usually gather in the houses at one side of the tent in order to participate in the occasion.

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(1) Due to the importance of the outside open spaces for the Sudanese family we will study their usage, in more detail, later.

Occasionally groups of men are to be seen in front of the main door of a house, opening into one of the compounds, sitting drinking tea and enjoying a discussion; passers-by are often invited to have a cup of tea or to join the group.

4.8. Special Social Occasions

For the Sudanese, such occasions as weddings, funerals, pilgrimages and birthdays are very important and demand special arrangements for the seclusion of women and guest reception. A brief summary of some of these events will indicate how they might affect house design and neighbourhood lay-out.

4.8.1. Weddings

(a) Weddings in the villages

On such occasions the whole village usually participates and celebrations may last from three to seven days. The occasion is organized principally in the house of the husband who normally invites the whole village plus his relatives and friends from all parts of the country. Guests are served with meals prepared by the women. At weddings, it is customary for the guests to contribute to the expenses, each paying a sum proportionate to his economic status and his relationship with the husband.

After the meals have been served, there is a folklore party and local or national singers are invited to celebrate the occasion. The reception of guests takes place in and outside the big diwan (guest room), but dancing is held in the open air under a large tent.

Women also take part in such occasions. They are served meals in an area separate from the men but late in the evening, when the party starts, young women join the main celebration where singing and dancing continue until the early hours of the morning.

After this, the husband goes with his close relatives and friends to the bride's house where they are received by the bride's father. Men and women are then taken to separate reception areas where meals and tea are served.

In the bride's house singing and dancing continues for three days after which the guests gradually depart leaving the husband in his new home.

(b) Weddings in Towns

Weddings in towns follow the same general pattern as in villages. Obviously, the number of guests invited is less, but even so a thousand people might be involved in that part of the celebration where meals and tea are served.

4.8.2. Funerals

(a) Funerals in the villages

It is normal for every member of the village to go to the deceased's house and offer condolences to his relatives.

After the burial of the body, the people return from the cemetary to the big diwan of the deceased's family. Tents are erected to receive the large numbers who come to offer their condolences and cold water and coffee are served. At meal times, close neighbours and people from different parts of the village bring food from their houses to the funeral place and take their meals together with the guests. Large quantities of food are also prepared for visitors coming from long distances. Women also take part in funerals; they are received in a separate tent by the deceased's female relatives and take their meals together.

(b) Funerals in towns

The procedure is the same as in villages, but few people are involved and the reception areas are smaller. Again, close neighbours bring their food but the major supply comes from the deceased's family. As in rural areas, expenses are shared and each participant contributes a small amount of money. Since guest reception areas are very small in towns, guests are received in the streets in tents.

In additon to weddings and funerals there are many social occasions when the Sudanese offer each other mutual help. For instance, the reception of an unusually large number of guests, the celebration of the birth of a child, or the completion of a pilgrimage to Mecca.

On all these occasions, the man concerned receives his relatives, neighbours, friends and guests and serves them food. The procedure is similar to that for weddings but the number of guests is far less.

4.8.3. Analyses and Design Recommendations

Obviously, the social behaviour of the Sudanese must affect the design of their houses and the subject requires careful study if the optimum housing solution is to be found, bearing in mind that any solution must be within the means of the majority low income groups.

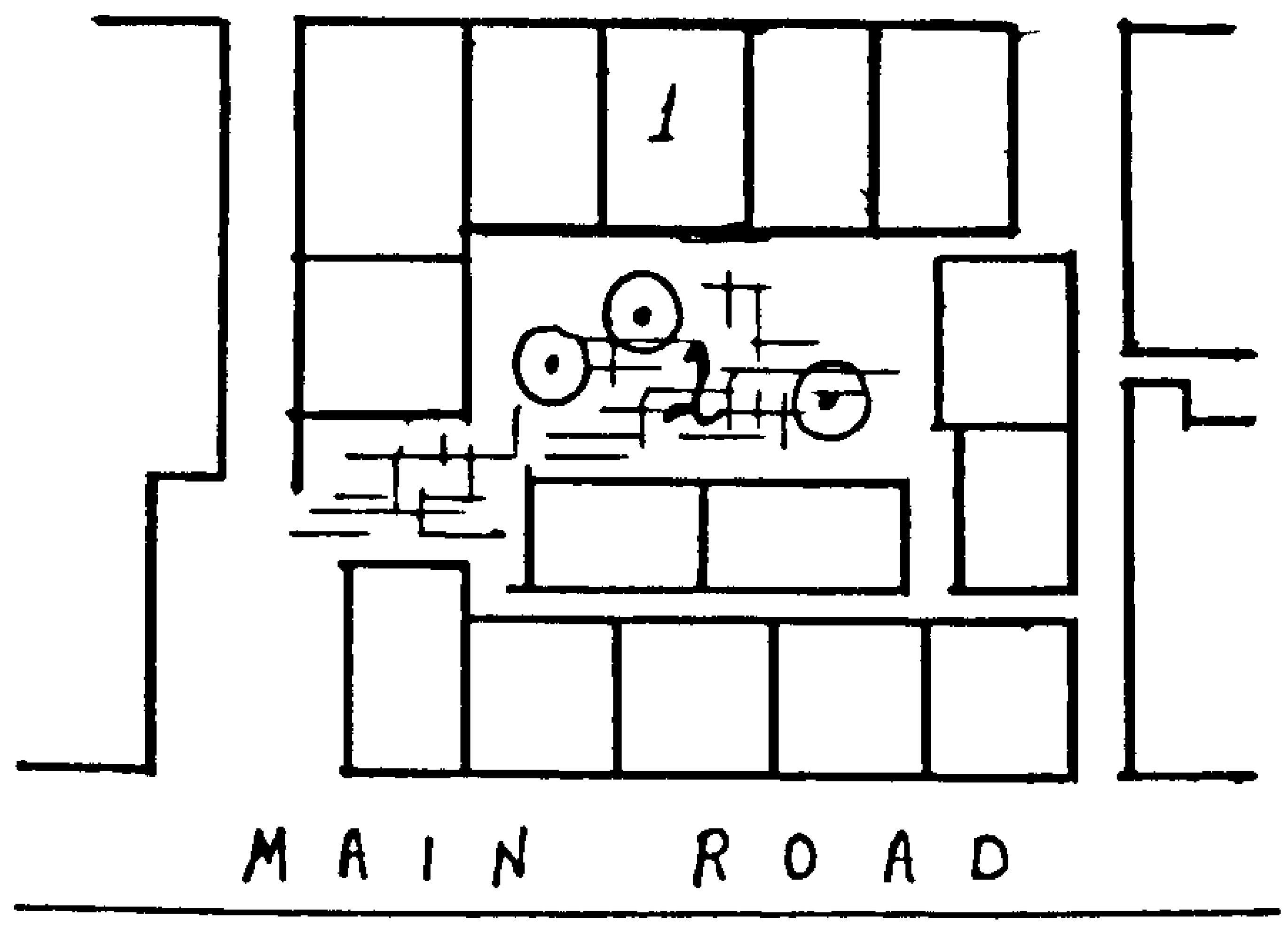
It is of course out of the question for every house to have facilities to meet special social occasions but these events ought to be taken in consideration when house complexes are being designed.

In the cities, guest recpetion rooms are too small to cope with the numbers of guests taking part. No provision is made by designers when the houses are erected and people are forced to use the narrow and often busy streets in front of their houses to receive their guests. To meet these special needs it should be the aim of the designer to create a semi-private open space between each small group of houses which could be used on a shared basis for reception, weddings, funerals, guest reception and children's playing area.

One corner of such open spaces needs to be reserved for tent erection, with special sockets in the ground. The tent will offer enough room for guests and its cost will be very low since it will be shared by many houses. A small store-room is also necessary for chairs, carpets, cushions, etc.

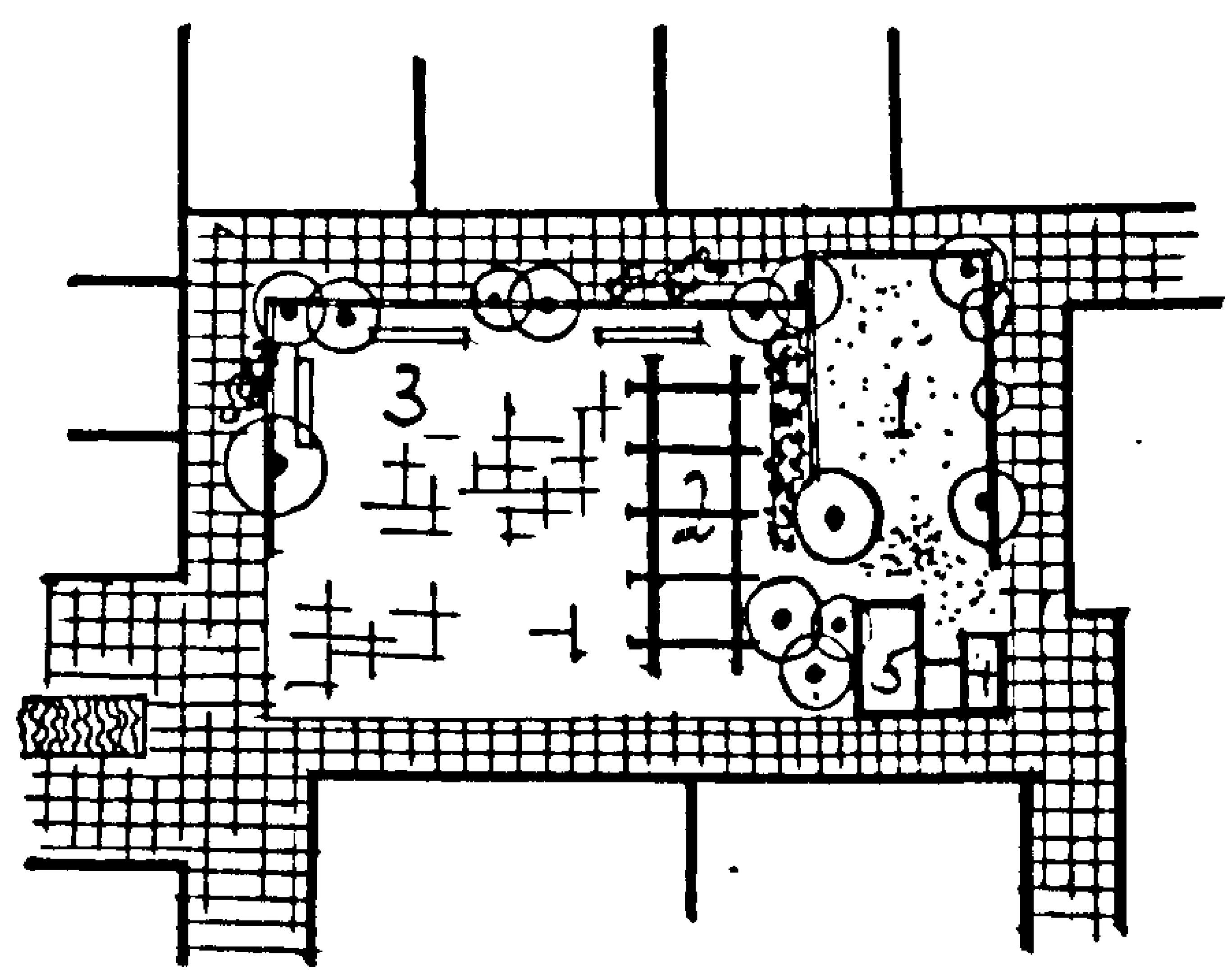
This kind of scheme has the great advantage that it requires no extra expenditure in building, only more care in fundamental planning.

Sketch plan of a small neighbourhood of 15 hourse sharing a common open space for all social activities.



1. Houses
2. Shared open spaces.

Rough sketch of the shared multi-purpose open space.



1. Children's play
2. Tent for occasional events.
3. Adults recreation.
4. Guest's w.c.
5. Store room.

4.9. Space Usage within the House

Because of the climate, the Sudanese are forced to live much of their domestic life in the open air within the enclosure of the house and this has an important bearing on house design. Rooms are used at certain times of the day for particular purposes:

(1) The use of Living Rooms depends on the time of day and the weather conditions. Rooms are mainly used for the storage of furniture and family possessions and are used for household activities only for a few hours at midday, when it is too hot to perform any activities in the open air. Furthermore usage of a room is considerably reduced if a veranda is attached.

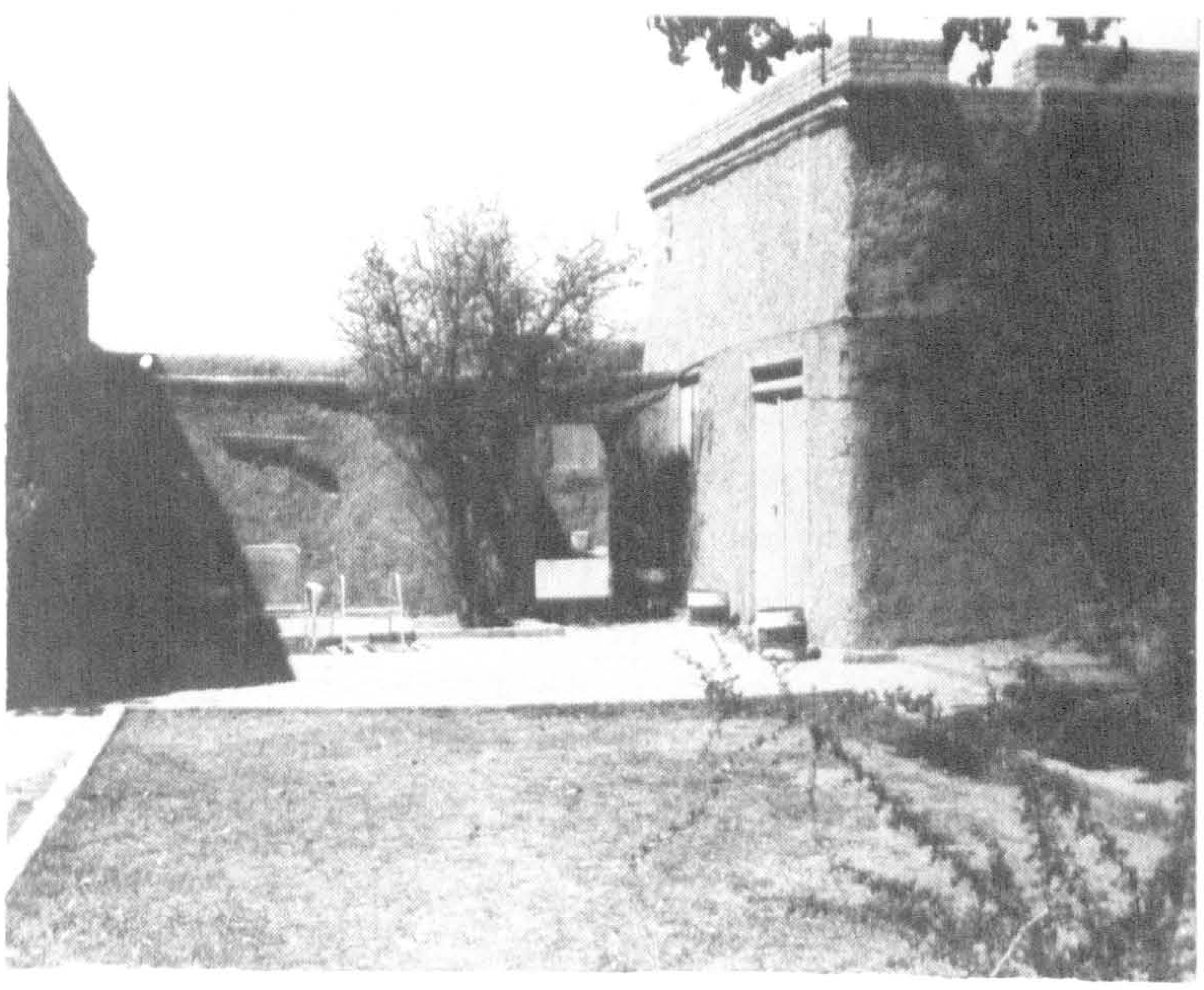
Living rooms are also used occasionally during periods of rain and dust storms and throughout the two or three winter months.

(2) The Veranda is used very intensively throughout the day. At midday when both the rooms and the open compounds are too hot, all domestic activities such as cooking, sleeping and children playing are performed on the veranda. In the mornings and evenings when it is rather cool, the veranda is treated as an extension of the open space in and around the house.

There is a distinguishable difference in the use of men's and women's verandas. Most of the household tasks and leisure activities during the day are performed in the family veranda and in the kitchen veranda, if one exists. The men's veranda is left mainly for the entertainment of guests and for the occasional afternoon siesta of the male household members.

(3) The Kitchen, is used for cooking and food storage. Kitchen functions are also carried out on the family veranda, in the living rooms in winter and in the open space in the compound in early mornings and evenings.

(4) Private Open Spaces within the homestead are intensively used by all family members most of the day, all evening and at night. These are divided into two main compounds: the private inner family compound, attached to the living rooms and the outer compound attached to the guest room. The inner compound is used for cooking, eating, playing, washing dishes and clothes, family meetings and sleeping; while the outer compound is used for entertainment of guests, children's playing area and special occasions.



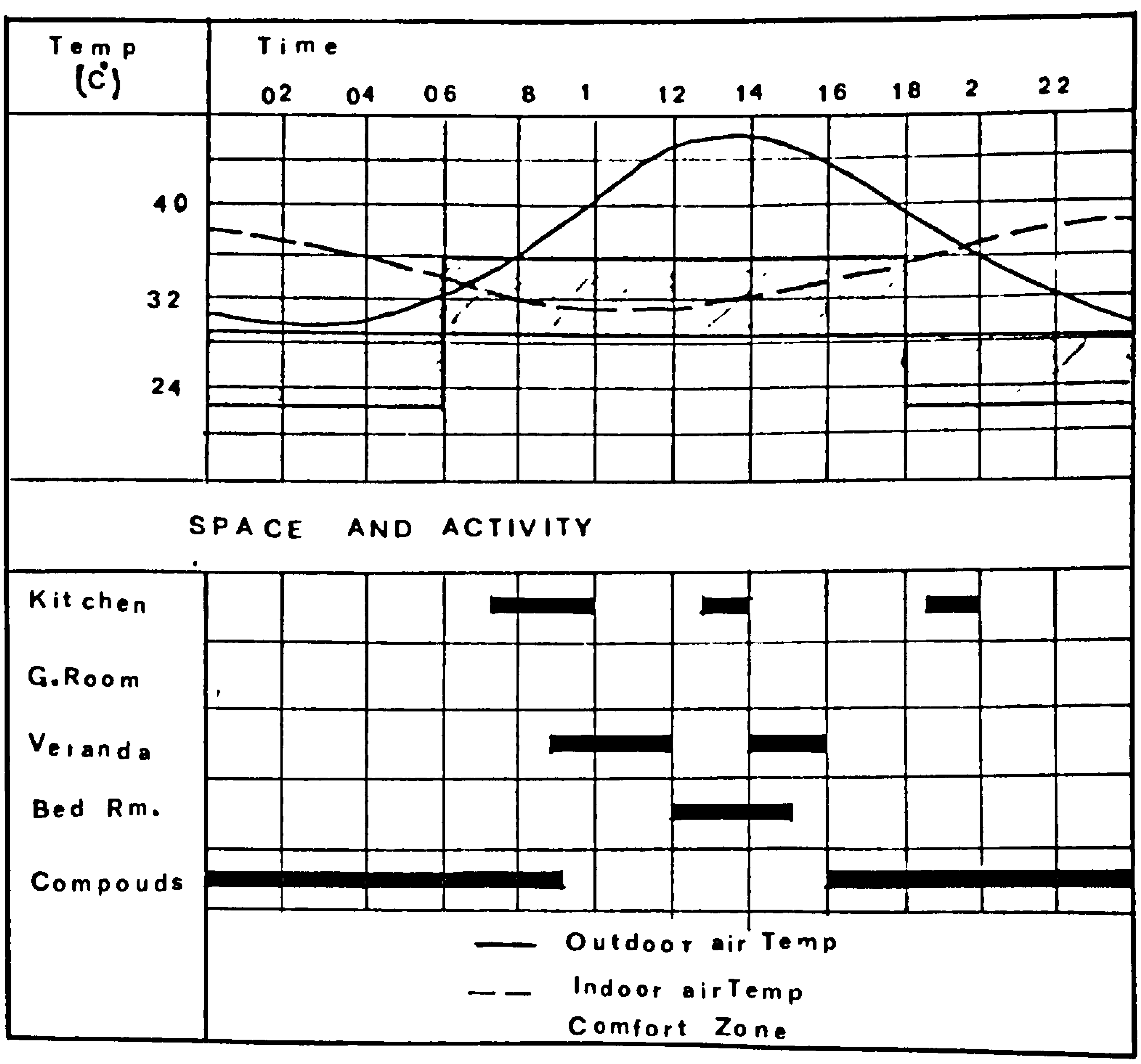
Usage of Outer Compounds for Guest Reception.

(5) Even the Semi-Private Open Spaces around the house are considered as an integral part of the family living space. These spaces attract various space-demanding activities from the house, such as entertaining a large number of guests, saying collective prayers, carrying out odd-jobs and special celebrations. It is therefore, not unusual to see various items of furniture, such as chairs, beds and prayer mats, moved out to these open spaces.

(6) Streets are also used for occasional family needs. Although designed primarily for traffic, in some areas they are considered as part of the private family domain and are therefore, used for various family functions when large numbers of guests are invited.

From a study of the living patterns of the Sudanese family in different seasons of the year, it is clear that the private open spaces within the family homestead and the veranda are far more intensively used than the room spaces during the day. A graphic illustration of the use of space will convey this very clearly.

The following graph shows daily personal activities in Khartoum throughout a typical summer day (summer and semi-summer conditions prevail in Khartoum for 10 months a year).



The graph shows very clearly, that for the majority of the day the people live outside the rooms: mainly in the private open spaces.

From the graph, it is clear that the guest room is subject to only very occasional use. The bedrooms are in use only for three or four hours at midday for the afternoon siesta while the veranda is more heavily used for about six hours per day. However the predominent area of use is the private open space within the compound where the family spends more than 17 hours every day.

4.10. Analyses and Design Recommendations

It is clear from the remarks above that the Sudanese way of life creates a need for space both within the boundaries of the house and outside it that is quite different from the European pattern. It is also evident that there is a wide and complex range of functions to satisfy within the framework of the present social and cultural traditions and that any proposed solutions must be economically viable in a society with large numbers of low income families.

For such housing improvement, in addition to professional skills, a deep knowledge of the local traditions, implicit ideals, habits and way of life is required. Only an architect equipped with a very clear picture of all the functions performed within and around the house, the owner's housing aspirations and future expansion possibilities will be able to suggest optimum housing standards which satisfy the comfort, welfare, convenience, good health of the occupants within their means and yet leave room for their different needs, personal interests and choices.

Ever since independence was achieved in 1956, many architects have tried to improve traditional housing standards, but unfortunately the majority of them have taken very little account of the habits and traditions respected by the people for many generations. The new designs have either imposed a completely alien structure on functions and activities within the house, or have mixed the local and imported designs irrationally; for these reasons, the new designers are still resisted by the majority of the population.

AMOS RAPOPART stated four objectives to be satisfied by any housing in order to be successful.[1]:

1. It needs to be socially and culturally valid.

2. It should be sufficiently economical to ensure that the greatest number can afford it.

3. It should ensure the maintenance of the health of the occupants.

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

All these points are entirely valid when considering alternative house designs to improve the living conditions in the Sudan.

It is also vitally important that the local urban authorities not only approve the layout and the drawings of the houses, but that they monitor their construction and make sure that the houses are erected exactly as they are shown in the drawings. Unfortunately in the cities, there is still very weak municipal inspection. House owners, after receiving their plots, arrange their rooms in a very haphazard way; either because they are trying to get the maximum living space on the land with a view to sub-letting, or because of their lack of expertise.

The housing aspirations of every house-owner must be interpreted in very detailed plans, showing all the different stages of the house's construction. The people must be educated and encouraged to follow these stages exactly because a small deivation might alter the use of many areas.

Under present conditions, some areas in the Sudanese house are seldom used although they are very expensive and occupy almost half of the living area. This is especially so in the case of guest room and guest compound and these should therefore be small in area, but well designed and carefully linked with the rest of the rooms to achieve their maximum use.

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(1) AMOS RAPOPORT ..... op.cit. page.129.

CHAPTER 5

HOUSING SOLUTIONS THROUGH NON-PROFIT HOUSING ASSOCIATIONS

5.1. The Role of Non-Profit Housing Associations in the Comprehensive Housing and Community Improvement:

All over the world, the provision of satisfactory housing has been a major problem and continuous efforts have been made to meet the ever increasing needs of each generation. The developed countries have been able to solve their housing problems by means of sophisticated technical knowledge, progressive design, standardization of building elements and mass production. But in the developing countries housing and community development still present one of the most serious problems and one that requires urgent solution because only through proper housing can the developing countries acquire better living conditions, higher agricultural and industrial productivity, good health and sanitation and a better standard of living.

Because it provides employment of many different kinds, such as the production of building materials, the construction of houses and the installation of community services and facilities, the provision of housing can become an extremely important part of a country's economic activity. For this reason priority should be given by governments in the developing world to the construction of housing along with other programmes of economic development. The low priority given to housing problems and the piecemeal solutions often applied in the developing world, and especially in the SUDAN, will never meet the ever-increasing housing problems. There is an urgent need for a comprehensive housing policy aimed at providing good sanitary housing which is within the reach of all income groups, especially the middle and lower income groups.

It is evident that house building is too complex and laborious a process to be solved by unaided and unorganized individuals, no matter how well intentioned they may be.

However, governments alone cannot always solve chronic housing problems, even if they have adequate economic means, because a government's assumption of total responsibility in housing construction will discourage private initiative, possibly alienate public interest and lay upon the State a responsibility with which it may not be able to cope, unless it has the population's interest and support. The discouragement of private initiative will not only waste a great deal of public money, but will also fail to provide the flexibility of wide varieties of housing need to meet the various needs of society. Moreover, it will create difficulties if any government acts as the landlord of its population, because it is open to the people to use their political power and refuse to pay housing costs and rents.(1)

It would therefore seem desirable that governments should not be responsible for constructing housing directly, but they should promote housing construction by the persons directly concerned i.e., the members of the population through co-operatives and other non-profit making housing associations. Through special ministries, such as the Ministry of Housing and other Community Development Agencies, the central government can control housing policy and promote and stimulate housing construction. They must also be prepared to offer partial finance to such building projects because it is almost impossible for non-profit making housing associations to be launched successfully without a substantial initial injection of capital. Such assistance would naturally be linked with certain obligations imposed by the State upon housing associations to prevent them from being diverted from their approved objectives. The major objectives of non-profit housing are to provide good sanitary housing at cost price, within the reach of all income groups, with any surpluses being channelled

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(1) Government failure to encourage private initiative and to encourage the people to help in solving their housing problems, was one of the main reasons for the failure of many government housing schemes in Latin America. This will be discussed in a later section.

into further building programmes.[1]

By encouraging non-profit housing to be carried out directly by the people concerned, governments in fact foster the community's initiatives in solving its own housing problems. The experience of non-profit housing initiatives in many European countries showed that this kind of organisation is the only way to ensure the active assistance of the citizens and to mobilize their inactive resources in the form of financial contributions, direct personal labour (through Self-help schemes) and their technical knowledge and experience.

Further government assistance can be given to such associations indirectly by exempting them from local and stamp taxes, land and income taxes, at least in the first stages until their financial position is securely based.

Voluntary non-profit housing organizations seem to present the most effective solution for the chronic and increasing housing problems being experiences throughout the world. By channelling and concentrating private and public endeavours they are capable of solving, not only the lower middle and middle income groups' housing problems, but, also with a little extra government subsidy, those of the lowest income groups. Furthermore they offer the various population groups, especially the lowest income groups, the best opportunity to begin solving their own housing needs immediately, rather than waiting and depending on government help which may or may not be forth coming.

Moreover, through non-profit housing associations local governments can take direct and effective actions for solving their local housing problems and not to depend exclusively on the central government.

All that central governments need to do is to provide partial financial help and to define the obligations of the housing assocation, such as continued pursuit of building activities and the use of surplus resources for additional housing construction. By this method a huge administrative task and economic burden can be developed from central government.

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(1) U.N. Non-profit Housing Associations. ESA/OTC/SEM/75/2.

5.1.1. Types of Non-Profit Housing Associations

1. Co-operative Housing Associations

Co-operative housing is the name applied to the system whereby people gather voluntarily in groups to assist one another in meeting their housing needs on a service basis, without the usual profit motive involved in building speculation. It differs from government sponsored housing in that co-operative groups usually have some degree of control over the building operation or management of their community envirnoment.(1)

In addition to the financial aid such co-operatives receive from the central and local governments and from savings and trade unions; the members themselves also contribute part of the construction costs from their own savings. There are different types of associations, but the most popular forms have two major features; they either pool all the financial resources, and distribute them as loans for their members to buy ready-made dwellings or, in addition to the pooling of financial resources, they carry out the building construction as well. In all the kinds of co-operative housing the members are regarded as shareholders and they have full control over all the activities of the association. The members elect the board and the executive committee of the associations yearly and through their individual votes control the policy and the management of all housing projects.

In co-operative systems dwellings are not the property of the individual members but are held in common by all members as co-owners. Each individual has permanent rights of occupancy which may be transferred by succession, but he may not alienate, let or sub-let his dwelling. Co-ownership has a great advantage, because unlike all other non-profit housing systems, where dwelling occupants are regarded as mere tenants, co-operative housing occupants would not be affected in the event of a general increase in rents.

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(1) U.N. Housing through non-profit Organizations No.10 ST/SOA/SER.C/10 September 1956.

2. The General Principles of Co-operative Housing Associations

1. Open membership. No restriction as to race, sex, religion or political or other affiliation.

2. Democratic control. One vote only for each member, regardless of number of shares held or percentage of property owned.

3. Non-profit objectives. All profits gained from building operations to be used for more house construction.

4. Safeguards against speculation. Sale of a member's equity or property permitted only with the approval of the co-operative or sometimes an appropriate government agency.

5. Uniform benefits and responsibilities. Benefits accure to all members equally, ultimate responsibility for direction of the enterprise rests on all members.

6. Limited personal liability. Each member's liability is limited to the amount he has contributed or committed himself to contribute to the co-operative in order to pay up his share of owner's equity or downpayment in excess of any mortgage amount given to or by the co-operative.

7. Educational purposes. A portion of all savings or rebates is used to further co-operative philosophy and objectives.(1)

3. Types of Co-operative Housing Associations

Within the framework of these general principles there are several types of co-operative housing associations. The most widespread forms are:

a) Co-operative Credit Societies

These co-operatives may operate under government supervision. They pool small individual savings, and make them available in the form of loans or mortgages to their members who wish to buy or build houses. Credit co-operatives have two forms - terminating, organized for a definite period and dissolved when a certain amount of money has been accumulated; and - permanent, in which members have neither fixed any definite sum to be accumulated nor length

(1) U.N. Housing through non-profit Organizations ...... op.cit.

of time for the association's duration.[1]

b) Aided Self-help Housing Co-operatives

In these co-operatives either government or a private agency provides all or part of the funds, materials, prepared sites, supervision etc., in a planned way, to expedite house production by groups of individuals or families. The most important feature of these co-operatives is that the different groups exchange labour between themselves to reduce overall construction costs.

Such groups usually acquire land or properties and give titles or full ownership to individual members or families for either the land and or buildings after completing one or several of the following:-

1. Bulk purchase of land and sub-division into individual parcels.

2. Joint architectural and planning services and legal work.

3. Communal installation of public facilities.

4. Mass purchase of supplies and materials.

5. Safeguards against speculation in the sale of property and/or dwellings whose value may have been enhanced as a result of co-operative activity. (2)

c) Savings and Building Housing Co-operatives

This is the most widespread type of co-operative housing association. It combines both saving and the construction of houses at the same time and usually retains collective legal ownership of the buildings or properties by the association as a whole. Members own shares equal in amount to the cost of the buildings or properties, and reside as tenants of the association, paying fixed periodic payments, or "rentals" based on the estimates of the total actual charges, including taxes, repairs and upkeep and reserve funds. All savings in management, maintenance or other factors may be credited to tenants in the form of rent rebates or refunds; but usually the co-operatives prefer

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(1) U.N. Financing of Housing and Community Improvement Programmes. E/CN.5/323 February 1957.

(2) U.N. Housing through non-profit organizations ..... op.cit.

to use these savings for the promotion and development of new projects.

Ownership of the shares gives members the right to occupy their dwellings, but generally they have no right to dispose of their shares without the consent of the association and the local authorities. If a member wants to withdraw, he is usually entitled to a sum at least equivalent to the value of his shares minus any debts or obligations owed to the assocations. Usually the heirs of a member may continue to reside in a co-operative building after his death.

d) Craftsmen's Housing Co-operatives

Membership or direction of these associations consists of building trades personnel and their primary objective is to provide building trades workers with employment.

e) Social Co-operative Housing Associations

These are permanent organizations which build housing on a non-profit or limited dividend basis, usually under appropriate government legislation. They cannot be classified strictly as co-operative in character because the tenants in buildings constructed by such trusts or societies usually have no direct voice in their management or other policies - although opportunities exist for inviting and expanding such participation. As a rule the dwelling units are "rented" or "let" but no effort is made to encourage or provide for ultimate ownership and responsibility.

f) Mutual Housing Co-operatives

This is a form of co-operative housing under which a government agency or private corporation builds a housing project, handling the numerous technical aspects of planning, site acquisition and construction and then disposes of the project to a tenants' association under a mutual ownership plan. Individual members gradually acquire, over a period of years on payment of periodic "rentals", full ownership of shares at little or no interest cost, and usually with no required down payment or equity investment.(1)

(1) U.N. Working Paper for the U.N. Seminar on Housing through non-profit organizations. Copenhagen September 1954.

g) Student Co-operative

This form of co-operative organization exists in universities to purchase and operate student dwelling houses or dormitories on a non-profit basis. It is often characterized by communal sharing of duties in the central kitchens and dining rooms to reduce student living costs.

It is not always easy to distinguish between the different types of co-operative housing associations on a functional basis because any individual one may perform more than one of the functions listed above. However, all the types of association listed are committed to solving the housing problems of particular population groups, even though the pattern of control over building and management operations may be a mixed one.

4. Limited-profit Housing Associations

In this kind of Housing Association most shares are held by trade unions, crafts unions, and various groups of skilled building workers. From the legal point of view, these associations are limited-profit joint-stock companies engaging in the construction of housing. The tenants have no voice in the administration, which is in the hands of a board elected by the central organization. Tenants may or may not be shareholders in the company, nor are they represented in the board.

Unlike the co-operative housing associations, in which the various sections manage their own affairs, tenants in limited-profit housing associations are regarded as mere tenants and required to pay a small fee on registering and another small fee latter when taking possession of the premises. The dwellings are made available in order of priority of registration. If it becomes necessary to move from one dwelling to another, members currently occupying one of the units have the priority over those who have not yet been assigned a dwelling. In addition to the above mentioned fees, members also must make a downpayment of 3% of the cost of the dwelling, and they receive between 3 and 4% interest per annum on this sum.

However, unlike the co-operative housing system, if one of these joint-stock limited-profit companies is dissolved, its movable and immovable assets become the property of the local authorities. Any accummulated surpluses from its various operations do not accrue to the members but are used for housing purposes.

5. Non-Profit Housing Associations

These associations are governed by a board of council consisting of building experts, persons of some standing in the community and people concerned with social problems. The occupants of the dwellings built by these associations do not participate in the management of the association and are looked upon simply as tenants.

The tenants pay 3 per cent of the total cost of the unit they occupy, but, contrary to the practice in the co-operative, this does not entitle them to become shareholders in the association. They are only entitled to occupy the premises permanently as long as they meet the payments and comply with the association's regulations. Tenants are regarded merely as creditors for the amount contributed by them to finance the construction. They pay 3 per cent of the total construction costs, this being the amount required to obtain government assistance.(1)

Although these non-profit housing associations are not required by the law to create special funds or reserves, they generally do so for purposes of repairs and to meet contingencies or possible losses. The surplus accruing from these funds, together with the rents which the members continue to pay even after the mortgages have been amortized, are the principle source of income to the "building fund".

The principal feature of this third type of non-profit social housing association is that after a certain period of time both the assets and the administration of the association pass to the local governments to become a separate fund devoted exclusively to the expanison and improvement of housing.

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(1) U.N. Non-profit Housing Associations ...... op.cit.

6. Other Organizations

In addition to the co-operation and associations listed above other organizations exist to advise and foster new housing associations, particularly in the provinces. They provide advice on technical and administrative matters before and during construction; they may also manage the construction operation and or deal with the financial arrangements. However such advisory organizations in no way restrict the independence of the housing associations consulting them and are not allowed to intervene after the project has been completed.

5.1.2. Organisational Structure and Work Procedure of Non-Profit Housing Associations.

In the previous pages the different forms of non-profit housing associations have been classified. There now follows a brief outline of the nature of the work carried out by the majority of non-profit housing associations, from their formation until the completion of the housing constructions.

It must be emphasised that good organisation of labour, understanding of human relationships, availability of materials and financing and speed of construction are the basic and most important features of all non-profit housing associations. They are needed not only to bring about savings on behalf of individuals but also to assure the survival and improvement of the association and to enable them to become self-sufficient in the event of government subsidies being withdrawn. In general, central governments usually offer every support to ensure the continuity of the assocaitions, because continuous housing production of this kind not only reduces building costs, but offers an on-going solution to the ever-increasing need for housing. After amassing financial capital from the sources listed above, non-profit housing associations work on bulk purchase of building materials and mass production of houses, which naturally results in reduced building costs.

Some non-profit housing associations prepare the sites, purchase the materials and then have the actual construction work carried out by private contractors in a very closely supervised relationship. The contractor, for his part, must fulfil the work both to a certain standard and at the required time. Other non-profit housing associations who carry out the actual housing construction work usually employ a permanent staff of specialist craftsmen/labourers who work in their own particular field on the various sites being developed.

In addition to the bulk purchase of building materials, governments usually encourage the associations by letting them have public construction equipment and machinery under very favourable conditions. This help, in addition to large loans on easy terms, and all other forms of incentive is offered by the government to the associations on condition that their housing construction actions are permanent and that any surplus coming from these operations must be diverted into further housing construction. Non-profit housing associations get different types of help and encouragement from local government and throughout the developed world such bodies enjoy the closest relationship with municipal authorities. In some countries the municipalities retain a certain degree of supervision over or representation in these housing activities, in return for public aid received. In others, the associations operate on contract from local governments as planning and building agencies.

Some housing associations are not involved directly in housing construction either through a private contractor of by direct labour. This group of associations simply offers to its members large loans to buy ready-built houses. In such cases an individual member places a down-payment and receives a loan equivalent to the cost of his dwelling; he then pays back the loan on monthly instalments over perhaps ten years. However, the most satisfactory system seems to be the one which combines the accumulation of savings and, the undertaking of housing construction, since they can produce housing at cost.[(1)]

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(1) U.N. Financing of Housing and Community Improvement ..... op.cit.

5.1.3. Administration of Non-Profit Housing Associations

The erection of housing is always a very complicated procedure, consisting as it does of many different kinds of work and a large variety of components. Non-profit housing is even more difficult because in addition to the normal building process it involves much preparatory work such as the accumulation of savings and other kinds of financial support, organisation of various building groups, purchase of land, organisation of different kinds of construction work, preparation of building materials and their distribution according to a fixed and well organised time-table and maintenance and up-keep of housing. Obviously failure or delay in any one of these areas will affect all the other parts and may result in the failure of the whole project. For these reasons, the success of the association rests heavily on the quality of its administrators, who must be able to deal with business management, budget preparation and accounting. Another crucial factor is the understanding and participation of the central and local governments, credit institutions and trade unions, and of the community in general, both as an entity and as individual consumers of housing.

Non-profit housing associations must support and help each other, financially and in other ways. For instance, managers of small non-profit housing associations can benefit immensely from the opportunity to study the organisation and operation of large associations. Indeed excellent administration is more vital in small non-profit housing associations, because usually the success or failure of these small associations depends entirely on the managers in charge of them.(1)

One of the principal tasks of the managers of such associations is to publicize the advantages of their system as widely as possible and to bring together people engaged in the many activities involved in such associations. For example managers may give lectures, arrange group courses, distribute large numbers of publications, give radio and television broadcasts and arrange exhibitions dealing with the social and economic aspects of non-profit

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(1) U.N. Administrative Aspects of Urbanization. ST/TAO/M/51
Sales No.E71.II.H.1.

housing. For those working on special technical, social and economic aspects of non-profit housing intensive training, extension courses and seminars must be available.

5.1.4. Financing of Non-Profit Housing Associations

The seed capital of non-profit housing associations in any country usually comes from the central government. It has already been stated (page 43) that central governments throughout the world allocate about 3 - 4% of their national budget (G.D.P.) for the improvement of housing conditions. These national funds are usually allocated for the following items:-

1. Administration costs of various bodies created to promote housing.

2. Grants to reduce the rent of special groups, such as disabled and large families.

3. Direct contribution in certain projects of social benefit.

4. Equalisation of interest rates to bring the cost of house financing within the reach of groups of special concern.

Throughout the developed world, central governments support non-profit housing associations with more than 90% of their housing construction costs.[1] The percentage of government financial support differs from one country to another, but the average government contribution in financing non-profit housing associations ranges between 85-94% of the total construction costs, with tenants contributing the other 6-15%.

Government support takes the form of large loans to be repaid over very long terms ranging from 10 to 60 years. These long-term loans are readily available either without interest or at very favourable interest rates for permanent non-profit housing associations.

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(1) State may grant housing loans for individuals as well as non-profit housing associations, but the latter are in a more favourable position because the loans granted to them run for a longer term and cover a greater proportion of the construction cost.

In addition to government funds, non-profit housing associations may also take large loans from savings banks and other credit institutions and associations. Some credit banks supply non-profit housing associations with loans of up to 75% of the assessed value of their properties and these loans might be repaid with favourable rates over 40-60 years or more.

1. Mortgage Loans

Besides their direct loans to non-profit housing associations, savings banks invest a portion of their despositors' capital in mortgages. Insurance companies also invest their capital in mortgage transactions. Throughout the developed world, mortgage associations are organised to take loans from savings banks, insurance companies etc... and lend them with certain interest rates to both individuals and non-profit housing associations. Mortgage associations are organised on the basis of joint liability of the mortgages, whose immovable property stands as security for the mortgage loans. Such mortgage associations act as an intermediary between the savings banks and insurance companies lending the money and the individuals and non-profit housing associations benefiting from these loans.(1)

Loans are usually offered in the form of bonds equal to the amount of loans granted; the value of the bonds plus the interest payable is repaid over a period of time during which the property is mortgaged. The aministrative expenses of the mortgage credit associations are covered by annual contributions levied on the members and by any differences there may be between the rates of interest on the various bond issues. In the event of losses, these would have to be borne by the members on a pro rata basis through special contributions.

There are many forms of mortgage loan transactions. Individual members may mortgage their properties and take mortgage loans from different associations; by so doing they automatically become members in the association giving them the loans. In some associations, such individuals may have full control on the association's activities and elect its board and executive committee.

(1) U.N. Report of the International Seminar on the Financing of Housing and Urban Development. ST/TAO/Ser.C/134.

As mentioned earlier, these loans are not given in the form of direct cash, but in the form of bonds equal to the value of the property of the individuals. The loans are secured by the joint liability of the members, which means that every member is responsible not only for his own debts, but also for the debts of the other members as well.

Some mortgage credit associations take loans from different sources and distribute them between their members according to joint liability.

Every lender who invests money against mortgages through the credit associations is protected by the security which the association provides.

Every state has laws to stimulate and control mortgage transactions but, it is a generally accepted rule that the amount of bonds issued by a credit association and the amount of mortgages which it holds should correspond.

In short, non-profit housing associations take mortgage loans from different credit associations against mortgaging all or some of their properties. These loans are obtained with certain interest rates and they may amount to 75% of the assessed value of the mortgaged properties and may be repayable over 40 - 60 years. Additional State funds for housing are usually available through the National Bank where private funds (bonds) are below the necessary level.(1)

Second mortgage credit associations also exist to obtain more money for housing. As additional security, such associations give loans against the property already standing, which can be mortgaged to get new funds to repay the first loans.

2. Trade-Unions Financial Support

Trade and crafts unions and even various labour organizations can be persuaded to provide capital to finance or assist in financing non-profit housing, because they are strongly interested in housing their own workers and staff members.

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(1) U.N. Housing through Non-Profit Organizations..... op.cit.

3. Government Financial Help for Special Families

Special government help is often granted to associations to help solve the housing problems of families with special problems, such as a large number of children, old age, inability to work or serious illness.

Very low income groups who cannot afford to pay for better housing are also helped through such special funding, which may be provided through local or central government. This ensures that since the initial seed capital of the non-profit housing associations comes from the National Government's subsidies, the benefits arising from it accrue not only to those who can afford to pay for better housing, but for the community at large.

4. Indirect Forms of Government Support for Non-Profit Housing Associations

Throughout the developed world, non-profit housing associations are supported indirectly by the creation of conditions favourable to them:

1. Central governments continuously encourage banks, savings institutions, insurance companies, social welfare institutions and the like to invest heavily in non-profit housing.

2. Central governments not only grant non-profit housing associations large subsidies on long-repayment terms, but they also considerably reduce State and local taxes to help them produce good housing at low cost. States in some European countries exempt non-profit housing associations, especially in their first stages of formation, from any kind of taxation whatsoever. Taxes are then applied gradually as the association becomes financially self-sufficient. (1)

3. Building land is leased at very favourable rates over periods up to 40 or 60 years. Some European States grant special loans for land purchase, even if immediate construction is not planned.

4. Indirect State help may be given by fostering the development of the building and building materials' industries, by means of government credits and other financial aids.

5. The initial provision of technical assistance and advice on the operation and management of certain supervisory services usually rank as one of the more important government services to non-profit housing associations.

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(1) U.N. Non-profit Housing Associations .... op.cit.

In many advanced countries agencies are created to co-ordinate and execute government housing and planning policies; such agencies usually contain a division concerned solely with technical assistance for non-profit housing associations.

6. Governments also encourage schools, institutes and universities to offer courses and programmes relating to non-profit housing techniques, housing management, construction research and education in non-profit housing principles. Such courses are aimed at three main groups:

   i. administrators and technicians,
   ii. extension courses and services for groups of people who intend to improve their own housing conditions,
   iii. instructions in management practice for housewives and women involved locally on a part-time basis.

7. Government-aided scholarship and fellowship programmes are offered to allow study in overseas institutions and training in the housing and planning fields.

8. Governments encourage the production of audio-visual materials and various kinds of publicity to stimulate interest in this kind of project.

9. Channels for the exchange of information and ideas with other countries are established.

From this it can be seen that there are numerous ways in which governments can offer indirect help to non-profit housing schemes. On a practical level governments can help deliver materials to sites, offer easy terms for use of tools and equipment and allow their use free of charge at weekends. Government block making machines may be sold cheaply or rented at nominal charges. Government research facilities can help determine the best possible use of local building materials and perhaps promote the use of local materials and encourage new factories for the production of building materials.

5. Local Government's Support for non-profit Housing Associations

In addition to the Central Government funds, local governments are also an important source of funds for the associations. Local municipalities bear the chief responsibility for providing better housing. For this reason many central government loans and other aids are channelled through the local or provincial authorities.

In the advanced countries, as one condition for making credit available to non-profit housing associaitons, central government requires municipal guarantees of repayment of the major part of mortgage loans, or require a matching municipal contribution of some kind. In some countries, to foster the local community planning objective, national aids for non-profit housing constructions are linked with the requirement that projects must first be approved by local authorities.

Local authorities are authorized by the central government to support non-profit housing societies by various financial means and by providing technical assistance and administrative services, sometimes on a contractual basis.

6. Reserve Fund

In developed countries, where non-profit housing associations operate on a national scale, it is usual for them to co-operate in setting up a reserve fund. Each association devotes a certain percentage of its annual profit to build up the fund and it is used:

1. for expanding the non-profit housing system itself,
2. for maintenance of dwellings in use, and
3. incidentally to pay dividends to members at moderate rates of interest. (1)

7. Building Fund

The purpose of this fund is to enable associations to become self-sufficient in financing the housing they build. A primary source of income to this fund is the surpluses accumulated from the non-profit housing operations.

Since the initial seed capital of the non-profit housing associations comes from national government, the benefits arising from it should accrue not only to the members of these associations, but to the community at large. For this reason, the associations are required not to share the surpluses resulting from the housing constructions between their members, but to use them for further housing constructions; thus all

(1) U.N. Financing of Housing and Community Improvement ..... op.cit.

surpluses go to build up the building fund.

The fund increases over the years, but it receives most of its resources when the loans taken by the housing associations have been paid off, since after this the members continue to pay their annual payments plus the amounts previously arising from amortization and profits.

8. Financing During the Period of Construction

The need for urgent loans sometimes occurs while housing construction is in progress and in such cases an association would obtain credit from private banks. However, the national bank is usually authorized by the government to intervene to re-discount construction loans granted by private banks.

5.1.5. Advantages of Non-Profit Housing Associations

The non-profit housing system has many advantages, the major ones being as follows:

1. It lessens the responsibility of national governments in seeking a solution for housing problems by taking advantage of the contribution that can be made by the population as a whole. The system has the advantage of taking into account the ideas, needs and financial resources of those who are to occupy the houses that result.

2. It eliminates housing monopolies who work for profit and accumulate capital at the expense of the tenants who, driven by the pressing need for housing, pay any price demanded by private builders. In non-profit systems construction is carried out and houses distributed at cost price.

3. The element of politics in the building, tenant selection and management of projects is likely to be reduced. In most countries all political parties support national legislation for assistance to non-profit housing. Because they are non-governmental, these projects are not dependent on a particular political party.

4. The resultant continuity of housing production helps to stabilize and develop the building industry on a long-term basis, and thus to improve quality and reduce costs.

5. It helps to achieve greater efficiency in housing construction because it seeks the optimum solution to providing the best housing standards with the greatest economy. This is achieved through progressive development of building design, continuous research for the best materials for each component, through building methods and techniques and various types of construction equipment. Because they work within the nation's comprehensive housing programmes and policies, they usually ensure effective use of money, labour, land and materials. They also lead to the accumulation of technical knowledge and the central organizational structures soon become capable of supplying the expertise to achieve even better housing.

6. A United Nations report devoted to the cost of house construction has pointed out that "The reduction of building costs cannot be brought about only through technical progress, but requires a better organization of the demand for the product of the building industry...." and that what is needed is "the grouping together of potential house owners, which makes it possible to increase the scale of demand and thus of output on the site." (1)

7. Most associations combine both financial savings and building operations and thereby they effect a sizable reduction in the construction costs.

8. Since the national governments usually help associations to secure suitable housing land (either by sale or by long-term lease) which is well served by utilities, on advantageous terms from municipalities, the typical "floating" values and large speculative profits in land transactions are eliminated and lower overall housing costs result.

9. In any country private housing enterprises are too speculative to assure a regular supply of housing and they always exploit the housing shortage to the detriment of the tenants. This is eliminated by a system where housing production is carried out under the supervision of the tenants themselves. Also, the private real estate market is susceptible to financial manipulation through the sale and resale of properties. Each owner tries to realize the greatest profit possible and tenants suffer by paying higher rentals. The control over resale exercised by most non-profit housing associations eliminates such speculative practices.

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(1) United Nations, Economic Commission for Europe: "The Cost of House Construction". E/ECE/165, IM/HOU/51/Rev.1

10. Non-profit housing associations lead to a reduction of the traditional time lag between new discoveries and application of research findings to actual housing operations. They are more consumer - responsive, and steadily accumulate experience and financial and technical knowledge. Being permanent organizations they employ housing experts and technicians whom other associations could not afford to employ.

11. In addition to providing good housing on easy-terms, non-profit housing associations enable the urban dweller to acquire a financial interest in his surroundings and thus become fully aware of his civic responsibilities. This usually causes an interaction between public authorities and private citizens which would be difficult to achieve under a regime of direct public construction or a system entirely dependent on private housing constructions.

12. Non-profit housing associations stimulate the interest and participation of the public in housing problems and utlize their ability to build their own housing.

13. They offer a wide variety of housing solutions to satisfy different housing needs. Non-profit housing principles are readily adaptable to a variety of tasks, whether in the urban or rural areas, for self-help building schemes of individual homes or for large-scale apartment house construction.

14. For the lowest income groups, which for economic and social reasons find it particularly difficult to pay the rent for the type of accommodation they require, non-profit housing associations are the only possible way to provide them with better housing. A special subsidy is provided by central and local governments to allow associations to allocate a certain percentage of their yearly housing production to be distributed to such groups at rentals within their reach.

15. Unlike private enterprises, non-profit housing associations offer the best community services and facilities. Non-profit housing is more likely to be supplied with cultural centres, meeting rooms, child welfare institutions and recreation areas for both children and adults. Some associations even help the occupants to furnish their flats and inner rooms by offering them special loans and furnishing guarantees.

16. The overall cost of non-profit housing to the occupants is far less than for equivalent accommodation in the private sector because of the elimination of speculative profits, the economies of large-scale building, the close adaptation of dwellings to family needs, the standardization of structures and equipment, the better credit of the group as compared with the individual family alone, and the co-operative techniques of maintenance by the occupants.

5.2. Case Study. Singapore and Hong Kong Housing Problems and Solutions and the Possibility of their application in the Sudan.

5.2.1. Industrial Development in Singapore

Modern Singapore was established as a trading station for the British in 1819, and expanded so rapidly that by 1823 the original treaty governing the establishment of the trading post was extended to cover the whole island. In 1824 the island was purchased by the British East India Trading Company and by 1867 the responsiblity of its administration was fully transferred to the British Colonial Office in London.[(1)]

Singapore achieved internal self-government in 1959 and became a State of the independent Federation of Malaysia in 1963. Two years later, 1965, it separated from the Federation and became a fully independent Republic.

The Republic comprises Singapore Island, with an area of 210 square miles, and 60 smaller islands which add another 15 square miles to the total. Its population at the end of 1969 was estimated at 2.04 million, of whom 80% lived in the main urban area of approximately 45 square miles. Though it is by no means the largest city in the South-East Asian Region, it is by far the most important centre of trade, commerce and industry. It owes its importance to its strategic location at the southern tip of the Malaya Peninsula, where the sea routes from Europe and India meet those from China, Japan and North America. This unique situation has made it the natural centre for the collection and distribution of the exports and imports of the region, whether they are carried by sea or by air. Besides trading activities the Singaporeans fully exploited the strategic position of their port in rapid development of the ship building and repairing industry. The port also began to develop oil refining and the provision of services for oil exploration and production for the whole South-East Asian Region.

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(1) Elizabeth Thomson and Henry Wardlow "Growth and Change in Singapore". Royal Australian Planning Institute Journal - April 1971.

For many years Singapore was heavily dependent on trading activity as a source of employment. In 1966 some 65% of workers were engaged in commerce, trade and communications and services.[1] However, trading activities alone could not sustain the required rate of economic growth nor provide the necessary additional employment for the expanding workforce and so the government adopted a new policy of developing its manufacturing sector. By 1961 the government embarked upon a programme of rapid industrialisation to meet the unemployment problem arising from the rapid growth of the workforce. The Economic Development Board was established to implement this programme and concentrated initially on attracting and assisting labour intensive industries. A number of industrial estates were established and more than 200 factories were put in production.[2] Besides this, the advantage of cheap labour and production costs in Singapore attracted many international companies to establish assembly industries and other more sophisticated industries which can economically use the labour pool.

Singapore is also a popular stopping-over place for tourists and the tourist industry is becoming steadily more important to the economy. In summary, Singapore is the world's fourth largest seaport; South-East Asia's regional centre of trade, commerce, banking and insurance; a centre for inter-regional air transportation and telecommunications; a tourist centre and a regional educational, cultural and industrial research centre. The combination of these factors has led to the rapid economic growth of the island.

5.2.1.1. Singapore Housing Problems

Singapore's rapid industrialisation and rapid economic growth attracted mass migration of workers from Malaya and China, but the British Colonial Office operated controls on this and from each wave of migration only a small proportion stayed permanently while the

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(1) Elizabeth Thomson and Henry Wardlow "Growth and Change in Singapore" ...... op.cit.

(2) Ibid.

remainder returned to China. Since the majority of the immigrants were unskilled workers employed mainly in the port on loading and unloading ships, the population of the island was predominantly male.

Further stability was achieved through the strict immigration measures introduced in the 1930's, which favoured female migration while restricting the entry of males.[1] As a result, natural increase became a more important component of population growth than migration.

Because Singapore is a small island with a limited housing area, there was no room even for the natural growth of population to be housed. The port workshops, ship-building and many other factories occupied much valuable urban land. Even the central urban area was occupied by century old 2-3 storey shophouses, the upper floors comprising crowded residentially occupied rooms and the ground floors shops, warehouses, Chinese restaurants or handicraft workshops.

(1) Elizabeth Thomson and Henry Wardlow, op.cit.

This situation forced the population to overcrowd in the central outskirts or to live far from the working and trading centres.

When Singapore became independent the housing problem was very acute, with large numbers of people accommodated in temporary squatter housing and the dilapidated and overcrowded shophouses in the Central Area.

Source: Annual Report. Singapore Housing and Development Board.

The new independent Government gave the housing problem top priority and formed the Housing and Development Board to solve the housing problems and to suggest an overall development plan for the whole Republic. The main functions of the Housing and Development Board (H.D.B.) were: the acquisition of land for public housing, the clearnace of areas for development, the resettlement of families affected by the redevelopment and the building of flats for rental and for sale under the "Home Ownership for the People" scheme. The Board was also instructed to build factories, shops, markets, hawker centres, creches, swimming pools, sports complexes and other recreational facilities for the residents.

Before describing the Housing and Development Board's actions, it is useful to consider whether the Singapore Government was capable of implementing such huge construction programmes in a single programme. In fact, due to the rapid industrialisation and the Republic's economic prosperity the Singapore Government was able to play a dominant role in the implementation of economic and urban development policy and more than 80% of the housing and most industrial development took place on Government investment. Other factors contributed to this, including the availability of civil service expertise, both administrative and technical and the acceptance of advice from the United Nation's and other foreign agencies.

The Board's building programmes were financed by loans from the Government as provided for in the Republic's Annual Development Estimates. Loans for construction of properties for rental were repayable over 60 years with interest at 7¾% per annum and loans for construction of properties for sale are repayable over 10 years with interest at 6% per annum.(1)

According to the Annual Report, the Board's building programmes were wholly financed by loans from the Government. During the 15 month period ending 31st March 1974, these loan advances totalled S.$439.48 million (Singaporean Dollars), comprising loans drawn during the first quarter of 1973 amounting to S.$65.57 million and the allocation in the Development Estimates 1973/1974 of S.$373.81 million. From these loans capital expenditure on housing including land costs during the period was some S.$480.00 million.(2)

To further improve facilities for the development programme, considerable investment was being channelled into improvements to the Republic's infrastructure and the sewerage system, which was serving about half the population, was extended and improved.

The skill and experience of the population were also utilized in this huge scheme of redevelopment. Because of its unique location, Singapore's population has developed a high concentration of skill, experience and capital in trade and commerce, and after the introduction of the new industrialisation policy, more than

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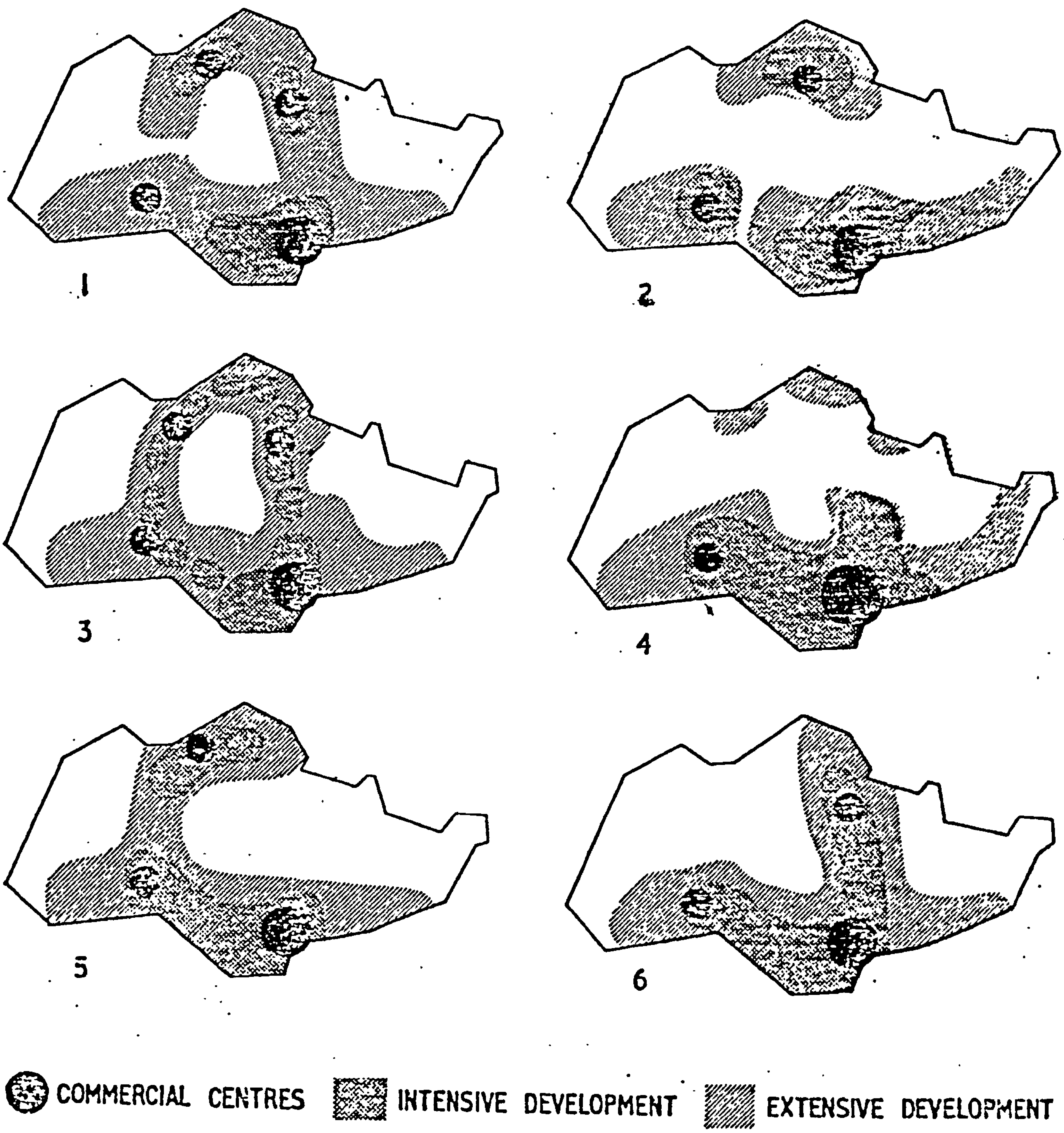
(1) and (2) Elizabeth Thomson and Henry Wardlow. op.cit.

350,000 of the population were employed in different manufacturing fields. In consequence, Singapore's population enjoys a standard of living second only to Japan in the whole of Asia.

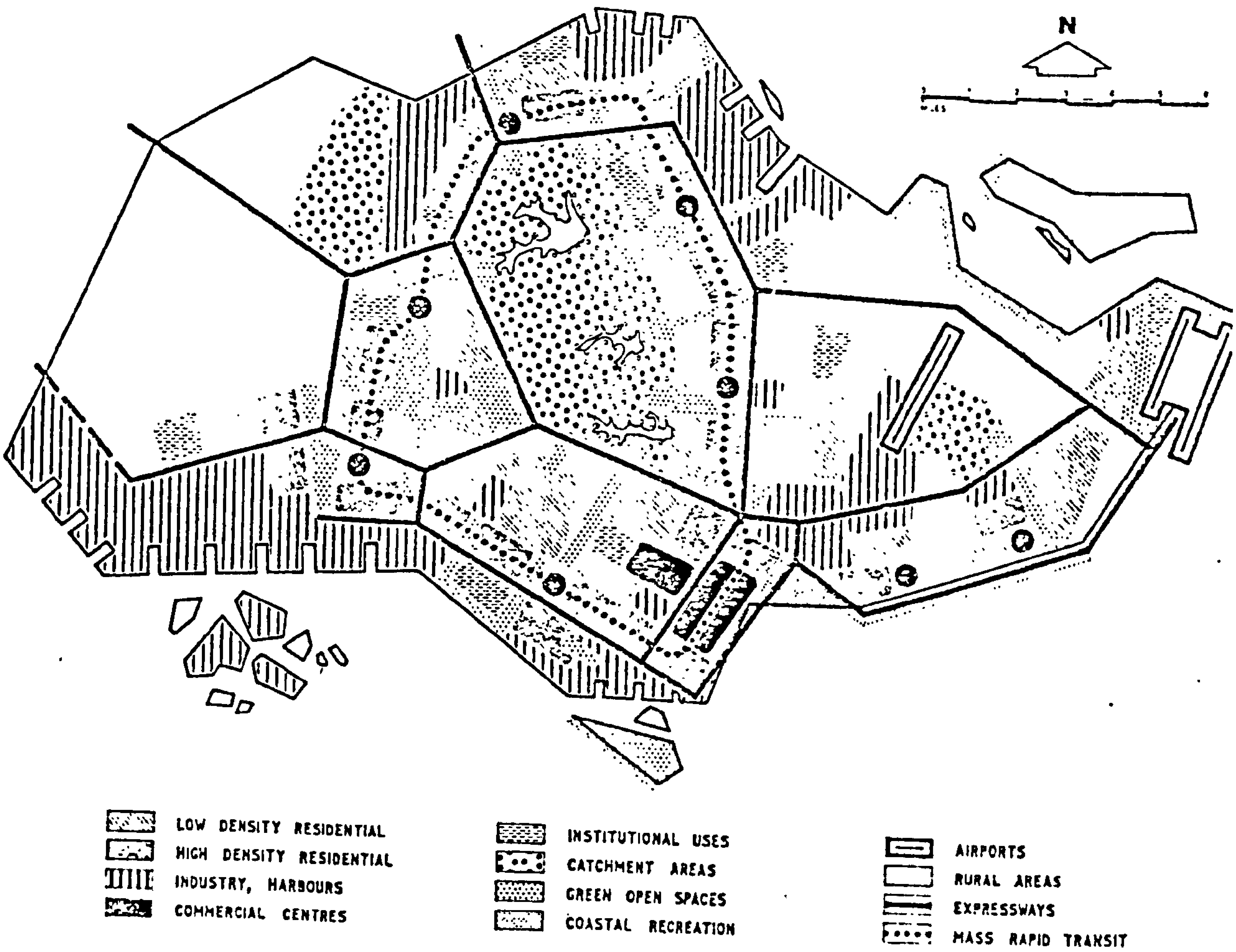
On the basis of the above factors, the Singapore Government went ahead in implementing the new development plan and in building a new modern Republic using all possible modern techniques. Through the new development plan the Government aimed at broadening Singapore's economic base, at improving the standard of housing and living, at reduing the island's unemployment, at slowing down the population growth rate and at providing stable government. However, public housing was given top priority and the Housing and Development Board was instructed to erect massive quantities of housing units, shops, schools, open spaces and other communal facilities which should ensure a steady improvement in the quality of living within the housing estates.

The Housing and Development Board began by setting a Master Plan for the whole of Singapore Island and after careful evaluation for different possibilities of development a "Ring Plan" development was selected as being the most economical one for utility services and for transport. The Ring Plan also makes the maximum use of the recreational potential of the island central green catchment area by bringing as many of the population as possible into close contact with it.



Master Plans suggested for Singapore Redevelopment
Source: Royal Australian Planning Institute Journal, April 1971.

Development was arranged on both sides of the spire of the ring with high density residential development on one side, to be served by an efficient public transportation system, while lower density residential development on the other side was to be served principally by a Ring Expressway. Variations of residential densities are therefore incorporated in the plan and should a greater population need to be accommodated in the External Area, this can be met by increasing the densities of some areas.



Singapore's Ring Plan Development

Source: Royal Australian Planning Institute Journal April 1971.

5.2.1.2. Housing Erection Procedure

After the approval of the Development plan, the Housing and Development Board declared that the whole lands of the Republic were needed for urban redevelopment and began to erect huge apartment complexes to rehouse the people. Squatters and the owners whose properties and lands were firstly affected by the development were given the first priority. The latter were provided with government housing, usually a flat in one of the apartment blocks and their land was cleared for new development. The old buildings were demolished, the land freed of encumbrances, the area master-planned, followed by the release of land on a competitive public basis for private enterprise development. After this tenders were invited from the public at a certain price per square foot, for a lease of 99 years. The government helped the developers by allowing them only to pay a down payment of 20 per cent on signing of a Building Agreement and the balance 80 per cent of the tendered premium to be spread over 10 years without interest. Also the percentage of property taxation was reduced and another exemption from property taxation for a period of six months plus one month for each storey of the building was arranged.(1)

Many local and foreign construction companies, British, Australian, Jananese, etc. took part in the construction of the new housing and other development units. By 1966 more than 121 hectares (300 acres) of slum and densely squattered areas in the strategic city centre had been cleared and systematically redeveloped. In 1968 about 8,000 flats were sold to the public and the range of accommodation provided has been extended.(2)

Renting and selling government flats to the public went on smoothly, because when the land was cleared for development the displaced occupiers, whether bona fide tenants or squatters, were offered a Housing Board's flat on very easy terms. Mortgage loans were granted by the Board to the public to purchase new flats under the "Home Ownership" Scheme. These loans were repayable

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(1) Harry J. Manning 'Some Aspects of Urban Renewal in Singapore' Royal Australian Planning Institute Journal October 1971.

(2) Singapore Housing and Development Board. Annual Report 1973/74.

over periods of 5, 10, 15 or 20 years with interest at 6¼% per annum.

In this way, by the end of March 1974, the first 1,038 units of flats were sold by ballot to the public.[1] With the successful relocation of large numbers of families from dilapidated houses in the city to the Housing and Development Board estates, approximately 9,000 units of flats and 1,000 units of shops have been built in the Central Area. Besides those rehoused in new public housing estates, another 40,000 persons were re-accommodated within the Central Area itself.

To cater for middle income groups who were not eligible for public housing and yet could not afford high prices of houses built by private entrepreneurs, the Urban Redevelopment Authority and the Housing and Development Board undertook a joint venture to build condominium housing for sale to middle income groups. In addition, sites had been earmarked under the Fourth Sale of Sites in 1974 for private developers to undertake the construction of condominium housing for sale to middle income groups.

5.2.1.3. Main Characteristics of Singapore Housing Programme

The Singaporean urban redevelopment plan is characterised by high-rise housing units, ranging from 13 floors high to 35 floors in the densely-populated areas and about 50 floors in the city centre.

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(1) Singapore Housing and Development Board Annual Report 1973/74. op.cit.

Source: Annual Report, Singapore Housing & Development Board.... op.cit.

The high-rise solution, in addition to its economic use of urban lands, fewer roads and less extensive services, was essential because Singapore is a small island with limited lands of 210 square miles which is needed for trade and industry as well as for housing. In order to make maximum use of every available square metre of land, full advantage was also taken of the presence of large, well-placed areas occupied by Chinese cemeteries. These were cleared of the graves by exhumation and the areas added to the store of land used for the erection of multi-storey public housing apartment buildings.

Even before the implementation of the new development plan, high density development already dominated land use and urban development on the island. The city area of about 40 square miles already housed about 1.6 million people at an average gross density of about 32,000 people per square mile.(1) After the collection and analyses of a considerable amount of sociological date and many Home Interview Surveys, the Housing and Development Board found that the implementation of the "New Compact" Plan of an increased rate of redevelopment in the already built-up Urban Areas provided optimum high densities of both population and jobs in the town Central areas.

Point High Buildings in Singapore

Source: Annual Report 1973/74... op.cit.

(1) K. Olszewski and R. Skeates "Singapore's Long-Range Planning" Royal Australian Planning Institute Journal October 1971.

5.2.1.4. Appraisal of the Singapore Housing Programme

The design and implementation of the new Singapore redevelopment plan is successful. It may be considered as an exceptional, to use the most up-to-date planning techniques and to apply the greatest possible degree of skill, experience and imagination in design.

In addition to the erection of intensive, unique, modern buildings for trade, commerce, industry and tourism, the Housing and Development Board was able to rehouse more than 1.5 million people in modern apartment blocks. With more flats being built and offered for sale and rent by the Board at prices within the means of the majority of Singaporeans, the Republic is well on the way to making the concept of home ownership for every working citizen a reality. What is important is that unlike the majority of the developing countries, where the minimum acceptable standard of housing is far beyond the reach of the poor majority, the Singaporean three-room flat remains at about twice the annual family income of the purchaser.(1)

The success or otherwise of any planning effort may be measured by the citizens concerned in terms of the degree to which it satisfies their daily needs and provides them with optimum utility, value and convenience. In the case of Singapore the Housing and Development Board was able to show a measurable improvement in living standards - average household size declined from 6.2 persons in 1968 to 5.7 persons in 1973; household monthly income increased from S.$318 to S.$445, and the number of income earners increased from 1.7 persons to 2.0 persons per household.(2)

As well as housing, the Housing and Development Board provided sufficient land for the development of parks, recreational, entertainment and commercial facilities. Pedestrian networks separating pedestrian movement from vehicular traffic were applied wherever possible. These provide uninterrupted,

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(1) Singapore Housing and Development Board Annual Report 1973/74 ...... op.cit.

(2) Singapore Housing and Development Board Annual Report 1973/74 page 29.

walkways for pedestrians through shops, department stores, offices, and landscaped areas. Several landscaping projects were undertaken by the Housing and Development Board in accordance with the Government's policy.

5.2.2. Hong Kong Housing Problems and Solutions

Hong Kong is a small island of 398 square miles with its capital city, Hong Kong, consisting of twin cities, Victoria and Kowloon which lie on either side of the harbour. Hong Kong has undergone an industrial revolution during the period since the end of the Pacific War and its rapid economic development has put it in the leading position in relation to neighbouring countries. It is now among the 20 largest trading communities in the world. Over the past 20 years exports of Hong Kong manufactured goods have increased by ten times and Government revenue has increased by 15 times. Hong Kong is now the world's largest exporter of garments and toys, the second largest exporter of watches.

Hong Kong's population is a very young one - in 1975 more than 43 per cent was below the age of 20. With a land area of only 400 square miles (including fairly large scale reclamations), it is one of the most densely populated places in the world. The actual island of Hong Kong is only 29 square miles, and almost a million people live there.

Hong Kong's narrow site flanked by steep hills plus the tremendous growth in the population since 1945, made the building of housing, offices and factories increasingly difficult, and the rapid expansion of the population soon created a housing crisis. In the five years from 1945 to 1950, the population of the British colony expanded roughly fourfold from 600,000 to 2,360,000.[1]

Pre-war houses were crammed to bursting point, whilst a quarter of a million people lived in squatter huts, mostly on the steep hill-sides surrounding the city. However, it was not only the

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(1) Keith Hopkins "Public and Private Housing in Hong Kong" The City as a Centre of Change in Asia. H.K. Univ. Press page 200.

natural growth of the population from 1945 to 1950 together with the inadequate stock of housing which provoked Hong Kong's housing crisis, but also the cumulative effect upon population levels of immigration from China. The population of the colony was about half a million at the end of the Pacific War. This total soon increased dramatically, as a flood of refugees moved into the colony as the civil war in China progressed.[1] Immigration restrictions introduced by the Hong Kong government in 1950 have proved only partially successful.

Urban squatting in Hong Kong was initially a direct result of this refugee influx from China. The pre-war buildings were wholly insufficient to house this enormous influx of people, and Hong Kong's squatting problem was perhaps the worst in the world. Those who could neither find nor afford accommodation built themselves flimsy wooden squatter shacks, which soon covered every imaginable sort of open space: bombed-out downtown lots, the flat roofs and verandahs of tenement buildings, staircases, boats, the steep hillsides of Hong Kong Island, farmland around the outskirts of Kowloon, alleyways, and even the streets themselves. Not only were these squatter shacks unsanitary and a serious fire hazard, but huge tracts of them made it impossible to develop urban land and thereby relieve the housing shortage.

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(1) D.J. Dwyer "The Problem in In-Migration and Squatter Settlement in Asian Cities" ASIAN STUDIES Vol.2 (1967) pp.145-69.

Roof squatters' shacks in Hong Kong

Source: Charles Abbrams Man's Struggle for Shelter

In 1951 the Hong Kong governemnt began a programme aimed at removing squatters from urban sites needed for other purposes and at reducing the dangers of squatter fires and epidemics. The squatters had to erect at their own expense a semi-permanent brick or stucco cottage, in "tolerated" areas located some distance away from urban centres. The government supplied them with communal water taps, toilets and provisions were made for drainage, fire breaks and paths.

However, the event that catalyzed the government into trying permanent solutions for the housing crisis was the most disastrous squatter fire in Hong Kong's history. On the night of the 25th December, 1953, the huge Shek Kip Mei squatter area in Northern Kowloon burned to the ground leaving more than 50,000 people homeless.(1)

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(1) Sheila K. Johnson "Hong Kong's Resettled Squatters : A Statistical Analysis" Asian Survey Vol.12, 1973.

The government's initial response was to erect temporary housing for the victims on the burned-over site. After this great fire thousands of homeless were living in the streets and being fed at public expense. The cost of providing relief for a family would, within half a year, equal the cost of housing the family permanently. Therefore cheap, multi-storey re-settlement blocks of flats were the only solution for the government.

The government began to construct huge housing estates on a large scale, the so-called Government Low Cost Housing. Hundreds of high-rise housing blocks were erected in order not only to accommodate those squatters who had originally occupied the site, but also to provide additional room for squatters of other areas, so that multi-storey buildings could then be built on the new cleared sites to house still more squatters. When an area was required for development, the squatters were informed some months ahead and then they were moved to new re-settlement estates in another part of the town which inevitably meant a completely new environment. The clearance was compulsory and all squatters were provided with government minimum housing standards (mainly a one room flat for a family of about 5 persons) regardless of their income.

To make it possible for squatters to afford to live in the re-settlement estates, the government supplied them with absolutely the minimum standard of housing. These estates are, by the standards of other countries, fantastically overcrowded. According to Otto J. Golger[(1)], the Mark 1 standard size for flats was 120 sq.ft. each. This meant floor space for 5 adults or 3 adults plus 4 children, or a net floor space rate of 24 sq.ft. per adult. In addition, the re-settlement blocks are of high-rise density, with an average height of thirteen storeys and this was compounded by high densities of people.

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(1) Otto J. Golger, "Hong Kong : a problem of housing the masses" EKISTICS vol.33 (196) page 175.

Source: U.N. Design of Low-cost housing and community facilities. Sales No.E75 IV.2.

It became a common custom in Hong Kong for several households to share a tenement floor, each household living in one or more cubicles, separated by wooden partitions about six feet high. Private housing sector was no better, as developers rented out even low quality buildings at high rents by packing poor tenants in at high densities. Preliminary results of a large survey of metropolitan area carried out in 1969 showed that 34% of the surveyed households had less than 35 sq.ft. per person.(1) Furthermore the majority of the government re-settlement blocks were provided with shared facilities. In 1968 a survey showed that 40% of households shared toilet faciltiies with three or more households, often in a combined toilet and washroom.

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(1) Keith Hopkins "Public and Private Housing in Hong Kong" The City as a Centre of Change in Asia. H.K. Univ.Press.

However, by carrying out housing construction in such a huge scale, Hong Kong government by December 1968 was able to provide squatter re-settlement accommodation for over one million people, or more than one quarter of the total population of the colony, and by 1974 the rehoused population was about 1.9 million.[1]

The Hong Kong government has spent-heavily in order to provide enough housing at a price the bulk of the population could afford and housing as a whole took up to 9.3% of total government expenditure during the financial year 1968-69. Even so, the private sector's investments in housing have been more than three times greater than public investments during the same period, exclusive of land costs.[2]

5.2.2.1. Main Characteristics of Hong Kong Housing Programme

The Hong Kong government rehousing of squatters is characterised by minimum housing standards and high-rise density of buildings. Housing three million people in a small area surrounded by hills poses obvious problems and it was clear that the only answer to the squatters' problem, given the shortage of urban land, was some form of publicly financed multi-storey housing. Besides the land shortage in the colonly, Hong Kong had a unique annual population growth rate of about 5% each year between 1951-1961; adding 1.5 million people to the metropolitan population in only fifteen years. Even when the growth rate of the colony dropped to 2.5% a year, the annual increase in population was still about 80,000 people a year.[3]

These factors meant that multi-storey buildings were essential not only for housing but also for industrial purposes. The majority of factories were built in multi-storey form and the space in them was allocated on the basis of the amount of space occupied by a concern in the squatter areas.

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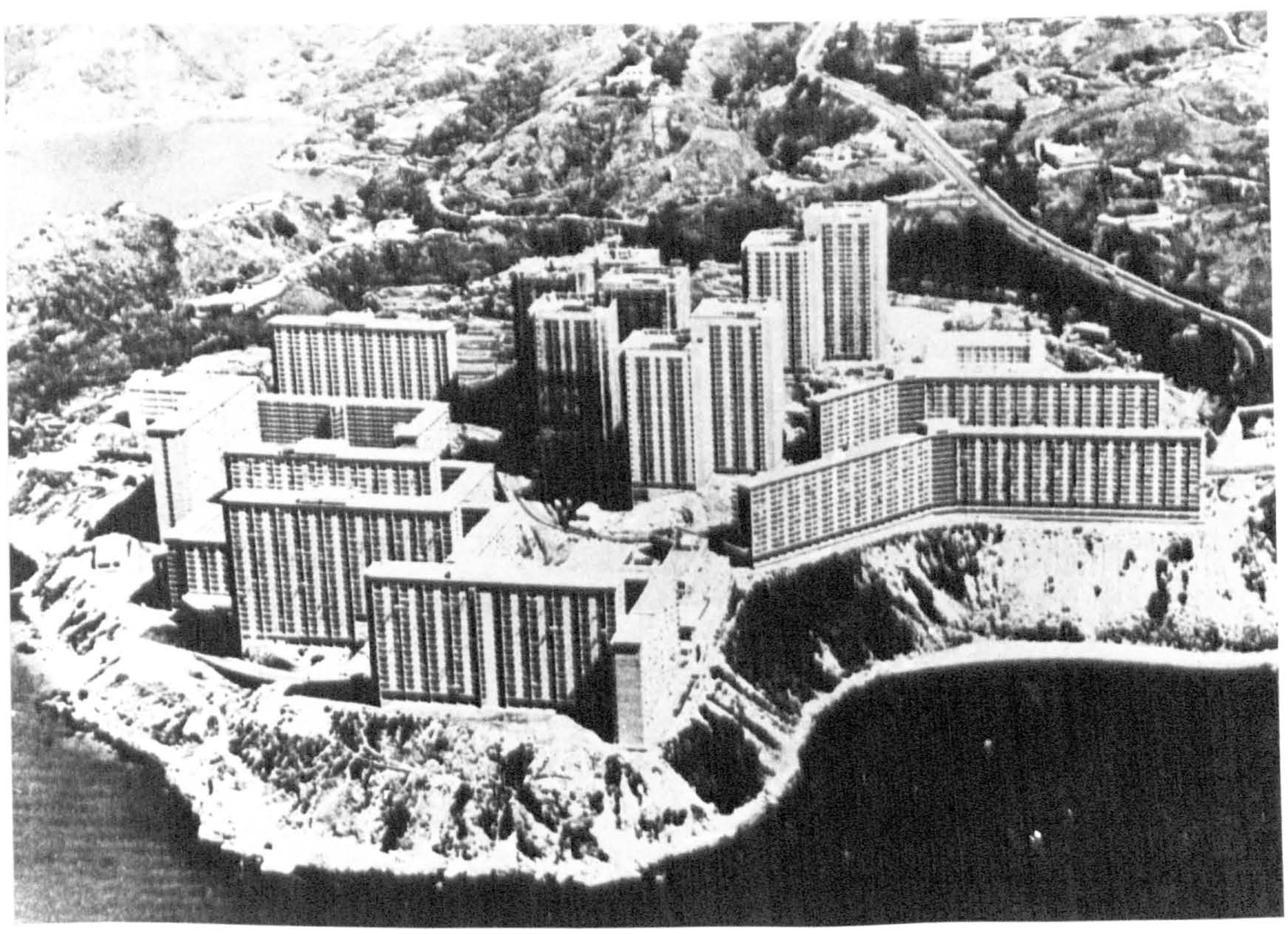
(1) Otto J. Golger "Hong Kong : a problem of housing the masses" op.cit.

(2) Keith Hopkins - op.cit.

(3) Keith Hopkins "Public and Private Housing in Hong Kong" - op.cit.

One must give due weight to the very real factors which forced the Hong Kong government into wholesale high-rise building and the consequent transfer of more than one million squatters from the ground up to the fifteenth or twentieth floor. However, the main criticism to be levelled at the government is not the high rising density but the absolutely minimal housing standard offered to the squatters. The average government housing estate provides about 6,200 flats with blocks up to 24 storeys, providing up to 35 square feet of net area per head. Such a unit is supposed to house up to 46,000 people. With such a density rate, the Hong Kong low-cost housing flats would be considered two-room prisons by Western standards. In these rooms, entire families, including the grandparents, live together.



Source: U.N. Design of Low-cost housing ...... op.cit.

Another disadvantage is that the majority of the re-settlement blocks are a considerable distance from the downtown business district, where most people work and where most of the condemned buildings were found and far from the shopping centres, schools and recreational facilities.

A particular social problem of the housing estates is the older children. The only places for the youngsters are the streets in between the huge blocks. Unlike the advanced recreational facilities in Singapore's new housing estates, in Hong Kong there are no meeting places and no places for being alone. In Hong Kong's new environments the organic needs of young people were almost entriely neglected. On the other hand, squatter areas often have much easier access to space in which children can play and in which people can sit out and move about. The external appearance of squatting shabby huts should not obscure the fact that squatter settlements - at least in Hong Kong - provide a more social, and occasionally a healthier environment, than the crowded tenements or re-settlement estates could offer, a rather unexpected finding. Although squatters have worse sanitation and are more vulnerable to infectious diseases, ground squatters in Hong Kong Island had a mortality rate lower than in re-settlement estates.(1)

One of the most serious criticisms on the Hong Kong re-housing policy for the low-income groups is the neglect of the fact that in Asia the extended family pattern is still very much alive. For the majority of Hong Kong squatters, the breaking-up of the extended families of bigger income and shared facilities into small family units of lesser income and usually greater expenses for costs of living, as well as the loss of part of their livelihood through small-crop farming or animal rearing, is a tremendous change.

The government's relative neglect of bad and deteriorating conditions among the poor living in many public and private tenements, aggravated the squatter problem. Due to the overcrowding and the lack of sufficient communal facilities, many squatters who were already re-settled in the new housing blocks left their

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(1) Otto J. Golger "Hong Kong : a problem of housing the masses" - op.cit.

flats and began to squat again. In spite of stringent efforts to prevent fresh squatter areas, it has been squatter settlements, new and old, which have absorbed the overflow, especially from private tenements. Judged by several criteria, the decision to move out into squatter settlements is not a bad one. Besides the enjoyment of better conditions than those in the new re-settlement estates, there is always the chance of being rehoused.

5.2.2.2. General Evaluations of Hong Kong : Housing Problems and Solutions

Positive Results

Since the re-settlement policy and its implementation was highly subsidized by the government, Hong Kong's squatters were able to get very cheap housing. The cost of the average flat in the government re-settlement estates was only two-fifths the price of the cheapest available privately-built accommodation of the same size. Besides the comfortable long-term repayment policy, the people had no problem in purchasing these flats because unlike the urban poor in many other countries, Hong Kong's squatters and re-settled squatters do not seem to have serious unemployment problems and almost all of them have permanent jobs.

Because in Hong Kong the provision of subsidised housing on a massive scale and the consequent control of urban squatting have been one element in an overall socio-economic policy, this has produced perhaps the highest continuous rate of economic growth in the developing world over the last two decades, excluding Japan. This rapid growth in prosperity has made possible the investment of considerable resources in housing. Therefore, in a sense, Hong Kong has solved its most urgent housing problems, partly through the large-scale provision of cheap housing by the government, and partly by the acceptance of low standards of housing.

Another success of the Hong Kong re-settlement policy is that it certainly cleared valuable land for more intensive use. As an administrative exercise in moving people out of old homes into blocks, it was brilliantly successful and provoked no major disturbances. If we take crime rates as one index of social disorganization, Hong Kong re-settlement estates are much freer of crime than the old squatting areas.

Comparing the old ugly housing features of Hong Kong with the new high re-settlement estates, the city has acquired almost a new modern shape. The majority of the pre-war domestic housing stock has now been demolished and Hong Kong is virtually a new city.

The Negative Results

The main negative feature of the Hong Kong re-settlement housing policy is that the government has over-concentrated on the obvious ills of squatter housing.

Its primary interest was not in squatters' rehousing, but in obtaining their eviction from the valuable urban land which they were occupying.

There are other serious criticisms of the re-settlement policy. Firstly, regarding the standard allocation of a maximum living space of 24 square feet per adult (12 square feet per child), maintained up to 1969. In itself the space was too small, but the natural growth of families led rapidly to grim overcrowding, well below that level. In a survey of three re-settlement estates carried out by the Department of Sociology of the University of Hong Kong in 1968, 12% of re-settlement households had less than 16 square feet per person, 38% of households had less than 24 square feet per person.(1)

A second criticism is that estates are too large and too unvaried in composition in terms of the social class of the inhabitants, room shape, room fittings and public facilities; in some cases, they are also too far from places of work or entertainment.

(1) Keith Hopkins "Public and Private Housing in Hong Kong" - op.cit.

Thirdly, all squatters were evicted compulsorily by the government from the old squatting areas to the new re-settlement estates, with no account being taken of their different housing aspirations, social needs and economic abilities.

Fourthly, due to the land shortage and the need of urban land for further development the estate houses were put so close together that people not only lack privacy, but cannot even sleep properly. By such dense location of the housing blocks together, Hong Kong gained the highest plot ratios in the world.

The demolition of a very considerable proportion of pre-war houses and their development has failed to clear Hong Kong of slums and squatting areas because of the inadequacy of the accommodation that replaced it. A quarter of a million people have spilled out of the houses to live on the streets, in rooftops, huts and in squatter settlements on vacant lots on the hillsides surrounding the town. Squatters still exist twenty years after the government's first rehousing actions and are likely to remain on several sites for many years to come.

5.2.3. Application of Housing Solutions in Singapore and Hong Kong to the Sudan

The case studies of Singapore and Hong Kong show how two particular governments responded to an urgent need for more housing. The same problem faces the Sudanese government but it is very unlikely that it will be able to apply the same solution, at least in the foreseeable future.

The most important factor to be borne in mind is the very limited ability of the Sudan (compared with Hong Kong and Singapore) to raise enormous funds to cope with large scale development programmes. As has already been shown, both Singapore and Hong Kong had undergone rapid industrialization accompanied with fast growth in trade and commerce, enabling both countries to raise sufficient funds to house the majority of their population.

By contrast the Sudan is one of the poorest countries in the world and lacks the kind of heavy industry necessary to cope with large-scale development and housing programmes. The Sudan is a mainly agricultural country, and like the majority of the developing countries is only just embarking on the path of industrialization. The Sudan's economic ability is put into perspective when one realizes that its G.D.P. is only 12½% the G.D.P. of Singapore. Rapid economic development enabled Singapore to expend more than 4% of its G.D.P. on public housing, and Hong Kong more than 5.3%; by contrast the Sudan was able to spend only 1.5% of its G.D.P. on housing.(1)

The comparison between the three countries is meaningless unless one considers the special problems of each one. The Sudan is the biggest of the three countries with a total area of 1,000,000 square miles, Hong Kong is 398 sq.miles and Singapore only 225 sq.miles. The Sudan's population is 18 millions while Hong Kong is 4 millions and Singapore is less than 3 millions people. With its enormous territories and low economic development, the Sudan still enjoys the lowest G.D.P. of the three countries.

Housing in both Singapore and Hong Kong has third priority in their national development plans, (immediately after defence and industrial development) and both countries generously subsidised the majority of their housing programmes and made available to their population sufficient government loans to purchase self-contained modern flats. The Sudan on the other hand, is not financially able to supply its population with the minimum standards of infrastructure and basic community facilities, much less with modern flats for sale or rent. At the moment it is the policy of the Sudan Government to concentrate on quick-return investment in industry in order to improve the country's economic base as comprehensively as possible. It is also significant that the private sector in Hong Kong's housing programme invested three times the amount of government expenditure; and the private sector in Singapore offered the population enough loans to buy houses of a good standard with long-term repayments. The housing problem in the Sudan is worsened by the non availability of housing loans

(1) See page 43

even for those who could afford to repay them in a reasonable length of time, simply because there are no private building societies for this purpose. For these reasons it is impossible for the Sudan to contemplate housing solutions of the same standared as Singapore and Hong Kong, and it must be accepted that to overcome the bulk of housing shortages, standards must be lowered to minimum levels.

5.2.3.1. Individual Population Economic Ability

The basic and most important factor which determines the level of the housing standard any urban household can afford is it economic ability. In both Singapore and Hong Kong the implementation of such a massive housing programme was possible mainly because the majority of the population was able to meet the cost of reasonable housing either in the short or long term. Unlike the Sudan, the squatters of Singapore and Hong Kong are employed and receive permanent and increasing monthly salaries. Sudanese socio-cultural traditions give a completely different picture.

For thousands of years and right until the present day Sudanese households have lived in a collective manner. The head of the household supports not only his wife and own children, but his mother, father, young brothers and sisters and sometimes close relatives as well. The average Sudanese urban household number is 5.87 persons.(1) Out of this figure, the actual wage earning power is only 1.2 persons per household. Contrast this with figures yielded by the 1961 census, which shows that in both Singapore and Hong Kong the average urban household is less then 4.37 persons and the active wage earning power is 2.1 persons per family.

Furthermore, the majority of the population in the Sudan is poor and mainly engaged in agriculture. The number of people engaged in manufacture in both Hong Kong and Singapore amounts

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(1) Population and Housing Survey 1965. Dept. of Statistics - Khartoum.

to more than 35% but the number of Sudanese engaged in industry in only 4.40% of the whole population. The following table shows the industrial distribution of labour force in the Sudan in the year 1956.

Table 32 Distribution of Labour Force in the Sudan

	Labour Force	Percentage
Livestock, forestry, agriculture and fishing	4,154,000	85.7%
Manufacture	247,000	4.8%
Construction	31,000	0.7%
Commerce	99,900	2.0%
Transport	31,000	0.7%
Services	223,200	4.6%
Unskilled and unclassified	63,700	1.5%
Total	4,154,000	100%

Source: Economic Survey 1963, Khartoum Sudan.

The figures in the above table show that the overwhelming majority of the Sudan's population i.e. 85.6% is engaged in agriculture, and it must be remembered that this is not the mechanized agriculture practised in Europe which offers a reasonably stable income.

A comparison between average monthly family incomes in the Sudan, Hong Kong and Singapore will give a clear picture of population's comparative ability to contribute to the acquisition of good housing. Taking the urban population of the Sudan (only 14% of the total population) it became evident that 85% are poor workers and handcraftsmen with an average monthly income of less than U.S. $40. Compare this with the Hong Kong monthly family income of U.S. $75 and Singapore $100, and the disadvantage of the Sudanese urban family is obvious.

In 1963 the minimum socially acceptable housing standard cost the Sudanese family five years income; in the same period, the minimum housing standard in Hong Kong and Singapore cost the average household only two year's income. Furthermore, urban families in Hong Kong and Singapore were able to buy complete flats with government loans on long term repayment, whilst in the Sudan housing loans are only available for a minority of government officials.

The following table gives a comparison of various factors which indicate individual family circumstances and economic ability:

Table 33 Comparative Table

	Singapore	Hong Kong	Sudan
Percentage of urban households	80%	70%	15%
Percentage of population in industry	30%	35%	5%
Number of persons per urban household	4%	4.4	5.9
Working power per urban household	2	2.1	1.2
Average monthly household income	$100	$75	$40
Cost of minimum housing standard	$2,400	$2,250	$2,880
Cost of minimum housing standard in years	2	2½	6
Materials of the house	Concrete	Concrete	Red bricks
Number of rooms	2-3	1-2	2
Services	Bath,kit., W.C.	Bath,kit., W.C.	Kit.,w.c.

5.2.3.2. Sudanese Social Traditions

The detailed study of Sudanese social behaviour set out in Chapter 4 showed how urban households often accommodate their relatives and occasional lodgers, whether strangers or having some relations with the household's members. All these people can live quite comfortably because of the extensive use of compounds and verandas, and the relatively small use of room space.

If the high-rise housing solution of Singapore and Hong Kong were to be applied (assuming that it could be made thermally comfortable) a minimum of 5 or 6 rooms would be needed for the smallest Sudanese household, while its economic ability to purchase such a large floor area is very doubtful.

The unique socio-climatic situation of the Sudan differs so much from Singapore and Hong Kong that it requires a totally different approach. The application of the housing solutions of Singapore and Hong Kong would be a complete reversal of Sudanese traditions and it might well take a period of two or three generations before it was accepted.

In addition, it is very expensive to produce acceptable standards of thermal comfort in high rise buildings, either constructionally or by the use of air-conditioning; at the moment either method is beyond the Sudan's economic capability.

One is driven to the conclusion that the housing solutions applied in Singapore and Hong Kong would be relevant only for the minority high and middle income population groups in the Sudan. For the overwhelming majority of the urban poor, the solution seems to lie in low-rise housing. This meets their socio-climatic needs within the limits of their economic ability and harnesses their spare working capacity in order that they may build their own homes within the help and guidance of a carefully conceived and well-organized governmental housing policy.

5.3. Self-Help Housing Solutions

Non-profit housing associations, which offer a good opportunity for the high, middle and even the top of the low income population groups to acquire good housing at low prices have been discussed previously. However there still remain large numbers of the population of within the lowest income groups who cannot make use of this opportunity. Added to these are certain families who cannot afford to pay the down payment required by the majority of non-profit housing associations.

For these groups governments must take the initiative and promote, train, organise, service and supervise a suitable housing process. Such groups are usually unskilled, poorly educated and of low economic means and are always reluctant to take the first step themselves to improve their environment. However, any housing policy which is to be judged adequate must take suitable measures to provide these groups with good housing.

For such low income groups self-help housing methods seem to be the most suitable answer and it is the duty of the central and local governments to provide the most favourable conditions for such schemes. Since these groups are often unable to make a contribution in cash, their contribution is made in the form of personal labour, producing block, bricks, lime etc., and building their houses under close governmental supervision. By this method government housing policies can be extended to include the lowest income groups.

5.3.1 Definition of Self-Help Housing

Aided self-help housing may be defined as the joint and voluntary action of a group of persons who come together to study their problems, and to formulate plans for solving them through self-help and community aid, and to organize themselves for purposes of mutual assistance and direct action, with minimum outside assistance and under the technical direction of agencies specially equipped for this purpose.(1) In other words, the term "aided self-help" applies where a family or a group of families combines to build houses with its own labour, skills, materials, equipments and occasionally money.

Self-help is most beneficial for families who are so poor that the only way they can get a house is by this method. It can also be brought to bear in the reconstruction and rehabilitation of existing old and obsolete dwellings.

The prime characteristic of such a programme is the collective action of the participants, who provide the necessary labour in building their houses in lieu of the 10 per cent down-payment required by non-profit housing associations. Often a small cash contribution is required, especially when the group is organised in corporate form.

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(1) U.N. Housing through non-profit Organizations ..... op.cit.

Self-help housing schemes operate not only in rural areas, but also in urban and suburban areas. Throughout Scandinavia and Latin America such programmes are extensively used in built-up areas. In Puerto Rico, for example, many public agencies have acquired, planned and leased urban and suburban lands to self-help families coming from slums or arriving from the country. These families have built or improved their own houses on the new lots, and installed sanitary and community facilities, including water supply and storm and sanitary services. In addition they have built medical clinics, community centres and schools.

In some Puerto Rican[(1)] towns the government has installed sanitary facilities, roads etc., and then sold or leased plots to individual families onto which their small houses were moved, then improved or replaced with new ones. This type of project is also found in Barbados, the Philippines, and Singapore as well as extensively in Latin America. In order to mark the low economic abilities of the families involved, the municipal authorities changed the specifications they laid down for roads and public facilities and services to a minimal standard within their reach. It is intended that better services and facilities should be installed as the financial situation of the inhabitants improves gradually over the years.

Self-helpers are usually supplied with developed lots in urban or rural projects and provided with building materials and technial assistance in putting up their houses. All these different aids are given in the form of loans whose repayment period differs from one country to another. However, it varies from 10 to 30 years with no, or very little interest rates. Unlike the non-profit housing associations, in self-help projects no initial deposit is required and self-helpers are usually given a period of grace of a year or so before the first instalment, while they are building their houses.

Self-help systems have certain common characteristics as regards procedure, finance and methods, but the progress of the projects can be governed either by the economic position of the

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(1) From United States of America, Housing & Home Finance Agency: "Administration and Costs of Aided Self-Help Shelter Improvement Projects in Puerto Rico". November, 1950.

families or the policy of municipal governments. An expert builder is usually hired to supervise construction and sometimes skilled electrician, plumber and carpenter.

Self-help house designs must be very flexible if they are not to be changed by the occupants to meet their various needs. This means that architectural and urban development plans must be revised from time to time to make sure that they meet as closely as possible the social and cultural needs of the occupying families. From self-help practices in many countries, it has become clear that proposals or methods that are too strange or unusual are apt to be rejected. Worse, they may be accepted but the basic apathy and indifference towards them becomes evident only after the start of a project.[(1)]

Self-help housing programmes are generally carried out either through a permanent association or through groups of people who join together for the purpose of constructing housing but are not bound to each other by legal ties. The type of organization is generally determined by the legislation of the country in question and by the particular advantages which the members wish to obtain. However, where the joint-stock type of self-help association is chosen, each group must in practice be incorporated separately, usually in the form of a subsidiary of a central promoting association. The organization also depends on the type of administration desired, for in co-operative self-help associations the members themselves are the managers, but in the joint-stock associations, members do not always exercise control even though they may possibly be represented on the board of directors. Moreover, in co-operative associations based on the principle of aided self-help, the very nature of the contribution of personal labour gives every member the right of co-ownership, and he can never be a mere tenant as is the case in other non-profit housing associations. This does not mean that every member is necessarily the owner of the dwelling which he occupies. As a body corporate, each association is the owner of all the immovable property, and the members are required to sign leases in its favour. In other words, a member does not get a clear deed to his house but is part owner of the property of the association;

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(1) U.N. Plot Housing Project in Central America. ST/ECA/172. N.Y. 1973.

and the individual's equity is the amount he paid for the land, his labour, and his share of the reserve fund. Each member is a tenant-owner with permanent rights of occupancy. But if he fails to make payments regularly, except in the case of sickness or for any other unavoidable reason, the leases may be subject to cancellation. Only when a member has paid off his debt, may he become an individual owner, and even then he cannot sell off his property without the permission of the association.

In the case of self-help housing constructed by temporary groups, there is the problem that a fresh start must be made with each one, because once a project is completed the members are no longer joined by any mutual ties except those which may have been established through personal friendship or community of interests. This obviously makes it difficult to preserve the continuity of effort needed to facilitate new projects. It is accordingly more appropriate that the construction of urban housing on the basis of aided self-help should be carried out through co-operative or non-profit housing associations. This would make it possible to set up not only higher-level associations, such as federations, which could facilitate continuity in the programmes, but also parent companies which could organize subsidiaries. For these reasons, throughout the world governments not only create and support self-help housing associations but they also encourage employers to support these associations continuously to help house their own workers on aided self-help basis; in such cases the governments provide any direction, technical assistance, advice and counsel that cannot be supplied by the employers themselves. However, such associations should not be taken over, directly or indirectly by the employers, and the freedom of action of the tenant-owner should not be influenced in any way. In other words, support from employers must not be allowed to infringe upon the social character of a voluntary housing association.

> "....Aided self-help on a large scale is very difficult, as it requires great organizing ability, the most skillful human engineering, the greatest ingenuity, and much patience. Nevertheless, it opens greater opportunities for providing more and better houses and communities than any other method, and at far less money cost. Its rewards in terms of a sense of achievement and the development of a greater spirit of co-operation are very great".(1)

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(1) As stated by the United Nation Mission of experts in their report: (Low Cost Housing in South & South-east Asia). 1951.

5.3.2. Preliminary Period and Preparatory Works of Self-Help Schemes

Extensive preparatory work in the form of collection and analysis of information about the families involved is essential if the best housing solution for a particular self-help group is to be found. It is first of all necessary to approach the people concerned through the leaders of social, political and trade organizations to explain the purpose of the study and to ask for their co-operation. Numerous meetings are held and films and slides shown, emphasizing existing housing problems and pointing out possible methods of improvement and examples of what can be achieved, with a view to stimulating the interest and enthusiasm of the low income populations. This initial approach is followed up by questionnaires and surveys which aim at obtaining useful information about the way of life, habits, traditions and daily work conditions of the prospective participants. In many countries experience has shown that self-help schemes are most successful when carried out by persons of similar background, employed in the same factory or business concern or engaged in the same trade or profession.

The next step is to educate the people in the principles of self-help procedure. With this in view, all agencies affecting the individual, such as the family, the school, the press, radio, television and religious institutions should be employed to eradicate undesirable social habits and encourage responsible citizenship. Educational programmes should aim at making the community aware of the advantages of self-help and at creating a favourable climate in which such schemes can be launched. Such programmes usually have two sides:[1]

1. Preparing the individual and his family for home life and for the development of neighbourhood and community relations.

2. Training the individual to build his own home through self-help methods.

Publicity should aim to reach all sections of the population in order to create a sizeable base of public support.

Here the stress should be on facts - advantages, benefits, savings - and the work required for results. In addition to the standard media and methods, such programmes must make heavy use of

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(1) U.N. Pilot Housing Project in Central America - op.cit.

films and audio-visual methods, such as film strips, which are particularly suitable for non-literate portions of the population. Universities and other institutes may also play a role in educating both self-helpers and social and technical workers.

Preliminary training of self-help groups before any housing construction begins is important as a means of testing the ability of the participating members. All groups must undergo an extended period of preliminary training not only in the housing problems and the methods of solving them from the point of view of the actual construction, but also in the philosophy of co-operation and its practical application. The participants must be completely conversant with the housing programme, local by-laws and the relevant legal provisions so that they are thoroughly aware of their responsibilities and prepared to accept them. This preliminary stage is also important in selecting a group that may be as homogeneous as possible. This will be helpful not only in establishing mutual understanding and a sense of solidarity but also in such particular matters as the time and place of meetings and the performance of the work. Past experience has shown that a fairly long period of preparation tends to weed out those who do not possess the sustained interest required to carry the project to a successful conclusion. Finally, the initial training period helps determine the right size for each group thus avoiding having idle hands during a working period, while ensuring that there are enough men to maintain progress on the job.

Because of the great importance of this preliminary training period it must be directed by people who are well qualified both in technical ability and in their understanding of human relations. Besides being acquainted with the methods of social organization and with motives which induce men to work for the benefit of their families and neighbours, the person in charge should also be familiar with the technical and administrative details of the programme including public policy, details of design, methods of organization, construction methods, financing, and the obligations of the participants.

One of the most important qualified advisers is the architect, who must address the groups on such topics as planning, materials, construction, purchasing and contracts.

The next phase is the construction of a demonstration house which will give the self-helpers an opportunity to decide if it really meets their needs while demonstrating the construction features far better than drawings, blueprints or slides. Only after the groups' members have been made fully aware of their responsibilities, should they be allowed to sign the financial loans' contract.

5.3.3. Financing of Self-Help Activities

Financing of self-help housing is similar to that of non-profit housing associations except that down-payments are not demanded from group members. Often, seed loans for self-help housing activities come from central and local governments; if local capital funds are scarce, governments may utilize existing international agencies such as the International Bank of Reconstruction and Development to obtain loans at easy terms. Governmental financial support for self-help housing varies from one country to another. In some countries governments provide self-helpers with 80% of the construction costs; in others this percentage might be as high as 90% with no initial deposits. The loans are either interest-free or at the lowest interest rates. The repayment period varies from 10 years in some countries to 60 years in others: anyone who can make early repayment is encouraged to do so.(1)

Government loans and subsidies are conditional upon the fulfilment of certain obligations such as improvement of housing standards and community development. If these obligations are not met, then loans plus interest may become payable in full. In other words, if any clause in the contract is violated or the house is sold, then the subsidy loans automatically become due.

In addition to direct financial loans, governments also encourage different governmental and non-governmental departments to supply self-helpers with equipment, machinery, transport and

(1) U.N. Housing through non-profit organizations .... op.cit.

and in some cases building materials. Self-help associations are also exempted from taxations and insurances, especially in the early stages. Governments also may foster gardening, encourage improvement schemes and give aid for recreational facilities.

Mortgage credit associations also help to finance self-help projects, usually offering loans covering up to 90% of construction costs and running for a fairly long period; this can vary from between ten to fifteen years, in the British West Indies to between forty and sixty years, in the Scandinavian countries.

Co-operative building corporations might also supply self-helpers with loans up to 75% of the cost of construction. Such loans are given at the lowest interest rates and are repayable in monthly instalments over a variable period up to twenty-five years. Big corporations, companies, various employers and even trade and craft unions also help to finance self-help schemes in order to house their own staff and workers.

Self-help groups are not normally required to pay any cash deposit or down payment, but it is customary to require from them a small cash contribution when a self-help project is carried out by a housing association, since such associations are always required to have some initial capital before they can obtain permission to function.

The system of land tenure for self-help housing activities varies from one country to another. Some countries customarily give land in freehold; others prefer to lease it, or to grant it in usufruct, for long terms, ranging from 60 to 90 or 100 years, at a low annual rental, with priority claim for a further leasehold. The advantages of the latter system are that it encompasses the necessary precautions to prevent speculation, improper subdivision of land and other undesirable features.

In some countries government authorities provide self-helpers with land as well as water supply, sewerage system, roads and other utilities. In others, the people participating in the programme are responsible for installing part of these utilities themselves; in such cases they may be responsible for the construction of the roads and of the water and sewerage systems as far as the main lines. In countries where the authorities provide the utilities, the cost is not always charged against the beneficiaries, since it is offered either by the central or local governments or by private employers or corporations.

Although, each self-helper signs a contract with the government unit or private association giving him the loan, there is virtually no cash transation between the two. Loans are given mainly in the form of building materials supplied to each self-help group on a piecemeal basis as the work progresses. Self-help borrowers are either provided with special cheque-books with which they pay for the materials as they are furnished by the office in charge of the programme, or they sign the suppliers' invoices, which have to be authorized by persons designated for this purpose.[1]

5.3.4. Organisation of Self-Help Activities

Good organization of self-help activities is difficult to achieve but it is of vital importance to their success. Because self-help housing is not constructed by specialized builders but by family members for whom the building process is entirely new, a very detailed and well organized construction programme must be laid down to ensure smooth completion of the work and maintenance of the interest and productivity of the contributors.

The first step is to divide constructional activities into those which can be done by the participating families themselves, and those in which family labour is out of the question. When selecting individual members to form self-help groups, great care must be taken to ensure a reasonable number of skilled labourers in each group. This is very important even though specialized constructional works are usually done by skilled paid workers.

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(1) Aided Self-Help Housing Seminar-Workshop 14.23 Oct.1953. San Juan Puerto Rico.

It is normal either for each family to build its own individual house or for a group of self-helpers to join together to construct their housing collectively. The latter system is the most usual because a group of self-help families working together carry out the work very quickly and to a better standard than an individual family working separately. In fact the principle of the team is basic to the self-help system. For this reason it is common for a team of 10 to 20 self-helpers to form one group to construct 10 to 20 houses, on the understanding that any one constructional stage in any one house will not be started unless the preceding one has been completed in all the houses.

The actual number of self-helpers in each constructional group can vary but experience in many countries has shown that 14 is the largest practical number for such a group. However, more important than the mere arithmetic number in each group is the fact that members in each group should have a good deal in common in respect of age, income, close social relations and background. This is because community organization is the cornerstone of progress in self-help projects. The long tedious work of self-help contructions demands a high level of co-operation between individuals and the various groups in a project. The participants are the future members of a new permanent social community whose success will depend upon the erection of an active communal life.

After signing the contract with the agency in charge of the self-help project, families are expected to begin the work immediately and to finish and reside in the new units not later than one year after the same date. The period required to finish the erection of self-help projects varies from one place to another; ranging from SIX months in some countries to FOURTEEN months in others. For example, in El Salvador it was estimated that with nine hours of work per week, the construction phase of a two-roomed single house, would last from 6 to 8 months.(1)

Participants undertake to work a certain number of hours a week, particularly at the weekends, in accordance with the work programme drawn up by the agency in charge. The time the families are expected to spend in building ranges from 14 to 16 hours a week, although self-helpers might also put in extra hours when possible.

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(1) El Salvador "Santa Lucia Colony Mutual-Aid Project" By the Instituto de Vivieda Urbana de El Salvador. UNITED NATIONS Sales No.ST/ECA/183 N.Y. 1973.

In constructing their houses, self-help families contribute their own labour; although, as we will see later, they may use their own money to finance the construction of special works. However, it is a common rule that self-helpers do the overwhelming majority of the construction by their own hands under the supervision of the technical staff of the agency in charge of the project. Usually at least two or three members of each family are engaged in the construction. Women may be involved in light jobs such as patching and painting of windows, walls, managing cement mixers, plastering and the covering of the roofs.

Skilled workers are employed by the self-helpers or the office in charge of the project for constructional jobs that require specialized skills or which may unduly delay the rest of the work; for example, the building of the roofs. Special works such as plumbing, wiring, plastering and heating are also done by skilled workers on contract for all the houses in the group. The expenses for these specialized works are usually met by funds established either by the individual groups or by the agency in charge, on behalf of the self-helpers. Besides organizing the various aspects of construction, the office in charge of the project (whether a government municipality or a private agency) must take all possible measures to ensure ease and speed of housing erection. Standardization of building elements and materials can be an important factor in achieving this.

One of the main duties of the agency in charge is to supply the participating groups with all building materials. Some agencies purchase all the materials needed by all the groups in a bulk-purchase and then distribute them piecemeal for the groups in the necessary quantities at the times when they are needed. Other agencies do not keep materials in stock but act as a mere purchasing body and intermediary between the manufacturers and the purchasers. In both cases the agency ensures greater benefit for the self-helpers by supplying them with materials at special prices through wholesale purchasing, and can also control the cost of the materials in detail.

A master builder is allocated to direct a certain number of self-help groups. He is a skilled workman who is employed to supervise all constructional works and must be well versed not only in all the phases of construction but also in ways of keeping groups working harmoniously and at the maximum productive capacity. The attitude of the master building should always be that of an instructor and never that of a foreman; his duty is to teach the self-helpers how to build and to ensure that the construction work is well done, but it is not his duty to build the house himself.

Finally, another element, less tangible must also be recognized in self-help activities. The work must be dramatized - it must not be "all work". There should be opportunity for "fun" and celebration at various stages of the building process - with whole families participating in "roof raising" or "open house" events. Projects may be initiated with a sod-turning ceremony and when completed a formal opening of "housewarming" should be carried out, to which government officials and prominent local citizens as well as newspapers, radio and T.V. are invited. Moreover, competitive desires are to be brought into play, with small prizes or awards to be given to for example the most popular or productive man in each working group. Such activities raise the morale of the self-help groups and encourage them to accelerate the construction process.

5.3.5. Administration of Self-Help Housing

In addition to the various kinds of aid they offer, municipalities or agencies in charge of self-help projects must maintain a high standard of administration of self-help activities. This is especially important because the participants generally do not have any experience in construction work and the supply of all the various aids will not ensure the success of the project, if the activities are not well organized. The training and organizing of self-help builders is a very complex process and requires both technical ability and the capability to handle people with patience and understanding.

Because of the complex nature of the undertaking, the administrative body is organized in a special manner and has divisions for management, social service, planning, land acquisition and construction and engineering; the staff of each section working under the direction of an Executive Director. There follows a brief explanation of the responsibilties of each administrative section.[1]

1. Functions of Administrative Head-Office:

The main responsibility of this section is to supervise all the other sections in order to ensure the best results. This section normally:

a) Determines the policies for orienting and organizing the participating self-help groups.

b) Establishes the necessary controls and supervision.

c) Co-ordinates the contributions of the various sections such as the engineering, social services and planning.

d) Seeks co-operation from all the authorities involved to promote further projects.

e) Reports on future programmes.

2. Functions of Social Orientation Office:

This section is vital to the success of any self-help programme; and it has a wide variety of functions:

a) To recommend the location and housing policies of the self-help programmes:

First of all, this section carries out research into such areas as demographic potential, payment capacity of participant families, leisure time, schooling, preferred zones and acceptance of the programme. It then recommends the zones where self-help programmes seem to be acceptable and where construction can be started. It also provides the engineering and planning sections with the statistical information upon which to base their designs.

(1) U.N. Admistrative Aspects of Urbanization - op.cit.

b) To publicize self-help projects:

Publicity is essential in generating enthusiasm among low income families, preparing them for the exploratory studies and obtaining the co-operation of the whole community under consideration.

c) To recommend the selection of candidates:

Self-help candidates are selected on the basis of socio-economic studies carried out by this section. Generally, the selection is made according to the following criteria - size and composition of the family, acuteness of a housing problem, financial situation, interest in the programme, level of education and occupation. The eligible candidates are then recommended for selection by the authority in charge of the project.

d) To orient and organize the different groups of participating families:

The families selected receive orientation throughout the process of organization of the groups, in order to enable them to participate effectively in the project. Many meetings are organized to explain the motives and the objectives of the programme, the responsibilities of the participants and of the agency in charge of the project, the cost and design of the units and materials, proper use of housing, and the regulations which are applied in cases of withdrawal or expulsion. In such cases a participant who withdraws receives no reimbursement, and his work is credited to the group; the person who participates in his place makes up the remainder of the contribution through labour or cash payment.

The Social Office must also inform families about the regulations relating to the houses to be built. For example:

(i) they are to be used only for dwelling purposes.

(ii) loans must be repaid in installments at regular monthly payments.

(iii) occupiers are expected to maintain the property.

(iv) no other family is permitted to share the house and no trade may be carried out there.

(v) if the disciplinary regulations in force are not respected, a penalty established and agreed upon by the groups themselves will be applied. (1)

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(1) U.N. Manual on Self-help Housing Sales No.64. IV.4.

The Social Office is also responsible for training the different groups in building and motivating them to work together well as a unit. This is partly achieved by skilful distribution of individual responsibilities and also by the appointment of a board of directors to manage the internal affairs of the group.

Every self-help group must elect a president (co-ordinator), a treasurer, secretary and auditor. In some cases such elections take place several months before the actual housing construction begins. In small self-help groups further responsibility rests on a "team captain" or "leader" who relays information on the groups and transmits particular criticisms or problems to higher authorities.

e) To ensure that the groups continue to meet their obligations:

The Social Office is responsible for holding periodic meetings with the participants for the purpose of educating them and strengthening and maintaining good relationships and habits. For this purpose social service caseworkers are assigned to the project.

Such aspects as control of tools and maintenance of work schedules are also undertaken by the Social Office. It is particularly important to ensure regular attendance of the participants so that the work may be finished in stated time and in some countries it is stipulated that at least one member of a participating family must be at work throughout the construction period. In others each family is allowed about 10% absence for good reasons but for any absence in excess of this a cash penalty per hour is established.

The causes of absenteeism and poor performance of any self-help participant must be investigated whenever such attitude persists.

f) To participate in periodic evaluation of new projects and recommend necessary adjustments:

The Social Office's final evaluations of different self-help projects are avaluable record for reference in planning future projects.

Case work and group work methods of social service must be applied whenever irregular situations arise to interfere with the progress of the work.

3. Functions of Technical Orientation Office

The main duties of this office are:

a) To study and analyse the background information on the proposed site and to prepare the reports for the authority in charge of the programme.

b) To recommend the design for the urban development and for the housing units, as well as the building system.

c) To work out a preliminary plan for the execution of the projects, in order to establish:

- (i) a suitable working schedule,
- (ii) classification of jobs by experienced and inexperienced labour,
- (iii) participation of the self-help families in the building work,
- (iv) organization of work groups,
- (v) delivery of materials,
- (vi) administrative and technical controls.

d) To assign both clerical and field staff to supervise the construction work. This supervision falls into two categories:

- (i) supervision of work done by the participants, according to schedules specifically arranged for them.
- (ii) supervision of the work contracted by public bidding or direct labour.

The Technical Office is also responsible for making field work assignments and recording the data regarding the cost, progress and the performance of the workers. The clerical staff of the office prepare summaries of the data and transfer them to graphs for record-keeping purposes. Meticulous record keeping is essential to ensure that all materials are specifically accounted for, purchased and delivered in the right time and in the correct quantities and that every man participating in the project has contributed the correct number of working hours.

These records are also most helpful in planning future programmes.[1]

e) To orient and train the families with regard to the building systems to be used in the project, especially those for which they provide physical labour. A number of orientation sessions are usually carried out before beginning the work and training continues during construction.

f) To prepare the final project and blueprint for site development, as well as for the dwellings; to draw up the construction blueprints, and to list the materials and the building system to be used.

5.3.6. Procedure of Self-Help Constructions

It is normal for participating families to do all the building including the clearing of the site, the making of the blocks, plastering, flooring, patching and painting of doors and windows etc. Only the specialized works such as carpentry, plumbing and electrical works, etc., are done by professional workers. Apart from these specialized workers no-one is paid, with the exception of the construction foreman or master builder and normally his wages are spread across the group on a proportional basis.

It is the duty of the supervisors to keep an eye on the progress achieved by the individual participants in different tasks so that they may be assigned to jobs for which they have the most apititude. The performance and ability of self-help workers usually improves afters a month or so of construction activities.

Work usually begins with the preparation of cement blocks and Block making machines and cement are distributed to the self-help groups under the condition that no house in any group is to be started until all the blocks needed for the project are completed.

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(1) U.N. Manual on Self-Help housing - op.cit.

The blocks are made by shovelling mortar into the block mould and pounding it tight.

After this the work is organized in phases so that all members are within a few days of each other in the stages of construction. This means that all the digging is done before any forms are made; all forms are made before any cement is poured; all foundations are finished before any floors are laid and so on. It is essential that all houses in any one group are built simultaneously and that it is understood, for example, that roofs will not be installed on any one house until all the houses are ready. After the organized group construction is finished, there is always an ample opportunity for individuals or for sub-groups to work together voluntarily on additional improvements for each household.

Main Points of Self-Help Constructions

It is quite clear that aided self-help housing is a long process consisting of various important stages:

1. The availability of financial resources and the readiness of the sponsoring agency to support housing construction.
2. General presentation of self-help programmes to the public.
3. Survey of applicants, using detailed questionnaires.
4. Selection of eligible families and notifying them of their priorities.
5. Training of self-help groups before and while the construction is in progress.
6. The distribution of building materials in the correct quantities and at the right time.
7. Supervision of constructional stages by competent master builders.
8. Supervision of works done by public biddings.
9. Provision of public and infrastructure services.
10. Distribution of houses to the self-help families after the completion of constructions.
11. Supervision of housing maintenance carried by the self-help families themselves.

Points 1, 6 and 8 have already been discussed in detail; some of the more important remaining points are discussed below.

1. General Presentation of Self-Help Programmes to the Public:

Having used all possible means to publicize the programmes, the organizing authority then invites all families who respond to a meeting to discuss further details.

A meeting with families interested in Self-help Housing System
Source: Manual on Self-help op.cit.

Questions and answers should be encouraged on a wide range of topics so that as many misunderstandings, misconceptions and inaccuracies as possible are cleared up.

2. Survey of Applicants Using Detailed Questionnaires:

The aim of the questionnaires is to investigate the present situation of the applicant family - type and conditions of present

Interview with Self-help applicant (Puerto Rico)
Source: Manual on Self-help... U.N. op.cit.

dwelling, its value, number of children: age, sex, occupation; family income: present occupation, family expenses: food, clothing, rents; attitudes and interests of the applicant towards the programme, his leadership qualities and spirit of co-operation.

These detailed questions should reveal:-

(a) the ability of the families to contribute the necessary amount of self-help,

(b) the ability of the families to repay the costs of the project,

(c) the need of the families for such housing programme based on their present living conditions and on their attitudes towards the relief of those conditions.

3. Selection of Eligible Families and Notifying them of their Priorities:

Analysis of the questionnaires will eliminate ineligible applicants and make it possible to group families on the basis of the size of house they require. Within each of these groups (requiring two-rooms, three-rooms etc.,) sub-groups are formed based on the ability to pay the costs of a house of the required size and the availability of time which can be devoted to the project. Priorities can be established within these sub-groups, based on:

- need for housing
- conditions of existing dwelling
- skills directly or indirectly related to building
- degree of acceptance of the programme.

After homogeneous groups have been selected, the eligible as well as the reserve families are notified.

4. Training of Self-Help Groups before and while Housing Construction is in progress:

a) Preliminary period:

Satisfactory training, especially in the preliminary period, is so important that the entire success of the project may well depend upon it. A number of meetings and training hours must be carefully planned and regularly scheduled. In addition to theory sessions participants must attend all the constructional stages of the demonstration house while it is being built by skilled paid labourers. In addition to serving as a training site, the demonstration house can also be used as a test of costs, an exhibition and an office/storage building.

At this stage the groups must discuss all details concerning the organization of construction and must be made fully aware of all their responsibilities including the care of construction materials, tools and equipment. In this stage too, each group must be trained to act as a "self-help housing society" with a president, secretary and treasurer. Finally, each group must meet to discuss the final preparations for the construction work.

b) Organization of Construction

Efficient organization is essential in sustaining the whole housing process because nothing is more discouraging to participants than wasted time and energy.

Template used for unskilled workers excavating earth for foundations of self-help houses. (1)

The most effective method of building is phased mass-construction, i.e., a system in which each process is completed for all the houses before the next stage is embarked upon. The advantage of the system is that the supervising foreman can show the group how to place the first footing, direct and supervise the second one and merely supervise the third; by the fourth, the group will be able to organize the work itself. If each member were to work only on his own house, there would be little, if any, inter-group exchange of ideas and the foreman would have to divide his attention among twenty different persons all working at different speeds and with varying skills.

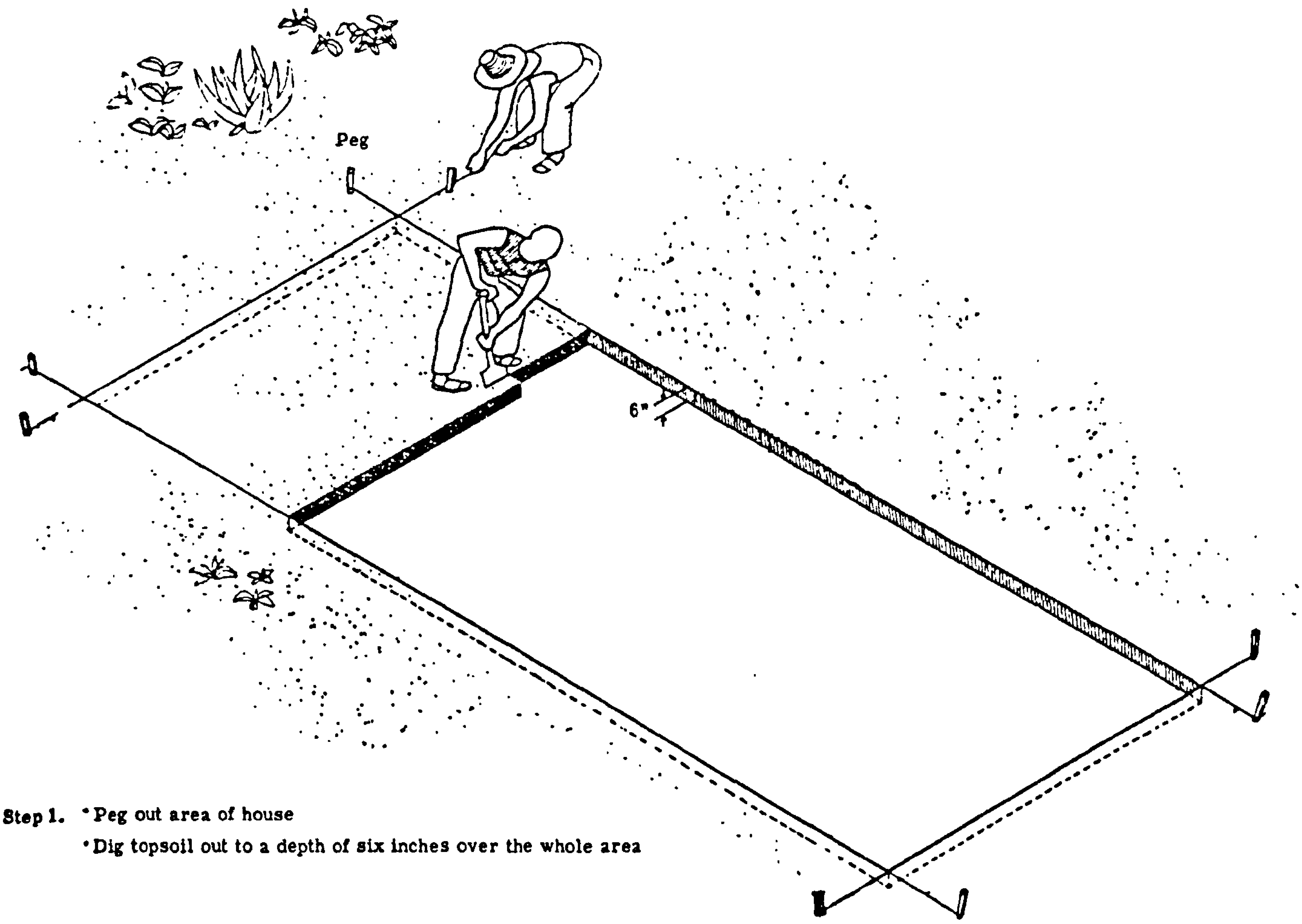
Another advantage of this system is that it allows sub-groups to be organized. For example, if it takes twenty men the first day to excavate the earth and place the concrete for the foundation of the first house, it may require only fifteen men to do the same task for the remaining ninteen houses. The other five men can then be transferred to making doors and windows.

(1) Manual on Self-help Housing op.cit. page 34.

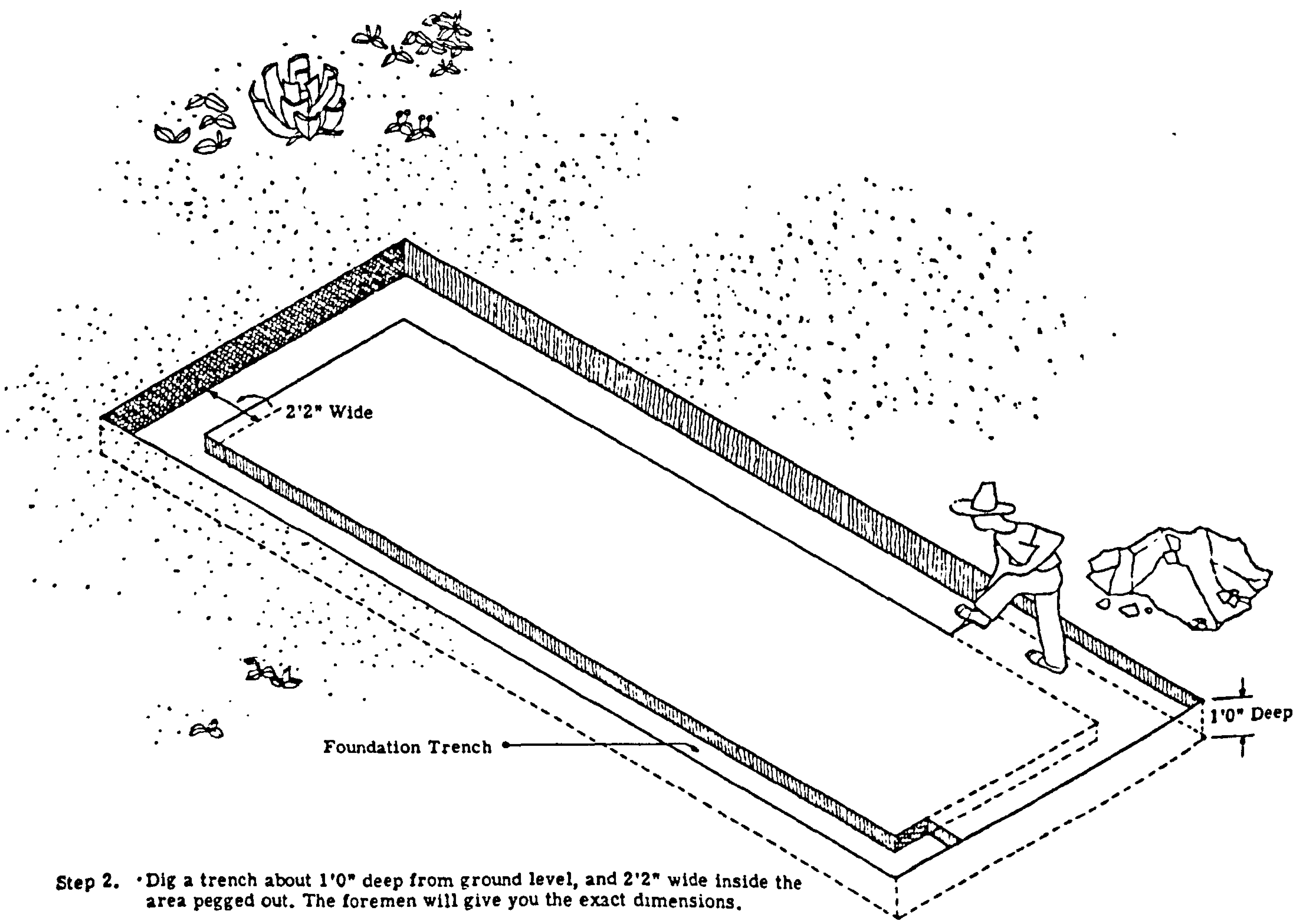
A sub-group preparing concrete beams while
the rest of the group manages the brick laying.

When all the foundations are completed teams of four men each can be assigned to build the walls of a small group of houses while another team finishes making the doors and windows. A primer on construction must be given to each family at the outset of the work.

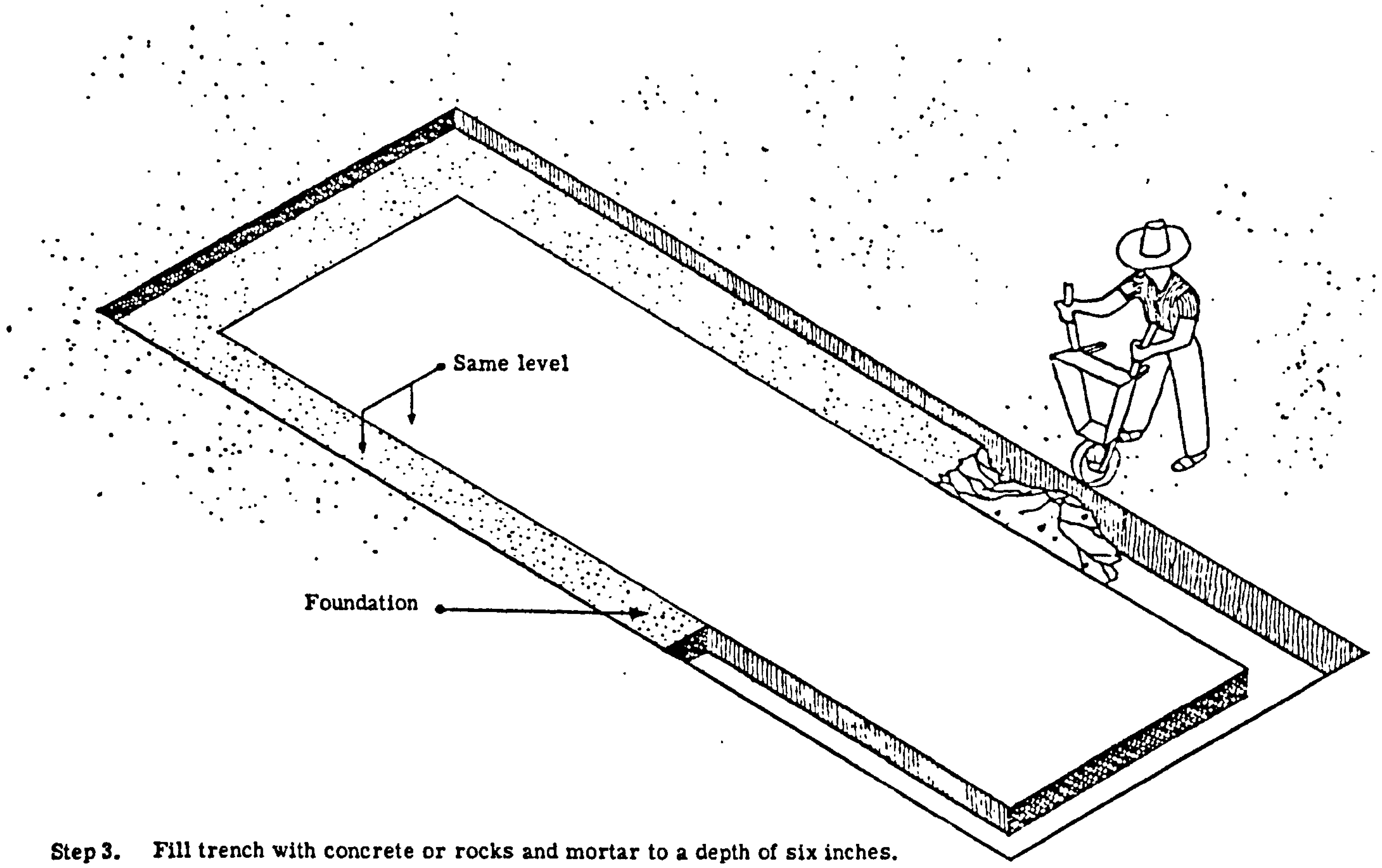
The following sketches represent a Construction Primer given by the UNITED NATIONS : Manual on Self-Help Housing Sales No.64IV.4. pages 108.113.



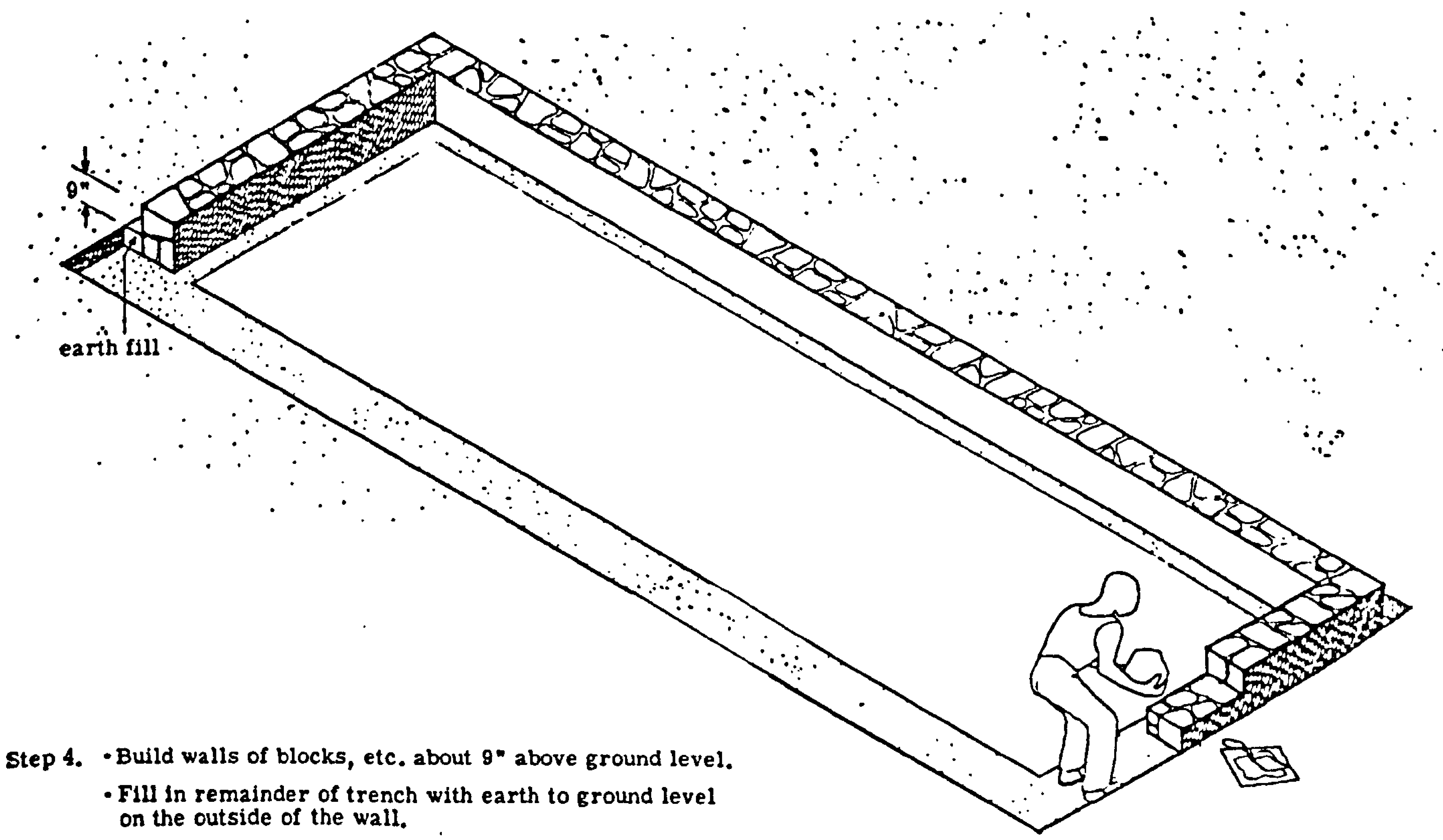
Step 1. • Peg out area of house
• Dig topsoil out to a depth of six inches over the whole area



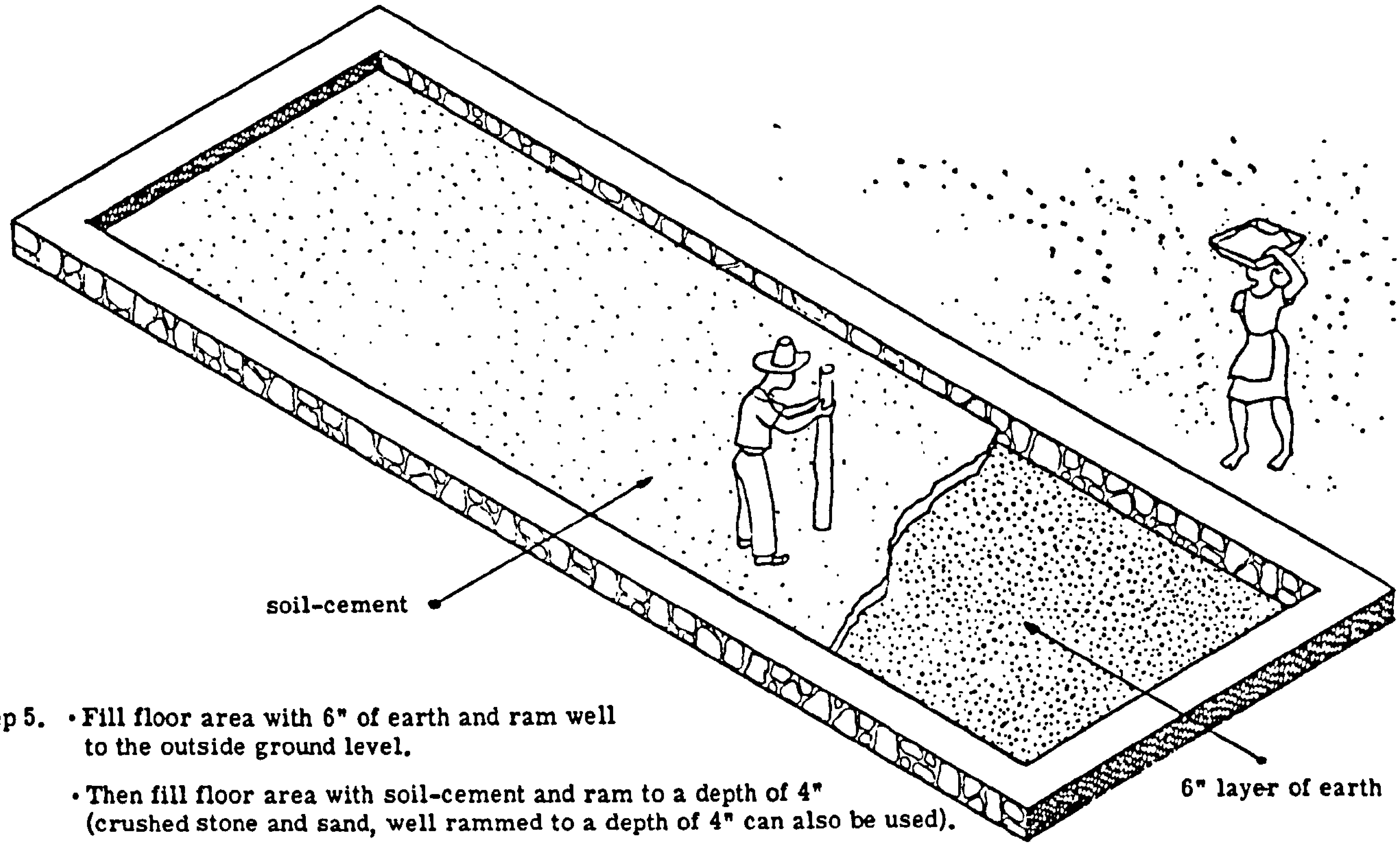
Step 2. • Dig a trench about 1'0" deep from ground level, and 2'2" wide inside the area pegged out. The foremen will give you the exact dimensions.



Step 3. Fill trench with concrete or rocks and mortar to a depth of six inches.

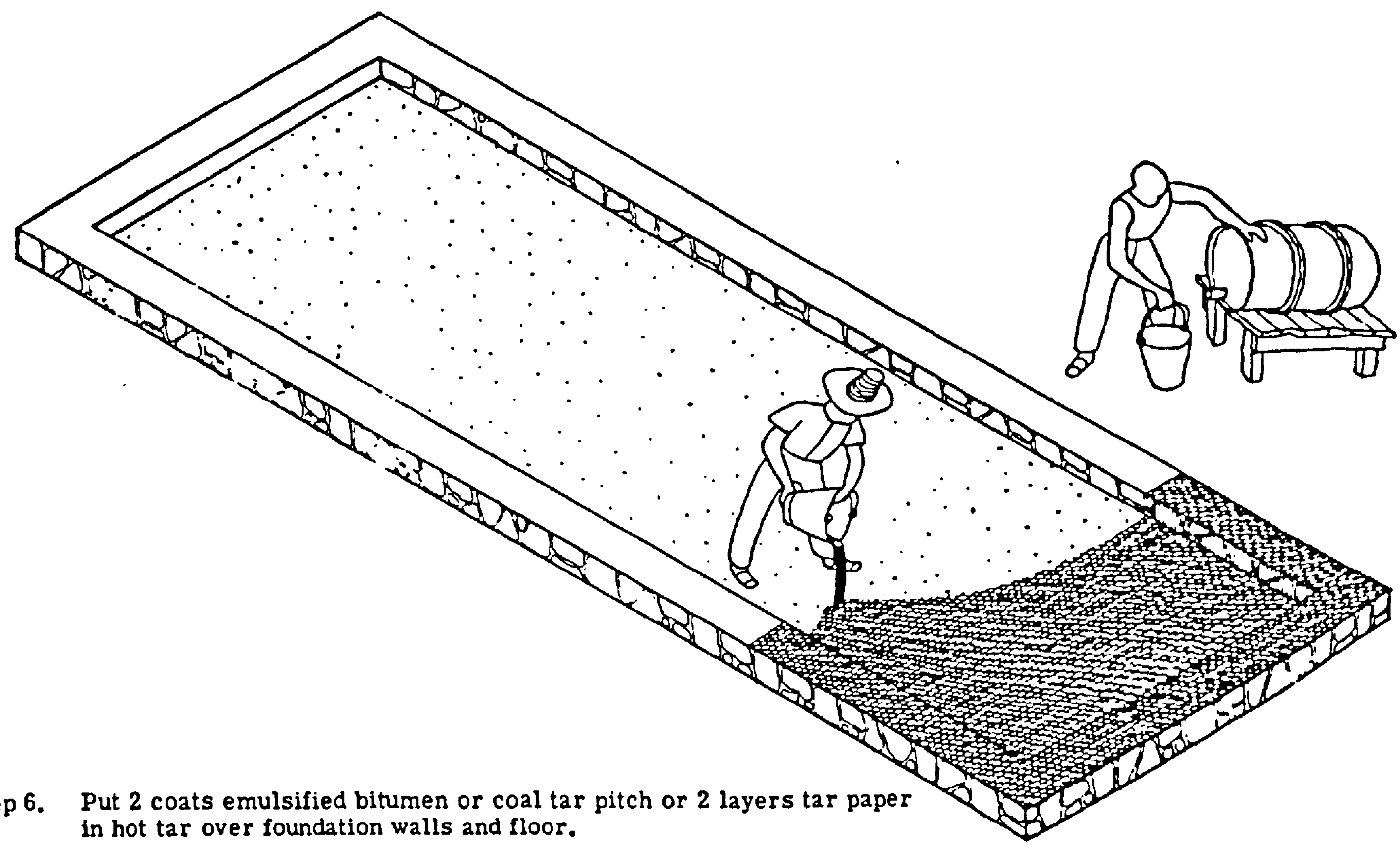


Step 4. • Build walls of blocks, etc. about 9" above ground level.
• Fill in remainder of trench with earth to ground level on the outside of the wall.

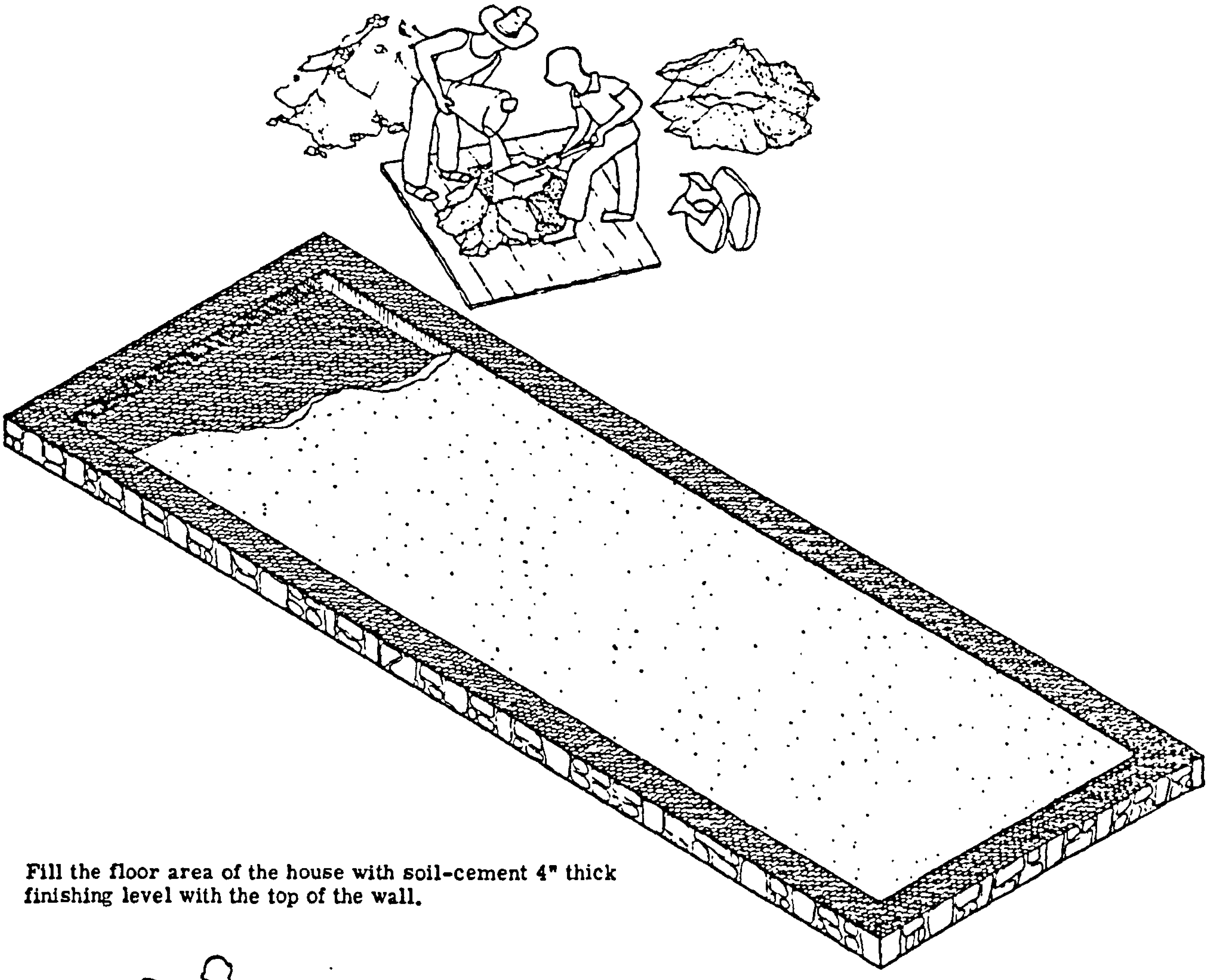


Step 5. • Fill floor area with 6" of earth and ram well to the outside ground level.

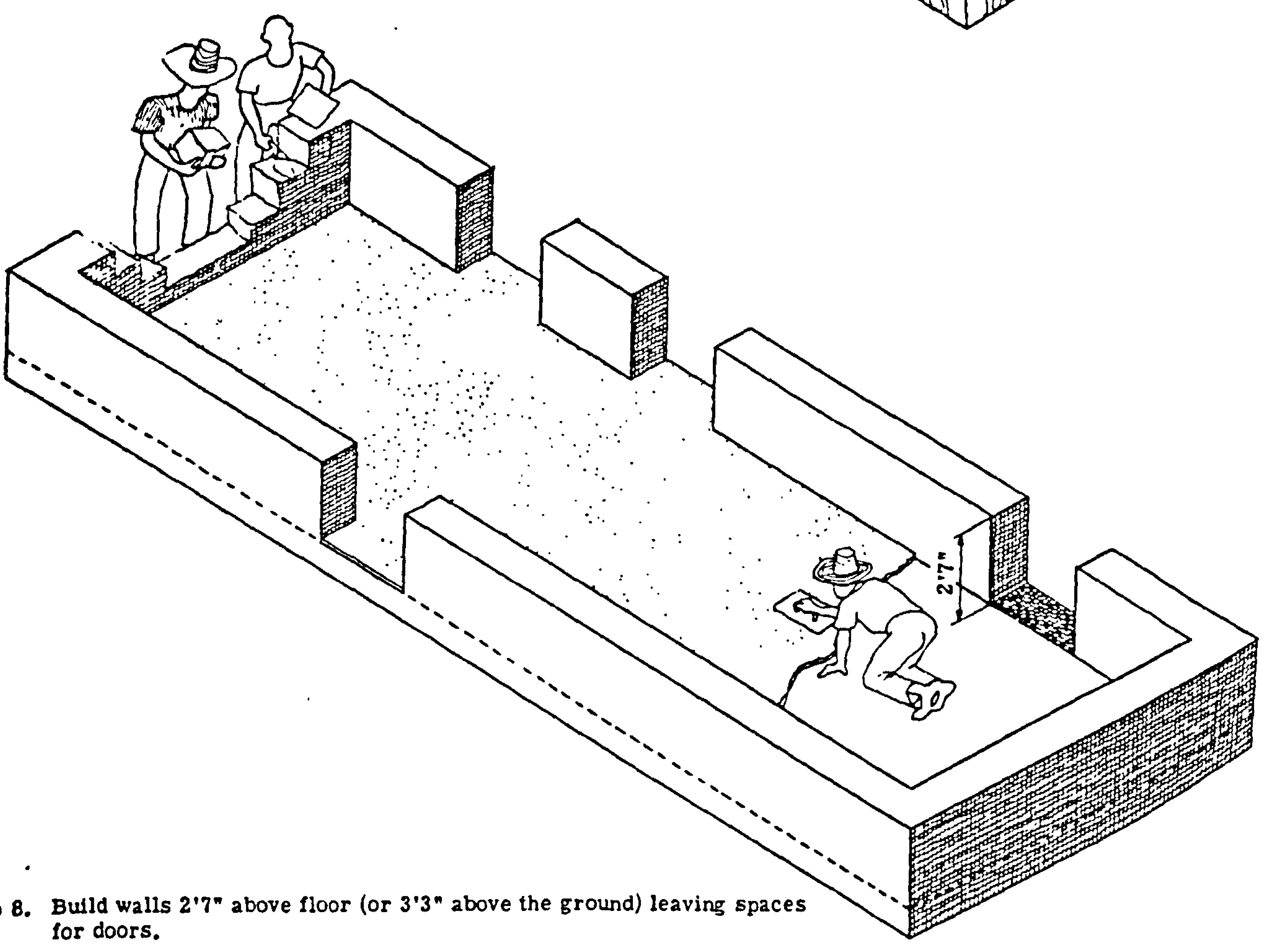
• Then fill floor area with soil-cement and ram to a depth of 4" (crushed stone and sand, well rammed to a depth of 4" can also be used).



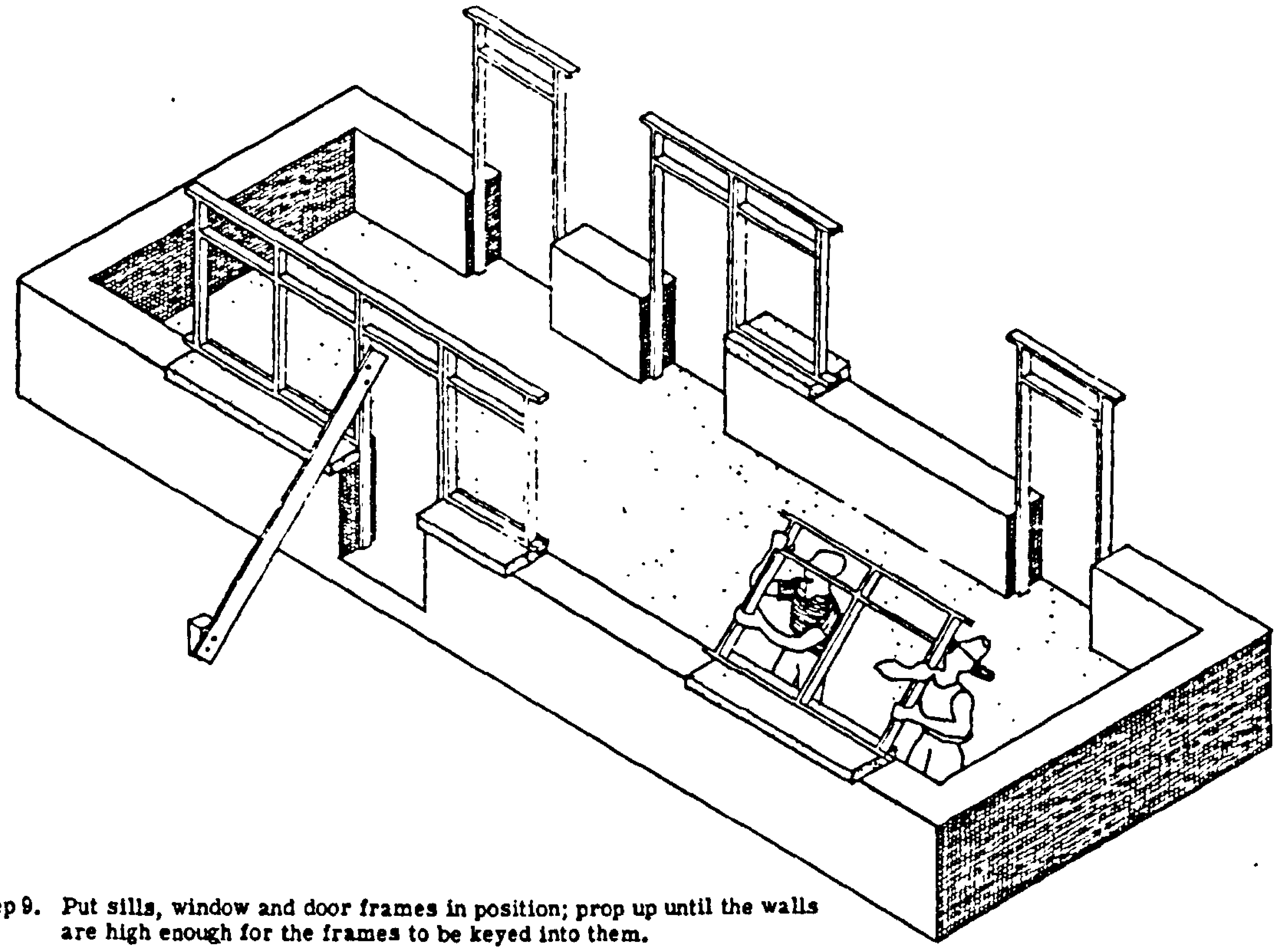
Step 6. Put 2 coats emulsified bitumen or coal tar pitch or 2 layers tar paper in hot tar over foundation walls and floor.



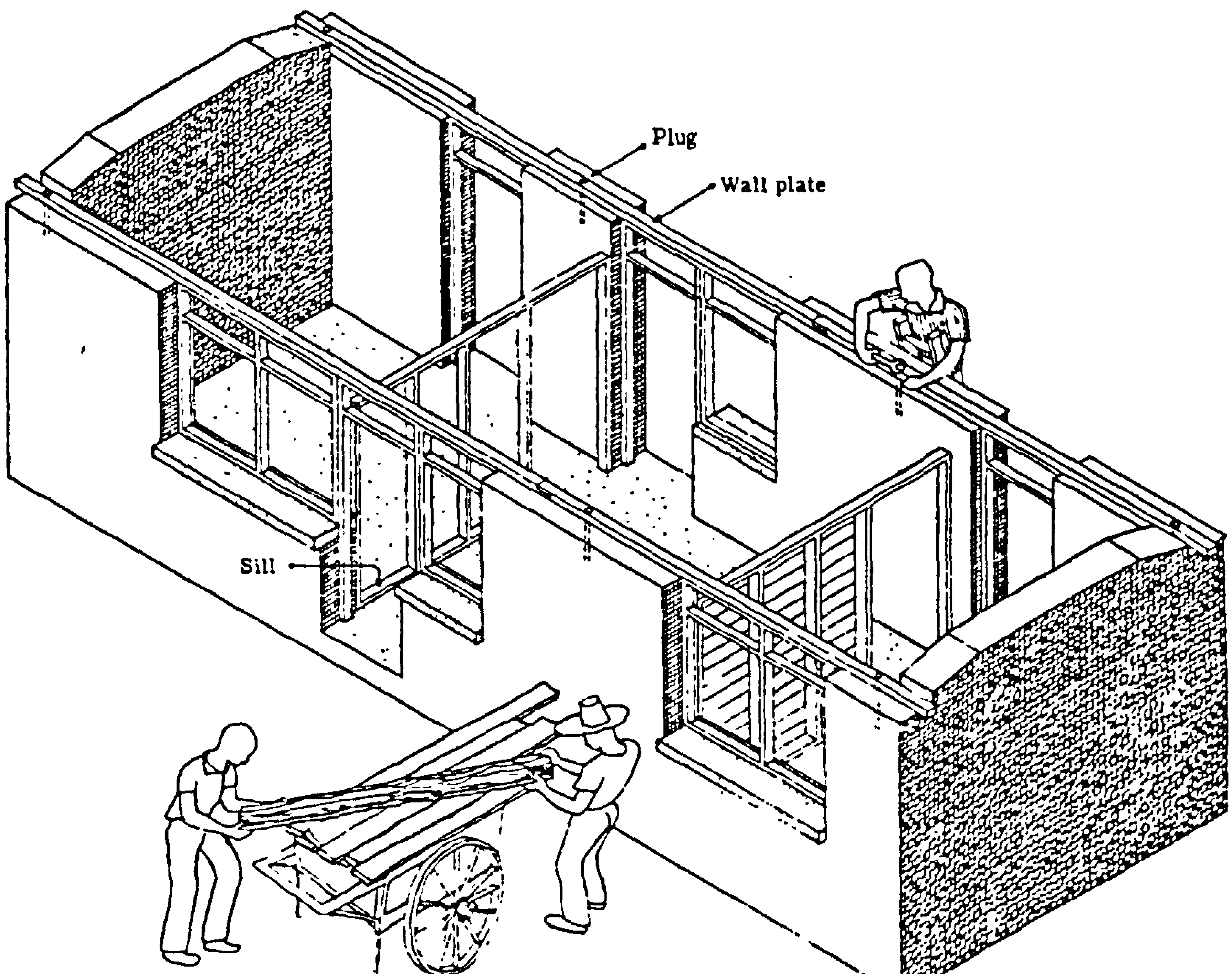
Step 7. Fill the floor area of the house with soil-cement 4" thick finishing level with the top of the wall.



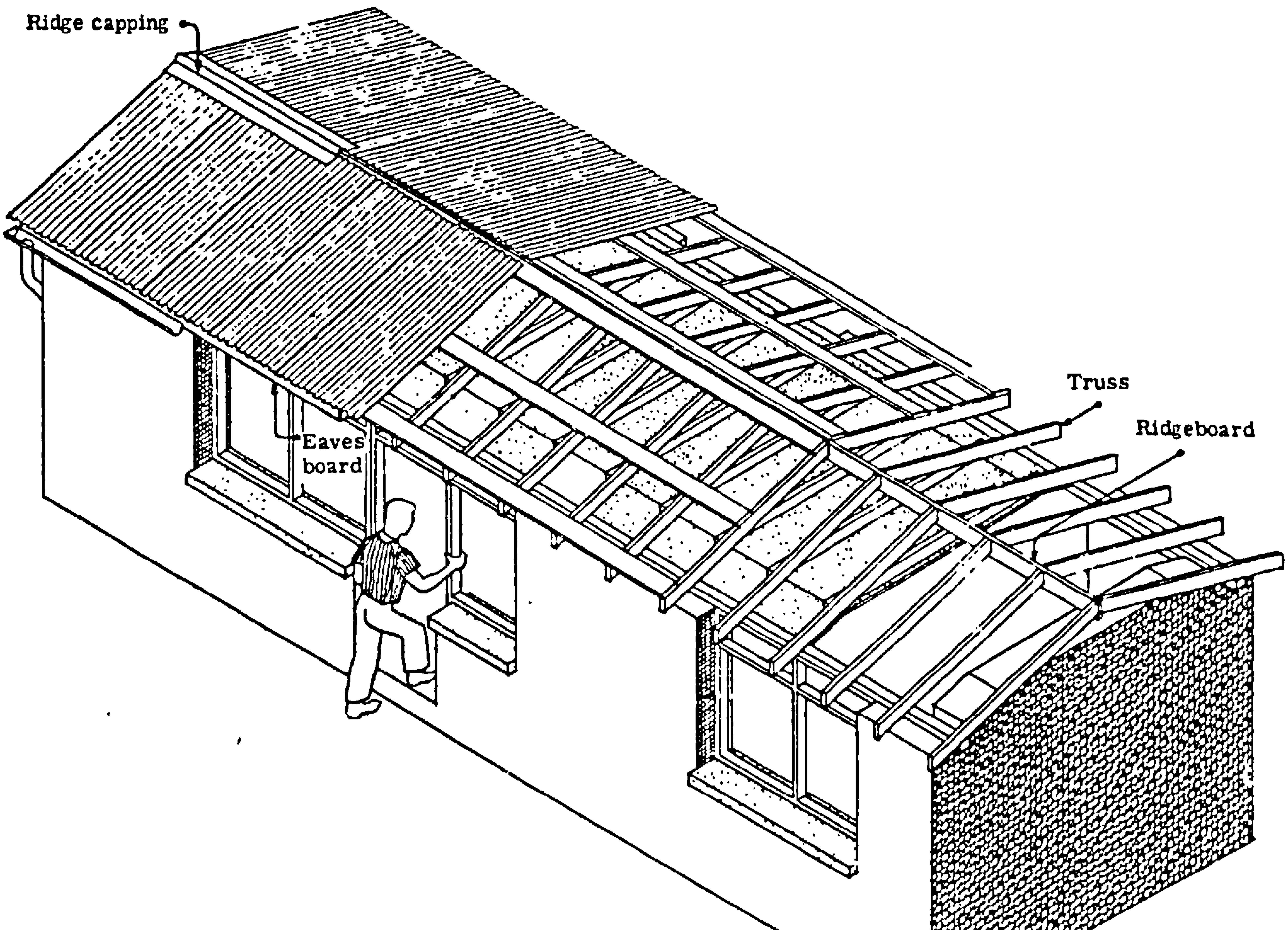
Step 8. Build walls 2'7" above floor (or 3'3" above the ground) leaving spaces for doors.



Step 9. Put sills, window and door frames in position; prop up until the walls are high enough for the frames to be keyed into them.



Step 10.
- Build walls and partitions.
- Build in plugs on top of wall in positions shown.
- Sills to be bolted into floor and side frames plugged into walls.
- Place wall plate 8" from outside wall face and bolt down. Joints in wall plate must not occur over openings.



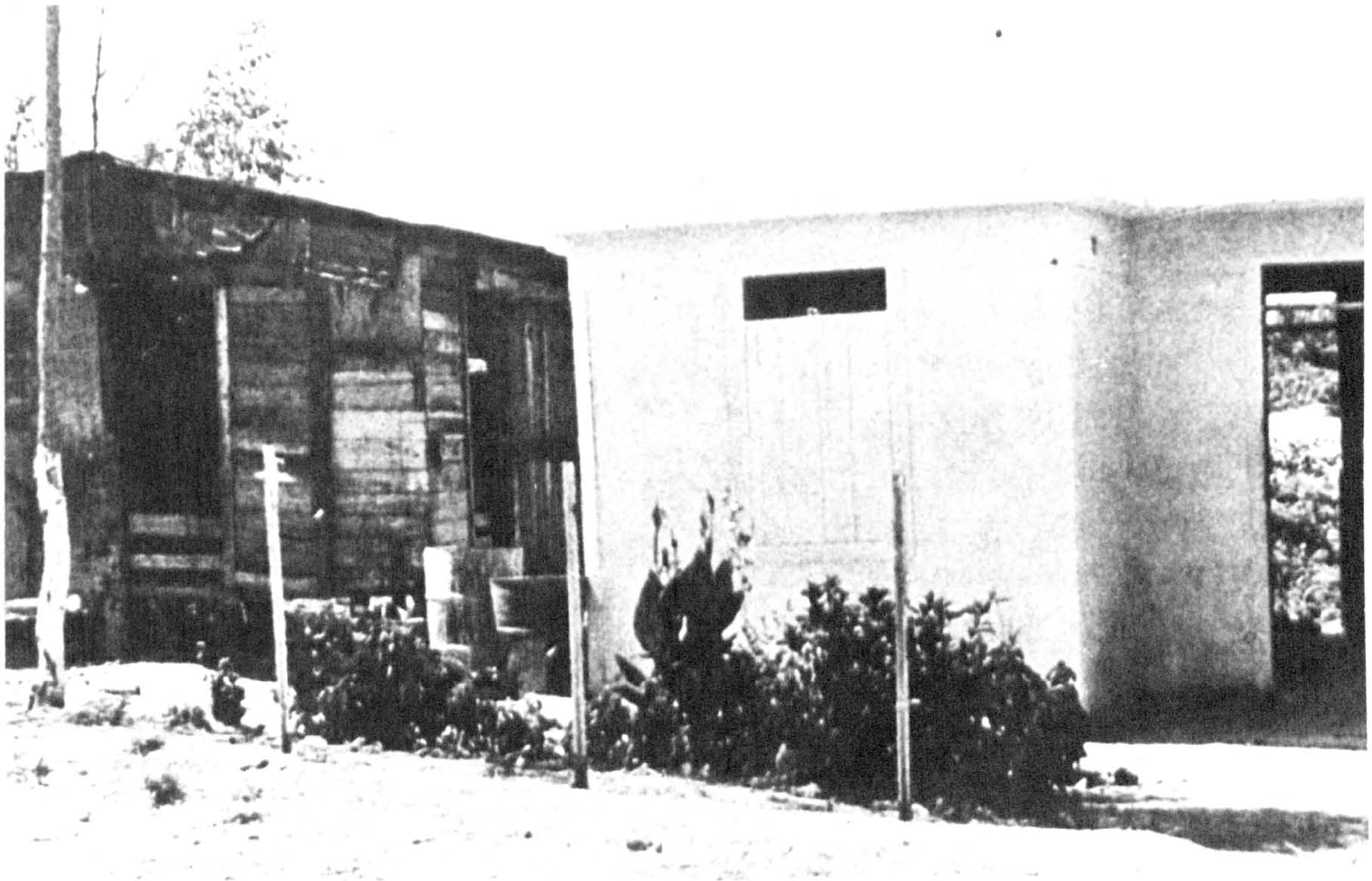
Step 11. Build roof. Ceiling can be 8'6" above floor level.

5.3.7. Temporary and Core Self-Help Housing

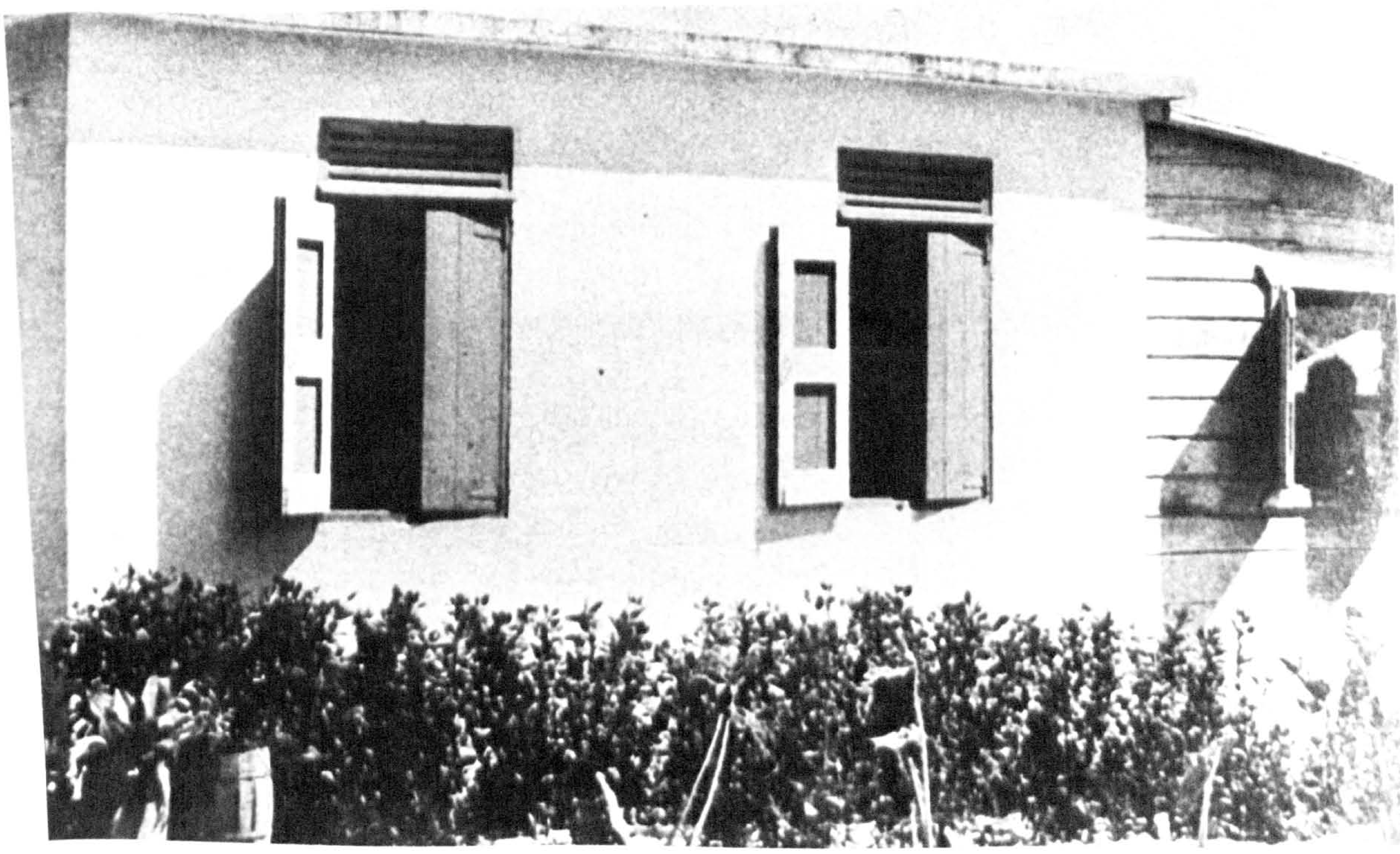
In cases where families must come from distances requiring more than one hour travelling time, as in rural resettlement schemes or relocation projects for slum-clearance families, Temporary and Core housing programmes are generally put in hand. The basic principle in both is that a partial house is constructed with paid labour on the site where the family lives while the family members build the permanent, complete house.

5.3.7.1. The Temporary House

This is the cheapest solution because it can be built of accessible local materials often including the materials of the family's old house, by the self-helpers themselves without the use of workers from the building industry. The temporary house is usually built on the rear of the new lot and it must be demolished after the permanent house is completed. Its components might provide salvaged materials that can be used for other projects, or can be used in the construction of the new house.



Temporary and permanent houses side by side
(Puerto Rico)



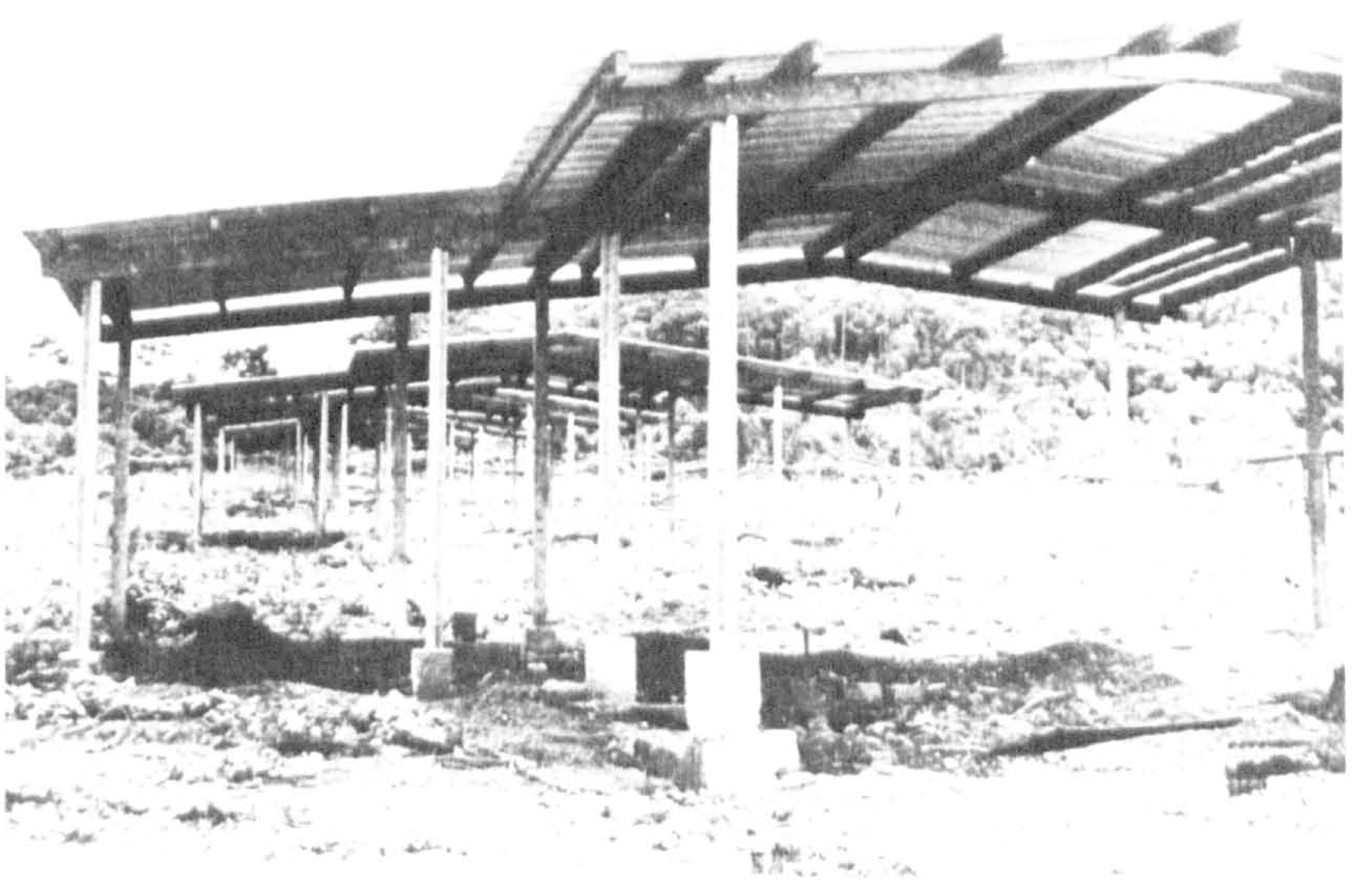
Temporary materials added to permanent house
(Puerto Rico)

5.3.7.2. The Core House

In spite of the fact that the Core house requires more paid labour, it provides immediate permanent housing for the self-help families and may be cheaper or as cheap as the temporary house in the long run.

The principle is that the preparation work and basic construction of a core unit are carried out by paid labour, leaving the construction of rooms etc., to be done by the self-help groups. As a rule the Core unit is integrated into the permanent house.

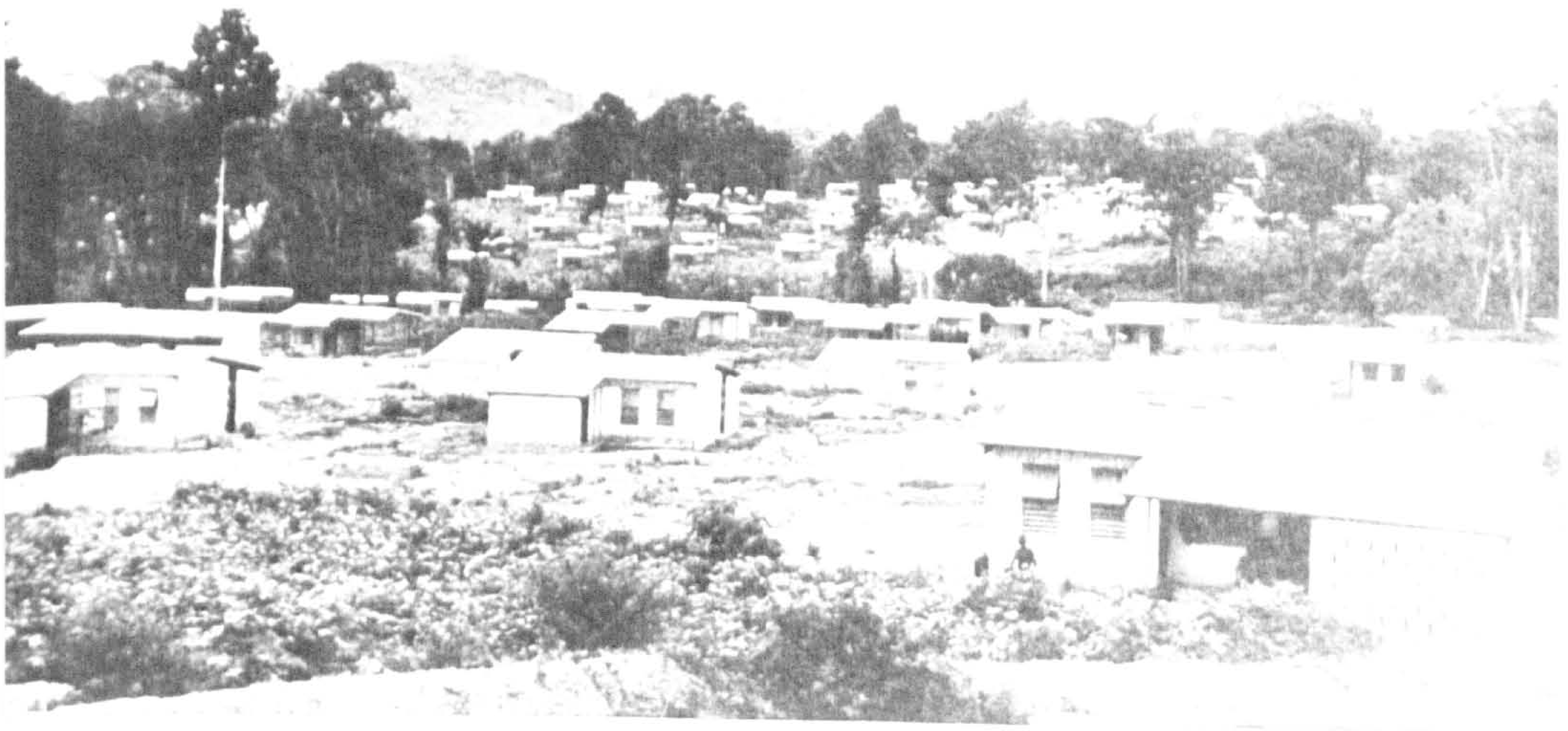
The following illustrations show a Core housing in Ghana



The sponsoring agency carried out the construction of the basic Core by paid labour.

Self-help families were transferred to the new site and began to finish the rest of the construction works.

Self-help families had already settled in the houses while the rest of the construction is in progress.



The final shape of the Core self-help housing community in Ghana.

Source: Manual on Self-help Housing.... op.cit. page 43.

The advantages of temporary and core self-help housing are that both solutions:-

- put the families on the site
- increase the possibility for more hours of self-help
- allow the families to save rent money paid on previous house
- allow materials, tools and equipment to be stored for safe keeping in members' houses.

5.3.8. Advantages of Self-Help Housing Constructions

1. Self-help housing methods enable the housing policy and programmes in any state to reach the very poor population groups, and free them from dependence upon economic development at national level.

2. Unlike all the other housing solutions, it considerably reduces the amount of ready money needed for building purposes.

3. In the developing countries, as money is scarce, self-help techniques often channel family savings directly in housing through the collection, manufacture or processing of certain building materials i.e., saving directly in kind.

4. Self-help methods minmize the total construction costs and make hosing easier for both households and governments. In some cases the cost of a self-help housing unit has been found to be less than half the cost of an equivalent unit in the private sector.

5. Since the instalments which the self-help house-owners pay on their houses are normally less than the rent they pay for similiar private housing, this frees a considerable part of their income which they can use to purchase goods and services, with great benefit to the national economy.

6. After constructing their own houses, some self-help participants become semi-skilled and may enter the house-building field, after learning a specialized vocation such as plumbing, electric wiring, masonry or carpentry.

7. Self-help techniques not only give the self-helpers good chances to exercise their political rights and duties, but also direct their education towards preparing the individual for better community life, developing his personality and filling him for his life's work.

8. Self-help housing methods greatly help in creating strong social relationships between the participating families. It may be possible by this method to recreate the old "friendship village".

9. Programmes of aided self-help are also considered one of the best ways to teach democratic action and develop a spirit of solidarity and a sense of responsibility in the participants.

10. The self-help system practically eliminates subsequent maintenance expenses, since the participants themselves assume this responsibility.

11. Aided self-help methods are not restricted to rural areas, but have proved to be very workable and important housing solution in suburban and urban areas as well.

12. New rural immigrants to the towns can be gradually absorbed in town life, through carefully designed self-help schemes.

13. It is equally applicable to slum clearance and re-housing programmes in towns.

14. Even the most poorly educated farm worker can learn to build his own home and this enables him to become at least a semi-skilled worker. This has various benefical side-effects - the family benefits because the man can learn how to maintain and improve his home; the construction industry benefits, because a new source of skilled labour can be created; and the government benefits because effective "vocational schools" can be established at an insignificant cost for people who would not otherwise have had the opportunity to attend such schools.

CHAPTER 6

APPROPRIATE SOLUTIONS FOR HOUSING PROBLEMS IN URBAN SUDAN

6.1. Introduction

Although, the Sudan is not yet highly urbanized, when compared with the European or even African standards,(1) it is quite clear (see Chapter 1) that the housing problem is very sharply felt in the major towns and especially in the Capital - Khartoum, where the greater part of the nation's economic and social development is concentrated.

In Chapter 2, it was pointed out that the neglect of rural development and the concentrated development of the Capital had resulted in an extremely high rate of migration to Khartoum and that this is one of the main causes of the present acute housing problem. The minimum socially acceptable dwelling is far beyond the reach of the overwhelming majority of the Capital's population, and this has become very evident in the overcrowding experienced in the centrally placed 3rd class residential areas and in the squalid squatting communities and illegal settlements around the periphery of the city.

In the same Chapter, page 41 an analysis revealed that three main factors accounted for the present housing difficulties in Khartoum:

(a) insufficient understanding of the role of housing in national economic development,

(b) the absence of adequate funds for housing and related facilities, and

(c) the absence of realistic Housing Policy and Master Plan for the development of Khartoum coupled with the absence of a central body in which the responsibilities for housing and planning could be vested.

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(1) According to the 1955-56 First Population Census about 8.3% of the population were living in urban settlements, but in the Second 1973 Population Census, urban settlements amount to more then 20%.
"2nd Population Census 1973". Dept. of Statistics, Khartoum.

Because housing is considered non-productive sector, the Sudanese Governemnt has given it the lowest priority in its economic development plans. Furthermore, even the limited public resources made available have been wasted and misused due to the lack of adequate national housing policies.

The situation calls for a radical change in the Sudanese Government's present attitudes towards housing. The construction of housing should not be relegated to the background or placed behind other programmes of economic development, but should be carried out concurrently with them, because its effect on increased productivity and on the construction industry and labour market makes it an essential element in the economic development of any nation. Housing must occupy its normal and correct place in the economic develop ment priority scales together with the other administrative and cultural aspects of the community.

The solution of the housing problem depends in large measure on the way in which other related problems are solved. Nevertheless, urgent attempts to solve the Sudan's urban housing problem should be made immediately without waiting for economic development. The usual policy of postponing the housing question and leaving it entirely to the efforts of individuals will only exacerbate the problem.

6.2. Promotion of Non-Profit Housing Techniques among the Sudanese:

In Chapter 5, the different types of non-profit housing associations, co-operative and self-help methods were dealt with and their advantages stressed.

From that Chapter, it is clear that only non-profit housing techniques could help to solve Sudanese urban housing problems quickly because they ensure the maximum use of limited public and private finance to meet the maximum housing needs. It is therefore necessary for the Sudanese Government to create the favourable 'climate' for carrying out housing programmes through co-operative and other non-profit associations, including housing programmes based on aided self-help, which seem to be the only solution for more than 85% of the capital's population (as will be shown later).[1]

Because non-profit housing is a new phenomenon in the Sudan, the government must give the co-operative housing societies top priority for the use of land, labour and materials and put all possible facilities at their disposal. Educational and audio-visual means, technical assistance, training and channelling and safeguarding savings for co-operative building purposes, are but some examples of government responsiblity. Since government monetary help is of vital importance in the initial stages, in the following pages it will be shown how the government can help finance non-profit housing associations.

6.3. Full Utilization of Population's Non-Monetary Resources

Because the Sudan is among the poorest developing countries, it would be unrealistic to expect its government to divert its resources away from agricultural and industrial development towards housing construction. In this situation the responsibility for housing development must be divided between the government authorities and private organizations. In such an arrangement it must be the government's responsibility to organize the untrapped resources of the people themselves to encourage their initiatives in solving their own housing problems. The betterment of housing and living conditions, the improvement of health and sanitation and the promotion of general social welfare are vitally important for the development of industrial and agricultural productivity.

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(1) The recommendations set out here deal with the capital's housing problems, but solutations through non-profit housing associations and self-help can similarly be applied in other provinces. This would strengthen the local governments and free the central government of many responsibilities.

6.4. Main Steps Towards the right Solution

6.4.1. Formulation of Comprehensive Housing Policy

The basis of any government action must be a comprehensive National Housing Policy with clearly defined steps towards the achievement of certain stated targets. It is self-evident that a period of five years is too short to solve chronic urban housing problems especially in Khartoum. A period of at lease 15-20 years is essential to achieve any worthwhile improvement.

Co-operative techniques in housing are obviously of prime importance in a country such as Sudan where economic resources are limited. Therefore, in the New National Housing Policy great emphasis must be laid on this method of housing provision and the role of co-operative housing and aided self-help building efforts clearly defined. As corollary to this employers and industries must be encouraged to provide housing for their employees and workers on an aided self-help basis with the government providing whatever is necessary in terms of direction, technical assistance and advice.

6.4.2. Adoption of well-attended Master Plan for the Growth of the Capital

In parallel with the establishment of a housing policy, a Master Plan must be laid down for the development and growth of every town and in particular the Capital. The Italian Engineering Company MEFIT has been asked by the Sudanese Government to draw up a Master Plan for Khartoum and this Company has been submitting its recommendations over a period of two years. If this plan proves to be suitable, it must be applied without delay.

Apart from the guidance and control of the capital's growth, the plan must also define suitable housing areas to meet the ever-growing housing need.

6.4.3. Encourage the Private Sector to invest in the Building Industry.

Since the production of building materials and the construction of housing are important sources of employment and an aid to economic development, the government must offer incentives to the private sector to make large investment in the building industry. Considerable private investment in the housing industry would take place if the government showed its real willingness and interest in improving urban housing conditions and ensured credit facilities for private investors.[1]

In any new housing policy, the government must take every opportunity to encourage private investment and clearly state the freedom of action of non-profit housing associations. If the government frees private investment and non-profit housing activities from any pressure, then the element of politics in the building industry, housing constructions, tenant-selection and management of projects will be reduced offering the private sector a secure basis for its investments.

6.4.4. Improvement of Rural Communities to check migration

Finally the government must ensure the development of rural communities and the improvement of rural housing and health and education facilities. A decentralization policy must be adopted to enpower the local authorities in the nine provinces outside Khartoum to deal with local affairs with the strong support of the central government.

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(1) Up to this time the private sector has received no encouragement from the government to invest in the building industry, and has reflected government policy for investing in quick turn-over industries.

The too rapid migration of the population from all the other provinces to the Capital will only be checked if positive action is taken to improve rural housing and community living conditions.

6.5. Possibilities of Sudanese Government's Material Support for Non-Profit Housing

6.5.1. Direct Government's Financial Support

Because the Sudanese government sees housing as a non-productive development sector, it is relucant to supply the necessary financial support. It is accepted that government "seed capital" is essential for the success of non-profit housing but it is not always appreciated that housing construction needs good organization and efficient administrative policies more than direct funds. In the following pages it will be shown how careful organization and channelling of external and local resources can ensure sufficient funds to support housing development.

Because Sudanese capital funds are scarce, the government must utilize existing international agencies such as the International Bank of Reconstruction and Development, the United Nations and the E.E.C. to obtain loans for investment in housing.

At the local level, the government has many opportunities to mobilize large funds for house building, either in kind or in cash, provided that it is able to formulate and apply measures to maximise every financial possibility. Such possibilities are numerous:

(a) The government should encourage saving through "saving and building" co-operative societies and encourage credit unions to help individuals with loans for "down-payment".

(b) The government should offer incentives to such bodies as banks, insurance companies, and, trade unions to invest in non-profit housing.

(c) Non-profit housing associations should be granted special credit facilities in the form of long-term amortization so that they may satisfactorily discharge their housing responsibilities. Such associations might also be exempted from property taxation or other municipal taxes, at least in the first stages, until they become established.

(d) Mortgage banks must be reorganized so as to serve the needs of co-operative housing assoications; with the government providing secure mortgages on low and medium-cost houses so as to reduce investors' risks and attract private capital to this type of investment.

(e) The government should establish and encourage the principle of joint liability for the mortgage obligations to attract and obtain larger credits.

(f) Government should establish funds supported by taxes and other resources of public revenue to provide direct grants for the housing associations.

(g) Encouragement should be given to the establishment of Savings and Housing Loan Associations, especially credit unions and building societies to provide housing loans at cost. Moreover, a system should be adopted to encourage joint housing and saving schemes.

(h) Special tax should be levied on all the employers to be invested in housing improvement. Employers who provide housing for their employees and workers would be exempted from such tax. State-built housing funds must be given to the N.P.H.A.'s as "seed capital", since they can supply the government with better houses.

6.5.2. Government Investment to develop the Building Industry

A solidly-based building materials industry is the foundation of all building activity and the Sudanese government must provide State loans, either from local resources or from outside, to support and encourage the development of the building industry and the adequate production of building materials. In Chapter2.6,it is clear how the serious shortage of both local and imported building materials is one of the major causes of urban housing problems. In the coming chapters a detailed study of the problems of the Sudanese building materials industry will be given and the basic requirements needed to solve the problem will be pointed out.

6.5.3. Distribution of Housing Lands Through N.P.H.As.

An important element in furthering the development of co-operative housing in the Sudan is the provision of housing land and infrastructure services to non-profit housing associations on favourable long-term leaseholds without the present speculative profits. More than 80% of all the Sudan's land is public, but up to the moment the government has only attempted to improve urban housing conditions by the partial distribution of bare housing plots to different population income groups. In Chapter 2, Section 6, it was pointed out that only a few fortunate people were able to obtain housing plots and the low income groups who were successful either sold the whole of their plots to the rich groups or sold half of them to raise money to build a minimum shelter. As mentioned,[1] the reasons which forced the low income groups to do so are mainly the lack of any financial support and the high costs of both local and imported building materials. The policy of distributing bare housing plots means that only a small number of those in need are satisfied and the overwhelming majority of the Capital's low income groups live either in overcrowded legal slums or in the squats and illegal settlements. It has led to housing land passing into the hands of speculative dealers who buy from the low and middle income groups and sell them at inflated prices to the wealthy.

At the heart of any new housing policy must be the law that housing land will only be distributed through co-operatives and on-profit housing associations. To stop urban land speculation the government should give the land to the non-profit housing societies at nominal charges to be distributed gradually for housing construction.

6.6. Mobilization of Government Resources

6.6.1. Introduction

The failure of present housing provision can be summarized as follows:

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(1) See page 43

(a) government efforts are characterized by lack of adequate funds for housing and lack of organized housing programmes, policies and master plans for housing and industrial development.

(b) individual house builders because of the lack of proper organization and technical skill cannot make the best use of their scarce financial resources.

6.6.2. Importance of Joint Mobilization of Government and Population's Resources

Any solution of the Sudan's housing problems must spring from a co-operative effort between government, private organizations and the people who are to benefit from the housing created. It is apparent from evidence quoted earlier that non-governmental housing co-operatives, community building corporations and aided self-help must be the basis of any new government housing programmes.

Any realistic programme must take in consideration the real material and financial resources of both the government and the population. To make an assessment of this Khartoum's population must be broken down into different groups in order to analyse the possible contribution of every individual and to pinpoint the best housing solution for each income group.

For high income groups co-operative housing organizations must be formed to buy, subdivide and improve land and supervise the design, group purchase of materials and the constructon of the houses. At present such groups manage their own construction, but this is wasteful of effort and resources.

The low income groups will require large-scale aided self-help building projects, which do not demand any substantial investment of cash from future ownerl-occupants. Such projects must be sponsored by municipal and other governmental agencies, industry, employees, trade unions etc. Their success depends heavily on group organization and co-operative techniques as well as on financial backing.

6.7. Solutions Appropriate for the Capital's Different Income Groups

Introductions

6.7.1. Estimation of the Capital's different income groups

Since 1956, The Sudanese Government has classified the urban population into three different groups according to their monthly incomes. In the last Housing Policy(1), the urban population was classified as follows:-

Table 34

Income Group	Monthly income in L.S. (Sudanese pounds)
1. Lowest income groups	L.S. 15-25
2. Low income groups	L.S. 25-50
3. Middle income groups	L.S. 50-100
4. High income groups	L.S. 100 and over

From the last Sudanese population census held in 1973, the percentage of these different income groups in the Capital's population can be worked out as follows:-

Table 35 Income Population Groups in Khartoum

Income groups by monthly income in L.S. (Sudanese pounds)	Khartoum	Omdurman	Khartoum North	Three-Towns Capital	Group in %
Lowest income group 15-25	116,872	104,790	52,847	274,509	35%
Low income group 25-50	166,961	149,701	75,496	392,158	50%
Middle income group 50-100	33,392	29,940	15,099	78,431	10%
High income group 100 over	16,696	14,970	7,549	39,215	5%
	333,921	299,401	150,991	784,313	100%

Source: worked out from census figures obtained by Dept. of Statistics Khartoum 1973.

(1) New Housing Policy Housing Dept. Ministry of Local Government Khartoum, July 1975.

From the above table it is clear that the middle and high income groups in the Sudanese Capital amount only to 15% of the total population; these groups are suitable for co-operative housing, as they can easily save the required downpayments. The lowest and low income groups form the overwhelming majority (85%) of the Sudanese Capital's population; these groups require aided self-help housing methods because of their low savings ability.

6.7.2. Housing Solutions for the Capital's High and Middle Income Groups

The Capital's high income groups are mainly government officials, trade and industry proprietors, managers, foreigners, small traders and skilled professionals, all of whom have relatively steady and rising incomes. The last table (page 281) shows that they amount ot 15% of the Capital's population, and their average monthly incomes range from L.S. 50-100 and L.S. 100 and over. These families can easily afford good housing from their own savings; they now occupy the Capital's first and second class residential areas.

However, their housing constructions are not organized or supervised by government or private housing associations. They manage the construction of their houses by themselves or through private contractors. The majority of these high income groups obtain land on nominal charges from the government and take loans from the State and private banks but they find it very difficult to finish the construction speedily and as a result their housing tends to be very expensive.

Each owner supervises the building of his house himself or with the help of a private contractor. Normally, the architectural designs and the building are not governed by specific measures or fixed quantities; this can mean a long building period and high costs. The Estate Bank distributes its loans to these groups in CASH payments and their lack of building experience can mean that all the money is expended before the house is completed.

In such situations to finish the house the owner is committed to more borrowing, often on harsh terms.

The need of the high income groups for good housing is real and pressing and their number is growing with the rising tide of industrialism and the increase in commerce. Such families can easily accumulate enough savings to be used as "down payments" on houses or on co-operative apartments serviced with all urban amenities. To cope with the housing needs of these high income groups, modern housing estates should be built similar to the present first class housing areas in Khartoum, Omdurman and Khartoum - North. They will differ from them because their construction will be co-ordinated and well carried out because they will be supervised by well-organized co-operative building organizations.

It is for these high and middle income groups that the techniques of urban co-operative and non-profit housing associations applied in most European countries, seem especially appropriate.

Co-operative organizations specializing in the continuing construction of basic houses or apartment buildings on a large scale should be developed to meet these needs. As such organizations grow, they may branch into other fields of activity, such as the manufacture of components for prefabricated houses. The most important benefit is that, since the elimination of speculation in housing construction, group organization, and the adaption of efficient building methods are basic characteristics of co-operative organizations, housing costs will be lowered sufficiently to enable these groups to acquire new housing without special government subsidy.

Finally, these high and middle income groups should be further analyzed in relation to available loans, guarantees, material, land, site layout, type of construction and community facilities and utilities desired.

6.7.3. Housing Solutions for the Capital's Low income Groups

The low income groups are the overwhelming majority (85%) of the Sudanese Capital's population. They are mainly small government clerks, trade and industry workers, labourers and farmers. They all live in the Capital's third and fourth class housing areas, that is in the new peripheral residential extensions of the three towns, far away from the Capital's centres and the working areas.

Their average monthly incomes are

(a) Lowest income groups 35% L.S. 15-20 (£25.40) per month.

(b) Low income groups 50% L.S. 26-50 (£41.80) per month.

In Chapter 2 it was shown that it is very difficult for these low income groups to meet the minimum expenses of their ordinary life, let alone to accumulate savings to improve their housing situation. Their accommodation consists of poor, overcrowded houses with no services other than drinking water and partial electrical supply.

For such low income groups large-scale aided self-help housing seems to be the appropriate solution. It is impossible for the Government to meet the needs of all people in these groups quickly, but a priority scale must be set to sub-divide the low income groups according to the emergency of their housing needs. The central government, local municipalities and industry must contribute sufficient funds to begin self-help housing projects for the most needy groups. The government must also help and encourage the co-operatives and non-profit housing associations to take over aided self-help housing activities.

The lowest income groups (35% of the Capital's population) who find it very difficult to accumulate any down-payment, must be encouraged to save "in kind". For example, with the help of government cement they can produce earth-cement blocks on sites distrubted to them on nominal charges. When they produce enough blocks to construct the minimum core of the house they should be supplied with loans in the form of low-cost wood roofs. In return for these government facilities, they should be expected to contribute their spare-time labour to the construction of roads, sewerage and water line additions and other community facilities under the supervision of local municipal authorities. After they settle in the core houses, they can gradually finish the construction of the remaining rooms as their financial resources permit.

Self-help projects must also be instituted by the government to achieve the rehabilitation of existing old and obsolete dwellings and slum areas in the three towns. The government must encourage such groups with material loans to construct minimum shelter on land given to them free of charge instead of their old sites.

Squatters

The low income migratory groups to the Capital are its main problem and if careful and well-organized plans are not carried out to minimize their number, no housing solution will improve the Capital's housing problems, no matter how well-organized and adequately financed it may be. The Central Government must encourage local governments to provide more better working opportunities for their local populations and to improve local housing conditions and social services. However, the authorities in the capital must realize that their present attempts to stop the waves of rural immigrants to the Capital by destroying illegal houses and squatting settlements has already failed. Continuous destruction of squatting settlements only aggravates the problem and wastes government efforts and resources, because the squatters merely utilize the light materials again to build new squatting areas.

The most positive approach is to plan and prepare the land in advance for rapid urban growth so that development may be guided in the desired direction. For these rural immigrants self-help temporary housing must be initiated by the Capital's municipal authorities on controlled sites with some supervision, proper site layout and the bare minimum of materials. The immigrants must be encouraged to built for themselves structures which, though temporary, will at least be reasonably sanitary and provide minimum shelter until they secure employment and then join others in building more permanent houses.

6.7.4. Appropriateness of Self-Help Systems

Self-help is not a new phenomenon to the Sudanese. They have very long established traditions in this respect going to the grass roots of the Sudanese State formation. In rural areas, social life if still based on complete mutual assistance and this extends to co-operation in housing construction. In rural housing constructions nobody is employed, since the house-owners, with the help of relatives and neighbours, manage the whole construction using local available materials, earth and wood.

The Capital's low income groups are already used to self-help housing, since the majority of them constructed their own houses. What they need is material aid and organization plus technical expertise. If they are to be educated for direct action, will be able to solve their own housing problems.

6.8. Reorganization of the Sudanese Estate Bank

An essential step in solving the Capital's housing problems is the reorganization of the Estate Bank's procedure to enable the majority of the low income groups to make maximum use of government resources invested in it.

Estate Bank's funds are supplied initially by the central government to help urban dwellers finance their house building. Unfortunately, the Bank's financial help is given mainly to government and private officials who are actually able to save their housing needs without special government subsidy.

The low income groups on the other hand have very little access to the Bank's resources because the majority of them either have no permanent monthly salaries or receive a very low income. The Bank mortgages the residential land of its better-off clients and gives them CASH Loans, according to their salaries, amounting to 90% of their construction costs. According to Guarda, R.[1] the Bank lends

(1) Guarda, R. .... op.cit.

its clients a total of L.S. lm. (one million pounds) annually for a period of 15-20 years with interest rates of 4.6% annually. With the co-operation of other government corporations, the Bank also supplies its customers with imported building materials at prices below market value.

The main disadvantage of this system is that having given its customers the loans in CASH payments, the Bank leaves them to supervise the construction independently. Because of their lack of experience in building management, the majority of the owners misuse their loans. Very few owners employ architects to quantify, price and supervise construction. This inevitably leads to delays and additional unexpected expenditure.

As a result the houses constructed with Estate Bank loans not only suffer from long periods of delay, but normally cost 1/3 (one third) or sometimes one half more than the original estimated costs.

According to the 1975 Housing Policy(1), the whole of the Bank's resources between 1970-75 were used in the construction of a few thousand very expensive first class houses. The Policy estimated that there resources could have housed at least ten time that number, if they had been reasonably and wisely used. It is also disturbing to note that the majority of the Bank's beneficiaries had no real pressing housing needs and that many of them leased their new houses to the embassies and the foreign visitors.

The working procedure of the Estate Bank must be totally reorganized to make the best use of the scarce governmental resources invested in it. The role of the Bank must not be the mere distribution of cash housing loans; it must stimulate and supervise the building activity generally, so that every citizen can be offered its help and facilities.

The Estate Bank must therefore be converted into a Non-governmental Housing Corporation to supervise, finance and support the housing activities carried out by the Co-Op's and the N.P.H.A.'s throughout the Sudan. In other words, the Estate Bank must be the mother of various housing co-operatives and non-profit housing associations. Instead of dealing with individual house owners, the Bank will encourage the formation of many non-profit housing societies

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(1) New Housing Policy ..... op.cit.

and support them financially in the provision of houses for their individual members. For this purpose appropriate state or provincial legislation should be enacted giving special recognition to co-operative or non-profit voluntary housing associations. Such legislation should be coupled with the provision that government aid on the most generous terms will only go to those societies or associations which undertake continuous building programmes. All public and private financial resources should be channelled through the Bank, which will in turn distribute them to co-operatives and non-profit housing agencies throughout the country. Not only financial loans, but also housing land, public utilities and services should be distributed through the Bank. To assure the associations that housing finance will not be affected by frequent political changes, the majority of the Bank's Board must be elected from non-government officials. It is the responsibility of the Bank authorities to ensure that the resources given to the co-operatives and associations are used in the best possible ways.

To allow the Estate Bank to undertake this task the Sudanese Government must, at least in the initial stages, supply the Bank with long-term loans. The government must also encourage private investors to support the Bank so that it enjoys a mixture of private capital resources underlying direct government loans or government guarantees. Adequate funds can be accumulated to increase the Bank's resources from such sources as direct taxation. A special tax may be imposed on employers, based on the percentage of the wages paid, to go directly into Bank funds. The justification for this is that employers have a direct stake in the well-being, efficiency, and low-turnover rate of their employees; housing, for course, is a very important means of fostering such conditions.

Another important possibility is that savings institutions may be induced (or required) to devote a portion of their funds to housing schemes.

The functions of the Bank must not be limited to the present loans system; it must cover a wide range of activities aimed at raising and improving housing conditions and social facilities, not only in the capital, but throughout the whole country. It should assist in the co-ordination of government policies related to housing investment, raising housing standards and guiding urban growth. It must supply the co-operatives and non-profit housing associations with long-term loans and help them in bulk purchase of land, joint architectural and planning services, communal installation of streets, water and power supply, mass purchase of materials and provision of services.

The Bank must establish well-organized savings and loans systems, encouraging people to save for house building with the incentive of a loan to meet the residue of the cost of the house once a certain savings target is attained.

The funds devoted by Government Units and different Ministries which build government houses for their employees must go to the Estate Bank so that such housing may be organized through a special department. The next chapters will show that the government Units who build housing are employing a large number of staff for this purpose and that the houses they build are expensive because of lack of experience and absence of a central organizing body.

Government housing for officials is now shared by the Ministry of Construction and Public Works, Ministry of Irrigation, Sudan Railways Dept., Dept. of Housing and all the departments of the Ministry of Local Government. It is suggested that these sections should transfer their housing activities to the Estate Bank or accept its supervision in planning, bulk purchasing of materials and constructions; this will free the government units from responsibility, save a large number of staff, and strengthen the financial position of the Estate Bank - the result should be considerable reductions in housing costs.

6.9. Building Materials Industry in the Sudan

The development of a reliable building materials industry is crucial to the solution of any large scale housing problem. Because the Sudanese government has been committed to quick-return industrial investments to create a solid base for the overall development of the country, first priority has not been given to the building industry, but to other kinds of heavy industry such as textiles and sugar. In fact, apart from two cement factories and a few workshops producing tiles and finishing materials, there is no building industry in the Sudan. There is no steel industry[1] for high-rise buildings and more than 60% of all the building materials such as timber products, roofing materials, joints, sanitary and electric equipment, and general items like glass, locks, paints and inner furniture are imported. These imported building materials are very expensive and far beyond the reach of the low and middle income groups; in addition they are not available constantly throughout the year because of seasonal interruptions of the Sudan Railways during the rainy season. There follows a brief history of the Sudanese building materials industry and suggestions on possible improvements.

6.9.1. Traditional Building Materials

According to Guarda, R.[2], 85.6% of Sudanese urban housing is built from traditional materials and only 14.4% is built from modern materails; this accounts for only 2% of the country's total housing stock. 73.4% of the stock built with modern materials is concentrated in the Capital, which means that by far the greater majority of the housing stock is built from tradtional materials, mainly adobe and mud "jalous" constructions.

Traditional building materials are available everywhere. They are relatively cheap compared with modern ones and have proved to be better thermally, since the thick mud walls heat very slowly and keep the cool air inside the houses for longer periods. By contrast modern building materials are found only in the major towns in small and fluctuating quantities. They are very expensive since they are generally imported.

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(1) Only in May 1976 did the Sudan Government, with the help of Japan, erect the first steel rods plant in the country.

(2) Guarda, R. op.cit.

6.9.2. Modern Building Materials

Modern building materials have only been introduced recently in urban Sudanese housing. Initially they were mainly used in high-income group housing, but demand for them has increased rapidly. Since the principal parts of housing constructions are generally traditional, modern materials are used chiefly in roof constructions, electrical and sewerage connections and internal fittings.

Modern Building Materials include:-

1. Concrete and concrete products such as prefabricated sheets, beams, columns. In first-class housing as much as 80% of modern materials may be used. Such houses are either built completely from concrete or with concrete foundations, columns, roofs, with red bricks or hollow-blocks walls.

2. Iron and steel - used as in reinforced concrete, as joists for Jack Arch roofing and for iron doors and windows or I-beams to support timber roofs.

3. Asbestos and zinc corrugated sheets used to roof second and third class houses.

4. Timber of different types and sizes used in doors, window frames and other fittings.

5. Glass for windows, doors and furniture.

6. Electrical products of all kinds.

7. Sewerage pipes, taps, joints.

The vast majority of these materials are imported in ever increasing quantities from outside the country. Although the southern part of the Sudan is very rich in good timber which can be transported very cheaply by means of the River Nile, timber products are still imported from Western countries and Russia. However, some materials such as cement, cement soild and hollow blocks, cement and mozaic tiles, prefabricated beams and columns and some paints are produced locally.

In short, modern materials in the Sudan are limited in both quantity and variety. There is complete lack of technical and traditional experience for their use in housing constructions. They are very expensive and can only be used by upper and high income classes. Moreover, they are not particularly suitable for the hot dry climate of the Sudan, partly because under the intensive solar heat and frequent dust storms their original colours soon fade.

6.9.3. Red Bricks

Red bricks are the next most common building material in urban Sudan. They are mainly used by high and middle income groups. Red bricks are available in three forms:-

1. Grey over-burnt bricks, rather misshaped. They are used in foundations, floors.
2. Well-burnt red bricks used for walls and floors.
3. Under-burnt yellow bricks used for secondary exposed works and internal partitions.

The dimensions of all types are around 24 x 12 x 6 cm.

Red bricks are manufactured manually using old traditional methods. A small amount of water is added to the dry Nile-silt with straw and dung. The mixture is well moulded and left for one day to ferment. In the next day it is again moulded and cut by hand into brick shapes using metal frames. The bricks are then left to dry under the sun and then burnt in primitive kilns using wood and dried reeds as fuel. After cooling they are classified according to the above stated standards.

Brick production depends heavily on weather conditions. During the rainy season, July-October, production stops completely, not only because the heavy rains wash away the clay bricks, but also because the River Nile floods and fills up all the clay production areas. When the rains stop, the river goes down leaving the brick production areas full of fresh dark silt.

During the rainy season bricks can be purchased only from producers who have withheld some of their stock from the previous season for speculative purposes. Since the amounts withheld are usually too small to satisfy the normal need for bricks, the increased demand substantially inflates brick prices in the rainy season, when they may cost 50% more than in summer.

High prices and reduced supplies rapidly reduce the rate of house production. Only the rich and high income groups can continue to build; the majority of house owners postpone building until the summer.

Even in summer when brick production is at its normal level, the prices drop but the supply is far less than the demand. There are two main reasons for this - postponement of building creates an extra demand and the producers withhold some production for speculation in the rainy season.

6.9.4. Cement

Cement is the most important building material and is essential not only for the major elements of a house but also for the manufacture of many ancillary items.

The first cement factory in the Sudan was established in Atbara town in the Northern province in the early seventies. After 1969 another factory was opened in Rabak, Blue Nile province. However, the production of these two factories is far too low to satisfy the growing demand for this material. The table below gives a clear illustration of the situation:

Table 36 Cement Production in the Arab World 1968.

Country	Size of Production in million tons
Egypt	3.147
Iraq	1.320
Morocco	1.011
Syria	0.917
Lebanon	0.906
Algeria	0.866
Tunesia	0.514
Jordon	0.381
Sudan	0.145

Source: Iraq Union of Manufacturing Industries 1970 Year Book.

The problem lies not only in the very low level of cement production, but also in the fact that there is great competition between the government and the private sector to purchase what is available. The government takes 80% of the cement production for such projects as dams, roads and government buildings leaving only 20% for the whole private sector.

The problem is further aggravated by the frequent delay in transporting the cement from Atbara and Rabak to the capital. The chief means of transport is the railway line which connects the Capital with Port Sudan (the country's only sea link). Since the same line carries the exports and imports for the whole country priority is always given to these products and very few trains are made available to deliver cement to the Capital. As a result, cement is cheap and available in production areas, but very scarce and very expensive in all other areas. Lack of availability of cement has become one of the chief contributing factors in the greatly reduced house production in the Capital in the last five years. Speculators have fully exploited the situation to sell in the black market at three or four times the normal price. The Ministry of Construction and Public Works gave the following prices of the cement in the recent years.

Table 37 Recent Cement Prices in the Three-towns Capital

Year	Price per Ton in L.S. Sudanese Pounds
1970	15
1971	18
1972	20
1973	25
1974	30
1975	40
1976	55

Source: M.S. Badry. Ministry of Construction and Public Works.

The situation is now so bad that it is often difficult to get cement at any price, even on the black market.

6.9.5. Main Problems of Building Materials.

1. Inadequate public and private investment. Lack of research facilities to improve and develop local traditional materials.

2. Seasonal fluctuation in production and frequent cuts and damages of the railway line always force up prices in Khartoum.

3. Manual production and absence of standardization and specification in local and imported materials. This is best described in relation to local materials by Mohammed M. HAMDI (1):

> "The uncontrolled quality and size of materials leads to high percentage of waste when selecting or cutting to shape various materials in the site. Very few building items are factory manufactured and thus each tradesman wastes effort and material to match the various components".

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(1) Mohammed M. HAMDI: "Cost Generators and Methods of Control in the Building Industry in the Sudan". National Research Council. Khartoum, December 1974.

5. Ineffective government measures to control prices and stop speculation. Government intervention has aggravated the problem because instead of enforcing suitable prices or encouraging competition between the merchants, the low prices enforced by the government encouraged merchants to hoard their stocks, thus encouraging the black market.

6.9.6. General Recommendations.

1. Government must heavily invest in technical assistance and scientific research not only to improve traditional building techniques and develop the local materials, but also to promote the efficiency and economy of their use.

2. To reduce the effect of extreme weather conditions and stop seasonal fluctuations in bricks production, semi-mechanized kilns must be introduced. The government must also help equip producers with the necessary drying machinery and adequate warehouse facilities.

3. Every effort must be made to solve the transportation problem of imported materials from Port Sudan and cement from Atbara and Rabak. The completion of the new motorway between Port Sudan and Khartoum next year will probably alleviate this problem by allowing more trains to be made available to deliver the cement from Atbara.

4. Effective government measures must be taken to stop speculation in building materials. It would be better to increase competition between the producers and merchants rather than to enforce low prices which only leads to hoarding.

CHAPTER 7

A PROPOSAL FOR HOUSING STANDARDS ACCORDING TO INCOME GROUP

7.1. The Capital's Current Housing Standards

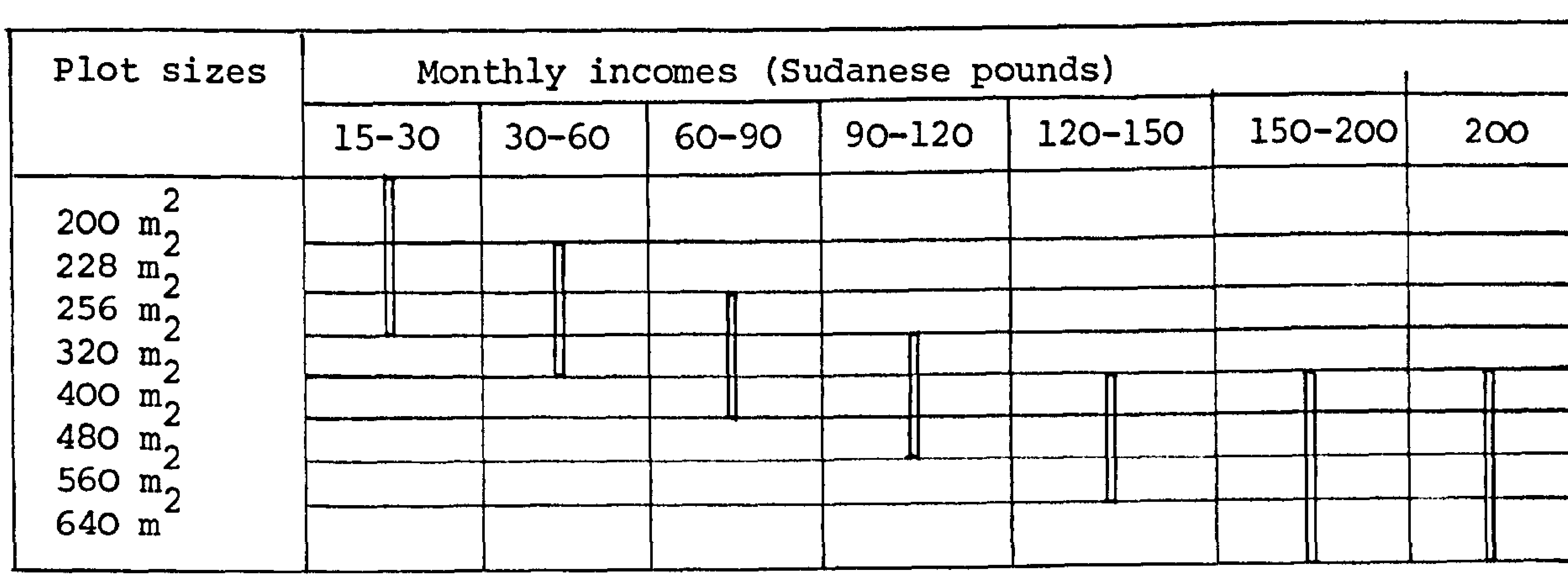
In addition to differences in building materials and infrastructure services, Capital's housing standards differ in plot sizes:-

3rd class housing plots	300-400 m^2
2nd class housing plots	400-600 m^2
1st class housing plots	600-1000 m^2 (1)

Plot sizes are based not on the demographic needs and life cycle of the urban family, but on its economic ability, and this is one of the main reasons for the Capital's excessive horizontal expansion discussed previously.(2)

To check this expansion and to achieve a higher density, the New Housing Policy for the years 1975/80, suggested the following plot sizes for the different income groups:-

Table 38.



Source: New Housing Policy 1975/76 page 23.

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(1) Town Planning Regulations. Khartoum. op.cit.

(2) See Chapter 2 Capital's Excessive horizontal expansion.

Although, for the first time, demographic needs are taken into consideration when distributing housing plots, it is quite clear that the high income groups will still have large housing plots merely because of their high economic ability.

Like the previous policies, the New Housing policy only went as far as the distribution of bare housing plots and suggested that housing constructions should be left entirely to individual owners. With the recent inflation in costs building materials and the present economic hardship, this simply means that the few low-income groups who receive housing plots will inevitably not be able to build on them.[1]

The most useful suggestion incorporated in the New Housing Policy is that the quality of the housing standards should be lowered in order to bring them, to some extent, within the economic means of the different income groups. Instead of concrete roofs, it is suggested that 1st class houses can be built with permanent modern materials such as red bricks with cement mortar, blocks etc. 2nd class houses can be built with Gishra constructions (inner layer of bearing walls from mud and the outer layer from red bricks), with corrugated sheet roofs and cement tile floors. The 3rd class houses can be built from mud construction with traditional roofs and brick floors.

In these circumstances the best solution is that which, after plot distribution, helps the occupants materially and guides and supervises all the construction procedures until the owners settle in their new houses. To achieve this a policy must be devised which will combine both the government's and the individual owners' efforts and resources.

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(1) See page 51 The Capital's Housing Problems

7.2. Proposed Housing Standards

Detailed house designs are outside the compass of this research but examples of housing standards are suggested to show how Khartoum's low income groups' housing problems can be solved. The ideal solution can of course only be provided by an experienced designer who is fully aware of the background, aspirations and cultural traditions of the occupants.

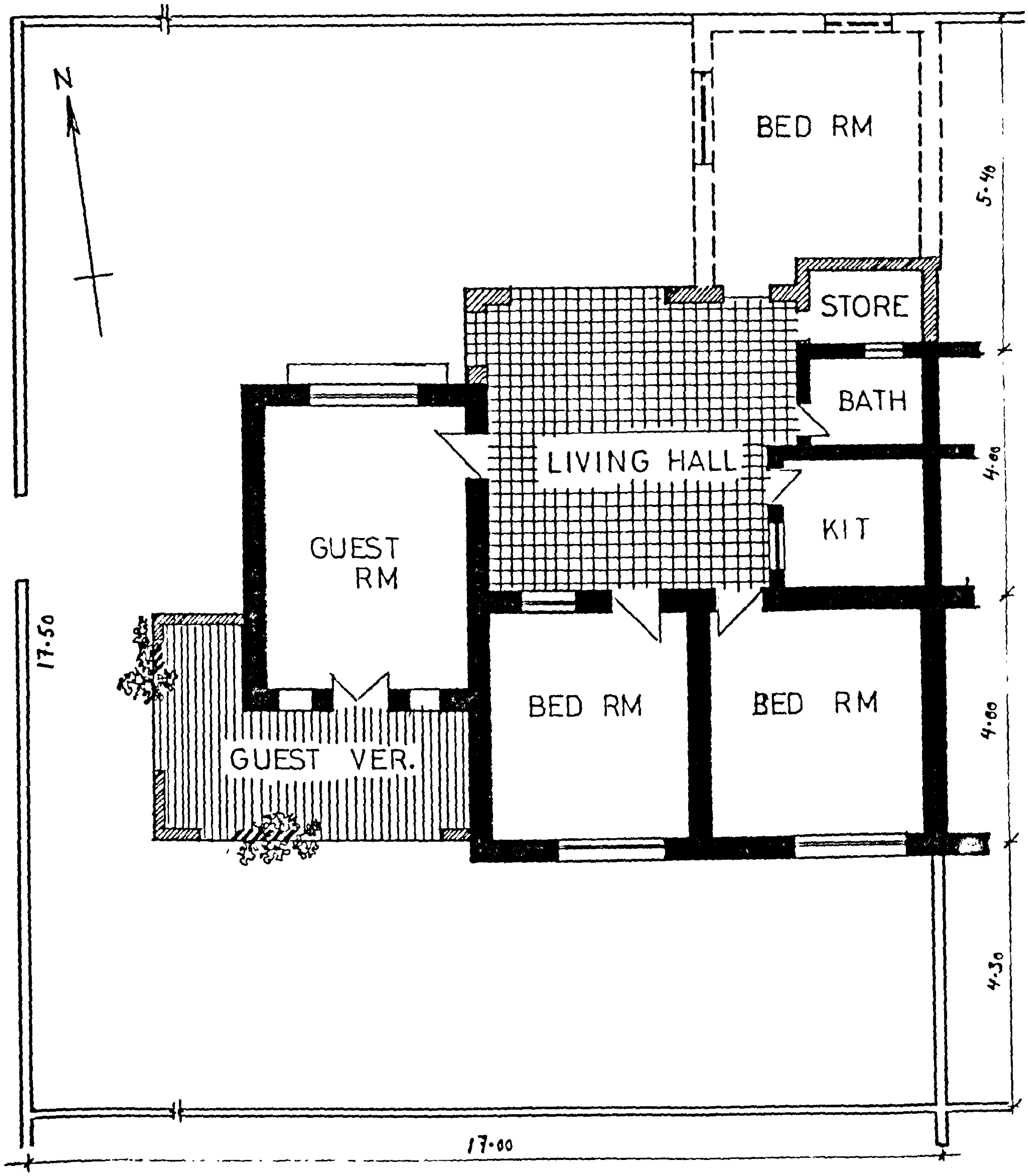
However, the most urgent need for the Capital's low income groups is to find housing within their means. It is always the case that in low-cost housing construction there is a conflict between rising social aspirations on one side and strict cost limits on the other. If the housing standards are forced too high, then the unit cost will be too great a burden for the tenants to bear. If standards are too low, the house plan becomes so restricted that family living is impossible or the health of the occupants is adversely affected.

Because of the wide gap between the ability to pay of the majority of poor families and the cost of the minimum socially acceptable dwelling, the standards proposed here are based on the occupants' economic ability plus their potential for contributing labour to the project.

The housing standards for high and middle income groups immediately satisfy most of their needs, but for the lower income groups the houses begin with the construction of minimum essential living areas, the rest parts of the house being constructed gradually as the economic ability of the family improves. This gradually improving standard of housing seems to offer the best solution because it demands far less initial investment compared with traditional complete houses.


HIGH INCOME GROUPS' HOUSING
20.00
20.00
18.00
18.00
N
GUEST VER
4.00
3.50
BED RM
BED RM
BED RM
GUEST RM
BATH.
KIT.
SLEEPING TER.
1st STAGE AREAS
ROOFED 64.7 m²
PLOT 360 m²
DENSITY 15 d/ac
CONST STAGES
1st STAGE
2nd STAGE
STREET
1:100
Scale

MIDDLE INCOME GROUPS HOUSING



1ST STAGE AREAS

ROOFED 55·3 m^2

PLOT 300 m^2

DENSITY 15 d a

CONSTRUCTION STAGES

First STAGE

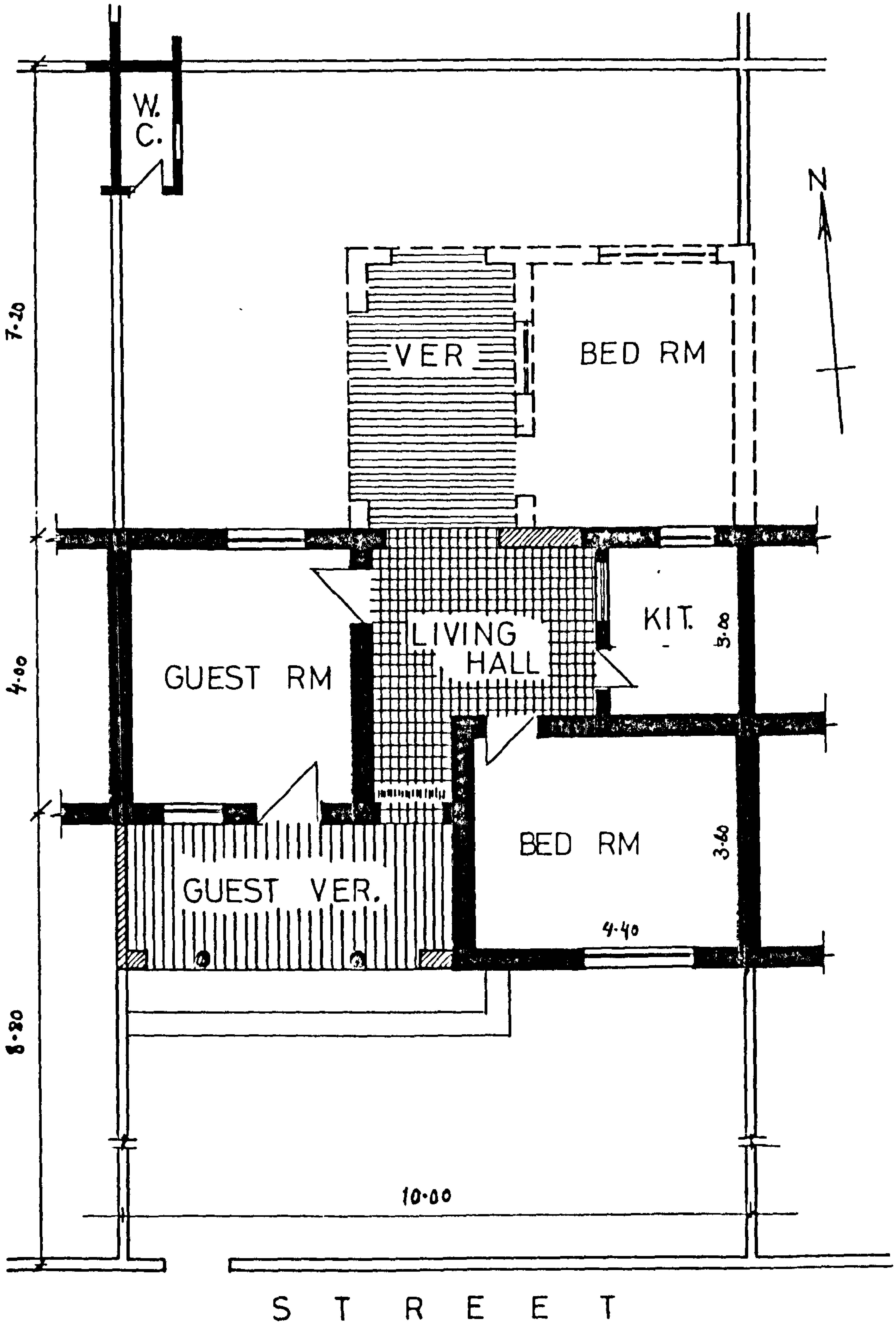
Second STAGE

Third STAGE

1:100

Scale

LOW INCOME GROUPS' HOUSING



1ST STAGE AREAS

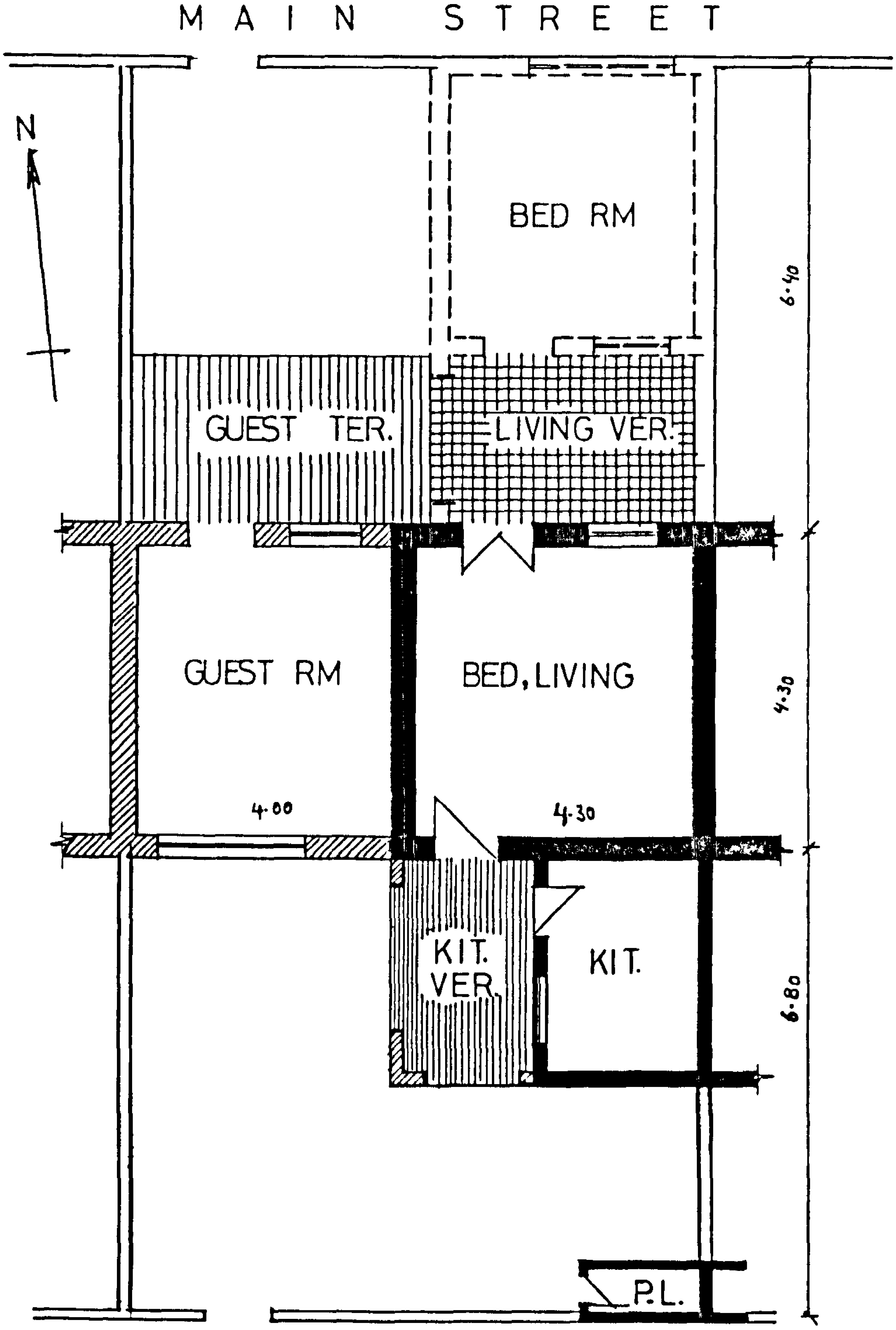
ROOFED 39 m²
PLOT 200 m²
DENSITY 25 d/a

CONSTRUCTION STAGES

First STAGE
Second STAGE
Third STAGE

1:100
Scale

LOWEST INCOME GROUPS' HOUSING



1ST STAGE AREAS

ROOFED AREA 288 m^2

PLOT AREA 150 m^2

DENSITY 34 dwg/ac

CONSTRUCTION STAGES

First STAGE

Second STAGE

Third STAGE

Spatial Dimensions of the Proposed Housing Standards

A. Initial Stage Areas

Table 39

Type of Dwelling	Built up Areas				Roofed Area	Plot Area	Av. Persons accom.	Av.dwg. size	Av.Occup. rate
	Guest Room	Main Bd/rm	Bed Rm	Bed Rm					
High income groups	20.7	14.4	14.4	-	64.7	360	4	3.25	1.23
Middle income gps.	16.3	16.0	13.6	-	55.3	300	4.9	3.2	1.53
Low income groups	14.4	16.2	-	-	39	200	5.9	2.15	2.74
Lowest income gps.	-	17.6	-	-	26.8	150	4 (1)	1.15	3.47

B. Final Stage Areas

Table 40

Type of Dwelling	Built up Areas				Roofed Area	Plot Area	Av. Persons accom.	Av.dwg. size	Av.Occup. rate
	Guest Rm	Main Rm	Bed Rm	Bed Rm					
High income groups	20.7	14.4	14.4	14.4	80.1	360	4	4.25	0.94
Middle income gps.	16.3	16.o	13.6	13.6	95.5	300	4.9	4.2	1.16
Low income groups	14.4	16.2	13.6	-	73.4	200	5.9	3.15	1.87
Lowest income gps.	16.8	17.6	13.6	-	62.6	150	6.4	3.15	2.03

(1) Most of the lowest income groups are rural immigrants recently arrived in the Capital. Initially they usually leave their elder children in the home lands. This occupancy rate is based on the initial stage but causes no problem since most of living functions are performed outdoors. After the completion of the house their occupancy rate is 2 persons/dwelling.

7.3. Comparison of the Proposed Housing Standards with the Capital's current Standards.

1. High Income Groups' Housing Standards

Table 41.

	Present Standards	Proposed Standards
Av. household size	4.0 persons	4.0 persons
Av. occupancy rate	1.25 persons/rm	0.94 persons/rm.
Av. dwelling size	3.2 rooms/dwg.	4.25 rooms/dwg.
Roofted area	55 m^2	80.1 m^2
Plot area	800 m^2	360 m^2
Net dwelling density	5.1 dwg/ac.	11.24 dwg/ac.
Net population density	20.4 persons/ac.	45 persons/ac.

2. Middle Income Groups' Housing Standards

Table 42.

	Present Standards	Proposed Standards
Av.household size	4.9 persons	4.9 persons
Av.occupancy rate	1.75 persons/rm.	1.16 persons/rm.
Av.dwelling size	2.8 rooms/dwg.	4.2 rooms/dwg.
Roofed area	44.8 m^2	90 m^2
Plot area	500 m^2	300 m^2
Net dwelling density	8.1 dwg/ac.	13.5 dwg/ac.
Net population density	39.7 persons/ac.	66 persons/ac.

3. Low Income Groups Housing Standards

Table 43.

	Present Standards	Proposed Standards
Av.household size	5.9 persons	5.9 persons
Av.occupancy rate	2.95 persons/room	1.87 persons/room
Av.dwelling size	2.0 rooms/dwg.	3.15 rooms/dwg.
Roofed area	30 m^2	73.4 m^2
Plot area	350 m^2	200 m^2
Net dwelling density	11.6 dwg/ac.	20.2 dwg/ac.
Net population density	68 persons/ac.	119 persons/ac.

4. Lowest Income Groups Housing Standards

Table 44.

	Present Standards	Proposed Standards
Av.household size	6.4 persons	6.4 persons
Av.occupancy rate	3.5 persons/room	2.03 persons/room
Av.dwelling size	1.8 rooms/dwg.	3.15 rooms/dwg.
Roofed area	29 m^2	62 m^2
Plot area	300 m^2	150 m^2
Net dwelling density	13.5 dwg/ac.	27 dwg/ac.
Net population density	86 persons/ac.	172 persons/ac.

7.4. Response of Proposed Standards to Occupants' Needs

The proposed housing standards are based on the satisfaction of the different urban family needs, but because the low income groups, account for the overwhelming majority of the Capital's population it is worthwhile looking at their standards to see how far they satisfy the Sudanese family's socio-economic and comfort requirements.

a) Satisfaction of Thermal Comfort

In Chapter 3 the basic requirements for thermal comforts in houses in Khartoum were discussed. Almost all these requirements are incorporated in the housing standards suggested above, which are intended to give protection against the natural factors such as solar heat, rain, dust and insects. The lower income housing is a terrace type which eliminates the heat gain from the east and west wall. (See the sketch plan).

Better thermal comfort could be achieved by the use of modern building materials and advanced techniques but these are too expensive to be applied in to housing of this type, and the aim should be to achieve comfortable conditions cheaply by the use of the traditional building materials and local techniques. Two simple but effective measures are correct orientation(1) and the use of external white wash. In addition, the front and the back house compounds not only facilitate cross ventilation, but also offer the possibility of growing trees and vegetation to produce enough shade to modify the environment.

Finally, housing of all standards is designed to have verandahs when complete; the importance of verandahs in Sudanese domestic life is discussed elsewhere.(2)

A summary of thermal comfort requirements and their satisfaction is shown on the following sketch plans.

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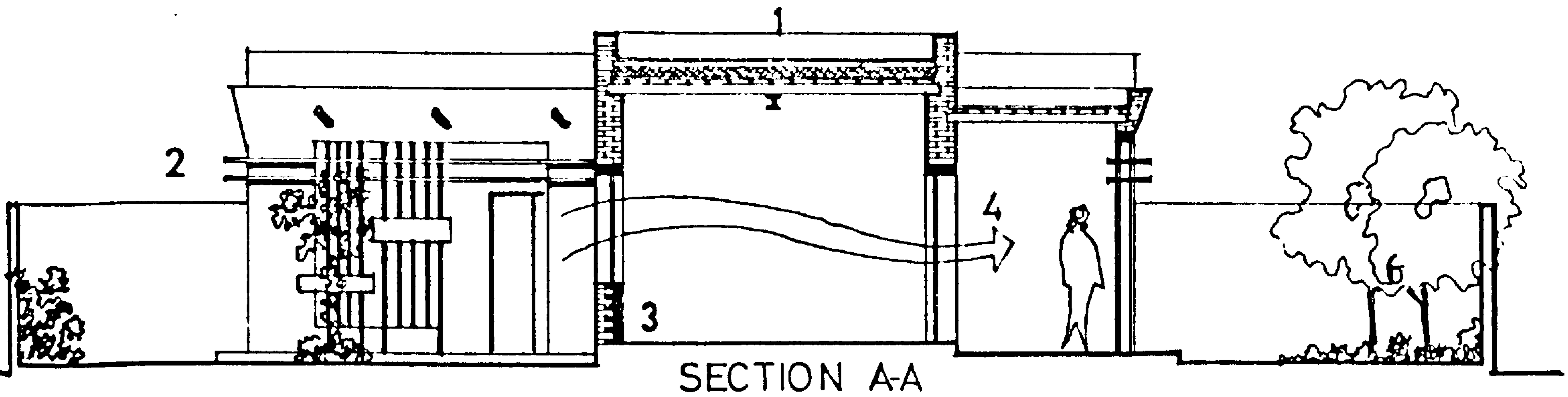
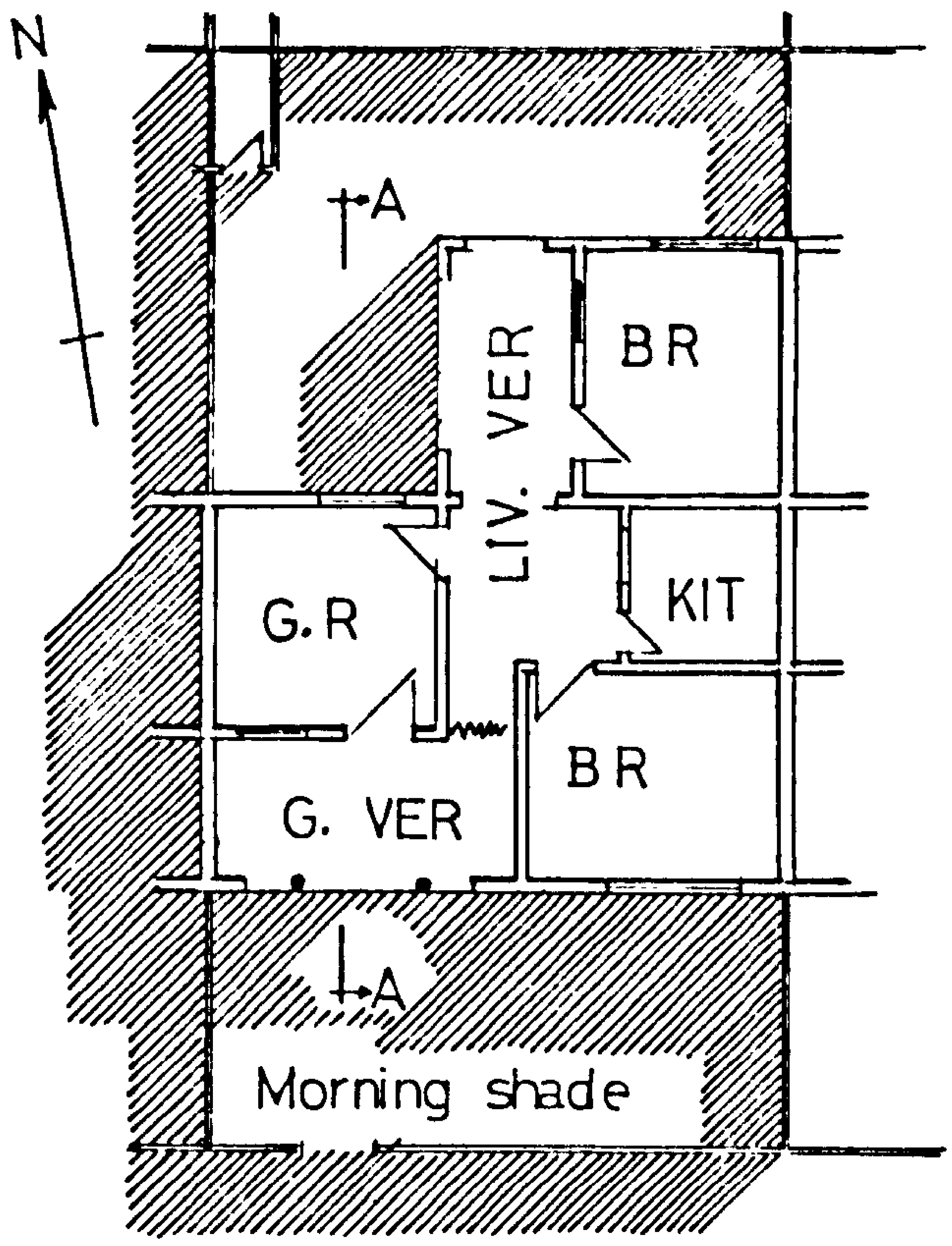
(1) See Chapter 3, Computer analysis for best housing orientation in Khartoum. Page 140

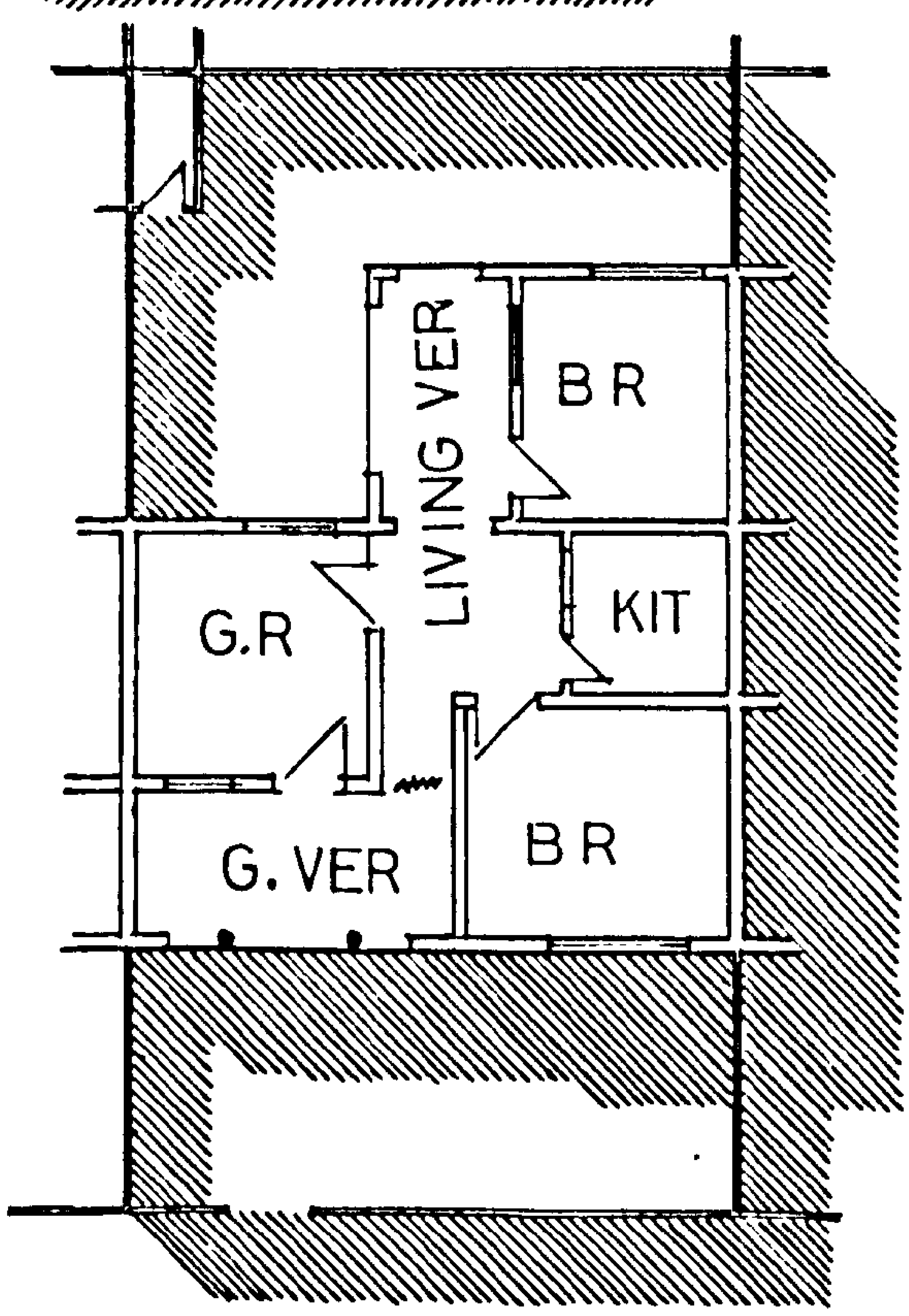
(2) See page 183

THERMAL COMFORT SATISFACTION



SECTION A-A





Afternoon Shade

1. ROOF CONSTRUCTION
   White wash
   Plastered R.Bricks layer
   Straw Insulation
   R
   Timber Boarding
   Timber Rafters
   I-beam

2. Hor. Sun breakers & Ver Perg protect Ver from Morn Sun

3. Gishra Construction:
   R.Bricks from outside
   Adobe Br. from inside
   damp heat

4. Cross Ventilation

5. Outdoor Living areas protected from both morning & evening Sun

6. Trees

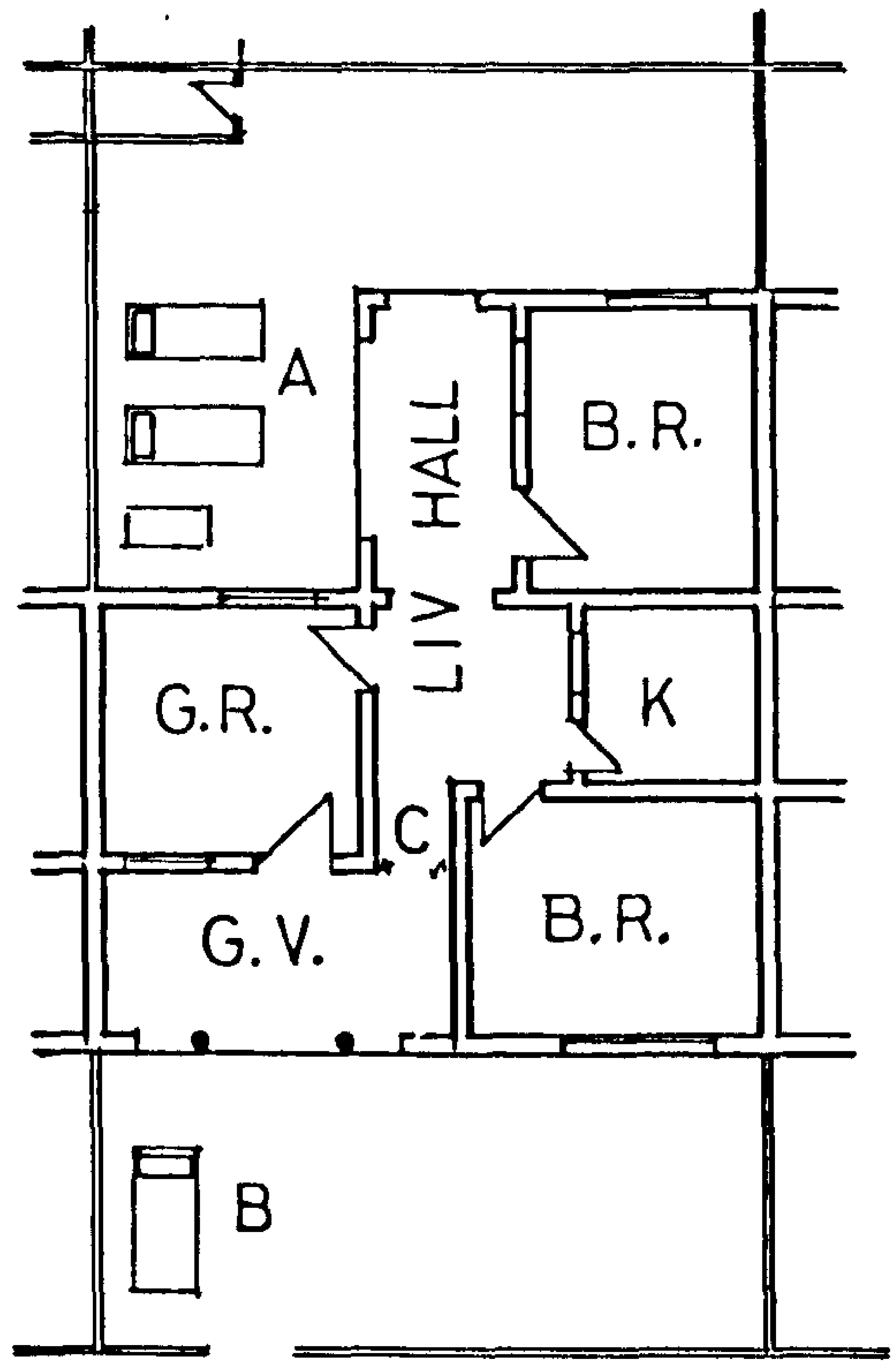
b) Satisfaction of Family Social Needs

In Chapter 4, it was pointed out that any housing design must satisfy two basic social needs i.e., privacy for women and their seclusion from occasional guests and passers-by, and the provision of separate guest reception areas.

The following sketches show that these requirements are met by the proposed housing provision. The first plan shows normal family life when most of the living functions are performed in the inner family compound in the living rooms, living hall, the inner veranda and the inner compound. Adult male members may use the guest room and veranda for occasional afternoon siesta. At night, the family sleeps in the inner compound, with special outdoor sleeping arrangements where there are adult daughters. Adult sons sleep in the outer guest compound.

The second plan shows how family functions are performed in the presence of guests. Occasional guests are usually received in the guest room and or verandah. Since guests normally come in the afternoons and evenings, they are also received in the outer guest compound. In the case of female guests, they might be received in the guest room or more likely they stay in the living hall and the inner compound with the wife of the house. In case of male guests, they use the guest room and compound and the family performs its normal living in the inner quarters once the curtain or door, which separates the two areas, is closed. If the guests are to sleep in the house, they use the guest veranda or the outdoor guests compound.

SATISFACTION OF SOCIAL FAMILY NEEDS



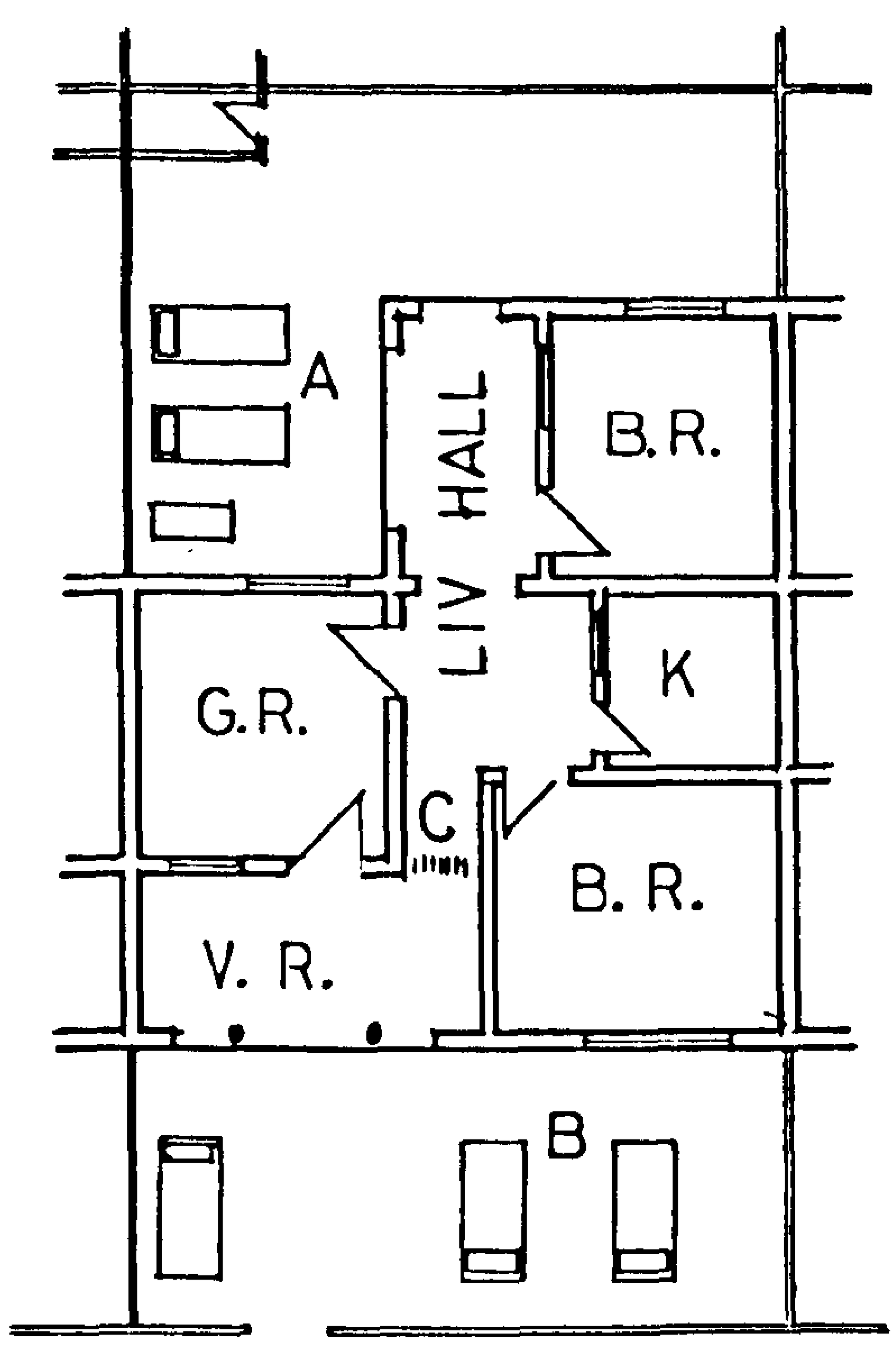
1. Normal Family Living Functions performed in inner living quarter
2. Guest Rm.& Ver. used for Adult males afternoon seiesta
3. Family sleeps in inner out door compound- adult sons in Guest compound.

A- Family sleeps out door

B- Adult son in Guest comp

C- Curtain open

NORMAL FAMILY LIVING



1 Female Guests received in both Guest Rm.Ver. or Inner Compound

2 Mixed Guests :

Males in G.Rm.,Ver.
Females in Liv. Hall & Inner comp.

3 IF Guests sleep in the house they use Guest comp.

A- Family sleeps in inner com.

B- Guest & Adult sons sleep in Guest comp.

C- Curtain closed

GUESTS IN THE HOUSE

c) Satisfaction of Future Expansion Possibilities

The housing lay-outs proposed are sufficiently flexible to allow expansion to satisfy the family social aspirations and future demographic and life cycle needs. The rear and front open compounds, provided in every case not only give room for normal family living and provide separate arrangements for outdoor sleeping, but they are also meant to accommodate future expansions as needs arise and resources become available.

It should be noted that extensions can be built without blocking up the light or ventilation to any of the existing rooms, and without any 'party wall' problems with the neighbours.

See the plans on page 300 303 which show the future stages of expansion in each housing type.

7.5. Cost Analysis of Proposed Standards

Costs of labour and building materials in the Sudan have increased so much in the last few years that building of new housing has become a very difficult problem even for high income groups. The factors which led to this have already been discussed.(1)

The New Housing Policy gave the following prices for the different standards of housing built in Khartoum in 1973(2)

1. 1st class houses for high income groups modern materials, concrete roofs	=	70	Sudanese Pounds/m^2 roofed area
2. 2nd class houses for Middle income groups bricks, corrugated sheets roofs	=	40	"
3. 3rd class houses for low income groups Gishra walls, traditional roofs, brick floors	=	20	"
4. 4th class houses for lowest income groups mud walls, traditional roofs	=	15	"

(1) See Chapter 6 Building Materials Industry in Sudan page 289

(2) New Housing Policy op.cit. Page 35.

Table 45 The current housing costs in 1978 in Khartoum are supplied by the Ministry of Construction and Public Works.

		Cost of 1sq.metre in Sudanese pounds
1.	High income groups housing	= 80
2.	Middle income groups housing	= 55
3.	Low income groups housing	= 40
4.	Lowest income groups housing	= 30

Source: Hassan M. ELZubeir : Ministry of Construction & Public Works Khartoum. January 1978.

The above costs are based on the current Municipal by-laws which approve no common walls between two next door neighbours, and take into consideration the present high infrastructure costs and large boundary walls brought about by the present policy of oversized housing plots.

The standards being proposed are based on reasonable housing densities and acceptable urban services, taking into account the present hardship of both the government and the general population. The proposed houses for high and middle income groups are to be built from modern imported or local building materials with the possibility of using both concrete and timber roofs. Services are to include water, electricity, paved main roads - others gravelled, covered drainage, sewerage pipes or a group of houses to share one septic tank, street lighting and tree planting. The housing for the lower income groups is to be constructed from traditional "Gishra" and "jalaus" mud construction with traditional roofs. The services include water, electricity, gravelled roads, open-ditch drainage, individual pit latrines, street lighting and tree planting by campaign. After the initial stages, both the houses and the standard of services will be gradually improved as the economic ability of government and population improves.

Present costs of infrastructure services in the Capital and the cost of the proposed housing standards are set out in the following tables:

Table 46. Estimated Costs of Proposed Housing Standards

Dwelling Types	Area x sq.m.cost	Cost per house (in Sudanese pounds)
High income groups housing	$64.7m^2$ x Ls80	5,176
Middle income groups housing	$55.3m^2$ x 55	3,041.5
Low income groups housing	$39m^2$ x 40	1,560
Lowest income groups housing	26.8 x 30	804
	(1)	

The current prices of the cost of infrastructure services are given by the New Housing Policy as follows:

Table 47. 1976 Costs of Infrastructure Services (in Sudanese pounds)

	High income groups	Middle income groups	Low income groups	Lowest income groups
Nominal Land cost (2)	48	24	12	-
Essential infrastructure services	800	340	75	40
Health services & Garbage	10	10	10	10
Water production,distribution	300	180	120	60
Electricity production,distrib.	67	64	60	40
Administrative fees	10	5	1	-
Total	1,235	623	278	150

Source: New Housing Policy op.cit. page

(1) For areas see page 304 prices page 312
(2) 90% of the land in the Sudan is public and so the government used to distribute housing plots at nominal prices.

Table 48 Overall Costs of the Proposed Housing Standard (in Sudanese Pounds)

	Costs of Construction + Services	Total Unit Cost
High income groups' housing unit	5,176 + 1,235	6,411
Middle " " " "	3,072 + 623	3,665
Low " " " "	1,560 + 278	1,838
Lowest " " " "	804 + 150	954

The following chapters will discuss how the Capital's different income population groups, with their present financial abilities and non-monetary resources, can afford the initial stage of the housing proposals.

7.6. Conclusions

Low-cost housing has been tackled by many countries in different ways according to local economy, social habits and available materials. The house standards proposed do not follow the usual procedure of reducing the dwelling areas and the quality of building materials, but give flexible quality low-cost housing which begins with minimum areas but gradually develops to satisfy all the occupants needs as their economy improves.

All the types proposed have verandahs as part of the first building or to be built in the immediate second stage, because of their importance for many family living functions. The main bedrooms are bigger since they are likely to be used for other living purposes as well; the guest rooms which are normally large, expensive, but very little used, have been reduced in size.

The optimum density is that which not only economizes on land use but gives the minimum total unit cost. The standards proposed have a far better density rate than the Capital's current low level which has led to its present excessive horizontal expansion. The higher housing and population density is combined with the provision of a greater roofed area and a smaller occupancy rate per room. If the average present housing density in the Capital is 10 dwellings per acre i.e. 54 persons per acre, the proposed standards give a density of 18 dwellings per acre and 101 persons per acre.

If this system were applied it would not only save valuable urban lands, but it would also bring overall housing costs within the reach of the various income population groups, especially the low incomes, because, unlike the buildings allowed by the present municipal by-laws, it is based on detached and semi-detached housing which allows common walls between neighbours. This reduces the cost of the boundary walls and greatly economizes on the infrastructure services.

It is also recommended that the current policy of wide roads and large neglected open spaces between the houses be reviewed. Roads should be just wide enough to satisfy the access requirements and the open spaces small enough to make their maintenance as easy job and to encourage the immediate neighbours to look after them.

High rise housing is not proposed for many reasons.

1. An American study showed that building costs per sq.ft. rise from \$20 to \$36 as building height increases. (1)

2. A Scottish housing study showed that maintenance costs per dwelling unit in 1970 were £8.39 for low buildings and £21.35 for towers. This evidence has been sufficient for the British not to encourage the building of high-rise public housing on a large scale. (2)

The costs of high-rise housing in the Sudan would be even higher because of inexperience, lack of modern building materials and shortage of adequate foreign resources. For these reasons only two or three-storey housing is recommended for the Capital's high income groups, while one-storey housing is proposed for the great majority of the population. Furthermore, low-rise houses give better opportunities for close social contact and can easily be erected on a self-help basis.

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(1) C. Alexander, S. Angel, M. Silverstein, S. Ishikawa and D. Abrams. "The Oregon Experiment" N. York, Oxford University Press 1974. Table 3.2 : Cost per sq.ft. of net usable space.

(2) Pearl Jephcott with Hilary Robinson. Homes in High Flats : Some of the Human Problems involved in Multi-storey Housing. Edinburgh, University of Glasgow, 1971, p.128.

Finally, to encourage the population groups to enjoy better urban facilities and to strengthen the social relations between the whole community, integral social neighbourhoods are recommended in which different housing standards are carefully placed together rather than following the current policy of segregating different income groups into separate residential areas.

CHAPTER 8

KHARTOUM'S HOUSING NEEDS 1980-1990

8.1 Projected Population 1990

The New Housing Policy for the years 1975/80 shows that the average percentage rate of population increase in the Three-towns Capital was 5.7% in 1956/65.[1] In 1965/73 this rate went up to 7.8%. If we take the yearly percentage of population increase due to natural growth to be 2.2%[2], then the rate of population increase due to migration is 5.6% yearly, which is a very high rate which results in a growing number of homeless people in the Capital.

The New Housing Policy gives the following table for population increase in the Captial:-

Table 49 Rate of Population Increase due to National Growth & Migration

	Population 1955/56	64/65	72/73	Yearly Rate of Increase 55/56	55/73	Yearly Migration Rate of increase
				%	%	%
Three-towns Capital	258576	438010	798593	6.8	6.9	4.7

Source: New Housing Policy 1975/80 page 16.

Rate of Migration Increase up to 1990

It is presumed that this rate of 4.7% increase in Capital's population number will continue up to 1980; after that, it is assumed that the different industrial plants being built by the Government in many rural areas will reduce the yearly rate of rural migrators to the Capital as follows:-[3]

(1) New Housing Policy 1975-80 op.cit.

(2) 1973 Population Census Dept. of Statistics Khartoum.

(3) See review of these plants on page 349

Rate of migration increase by 1980 will be 3%
by 1985 it will be 2.5%
and by 1990 it will be 2.0%

Increase of Capital's population due to Migration:

Capital's population in 1973	=	784294	(1)
Population increase by 1978 (4.7%)	=	184000	
Capital's migrators by 1980 (3.0%)	=	165000	
Capital's migrators by 1985 (2.5%)	=	240000	
Capital's migrators by 1990 (2.0%)	=	270000	

Population Increase due to Natural Growth

Capital's yearly Natural Growth rate of population = 2.2% (1)

Natural increase by 1978	=	86000
Natural increase by 1980	=	125000
Natural increase by 1985	=	210000
Natural increase by 1990	=	300000

Table 50. Overall Capital's Population Increase (Migration + Natural)
(in thousands)

Capital's population 1978	785 + 184 + 86	1,055
Capital's population 1980	785 + 165 + 125	1,075
Capital's population 1985	785 + 240 + 210	1,235
Capital's population 1990	785 + 270 + 300	1,355

8.2 Projected Housing Stock 1990

Capital's housing stock by 1973 = 95376 houses (2)
Number of households in Capital 1973 = 132380 houses (3)
Average household number is 5.9
Capital's housing Deficit by 1973
132380 - 95376 = 37004 houses

(1) 1973 population census

(2) New Housing Policy .... op.cit page 12

(3) 1973 population census

Increase in Capital's Housing stock 1973-75

Due to the hardships felt in the Capital between 1973-76, housing production was at a minimum. Because of inflation in prices especially those of building materials, only the high income groups were able to build houses, and even then with great difficulty. This phase (and even the present day) is characterized by lack of building materials, especially cement and imported materials due to the bottlenecks in transportation from Atbara and Port Sudan respectively. In this period the cost of some building materials was multiplied, and for some materials, like cement, the inflation rate was more than 150%. For example, the cost of a ton of cement rose from L.S.15 (Sudanese pounds) in 1972 to L.S.35.0 in 1975. Even with 100-120% increase there are scarcely any building materials on the market and the population has been forced to rely on the black market.

From the records of the Municipalities in the Three towns, the new houses added to the Capital's stock can be worked out as follows:-

Table 51. Capital's Housing Stock added between 1973-75.

	1st class houses	2nd class houses	3rd class houses	Total
Khartoum	Greif West 800	Arkaweit 500	- -	1300
Omdurman	El Thaura 500 Old town 100	Aburuaf Beit Elmal 500		1100
Khartoum North	Kobar 300	Shambat 300		600
Capital's Total	1700	1300		3000

Stock added due to the application of the New Housing Policy:

The New Housing Policy is expecting to distribut 15,920 plots (1) in the Capital by 1975 and the same number by 1976, but for the reasons discussed in this Chapter and previously (2), only 25-30% of that amount might be built. The most optimistic estimate would be that 35% of the total will be added to the Capital's housing stock by 1976 and 79.

(1) New Housing Policy page 17 op.cit.

(2) See Chapter 2 = Capital's Housing Problems.

1976 new houses 35% of 15920	=	5,572	
1977 new houses	=	5,572	
New stock added due to the New Policy	=	11,144	= 11,200

Overall Capital's Housing Stock

Stock by 1973	95,376	(1)	
Estimation of stock added 1973-75	3,000	(2)	
Estimation of stock to be built due to the New Housing Policy	11,200		
Capital's Housing Stock by 1978	109,576	=	110,000 houses

Housing stock required by 1978 1055,000 - 5.9	=	180,000	houses
Existing stock by 1978	=	110,000	"
Overall Housing deficit by 1978	=	70,000	"

8.3. Projected Housing Deficit 1990

Housing deficit by 1980	=	72,000	houses
Housing deficit by 1985	=	100,000	"
Housing deficit by 1990	=	118,000	"
Substitute caused by time and damage 2.5% of 1978	=	2,000	"
Overall Capital's Housing Deficit by 1990		120,000	"

Analysis of Capital's Population according to their Economic Ability

In 1972, Guarda,R.I.(3) analysed the Capital's population by incomes and earning capacity as follows:-

1. High income groups 2% of Capital population
2. Middle income groups 8% of Capital population
3. Low income groups 56% of Capital population
4. Lowest income groups 34% of Capital population

In the New Housing Policy(4), Capital's population is analysed in 1975 as follows:

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(1) New Housing Policy page 12.

(2) See page 319.

(3) Guarda, R.I. .... op.cit page 40

(4) New Housing Policy .... op.cit page 6.

Table 52. Distribution of Capital's Population by Income

	Av.annual Income (Sudanese pounds)	100%
High income groups	1200 and above	5
Middle income groups	600-1200	10
Low income groups	300- 600	50
Lowest income groups	300 and under	35

Source: New Housing Policy 1975/76 Khartoum.

Possibly difference between the two estimates stems from the movement of some people from the low income groups to the Middle and High income groups because of wage increased.

Table 53. Breakdown of the Capital's Housing Deficit according to income groups

High incomes	Middle incomes	Low incomes	Lowest income	Total
5% 6,000	10% 12,000	50% 60,000	35% 42,000	100% 120,000

8.4. Additional Resources Required to Satisfy Housing Requirements by 1990.

8.4.1. Introduction

As already shown, the Capital's housing deficit by 1990 will be 120,000 houses. Obviously the government cannot satisfy all these housing needs in one attempt; this would not only cause bottlenecks in building materials, labour, imported components etc., but it would also seriously affect other development projects requiring government money.

8.4.2. Stages of Housing Satisfaction.

For these reasons, the Capital's housing deficit must be satisfied in stages up to 1990.

1978	10,000 houses		
79	10,000 "		
1980	10,000 "	=	30,000 houses by 1980
81	9,000 "		
82	9,000 "		
83	9,000 "		
84	9,000 "		
1985	9,000 "	=	45,000 houses by 1985
86	9,000 "		
87	9,000 "		
88	9,000 "		
89	9,000 "		
1990	9,000 "	=	45,000 houses by 1990
Total	120,000		

8.4.3. Breakdown of Houses Needed in Each Stage by different income groups

Table 53.

	High income 5%	Middle income 10%	Low income 50%	Lowest income 35%	Total houses
1980	1500	3000	15000	10500	30000
1985	2250	4500	22500	15750	45000
1990	2250	4500	22500	15750	45000
	6000	12000	60000	42000	120000

8.4.4. Analysis of Total Investment needed to meet the Capital's Housing Problem.

From page 314 the costs of the proposed housing units for the Capital's different income groups are:

1. High income groups' housing unit = L.S. 6411 (Sudanese pounds)
2. Middle income groups' " " = L.S. 3665
3. Low income groups' " " = L.S. 1838
4. Lowest income groups' " " = L.S. 954

Table 54. Overall Investment Needed to solve the Capital's Housing Problem. (in thousands Sudanese pounds)

	High income groups	Middle income groups	Low income groups	Lowest income groups	Total
1980	9,617	10,995	27,570	10,017	58,199
1985	14,425	16,492.5	41,355	15,025.5	87,298
1990	14,425	16,492.5	41,355	15,025.5	87,298
	38,467	43,980	110,280	40,068	232,795

8.5. Analysis of Required Resources

8.5.1. Contribution of Different Income groups to satisfy their Housing needs.

a) High Income Groups

- Their percentage is 5% and income L.S. 1200 and above yearly.
- They are government officials, managers, top staff in companies, banks, trade and industry.
- They occupy at present the Three-towns 1st class housing areas.
- Used to solving their housing mainly from their own resources plus loans from Estate bank, government, trade and industry.

- The government should encourage these high income groups to continue to solve their housing problems from their own resources plus loans from banks etc.
- They should be encouraged NOT to manage the housing constructions themselves, but to build through CO-OP's and N.P.H.A's, since these associations are more likely to produce quickly-built, well-organised housing of good quality.
- ONLY little direct government help, in the form of services, land, technical help etc., is to be offered to these high income groups, but the government MUST make sure that all necessary

building materials are consistently available.

- High income groups should be encouraged to save for housing, in advance, before they are allowed to get involved in the actual building. Savings are essential, since they allow these groups to accummulate the downpayments required by the CO-OP's and N.P.H.A's.

- Guarda, R.I. in 1973 said, that they can devote 50% of their monthly incomes for housing,(1)
- The New Housing Policy in 1975 suggested that they can give 30% of their incomes for housing. (2)

- If we take the average, then the Capital's high income groups can easily devote 40% of their incomes by 1978 for housing.

- If they deposit their savings continuously for housing, through CO-OP's and N.P.H.A's, by the passage of time they will accummulate enough money to meet all their housing needs.

- If they are encouraged to save continuously with the above rate then:
  By 1980 they can easily afford 25%(3) of their housing costs.
  By 1985 their savings will grow to 40% of their housing costs.
  By 1990 their savings will be more than 60% of their housing costs.

b) <u>Middle Income Groups</u>

- They come next to high income groups and account for 10% of the Capital's population.
- Their incomes (annual) L.S. 600-1200
- These are mainly government officials, clerks, trade and industry staff etc.
- Like the high income groups, they normally provide their housing from their own resources plus loans from banks, industry and trade, but the amounts of loans given to them are less than those given to the high income groups.
- Unlike the high income groups, their incomes are too small to fully solve their housing needs and so they need some government help plus private loans from banks, CO-OP's and N.P.H.A's.
- Since they can easily afford reasonable down payments, N.P.H.A's and CO-OP's are the best solution for them to have good housing.
- In 1973 Guarda R. estimated that they can easily afford 40% of their housing costs.
- The New Housing Policy in 1975 suggested that they can afford 25%
- If we take the average, they can afford 32.5% - say 30%.
- Again savings procedure is essential for them. They must be encouraged to save in advance with CO-OP's and N.P.H.A's.

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(1) Guarda, R.I. op.cit.

(2) New Housing Policy op.cit.

(3) Percentage lowered because candidates may withdraw some savings for occasional essential needs.

If they continue to save by the above rate then,

By 1980 they can easily afford 25% (1) of their housing costs
By 1985 their savings will grow to 40% " " " "
By 1990 their savings will be more than 55% of their housing costs

c) Low Income Groups

- They form half of the Capital's population 50%
- Although government housing plots were distributed to some of them, because of their low economic ability and the high prices of housing construction, they have sublet or sold their plots outright to the high and middle income groups to raise funds for building illegal cheap houses.
- They mainly live in the 4th class uncontrolled housing areas with no services.
- Their incomes L.S. 300-600, not enough even for basic essentials, let alone good housing. No loans whatsoever are offered to them, since their wages are very low.
- Some of them work with the government, but the majority work in trade and industry.
- Self-help housing methods seem to be the only solution for the majority of them, since their work might save them up to 30% of the housing costs.
- Loans are essential for this group. The government must bear the greatest responsibility in helping them to build decent housing. N.P.H.A.'s assisting these groups must enjoy special government help.
- Besides government help, industry and trade must pay special tax to house their own workers or give them direct loans in the form of materials to build their houses and then gradually recoup the loans.
- Government technical help and organisation is essential to ensure the constructon of good housing. They must be supplied with minimum essential services at first, but it is most important to guide and help them so that their housing standards will gradually be improved.
- Guarda, R.I. suggested that they can devote 30% of their incomes for housing.
- The New Housing Policy suggests 25%.
- Due to the present economic hardship, it is reasonable to consider the latter figure i.e., 25%.
- Again savings and loans system is a must for them to accumulate reasonable down payments for housing.

By 1980 they can easily afford 20% of their housing costs
By 1985 their savings will grow to 30% of their housing costs
By 1990 their savings will be more than 40% of their housing costs

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(1) Savings percentage lowered because candidate may occasionally withdraw some funds for other urgent needs.

d) Lowest Income Groups

- They account for 35% of the Capital's population.
- Mainly migrators coming from rural areas for work.
- Can hardly afford any housing, nor the Capital's high living costs.
- No stable jobs. They are mainly unskilled workers with minimum unstable wages, and some of them may go for several months without work.
- They mainly live in illegal and squatting areas which constitute fire and health hazards.
- Continuous government efforts have failed to evict them.
- The government always destroys their hovels, but they very quickly build them back. Obviously, such government policy will never solve the problem.

The best way is to apply positive practical solutions by developing certain housing areas in advance especially to receive these migrators and the lowest income groups.

It is proposed that they should receive help to build minimum or core houses which can be improved gradually. They may begin with one small room in well-planned housing plots with minimum services and gradually complete their houses as they get permanent jobs and increased wages.

There are no reliable data about their incomes, but they fall far below the annual income of L.S. 300 estimated by the New Housing Policy.

Due to their low unstable incomes, N.P.H.A's will not be willing to build for them and so the whole responsibility lies on the government to supply them with reasonable loans and technical guidance. A special public agency must be set up to deal with their housing. They can afford no down payment, at first, but they can do 50% of the work in building their houses.

The government must supply them with the remaining 50% in the form of minimum services and traditional roofs; this will be paid back over a long period as they get permanent jobs.

If the government shows its real willingness to settle them in reasonable legal housing, their savings will soon be improved.

By 1980 they may save 5% of their housing costs.
By 1985 their savings will grow to 20% of their housing costs.
By 1990 their savings will be more than 30% of their housing costs.

8.5.2. Repayment Analysis

From the previous discussions, procedure for housing payment can be tabulated as follows:-

Table 54. 1980 Contribution

	Occupants' Direct Payment	Bank CO-OP's N.P.H.A's	Occupants Work	Government
High income groups	25%	70%	-	5%
Middle income groups	25%	60%	-	15%
Low income groups	20%	20%	30%	30%
Lowest income groups	5%	-	45%	50%
				100%

Table 55. 1985 Contribution

	Occupants' Direct Payment	Banks CO-OP's N.P.H.As	Occupants Work	Government
High income groups	40%	60%	-	-
Middle income groups	40%	50%	-	10%
Low income groups	30%	30%	25%	15%
Lowest income groups	20%	-	40%	40%
				100%

Table 56. 1990 Contribution

	Occupants' Direct Payment	Banks CO-OP's	Occupants Work	Government
High income groups	60%	40%	-	-
Middle income groups	55%	40%	-	5%
Low income groups	40%	35%	20%	5%
Lowest income groups	30%	-	40%	30%
	(1)	(2)	(3)	(4)

(1) Occupants' direct payments increase through time as different income groups yearly accumulate their savings for housing.

(2) CO-OP's and N.P.H.A.'s activities increase gradually. First they deal with housing for High and Middle income groups because they have down payments available. Then they gradually increase their activities to support and supervise self-help housing. From 1990 onwards, they will be able to deal with all the Capital's housing.

(3) Low and lowest income groups, by the passage of time accumulate more savings for housing and the amount of their direct labour will be reduced to employ more skilled workers for specialized works.

(4) Government contribution is heavily needed in the early years, but gradually, as savings accumulate and CO-OP's and N.P.H.A.'s take over, government help will be considerably reduced and mainly directed to the low and lowest income groups. Government role will mainly be guidance and supervision to ensure smooth running of housing activities.

8.6. Government Contributory Requirements

8.6.1. Actual Government Contribution needed to solve The Capital's Housing Problem

Table 57. 1980 Contribution in (th. Sudanese pounds)

	Cost of the Houses	Occupants Direct Payment	Banks CO.OP's N.P.H.A.s	Work	Government.
High income groups	9,617	2,404.25	6,731.9	-	480.85
Middle income groups	10,995	2,748.75	6,597	-	1,649.25
Low income groups	27,570	5,514	5,514	8,271	8,271
Lowest income groups	10,017	500.85	-	4,507.65	5,008.5
	58,199	11,167.85	18,842.9	12,778.65	15,409.6

Table 58. 1985 Contribution (in th. Sudanese pounds)

	Cost of the Houses	Occupants Direct Payment	Banks CO-OP's N.P.H.A.s	Work	Government
High income groups	14,425	5,770	8,655	-	-
Middle income groups	16,492.5	6,597	8,246.25	-	1,649.25
Low income groups	41,355	12,406.5	12,406.5	10.338.75	6,203.25
Lowest income groups	15,025.5	3,005.1	-	6,010.2	6,010.2
	87,298	27,778.6	29,307.75	16,348.95	13,862.7

Table 59. 1990 Contribution (in th.Sudanese pounds)

	Cost of the Houses	Occupants Direct Payment	Banks CO-OP's N.P.H.A.s	Work	Government
High income groups	14,425	8,655	5,770	-	-
Middle income groups	16,492.5	9,070.9	6,597	-	824.6
Low income groups	41,355	16,542.0	14,474.25	8,271	2,067.75
Lowest income groups	15,025.5	4,507.65	-	6,010.2	4,507.65
	87,298	38,775.55	28,841.25	14,281.2	7,400

Actual government contribution required to solve the Capital's housing problem up to 1990 =

	1980	1985	1990	
Government contribution	15,409.6 +	13,862.7 +	7,400	= 36,672.3

Government contribution = 36.6m say 36.5 million pounds

8.6.2. Government's Current Plans and Efforts to solve the Capital's Housing Problem:

From many studies throughout the developing countries, U.N. housing experts have suggested that these countries must devote at least 5% of their G.D.P. for housing and community improvement. In Chapter 2 page 43 it was pointed out that the Sudan devotes only 1.5% of its G.D.P. to housing, which is far below the minimum suggested by the United Nations. Lack of finance is a crucial point in the Capital's housing situation.

Lack of government investment in housing has exacerbated the problem and currently 50% of the Capital's population live in squatting and illegal housing areas.(1)

In addition to state-built housing and some loans the Government's main contribution to the solution of the urban housing problems has been the distribution of open housing plots with minimum infrastructure services. Plots are distributed with nominal charges since 90% of urban land is public, but the actual building is left entirely to the owners. However, the quantity of housing plots distributed is far less than the actual needs, and those affected most are the low income groups, who are forced to solve their problem through illegal and uncontrolled settlements.

8.6.3. Actual Government Contribution paid annually to improve the Capital's Housing.

The total resources invested in the 1970-75 Five Years' Development Plan in the Housing Sector had been estimated by Guarda, R.I.(2) to be L.S. 182.5 millions (Sudanese pounds). Out of these, Public utilities accounted for 29.6%, Private Housing 66% and Government houses for officials and Housing allowances accounted for the remaining 4.4%.

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(1) Guarda, R.I. Proposal on Housing Policy op.cit. page 9.
Capital's illegal housing 20%
Capital's squatting areas 30% > 50%

(2) Guarda,R.I. op.cit. page 3.

This can be worked as follows:

	Million pounds	
Total housing investment 1970/75	LS.182.5	100%
Public utilities (1)	54.02	29.6%
Private Housing	120.45	66%
Houses for officials and housing allowances	8.03	4.4%

In the same period, 4% of the total Housing Investment were also given by different government units as loans for their officials to help solve their housing problem i.e. L.S.7.3 millions sudanese pounds. Out of these the Estate Bank used to invest L.S. 1 million annually to help house urban dwellers.(2)

8.6.4. Annual Government Contribution in Housing Investment

			million pounds
1.	Government houses for officials (1/5 of L.S.8.03m)		= L.S.1.606
	(a) Houses by Ministry of Construction	L.S.1.220	
	(b) Economic houses by Housing Dept.	0.030	
	(c) Housing Allowances	0.356	
2.	Loans furnished by Estate Bank and different government units to help house their officials		L.S.1.460
3.	Government annual contribution for Housing		L.S.3.066

Source: Worked out from figures given by Guarda, R.I. page 21.

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(1) Infrastructure, bridges, etc.

(2) Guarda, R.I. op.cit.

Annual Government Contribution invested in the Capital

		Whole urban Sudan million L.S.	Capital million L.S.
1.	Funds for Government Officials Housing:		
	a) Houses built by Ministry of Construction & Public Works	1.220	
	According to McLoughlin (1) 60% of Sudan's senior clerical category are employed in the Capital. therefore Capital share 60%		0.732
	b) Economic Houses	0.030	
	These houses are built by the housing Dept. and all its low cost research houses were built in the Capital		0.030
	c) Housing Allowances	0.356	
	The above are the 1974 figures when housing allowances were given only to the Ministry of Interior's officials. Allowances for housing have come to be right now claimed by most government officials. Allowances are now given by Ministry of Judiciary, Local Government, Construction & Public Works and many other government units. However, we assume that the above figures went up only by 40% i.e. total of 0.498m. Out of these 60% went to Capital's officials.		0.300
2.	Estate Bank's yearly investment in urban housing:	1.0	
	According to Guarda, most of the Bank's funds are invested in Capital. Assume 80% invested in the Capital.		0.800
3.	Other government loans furnished by different units to help house their officials:	0.460	
	60% of these went to officials in Capital		0.276
	Total public funds invested in the Capital		2.138m

(1) McLoughlin see Capital's Housing Problems page 20

At the moment annual Government contribution of L.S.2.138m is shared between many public units, each working to its own plans, with no clear overall policy.

If this procedure continues, the problem will not only persist, but it will actually get worst, because increasing prices will mean that government will have to expend more funds to occupy the same housing area. Moreover, this type of investment will neither solve the Capital's problem nore create a surplus of resources, because government houses are rented with nominal charges which are not sufficient to cover their maintenance costs.

The above annual government contribution will give far better results if it is used as shown in tables 54-56 pages 327-328

a) By 1980 Government helps the Capital's =

1. High income groups by loans equal to 5% of their housing costs
2. Middle " " " " " " 15% " " " "
3. Low " " " " " " 30% " " " "
4. Lowest " " " " " " 50% " " " "

b) By 1985 the government gives the:

1. Middle income groups loans equal to 10% of their housing costs
2. Low " " " " " 15% " " " "
3. Lowest " " " " " 40% " " " "

c) By 1990 the government gives the:

1. Middle income groups loans equal to 5% of their housing costs
2. Low " " " " " 5% " " " "
3. Lowest " " " " " 30% " " " "

In page 330 it is estimated, that Government contribution needed to solve the Capital's housing problem up to 1990 is L.S.36.5 m.

From page 333 the actual annual government investment to improve the Capital's housing is calculated to be L.S.2.138m. therefore usual Government contribution up to 1990 = 2.138 x 13 L.S.27.8 m.

Extra investment needed from the Government to solve the Capital's housing problem correctly, in a well-planned and organized way = L.S. 8.7 m.

say L.S. 9 millions Nine million Sudanese pounds.

Conclusions

From the previous figures, it is quite clear that the Capital's housing problem is not aggravated by an overall lack of government finance. Government's annual contribution is quite adequate and capable of solving the problem, but the main tragedy lies in the fact, that government contribution is shared by many units with no comprehensive plan.

The extra government contribution needed to ensure the best solution for the Capital's housing problem, besides the approval of the suggestions stated in this study, is an amount of some 9.0m, nine millions Sudanese pounds. This sum is needed over a period of 10 years (1980-1990) and this can easily be borne without causing a heavy burden on governmenrt resources; alternatively it may be borrowed as a loan from local banks or international sources such as United Nations or E.E.C.

8.7. Private Sector Investment

According to Guarda, R.I.[1], the Sudanese Private Sector invested during the 1970-75 period more than L.S.120.45 million pounds in housing. As already stated, over 60% of this investment was spent in the Capital.

Even assuming that only 50% of the above amount is invested in the Capital, then at least L.S. 60 millions of private money were invested in housing in the Capital, an average of 5 millions annually.

(1) Guarda, R.I. op.cit. page 7.

If the same rate of 5 million pounds investment annually continues then the private sector is likely to put

5 x 13 = 65 millions by 1990

In table 57-59 it is estimated that, in order to solve the Capital's housing problem, the private sector must contribute L.S.77.0 million pounds, so the suggested figures seem to be well within the means of private investors.

8.7.1. Financial Situation of House Occupant's in different Income Groups.

a) High Income Groups: — Sudanese Pounds

Average cost of dwelling			L.S.6411
Average of their direct payment	40%	= 2564	
Loans from N.H.P.As.	55%	= 3526	
Loans from Government	5%	= 321	
		6411	

1. Loan settlement to N.P.H.As over 8 years
   3526 ÷ 8 = 441 ÷ 12 = L.S.36.7 monthly

2. Loan settlement to government over 10 years
   321 ÷ 10 = 321 ÷ 12 = 2.7

   Overall monthly payments = 39.4 40 pounds
   which is quite easy to pay since it is only 35% of their monthly incomes and equivalent to their present housing rents.

b) Middle Income Groups: — Sudanese Pounds

Average cost of dwelling			L.S.3665
Average of their downpayment	40%	= 1466	
Loans from N.P.H.As.	50%	= 1832.5	
Loans from Government	10%	= 366.5	
		3665	

1. Repayment of loans to N.P.H.As. over 8 years
   1832.5 - 8 = 229 - 12 = L.S.19.1 monthly

2. Repayment of loan to government over 10 years
   366.5 - 10 = 3665 - 12 = 3.1
   L.S.22.2

For the middle income groups L.S.22 monthly is very easy to pay since it is only 29% of their monthly incomes and less than the actual housing rents they are now paying.

c) Low Income Groups: Sudanese Pounds

Average cost of dwelling			L.S.1838
Average down payment	30% =	551.4	
Their work	25% =	459.5	
Loans from N.P.H.As	30% =	551.4	
Loans from Government	15% =	275.7	
		1838	

1. Loans repayment to N.P.H.As over 8 years
   551.4 ÷ 8 = 69 ÷ 12 = L.S.5.75 monthly

2. Loans repayment to government over 10 years = 2.30

   Overall monthly payment = 8.05

   which is very easy since it is only 20% of their monthly incomes and far less than their present housing rents.

d) Lowest Income Groups: Sudanese Pounds

Average cost of dwelling			L.S. 954
Average down payment	20% =	190.8	
Labour	40% =	381.6	
Loans from Government	40% =	381.6	
		954	

Repayment of loans to government over 8 years
381.6 ÷ 8 = 47.7 ÷ 12 = 3.9
say = L.S.4 pounds monthly

To sum up, all income groups can easily repay the amounts of loans given to them by both government and Non-Profit housing assocations, without causing a heavy burden on their living expenses, since the repayment installments are within, or far less than the actual housing rents they are now paying.

The main important point is that, instead of paying housing rents to landlords, the houses they occupy will be theirs in a period of 8-10 years.

On the other hand, by receiving most of the loans back in a period of 8-10 years, government and Non-profit housing associations will be in a better position to finance yet more housing development.

8.8. Financial Situation and Work Procedure of CO-OP's and N.P.H.As.

It is outside the compass of this study to give detailed analyses of the work procedure of housing CO-OP's and Non-profit housing associations and how they can be fully adapted to local Sudanese conditions. However, it will be shown that from the financial view point, housing CO-OP's and N.P.H.A's can solve not only the Capital's housing difficulties, but those of all Sudanese urban areas.

8.8.1. Financial Resources of N.P.H.As.

In Chapter 6, page 199 it was pointed out that N.H.P.As can be financed by direct and indirect resources.

(a) Direct funds: These can be raised as:-

1. Direct long-term loans from the Central Government as a Seed capital for non-profit housing activities. U.N. housing experts suggest a minimum of 5% of G.D.P. and many developing countries used to support N.P.H.As with more than 90% of their construction costs.

2. Direct loans may be taken from Insurance companies, Savings Banks and other credit institutions.

3. Trade and industrial plants may also give direct loans to help house their staff and workers. Even trade unions can give direct loans to help house their members.

4. Central Government can help N.P.H.As to have loans from outside international funds on a long-term basis.

8.8.2. Indirect Resources:

These include all the possible favourable conditions, furnished by the government to promote non-profit housing such as:

1. Continuous Government encouragement for banks, Savings institutions and insurance companies to invest and support non-profit housing and ensure sufficient funds for house production.

2. Considerable reduction of State and local taxes, especially in the first stages.

3. Housing land to be leased to non-profit housing associations on very easy terms for a period of 40-60 years.

4. Government technical assistance to be offered free to help N.P.H.As produce technically guaranteed economic housing production.

8.8.3. The Possibility of Non-Profit Housing's Finance in the Sudan.

From the figures caculated by Guarda, R.I., it is clear that the Sudanese Private Sector invested L.S.120 million pounds in housing during the 1970-75 period. Out of these, at least 60% i.e., 72 millions - an average of L.S. 6 millions annually - were invested in the Capital. If the government approves a long-term Housing policy and makes it clear that it will support housing CO-OP's and N.P.H.As to carry out most of the housing activities, then private sector agencies are more likely to invest in and finance non-profit housing.

Even assuming that, instead of the L.S.6 millions annually invested in the Capital's housing, the private sector will invest in non-profit housing only L.S.5 millions per year(1), then in the first three years 1978-80, the private investors will supply N.P.H.As with at least L.S.15 millions. On the other hand, the Government has invested L.S.2.138 millions annually in the Capital's housing(2), which means it is quite easy for the government to furnish

(1) Private sector banks and agencies may continue to give individuals direct loans to buy ready constructed houses from N.P.H.As. However, it would be far better if the private sector, at least in the first stages, supplied N.P.H.As with the financial means to become firmly established.

(2) See page 333 of this report.

L.S. 5 million pounds in the first three years 1978-80.

The total sum of L.S.20millions would be enough to start considerable non-profit housing activities.

From these funds it would be quite possible to erect the factories to produce basic building materials such as red bricks, and cement blocks to supply the required materials for the first stages of construction.

Cement can be purchased in bulk from the two existing factories of Atbara and Rabak, on long-term payment arrangements, with the possibility of furnishing some funds to erect a cement factory inside Khartoum Province.

Imported building materials such as sanitary equipments, electrical and finishing materials can be purchased in large quantities on long-term settlement, while the possibility is considered of manufacturing some or most of these imported materials locally. Labour and professional costs can also be met from these funds.

With these materials and equipment, N.P.H.As can easily erect the number of houses required to house the people in the first (1980) stage. From the collection of occupants' repayments and the down payments saved by the new (1985) house candidates, N.P.H.As can settle some of the building materials' costs and build more housing. On this procedure N.P.H.As will gradually begin to settle their loans. In time, as the loans are settled, the factories and equipment will gradually become theirs, to help in more housing production.

With good management and competent staff N.P.H.As soon become profitable and self-sufficient and thus in a position to free the government from a difficult problem.

From table 57 on page 329 if N.P.H.As will construct the whole first (1980) stage's housing for the high, middle and low income groups, which amounts to L.S.48 millions, then from the same table:

Occupants' down payments	=	L.S. 10 millions
Occupants' work	=	L.S. 8 millions
Government investment	=	L.S. 10 millions
	=	28 millions

With these L.S. 28 million pounds and other private sector's help, the N.P.H.As, using the above precribed procedure, can easily produce the required housing for L.S. 48 million pounds.

By 1985 in addition to the outside and local loans, new occupants' down payments etc., the N.P.H.As will also collect the repayments of the houses built in 1980.

Using the monthly installments' possibilities shown on pages 336-337, these repayments will amount to:

High income groups	L.S. 4m.
Middle income groups	L.S. 3m.
Low income groups	L.S. 3m.
Total	10 million pounds

a considerable sum for re-investment in non-profit housing.

8.9. Better usage of Government Housing Investment

8.9.1. Private Houses Rented by the Government.

In addition to the annual L.S. 1.2 million pounds invested in the construction of state built houses, the government also rents private housing for some officials. These private housing rents are not controlled by a central body or definite policy. They are left entirely for the heads of the departments concerned to negotiate with the house owners, and this can lead to corruption and wastage of government resources. Moreover, the private owners often claim extra maintenance costs, which leads to further misuse of government funds.

In March 1975 the author was elected as a committee member, together with other architects, engineers and economists to evaluate the private houses rented by the government in the Capital. It was found that the expenditure involved in paying rent for six years from the government to the private owners, was sufficient to enable the government to establish a permanent equivalent housing area of higher quality building materials.[1]

Payment of such rents must be stopped immediately and the officials concerned given housing allowances to be used as down payments for non-profit permanent housing.

8.9.2. Government Monthly Cash Allowances for Employees.

These monthly housing allowances were intended to help solve the housing problem of government officials, for whom State-built houses were not available. Although these allowances were initially available for the Ministry of Interior's officials, they are now given to senior officials in many other government units.

Monthly cash allowances are given to employees according to their official scales and range of annual wages.

Table 60. (Sudanese Pounds)

Scale Q officials are given	L.S.15 per month
Scale D.S. officials are given	24 "
Scale B " " "	35 "
Group 7 " " "	40 "
Group 5 " " "	45 "
Group 3 " " "	50 "
Group 1 " " "	60 "

Source: Budget Section Ministry of Local Government, March 1977.

They are paid monthly in addition to normal wages. Since these allowances are used for private housing rents, they do not enlarge the housing stock.

(1) The report was presented to the Minister of Local Government by the Social Survey Dept. in July 1975.

Taking the average of such allowances to be L.S.40 pounds, then allowances over 15 years will amount to L.S.7200, a sum equivalent to the cost of a high income groups' housing unit. In other words, 15 years housing allowances are quite enough to buy a highly-paid government official a permanent first-class house. Allowance for 25 years will amount to double the cost of such a 1st class housing unit.

Therefore, instead of giving government officials housing allowances for 10, 20, 30 years or throughout their employment period, payments for only 10-12 years are quite enough to solve their housing problem permanently and save twice or three times the cost for the government.

To help such employees to acquire permanent houses, they must be given an initial lump-sum equal to 25% of their housing costs to be used as down payment for non-profit housing agencies. The remaining 75% will then be settled by the government, in monthly installments, to the non-profit housing agency concerned.

This procedure will not only save the government twice or three times the present housing allowances, but will both support non-profit housing activities with considerable funds and provide employees with good permanent housing rather than leaving them at the mercy of the everincreasing rents.

CHAPTER 9

PRACTICAL FEASIBILITY OF PROPOSED HOUSING SOLUTIONS

1. Capital's High and Middle Income Groups:

Although these groups still enjoy the maximum share of government and private investment for improving housing conditions, it is clear that their house-building process is not efficient and that the proposed non-profit housing system offers a better alternative. Compared with the present uneconomic 'direct contract' system, non-profit housing associations give these groups completed well-built houses for the price of the initial down payment and average monthly payments amounting to less than their current housing rents.

2. Capital's Low Income Groups:

The proposed aided self-help construction frees these groups from subletting or selling their plots and uses their available resources and unexploited spare time to satisfy their present and future needs in providing good permanent housing.

This allows both the government and the low income groups from the problems of illegal housing and enables poor families to enjoy the urban and infrastructure services which are not normally available in the illegal housing areas.

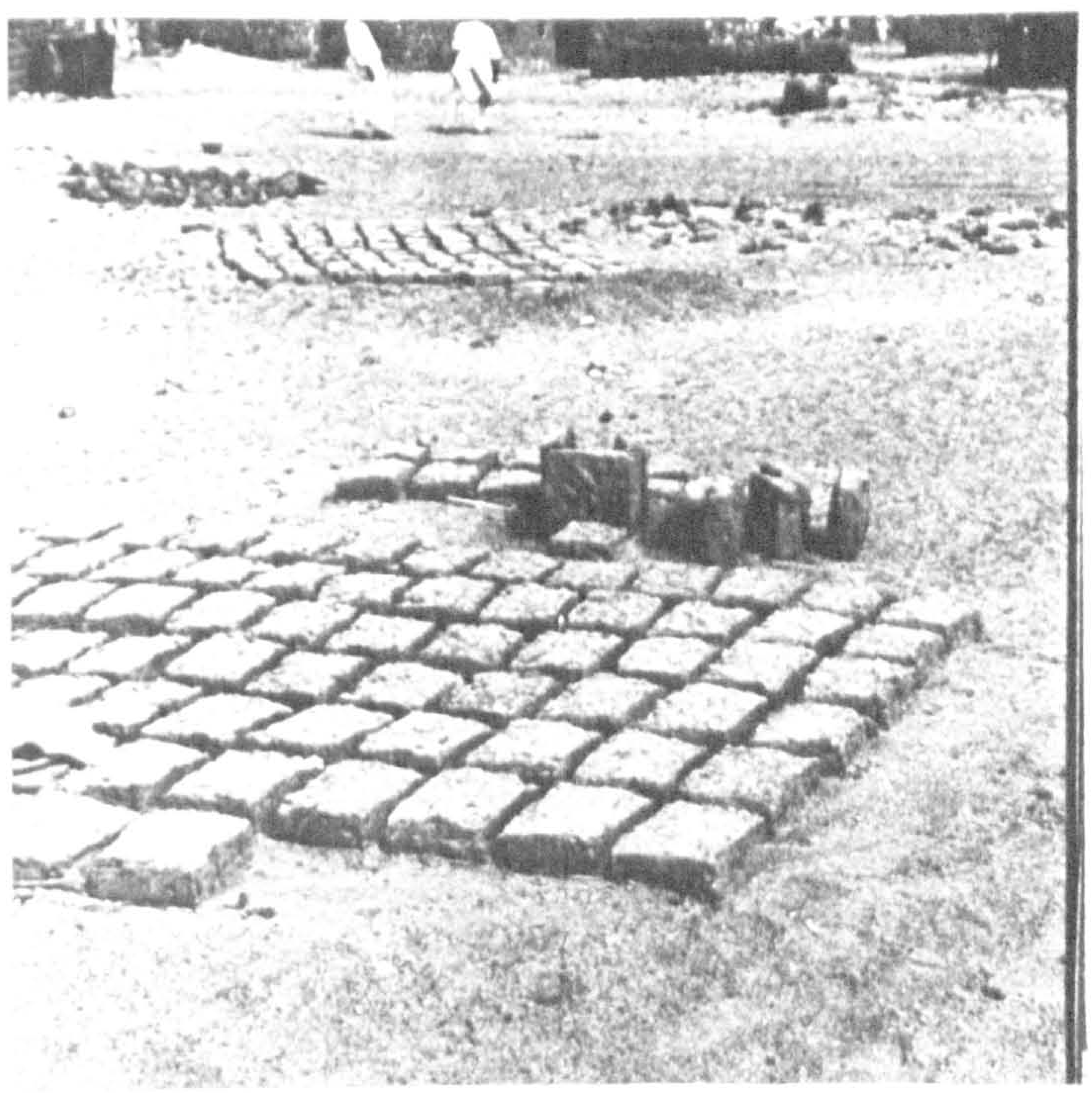
3. Capital's Lowest Income Groups:

The proposed solution recognises the problem of squatting and attempts to eradicate the root causes. It calls for government to check migration by improving the rural communities. However, until the migration is checked squatting settlements must be regarded as a real and permanent part of the Capital. The government must permanently settle these groups in well-planned, reasonably-serviced housing areas. The study proposes minimum core houses for these groups beginning with a one-room dwelling with a kitchen and a w.c., but gradually expanding to meet future needs. The houses are to be built by the owners themselves under government supervision.

This solution will not only attack the squatting problem and give the Capital's lowest income groups permanent, secure housing, but it will also channel their resources and efforts. Moreover, instead of the present ugly squatter settlements which are a feature of the Capital's peripheries, the government will be able to control the Capital's growth and use its efforts and resources rationally to improve housing conditions generally.

All the proposed housing standards are based on simple construction techniques involving the minimum use of machinery. The low and lowest income groups' housing will be constructed with local building materials using long-established traditional building techniques.

Both the 'gishra' construction (dried adobe bricks inside and red bricks outside) proposed for the low income groups' housing:



and the 'jalous' (mud construction) proposed for the lowest income groups' housing:

are well known to the Sudanese and widely used. The vast majority of urban housing and 60% of the Capital's present housing stock is built from these materials but the quality of the accommodation could be greatly improved if, as the study suggests, all the houses are well orientated, whitewashed and well-organized under supervision, whether they are built by N.P.H.As or by the self-help owners.

although the proposed housing standards are simple and of reasonable area, they still consider all the socio-functional requirements and are based on the families' economic ability and community resources. Moreover, new extensions for the low and lowest income groups' housing will be built by some occupants, gradually as capital and time become available, without commitment of regular payments.

Conclusions

After careful analyses of the housing problem in the Sudanese Capital, it is clear that if urgent public efforts are not made to begin solving the problem, current government action and resources will continue to be wasted and the problem will soon be too difficult to solve.

Although public finance for housing seems to be very scarce, lack of public housing investment is in fact NOT the main cause of the housing problem. The main problem is that these resources and efforts are shared by unrelated government units and so the limited resources are misused and frittered away.

Present housing needs can only be met by promotion and co-ordination of all available resources. The gap will be bridged by passing legislation and creating motivation for further individual, community and state investment. The first step is the formation of a well-planned comprehensive Housing Policy based on suitable finance and reasonable housing standards.

In order to ensure maximum use of available resources, government units concerned must be guided by a central body towards common objectives and definite responsibilities.

Instead of the present partial distribution of open housing plots for a few families, non-profit housing techniques are more appropriate, since they give equal housing opportunities for all income groups, with special assistance to the lowest income groups for whom provision has not previously been made.

Non-profit housing methods seem to be the only means for solving the housing of 85% of the Capital's population.

The combination of monetary and non-monetary resources enables N.P.H.As and housing CO-OP's to mass-produce good housing and maximize the repeated use of limited available resources.

(a) The needs of the high income groups can be met with reasonable well-built housing standards.

(b) Self-help is best for the lower income groups since it supplements their scarce finance with unexploited non-monetary resources.

(c) Squatters' non-monetary resources will be put in a proper institutional housing structure and the present chaotic non-profit techniques produce considerable savings in housing costs; they reduce high income groups' housing by 25%, lower income groups' housing by 40% and for all groups reduce the cost of a housing unit from the current cost of 7 years' income to only 2½ years' income.

As soon as N.P.H.As are established and self-sufficient, pressure will be taken off limited public funds, freeing them for more food production, education and health care services. The use of low income groups' non-monetary resources will encourage them to master new skills and have better working opportunities; poor families will have good housing and steady improvement; the community will be stable and population freed for more prosperous production.

Non-profit housing techniques will not achieve better results unless the following points are considered:-

1. Housing policy is not to be restricted to open plot distribution, but must offer guidance and assistance if good housing with reasonable services is to result.

2. Public financial help is essential in the early stages, but all means must be employed to ensure that housing is self-financed by the private sector and the occupants.

3. Government must mobilize all resources to promote non-profit housing; local credit institutions encouraged to support N.P.H.As; foreign seed capital injected; and the Sudanese private sector encouraged by easy-terms and tax exemptions.

4. A well-organized savings and loans mechanism must be developed to attract the savings of lower income groups.

5. Estate Bank should be empowered to supervise non-profit housing activities throughout the country. The Bank is to finance and support N.P.H.As and CO-OP's ensuring the maximum use of resources given to them.

6. The present 'direct contract' building process is uneconomic. All house building must be carried out by N.P.H.As and CO-OP's with direct contract construction limited to isolated projects.

7. Frequent checks on the Estate Bank's and N.P.H.As' activities must be carried to ensure smooth running of housing activities.

8. Sufficient funds must be invested to develop the internal building industry and bring basic materials within the reach of all income groups.

9. Current unrealistic municipal by-laws should be changed to allow the use of traditional materials and new cheap ones.

10. Present segregation of housing into 1st, 2nd and 3rd classes should be replaced by homogeneous well-integrated neighbourhoods.

11. Reasonable housing standards must be enforced to bring housing within the reach of majority poor families; special help must be given to lower-income groups since they are outside the interest of N.P.H.As. The lowest income groups and squatters must be supplied with the basic essential services in public land and encouraged to build permanent shelter gradually as their means improve.

12. Infrastructure must be installed in advance to ensure quick house erection. Whenever possible the semi-skilled work of lower income groups should be used to reduce housing costs.

13. House owners must be encouraged to participate in planning, decision-making and management of building. N.P.H.As working for low income groups must work 'with' and not 'for' them.

14. Self-help housing must be encouraged with good supervision and organization. Self-helpers should be allowed to build in stages and schedule building according to available time and resources.

15. More architects, townplanners, engineers and technical personnel must be trained.

16. Without a controlled reduction in rural migration, the Capital's housing problem will not be solved. The rural population should be encouraged to stay in their homelands by improvements in rural communities. Since 1972 the Sudanese Government has begun an intensive programme of agricultural and industrial development throughout the country, and particularly in the rural provinces. The following are but some examples of the new rural projects:-

    a) Textile Industry:

    1. Hassaheise - Blue Nile Province
    2. Kosti - White Nile Province
    3. Shendi - Northern Province
    4. Mangala - Equatoria Province
    5. El Duweim - White Nile Province

    b) Sugar Industry:

    1. El Geneid factory - Blue Nile
    2. Sennar factory - Blue Nile
    3. Hager Asalaya - Blue Nile

    c) Jute Industry:

    Tong factory - Equatoria Province

    d) Agricultural Industry:

d) Agricultural Industry:

1. Tractor factory - Blue Nile
2. Paper factory - Blue Nile

e) Port Sudan - Khartoum Motorway, which will not only accelerate the import-export activities and solve the present railway bottlenecks, but it will also develop the areas immediately connected with it.

f) The opening of Wad Medani and Juba universities which considerably reduces the over-concentration of university students in Khartoum.

This policy will not only develop the rural provinces, but will also encourage the local population to stay in their own home areas. Further government investment is needed to encourage these projects and to initiate further new industries, including building materials.

17. Finally, although this study offers solutions to many Sudanese urban housing problems, the problem obviously calls for more detailed investigations. Further research is required on suitable house designs which satisfy all the Sudanese different, and sometimes contradictory social and privacy needs. Economic research is needed to analyse the ability of different income groups to pay housing rents. There must also be an investigation of each element of low-cost housing with a view to reducing costs and optimizing the use of labour and materials.

Finally, research is required into the achievement of better thermal comfort with natural menas, optimum site selection and urban housing densities.

TYPE IN THE VALUES OF LATITUDE AND THEN LONGITUDE OF SITE.
N.B. NORTHERN LATITUDES AND LONGITUDES WEST OF GREENWICH
ARE POSITIVE(SOUTHERN LATITUDES AND EASTERN LONGITUDES
ARE NEGATIVE).
TYPE IN LATITUDE IN DEGREES AND MINUTES, SEPARATED BY A COMMA
-15,36
TYPE IN LONGITUDE IN DEGREES AND MINUTES, SEPARATED BY A COMMA
--32,33

TYPE IN THE HEIGHT OF THE SITE ABOVE SEA LEVEL IN METRES-275

---INPUT DATA COMPLETED---

LATITUDE OF SITE IS 15 DEGREES 36 MINUTES
LONGITUDE OF SITE IS -32 DEGREES 33 MINUTES
HEIGHT ABOVE SEA LEVEL IS 275 M.

THE DAY OF THE YEAR IS MAY,22

WATER CONTENT OF THE ATMOSPHERE =15 MM.
ATMOSPHERIC TURBIDITY =0.15

ORIENTATION (DEGREES)	GRD. REFLECTED (KJ/M↑2)	SKY DIFFUSE (KJ/M↑2)	DIRECT SOLAR (KJ/M↑2)	TOTAL (KJ/M↑2)
0	2808	1508	5225	9540
15	2808	1521	5145	9473
30	2808	1654	6815	11276
45	2808	1830	8216	12854
60	2808	1946	9076	13829
75	2808	1943	9335	14086
90	2808	1935	8958	13701
105	2808	1781	7983	12572
120	2808	1596	6463	10867
135	2808	1431	4521	8759
150	2808	1263	2290	6361
165	2808	1112	97	4017
180	2808	1109	0	[illegible]

THE DAY OF THE YEAR IS JUN,22

WATER CONTENT OF THE ATMOSPHERE =25 MM.
ATMOSPHERIC TURBIDITY =0.2

ORIENTATION (DEGREES)	GRD. REFLECTED (KJ/M↑2)	SKY DIFFUSE (KJ/M↑2)	DIRECT SOLAR (KJ/M↑2)	TOTAL (KJ/M↑2)
0	2694	2058	6156	10909
15	2694	2072	5946	10712
30	2694	2192	6748	11634
45	2694	2340	7772	12807
60	2694	2374	8320	13389
75	2694	2362	8331	13387
90	2694	2332	7791	12818
105	2694	2104	6738	11537
120	2694	1874	5242	9811
135	2694	1681	3419	7795
150	2694	1492	1417	5604
165	2694	1370	0	4064
180	2694	1359	0	4054

THE DAY OF THE YEAR IS JUL,22

THE DAY OF THE YEAR IS JUL,22

WATER CONTENT OF THE ATMOSPHERE =40 MM.
ATMOSPHERIC TURBIDITY =0.3

ORIENTATION (DEGREES)	GRD. REFLECTED (KJ/M↑2)	SKY DIFFUSE (KJ/M↑2)	DIRECT SOLAR (KJ/M↑2)	TOTAL (KJ/M↑2)
0	2522	2390	3642	8553
15	2522	2426	3609	8556
30	2522	2528	4823	9878
45	2522	2684	5823	11028
60	2522	2806	6443	11770
75	2522	2800	6637	11958
90	2522	2789	6378	11688
105	2522	2588	5694	10803
120	2522	2351	4622	9495
135	2522	2126	3248	7895
150	2522	1918	1669	6108
165	2522	1788	92	4401
180	2522	1773	0	4294

DO YOU WANT ANOTHER RUN?
←NO
STOPPED AT LINE 4950
←RUN

```
←BYE
OK
12.58.30← OPEN LTMASR←TLT,LLLI
12.59.02← BASIC


UNIVERSITY OF SOUTHAMPTON BASIC MARK 7L  ON 06/08/76 AT 12/59/16


←OLD SUN3
OK
←RUN

IRRADIATION OF SPECIFIED SURFACES BY DIRECT AND DIFFUSE
SOLAR RADIATION FOR CLOUDLESS SKIES.
                ---------------

FOR A GIVEN SITE AND A GIVEN DATE THIS PROGRAM
FINDS THE TIME OF SUNRISE AND OF SUNSET ON THAT
DATE AND ALSO TABULATES THE DIRECT,DIFFUSE AND
TOTAL IRRADIANCES (W/M↑2) ON A SPECIFIED SURFACE
LOCATED AT THE GIVEN SITE FOR HOURLY INTERVALS
ON THE GIVEN DAY.

TYPE IN THE TIME SYSTEM YOU WISH TO USE. THE CHOICES ARE:
1) LOCAL APPARENT TIME (SUN TIME)     - 'LAT'
2) LOCAL MEAN TIME                    - 'LMT'
3) GREENWICH MEAN TIME                - 'GMT'

PLEASE TYPE IN EITHER 'LAT' OR 'LMT' OR 'GMT'←LAT

TYPE IN THE VALUES OF LATITUDE AND THEN LONGITUDE OF SITE
N.B. NORTHERN LATITUDES AND LONGITUDES WEST OF GREENWICH
ARE POSITIVE(SOUTHERN LATITUDES AND EASTERN LONGITUDES
ARE NEGATIVE).
TYPE IN LATITUDE IN DEGREES AND MINUTES, SEPARATED BY A COMMA
←15,36
TYPE IN LONGITUDE IN DEGREES AND MINUTES, SEPARATED BY A COMMA
←-32,33

TYPE IN THE HEIGHT OF THE SITE ABOVE SEA LEVEL IN METRES←275

TYPE IN THE FIRST 3 LETTERS OF THE MONTH, FOLLOWED BY THE
DAY - EG., DEC,25-(MONTH AND DAY MUST BE SEPARATED BY A COMMA)!
←MAY,22

TYPE IN THE PRECIPITABLE WATER CONTENT OF THE ATMOSPHERE
NOTE-PREC. WATER  CONTENT LIES BETWEEN 5 AND 40 MM.
←15

TYPE IN THE TURBIDITY OF THE ATMOSPHERE.
TURBIDITIES LIE BETWEEN 0.05 AND 0.4
←0.15

TYPE IN THE ANGLE OF INCLINATION OF THE SURFACE
IN DEGREES MEASURED FROM THE HORIZONTAL←90

TYPE IN THE SURFACE AZIMUTH ANGLE IN DEGREES
MEASURED CLOCKWISE FROM NORTH←90

TYPE IN THE ALBEDO OF THE GROUND←0.2

                 **--INPUT DATA COMPLETED--**
```

LATITUDE OF SITE = 15 DEGREES 36 MINUTES.
LONGITUDE OF SITE = -32 DEGREES 33 MINUTES.
SITE ELEVATION = 275 M. ABOVE SEA LEVEL.

THE ANNUAL DAY NO.IS 143 FOR MAY,22.
CORRECTION FACTOR FOR SUN-EARTH DISTANCE IS 0.975113

DECLINATION= 20 DEGREES 24 MINUTES
EQUATION OF TIME= 3 MINUTES 24 SECONDS

PRECIPITABLE WATER CONTENT OF THE ATMOSPHERE = 15 MM.
THE TURBIDITY OF THE ATMOSPHERE = 0.15

SURFACE AZIMUTH ANGLE = 90 DEGREES CLOCKWISE FROM NORTH.
SURFACE INCLINATION = 90 DEGREES FROM THE HORIZONTAL.

THE ALBEDO OF THE GROUND= 0.2

TIME SYSTEM = LAT.

SUNRISE OCCURS AT 5 HOURS 32 MINUTES LAT.

SUNSET OCCURS AT 18 HOURS 28 MINUTES LAT.

SURFACE IRRADIANCE RESULTS

TIME HOURS	V.SHADOW (DEGREES)	H.SHADOW (DEGREES)	DIRECT (W/M↑2)	DIFFUSE (W/M↑2)	GRD REFLECTED (W/M↑2)	TOTAL (W/M↑2)
6	6	-20	179	36	5	220
7	20	-17	515	77	26	618
8	34	-14	604	84	50	738
9	48	-13	552	75	72	699
10	62	-14	413	60	88	561
11	76	-21	220	44	99	363
12	90	-90	0	33	102	135
13	104	201	0	26	99	125
14	118	194	0	27	88	115
15	132	193	0	28	72	100
16	146	194	0	26	50	76
17	160	197	0	18	26	44
18	174	200	0	6	5	11

DAILY GRD. REFTD. DIFFUSE IRRADIATION = 2808 KJ/M↑2

DAILY SKY DIFFUSE IRRADIATION = 1935 KJ/M↑2

DAILY DIRECT IRRADIATION = 8958 KJ/M↑2

DAILY TOTAL IRRADIATION = 13701 KJ/M↑2

DO YOU WANT ANOTHER RUN?←NO
STOPPED AT LINE 4950
←

(1)

2nd Population Census 1973

Population & Households Distribution In Urban Areas.

Northern

Province	Households	Population	Males	Females
Atbara	10,501	66,116	35,572	30,544
Ed Damer	2,734	17,086	8,729	8,357
Berber	1,886	11,303	5,202	6,101
Shendi	3,920	24,161	12,561	11,600
Wadi Halfa	1,227	5,701	2,975	2,726
Abri	285	1,605	837	768
Kerma	1,349	7,152	3,243	3,909
Argo	1,088	6,275	2,876	3,399
Dongola	820	5,626	2,897	2,729
El Khandaq	192	826	345	481
El Bauga	1,230	7,143	3,338	3,805
Abu Hamed	386	2,277	1,169	1,108
Karima	1,203	7,118	3,724	3,394
Merowi	417	2,402	1,200	1,202
Ed Debba	249	1,435	770	665
Kabushiya	714	3,934	1,706	2,228
		170 160		
Red Sea				
Port Sudan	29,130	132,631	74,471	58,161
Tokar	2,904	13,394	7,353	6,041
Sinkat	1,639	6,439	3,186	3,253
Gebeit	1,289	5,208	2,845	2,363
Suakin is part of Port Sudan.				
		157 672		

أ-٢ معدل الزيادات التقديرية كان حوالي [illegible]
وتفترض مصلحة الاحصاء أن يكون معدل الزيادة
بعد عام ١٩٧٣ حوالي ٢,٥٪ وذلك لاستقرار
في مدن السودان [illegible]

Blue Nile (2)

Province	Households	Population	Males	Females
Medani	16,193	106,776 ✓	57,580	49,196
Ed Dueim	4,597	26,257 ✓	13,781	12,476
Kosti	11,879	65,257 ✓	35,116	30,28[illegible]
Rufa'a	2,401	15,681	7,605	8,076
Kamlin	906	6,690	3,281	3,409
Abu Usher	1,273	7,590	3,899	3,691
Al Masudiya	845	5,039	2,604	2,435
El Mielig	616	3,491	1,862	1,629
El Geteina	1,012	8,966	2,799	3,167
El Gurashi	814	4,393	2,471	1,922
El Kawa	437	2,741	1,289	1,452
El Meheriba	488	3,022	1,559	1,463
Hassaheisa	3,188	18,747 ✓	11,025	7,722
Messellemiya	854	4,628	2,309	2,319
Tabat	811	4,891	2,530	2,361
El Hilaliya	1,463	8,384	4,068	4,316
Managil	2,464	15,223	8,175	7,048
El Huda	941	5,288	2,742	2,546
El Madina Arab	644	3,895	2,073	1,822
El Hosh	587	3,290	1,731	1,559
Sennar El Madina	5,333	28,546 ✓	15,608	12,938
Sennar El Tagotou	1,591	7,714	4,064	3,650
Mairno	2,759	14,361	6,868	7,493
El Gezira	4,579	22,218 ✓	10,210	12,008
Kabak	3,588	18,399 ✓	9,718	8,681
Tendalti	1,957	10,028	4,845	5,183
Galgani	1,470	6,892	3,307	3,585
Abu Hugar	744	3,711	1,803	1,908
Abu Na'ama	853	4,312	2,333	1,979
Singa	3,375	19,452 ✓	9,971	9,481
El Suki	2,837	16,197	8,221	7,976
Um Shoka	1,476	7,666	3,911	3,755
Kurkoj	700	4,079	1,992	2,087
El Dinder	960	5,303	2,754	2,549
Kurmuk	1,155	5,643	2,883	2,760
Ed Damazin	2,589	12,233	7,036	5,197
E. Rosetres	2,539	12,951	6,945	6,006

519 954

Equatoria

(3)

Province	Households	Population	Males	Females
Juba	9,830	56,737 ✓	30,864	25,873
Tumbura	2,205	8,778	4,110	4,668
Anzara	3,645	14,189	7,095	7,094
Yambio	1,697	6,675	3,425	3,250
Maradi	1,991	9,631	4,912	4,719
Torit	2,668	14,645	7,681	6,964
Kapoeta	1,158	5,332	2,874	2,458
Yei	2,798	11,953	6,175	5,778
		127 940		

Khartoum

Khartoum	58,479	333,921 ✓	189,205	144,716
Omdurman	48,121	299,401 ✓	161,959	137,442
Khartoum North	25,780	150,991 ✓	85,931	65,060
5·9 [illegible]	132,380	784,313	437,095	347,2[illegible]

Kassala

Kassala	16,929	98,751 ✓	50,825	47,926
Gedarif	12,476	66,465 ✓	36,105	30,360
Aroma	13,98	7,369	3,807	3,562
Wagar	711	3,562	1,946	1,616
New Halfa	4,188	24,373 ✓	13,555	10,818
Khasm el girba	1,766	8,343	4,543	3,800
Showak	925	4,824	2,426	2,398
Doka	1,011	4,857	2,631	2,226
El Hawata	1,476	7,841	4,131	3,710
Gala En Nahal	800	3,892	1,991	1,901
		230 277		

Iordofan
========

(4)

?vince	Households	Population	Males	Females
Nuhud	4,529	26,002 ✓	12,986	13,016
Obeid	15,769	90,060 ✓	45,927	44,133
lari	605	2,676	1,281	1,395
ra	1,620	8,960	4,159	4,801
u Zabad	1,427	7,177	3,381	3,796
Rawaba	3,292	19,713 ✓	9,943	9,770
Rahad	2,622	14,444	6,936	7,508
anosa	2,476	12,051	6,119	5,932
lad	1,424	6,936	3,135	3,801
awa	1,323	7,197	3,389	3,808
Fula	1,052	5,294	2,502	2,792
ling	3,743	19,216 ✓	9,189	10,027
ugli	3,449	18,468 ✓	8,841	9,627
Gubeiha	1,707	10,418	5,305	5,113
di	1,406	7,738	3,900	3,838
Kershola	943	5,274	2,563	2,711
lbbasyia	980	4,801	2,229	2,572
had	759	3,588	1,687	1,9o1
		270 013		

l Gazal
=======

l	1,981	8,741	3,983	4,758
ll	2,843	17,773 ✓	9,412	8,361
j	1,539	8,471	4,623	3,848
	11,008	52,752 ✓	29,143	23,609
ek	2,379	16,732	9,044	7,688
l	1,914	14,664	7,077	7,587
		119 133		

r Nile
======

al	5,066	34,898 ✓	18,737	16,161

34 898

(5)

Darfur

rovince	Households	Population	Males	Females
tum	1,018	4,762	2,223	2,539
neina	8,517	35,424 ✓	16,586	18,838
lingei	2,853	13,791	6,630	7,161
l Fasher	10,684	51,932 ✓	25,432	26,500
m Keddada	988	4,693	2,212	2,481
ala	12,094	59,852 ✓	30,268	29,584
l Da'ein	3,482	18,457 ✓	9,284	9,173

1973

Province / Age Group	Red Sea	B. El Ghazal	Blue Nile	Darfur	Equatoria.	Kassala	Khartoum.	Kordofan.	Northern	Upper Nile	Total
All Age	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Less Than 1	2.05	3.25	3.07	2.53	3.23	2.75	2.98	3.18	3.26	2.40	2.95
1 - 4	12.36	16.05	15.86	16.13	13.66	14.50	12.15	16.46	14.29	15.62	15.27
5 - 9	16.87	18.57	18.11	19.79	16.16	17.49	13.58	20.54	17.72	18.16	18.08
10 - 14	10.18	10.47	12.45	10.93	10.85	11.14	10.59	11.51	15.82	10.08	11.52
15 - 19	7.90	8.64	8.07	7.26	8.65	7.55	10.71	6.39	9.81	9.05	8.20
20 - 24	7.59	7.26	5.85	4.54	6.31	6.25	10.99	4.52	5.16	6.26	6.22
25 - 29	8.53	8.20	7.08	6.72	7.96	8.23	10.53	6.33	5.31	8.02	7.50
30 - 34	7.26	6.37	5.65	5.52	5.99	6.58	6.95	5.20	4.13	5.92	5.83
35 - 39	7.37	7.19	6.22	6.73	7.30	6.70	6.37	6.60	5.03	7.53	6.60
40 - 44	5.63	4.55	4.39	5.02	4.78	4.76	4.19	4.57	3.90	4.43	4.56
45 - 49	4.25	3.75	3.33	3.89	5.16	3.58	3.15	3.92	3.45	4.54	3.76
50 - 54	3.56	2.08	2.86	3.10	3.11	3.13	2.42	3.08	2.98	2.40	2.83
55 - 59	1.91	1.15	1.63	1.52	2.16	1.65	1.41	1.82	1 95	1.58	1.63
60 - 64	2.01	1.05	1.86	2.08	1.70	1.82	1.43	2.13	2.45	1.10	1.78
65 - 69	1.00	0.48	1.09	1.03	1.22	1.12	0.84	1.19	1.51	0.70	1.01
70 & Over	1.53	0.94	2.39	2.98	1.76	2.55	1.62	2.32	3.21	0.88	2.13
Not Stated	0.00	0.00	0.09	0.22	0.00	0.19	0.09	0.24	0.02	0.33	0.12
Actual Total	255643	715317	1958581	1018624	350207	600551	639654	1069217	468356	416667	7492817

Province / Age Group	Red Sea	B. El Ghazal	Blue Nile	Darfur	Equatoria.	Kassala	Khartoum.	Kordofan.	Northern.	Upper Nile	Total
All Age	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Less Than 1	2.18	3.15	3.18	2.18	3.03	2.94	3.41	2.93	2.64	2.25	2.86
1 - 4	12.85	14.93	16.46	13.93	12.43	15.68	14.36	16.28	13.40	14.74	14.84
5 - 9	17.17	16.78	18.20	17.13	14.03	18.26	16.34	18.47	15.94	15.69	17.18
10 - 14	10.46	9.54	11.66	8.90	9.14	10.87	11.92	9.93	12.57	8.60	10.43
15 - 19	8.11	9.03	8.63	7.47	9.24	8.30	10.47	7.41	9.39	9.16	8.56
20 - 24	7.37	9.62	7.50	6.84	8.40	7.40	9.35	6.73	6.53	9.50	7.75
25 - 29	9.37	11.18	8.65	10.32	10.72	8.95	8.97	9.30	7.24	12.24	9.[illegible]
30 - 34	7.81	7.74	5.96	6.97	7.75	6.46	5.68	6.29	5.64	7.22	6.57
35 - 39	7.11	6.38	5.57	7.02	7.74	5.64	5.46	6.51	5.96	7.03	6.30
40 - 44	5.14	3.74	3.98	4.96	4.78	4.25	3.66	4.39	4.28	3.76	4.24
45 - 49	3.63	2.85	2.56	3.30	4.41	2.77	2.82	3.38	3.14	3.51	3.11
50 - 54	2.97	1.88	2.46	3.07	2.71	2.53	2.33	2.91	2.80	2.08	2.59
55 - 59	1.57	0.99	1.11	1.36	1.82	1.19	1.27	1.50	1.54	1.49	1.33
60 - 64	1.69	0.89	1.50	2.26	1.45	1.42	1.41	1.83	1.96	0.97	1.59
65 - 69	0.86	0.44	0.69	0.97	0.98	0.79	0.76	0.91	0.95	0.62	0.79
70 & Over	1.71	0.85	1.86	3.06	1.37	2.49	1.73	2.04	6.00	0.80	2.21
Not Stated	0.00	0.01	0.03	0.17	0.00	0.06	0.06	0.18	0.01	0.34	0.09
Actual Total	209400	681596	1854410	1162537	405543	522836	528515	1133129	530527	331584	7110077

Population of the Three Towns

By Place Of Birth

	Town Of Residence				
Place Of Birth	Khartoum	Omdurman	Khartoum North	Total	%
Born Here	153316	183846	78367	415529	53%
Come From Other Places	180590	115553	72622	368765	47%
Total Greater Khartoum	333906	299399	150989	784294	100%

Note:

(i) Pop. born in the specified towns are those born in Khartoum Province.

(ii) Pop. coming from other places to the specified towns exclude those coming from Khartoum Province to the towns.

E DEMOCRATIC REPUBLIC OF THE SUDAN
Ministry of Construction
& Public Works
Undersecretary's Office
Telephone No. 72030
P.O. Box 300
Khartoum

جمهورية السودان الديمقراطية
وزارة التشييد والأشغال العامة
مكتب الوكيل
صندوق بوسته رقم ٣٠٠
تلفون نمرة ٧٢٠٣٠
الخرطوم

M.C.&P.W. وزارة التشييد والاشغال العامة

No. ....
No. ....
ject :—

رقم رسالتنا : وت أع / دثاسه / ....
الموضوع : ....
التاريخ : ....

21th, November, 1977

The cost of four types of houses
in Sudan per Square metre

1/ FIRST CLASS HOUSE :-

Red brick with cement mortar as walls and concrete roof

The cost LS.80

2/ SECOND CLASS HOUSE :-

Red brick with mud mortar walls and zinc with ceiling(cladding) as roof

The cost LS.55

3/ THIRD CLASS HOUSE :-

Red brick (internal) and mud brick (external facing) with mud mortar as walls, native type roof (rughly treated log, braches and ~~plan~~ Palm leaves).

The cost LS.40

4/ FOURTH CLASS HOUSE:-

Mud type of walls (~~Glvose~~ Galoose) and native type roof

The cost LS.30

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