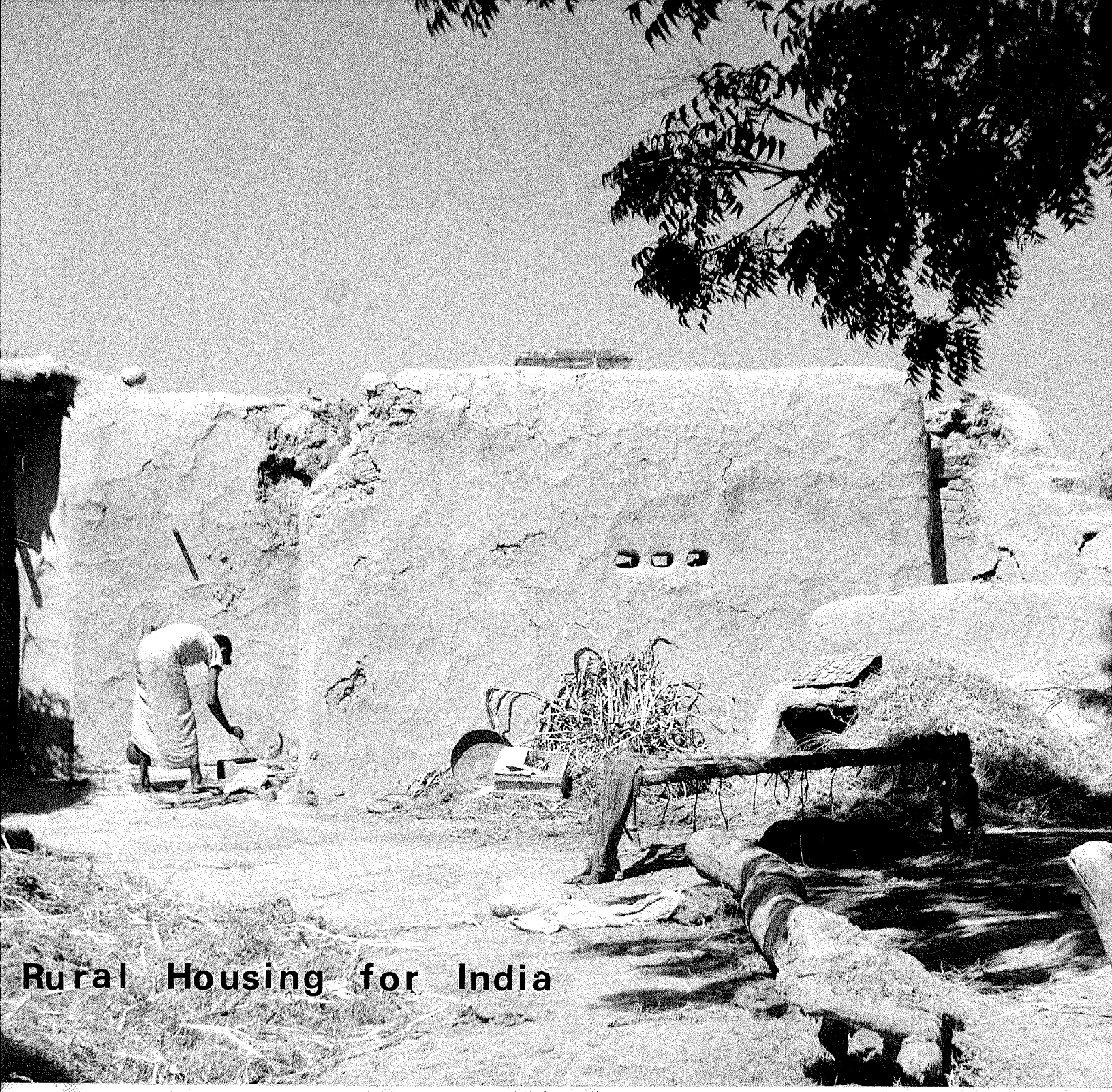

Rural Housing for India

Master in Architecture Thesis,

Faculty of Architecture,

University of Manitoba, 1965-66

RURAL HOUSING FOR INDIA

j.m. kumar
b.arch delhi university 1962

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ACKNOWLEDGMENTS-

The author takes pride in expressing his sincerest gratitude to Dr. D. Styliaras, Dept. of Architecture for his instructions and able guidance. He also wishes to thank Professors Claude P. DeForest, A.N. SenGupta, and Gordon Adaskin, Dept. of Architecture and Prof. V.L. Dutton, Dept. of Civil Engineering for their valuable criticism.

Thanks are due to Mrs. Martha Stupen for her efforts in typing this report.

OBJECTIVE OF THESIS

The objective of the present Thesis is to evolve a 'design concept' of a dwelling unit for rural India which could be multiplied to form a community. An attempt will be made to introduce a building system which synthesizes mechanization (for mass production) and self-help (for economy), apart from integrating all functions of the community.

The objective, in view of the low income of most of the families involved, is to spread among the population concerned the knowledge required to enable them to build their own houses in a manner which will give them a great degree of health and comfort.

The author, in the present context, intends to confine his attention to Northern part of India and concern himself with the needs of the people in that region. The planned villages are hoped to serve as a source of inspiration for adjoining areas or models for duplication in course of time elsewhere with local initiative and enterprise.

INTRODUCTION

India is a land of villages, with nearly half a million villages comprising 80% of its population. Also, Indian economy is agrarian, having three fourths of its population earn its living by agriculture.

After independence, industrialization stirred the activities in urban parts and resulted in the sudden influx of rural population into urban areas. This was for two reasons:

a. for the prospect of better employment opportunities,
b. the lack of certain basic amenities in villages the want of which attracted the people to cities.

This has resulted in creating highly unsatisfactory living conditions in cities and towns. The growth in housing and the number of people which industry is able to absorb, is far less than the number of people migrating to the cities.

With a view to check this, government has envisaged Village Housing Projects which will aim at improving the housing conditions in rural parts. The underlying objective of these projects involve the assumption that if the rural population is properly looked after and their living conditions are improved, it will check the disproportionate migration to cities and also the formation of certain small scale

industries located in the villages would really balance the economy which, at present, remains solely based on agriculture.

In rural India, the increase in population is only by natural growth and not by immigration, moreover the shortage in housing is only qualitative and not quantitave. The data collected by National Sample Survey in its 7th round in 1961 indicated that in rural parts about 85% houses had mud plinth, 83% walls of mud, bamboo and reed and 70% roofs of straw, grass, reed etc., and only about 7% of the houses had plinths and walls of brick, cement or stone and roofs of corrugated sheets, tiles etc.

More than 90% of the houses have no water closets attached to them. As regards sources of drinking water, about 70% depend on wells, 13% on tanks and ponds, 12% on natural sources like lakes, springs, and rivers, 3% on tube-wells and about 2% on tap water supply.

About 81% of the houses had three rooms or less; one-roomed houses accounted for 34% and two-roomed houses for 32% of the houses studied in the survey.

About 38.5% of the households had less than 100 sq. ft. per head of floor space and about 32.5% between 100 and 200 sq. ft.

Out of 54 million houses in rural parts about 50 million have to be either rebuilt completely or improved substantially. The financial resources of the country do not permit the complete rebuilding or improving of all the 50 million houses of the rural India. At the same time the economic resources of individuals also do not permit such an attempt. Any programme must produce a plan which is self financing and possible for anyone to adopt and put into operation. Considerable emphasis has to be laid on the techniques of aided self-help.

CHAPTER 1

RURAL HOUSING OF NORTHERN INDIA

A visit to a village in Northern India is a thought provoking experience. For hundreds of years, the rural papulation has been living with bare essentials. Due to the low level of living standards and the prevalent illiteracy, housing is assigned low priority in the scheme of expenditures by the villagers, but still they have shown a great understanding of natural phenomena. Despite few resources the rural communities have built dwellings that have protected them from the inclemency of hot weather and provided some bare minimum conveniences for their day to day living.

PEOPLE AND THEIR LIVING HABITS: An average village consists of 200 to 300 houses, the size being dependent upon the number of people owning land around villages which can be easily supervised. A farmer has to travel with his pair of bullocks, one to two miles to reach his small holding and he spends about three hours daily in this process. If he has to live in a bigger village, thus increasing the distance of the fields from his house, then he will not be able to look after them efficiently.

Already, per unit family land holding in India is less than five acres and these too are scattered due to the system of succession. All the children and wife inherit land equally and thus even the bigger land holdings are getting split up. It is only recently under the provisions of the Consolidation of Land Holdings Act that these scattered land holdings have been consolidated in bigger plots, but still they are too small to be economical.

The major handicaps in forming bigger villages may be summed up as:

a. *Slow growth of economy.*
b. *Almost static per capita income and therefore meagre financial resources.*
c. *Small land holdings.*
d. *Lack of automation.*
e. *Bad road system; most of the roads are just dirt.*

An average family consists of five members. The Man of the house looks after the fields and does other work involving great physical labour. Milch cattle form an important part of every household, and many people rear them just to sell surplus milk to the nearby townfolk.

While men depart for the fields, early in the morning, most of the women stay at home to do the household chores including looking after milch cattle. They may join their husbands at lunch time and take with them the cattle also, for grazing. Most of the women do a lot of spinning at home to make the conventional dowry for their daughters.

On an average, about 70% of the rural people own land and are engaged in agricultural operations. The other 30% of the population consists of landless Harijans and few people are artisans or engaged in business. The 'Harijans' earn their livelihood by doing odd jobs for the land owners or act as tenants. There are a few families of weavers who work on hand looms of pit type and weave rough cloth for the use of average villager for the cold season. They also weave beddings and sheets etc.

Every village has its own shoemaker. The oil presses and grinding mills are used for rice husking, flour grinding and making brown sugar out of sugar cane. The village carpenter prepares indigenous ploughs for the farmers; makes cots and other small items and does woodwork for the construction of new houses .

There are a couple of ironsmiths in every village who sharpen the shears of wooden ploughs and do other work of the same sort. These landless villagers have begun to keep fowl and poultry on a small scale and they sell the products to peddlars from the town. Many of them sell milk also and few rear pigs as well.

The village shopkeeper is also a necessity. He supplies articles of daily need such as kerosene oil, cloth, cigarettes, condiments of sorts and cereals etc. Many times he would buy the crop from the farmers and sell it in the central town market. Thus, for villagers, he is the link between village and town.

The richer among the land-owning communities now own tractors and other improved implements. The rest of them still work on their persian wheels to irrigate their fields, by bullock driven contrivances. Hardly 1% area in the villages is yet irrigated by electric pumps and the canal water reaches barely 30% of the area. The rest of the area is irrigated by wells and this process consumes most of their time.

LAND LEGISLATION: According to the land reforming legislation, the average land holding has been limited to 60 acres. Over and above this limit, the state has assumed the powers to distribute the land to landless tenants. In this part of India, about 20% of land belongs to persons of middle group viz. between 20 acres to 50 acres and only 5% of the land belongs to persons owning more than 50 acres. The rest of them have just enough land for their meagre subsistence.

PLANNING OF THE HOUSES: The internal setup of a house is based upon the free and unobserved movement of the womenfolk for doing their chores while the men use the living room (baithak) for entertaining their friends. Courtyard is the main centre of activity of the individual house.

The most obvious aspect of village life is the predominance of communal life over private life. It is the street where 'life occurs'. Quite often, a street widens to form a 'group courtyard' or a semi-public open space which facilitates cross visiting and talking between neighbours. The other communally shared spaces include,

a. *The Lake (or pond) - It is mainly used for watering and washing the cows; sometimes for bathing and washing clothes also. At present these lakes pose a 'mosquito-bed' problem. During the monsoon they rise 8 to 10 feet and flood a much larger area. However, the inherent value of the lakes (physical, social, psychological) cannot be overlooked. With proper cleaning, lining and deepening the edges, stocking with fish and ducks, they could be a major asset to the villages, instead of being murky and muddy places.*

b. *The water wells- All drinking and cooking water is obtained from these wells and this common need makes a well, an important meeting place in the villages.*

c. *Larger open spaces, and the temple- Many villages have at least one large open space, particularly near the temple or school, where religious activities can take place. Their dogmatic faith in religion makes them perform many functions during the year, on a community basis. Religion dominates their life. Almost every woman of the village visits the temple at least once a day; many families pray for as much as six hours weekly.*

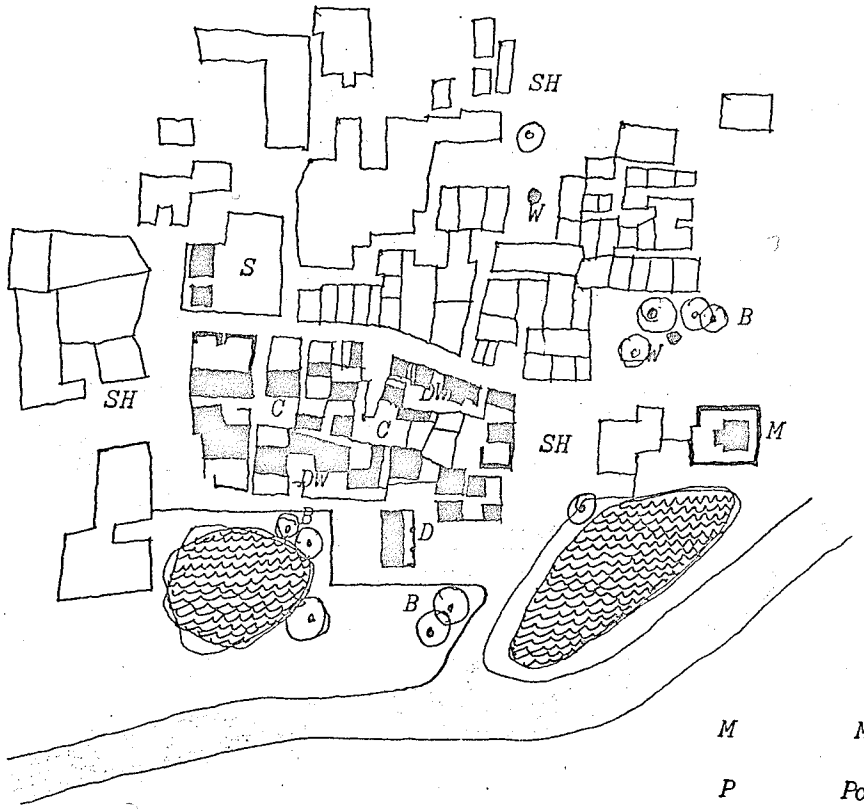
According to the Village Survey Monograph of Punjab there are more or less two types of houses in the villages:

1. *Consisting of just one big room subdivided into areas according to use. These houses are for slightly smaller and poorer families and each one of these is clustered around a courtyard used by all the houses together, (refer page 15). Mostly service, labour and artisan classes live in these houses.*

2. *Bigger type houses are arranged around private courtyards. Sometimes enough space is left for the addition of a room or two at a later stage. Designs of these houses vary and most of these have stairs leading to roof which is used for sleeping at night during summer. 75% of the houses fall in this category and they are occupied by agricultural, trade and business classes, (refer pages 16 to 20).*

Villagers, particularly those in the younger generation are getting conscious about improving their housing conditions, though at present, due to lack of any incentive and any organized technical help, they are

unable to do much about it. If one becomes wealthy the first impulse is to go for costlier and better clothes and more cattle which is the proudest wealth symbol of the villager. Those who get fed up with the insanitary surroundings and insufficient community facilities, find an escape by trying to migrate to the urban centres.



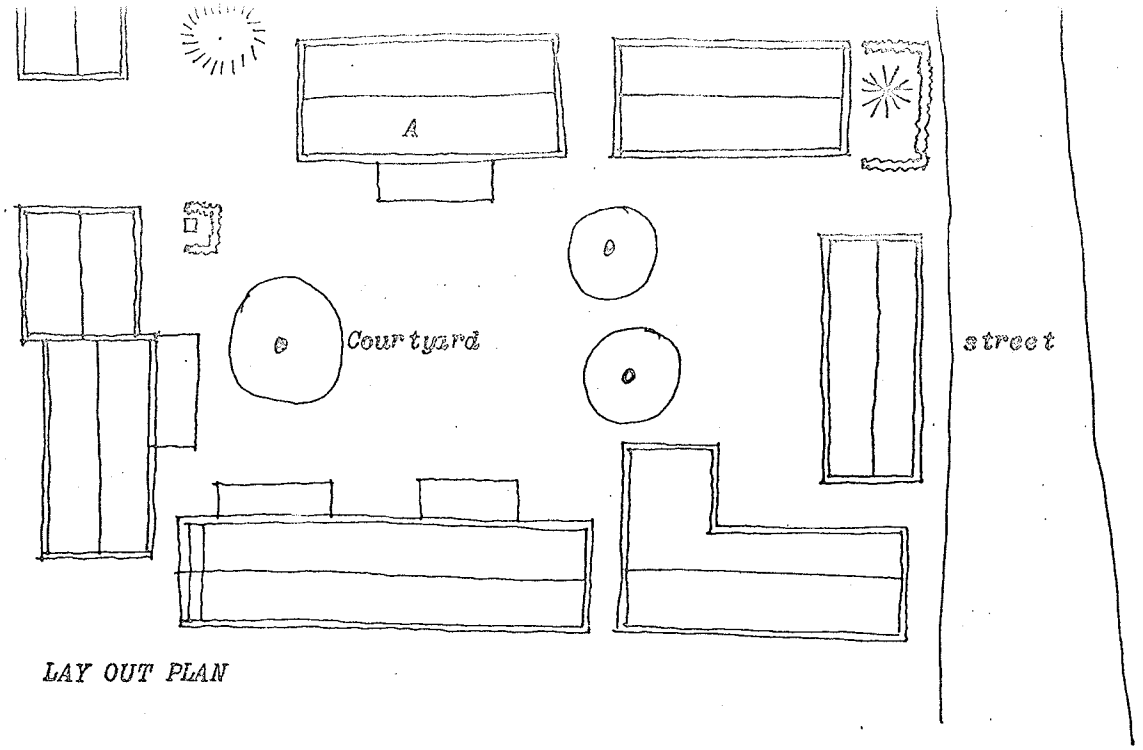
Site plan of a typical village of Northern India.

This plan shows how the individual buildings pile together in collective mass protection against excessive stress of hot and arid environment.

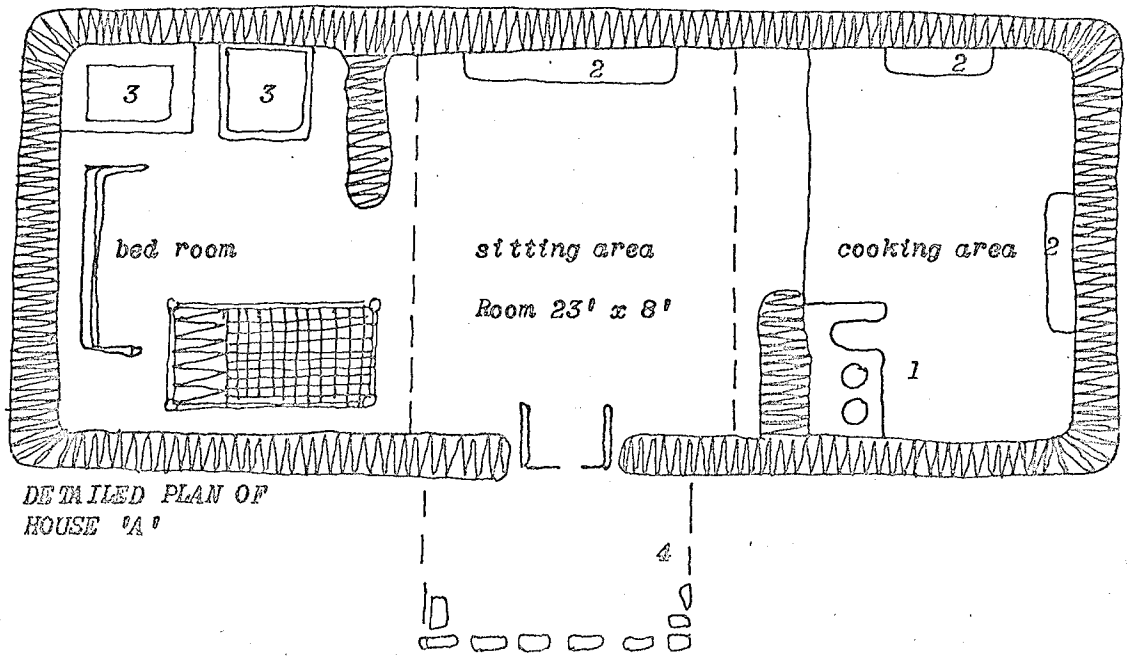
M	*Mandir (temple)*
P	*Pond*
S	*School*
W	*Well*
D	*Dispensary*
B	*Banyan trees*
C	*Courtyards*
SH	*Shamilat (common areas)*
DW	*Dwellings*

Sketch from 'Tropical Architecture'

Architecture in Australia, December, 1963.



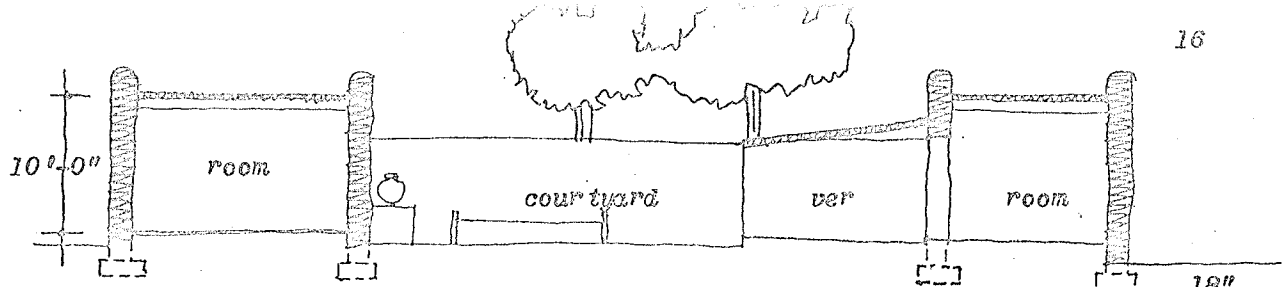
LAY OUT PLAN



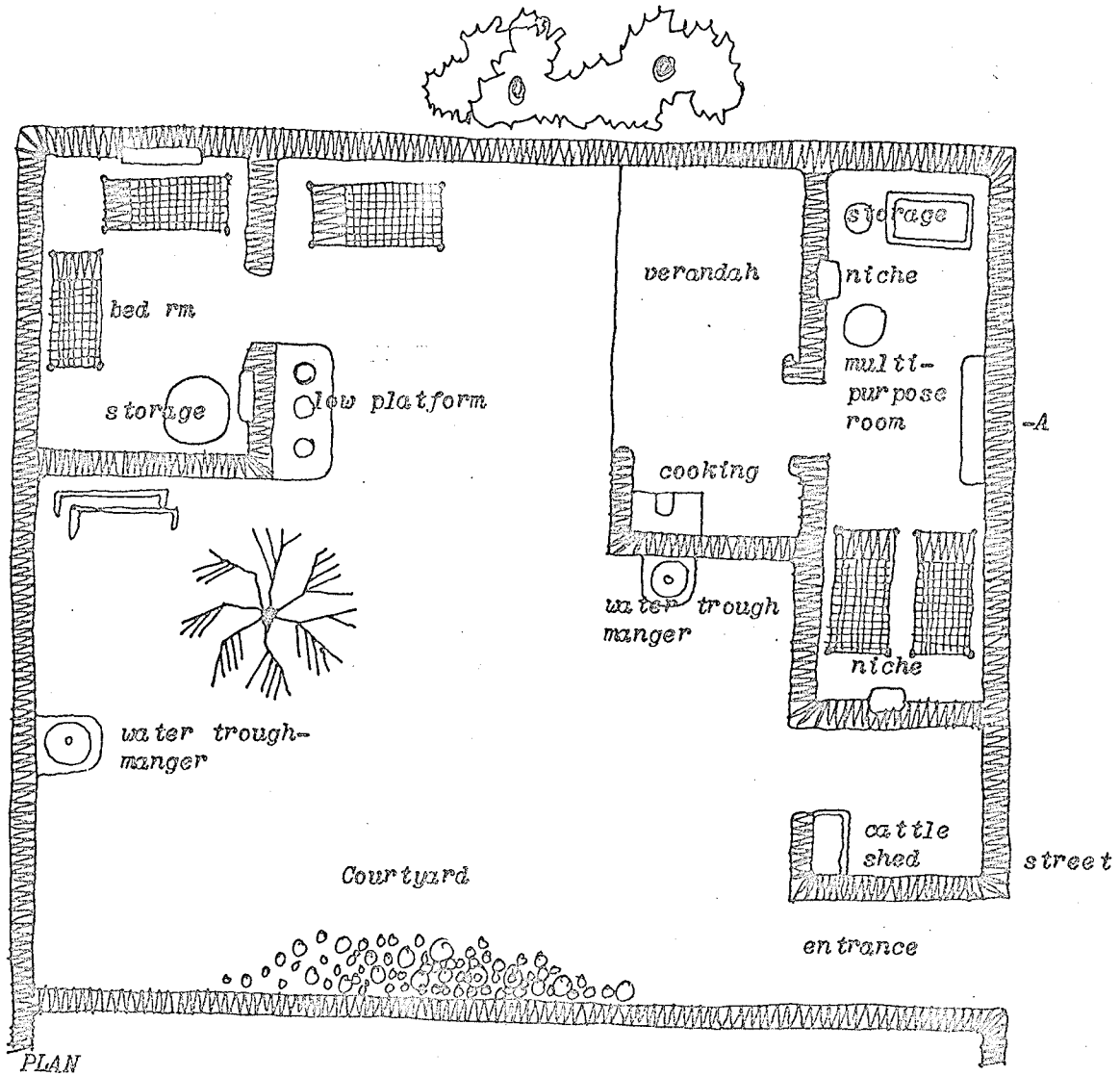
DETAILED PLAN OF HOUSE 'A'

Legend

1. Chula (hearth)
2. Shelf
3. Storage
4. Porch or Verandah

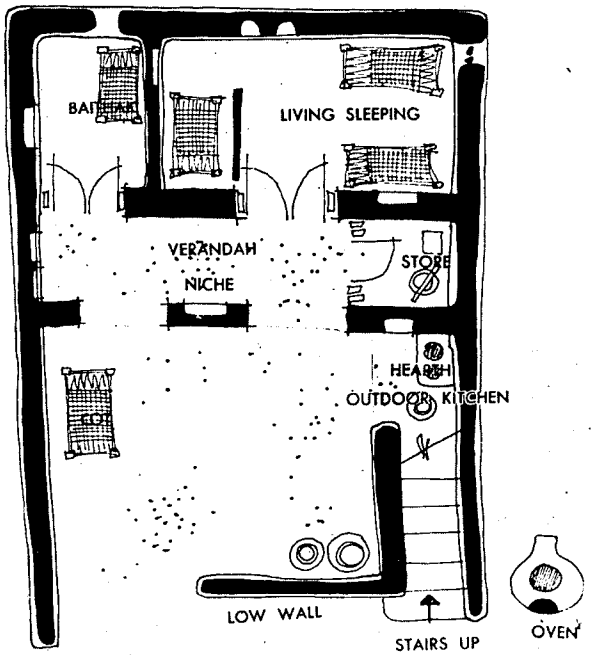


CROSS SECTION A-A

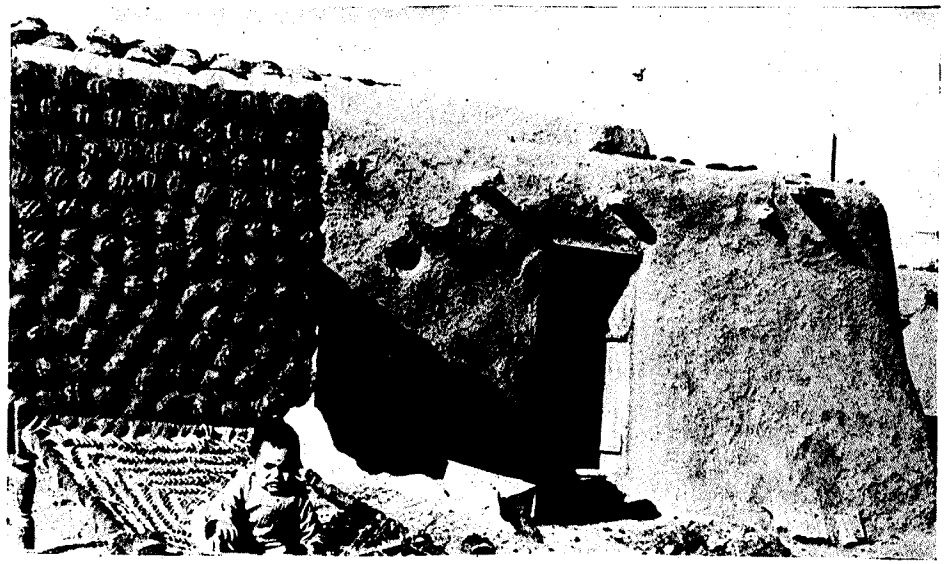


PLAN

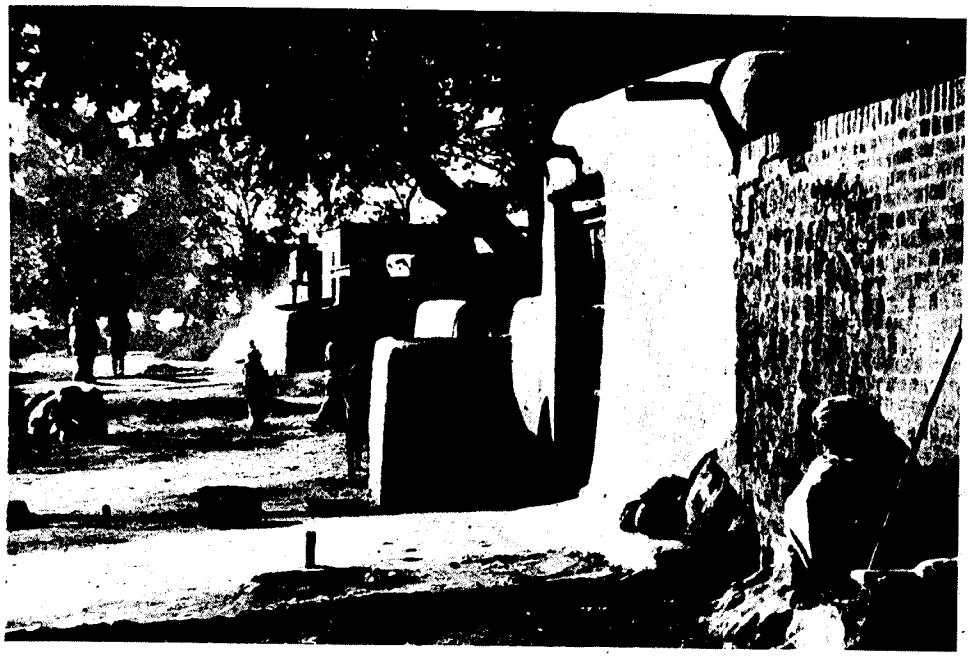
TYPICAL LARGE DWELLING



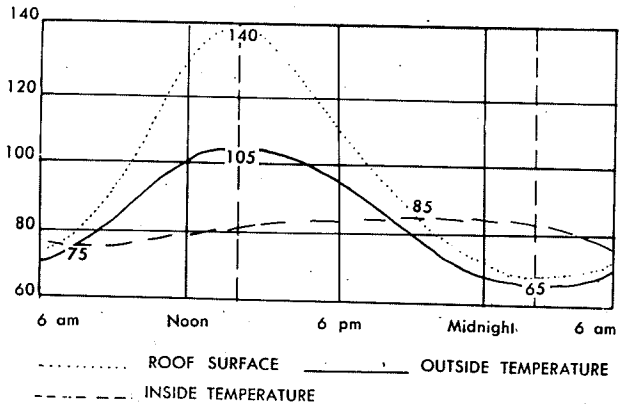
Plan of typical 'kacha' dwelling of the upland plains



Photograph from 'planning open spaces in the Tropics' Design July, 1958.

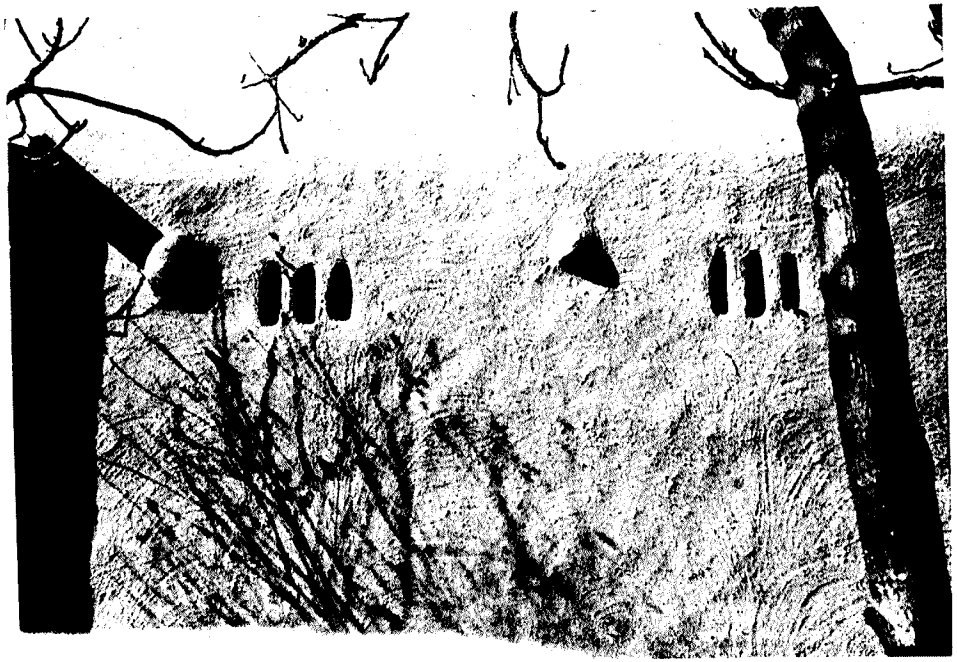


A village street

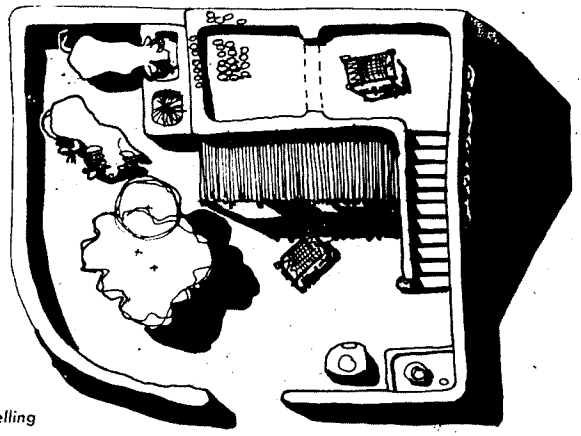


Mud house temperatures compare favourably with those obtainable in modern air-conditioned houses

Photograph from 'planning open spaces in the Tropics' Design July, 1958.



Openings in the wall



View from the top of a typical 'kacha' dwelling

Photograph from 'planning open spaces in the Tropics' Design July, 1958.

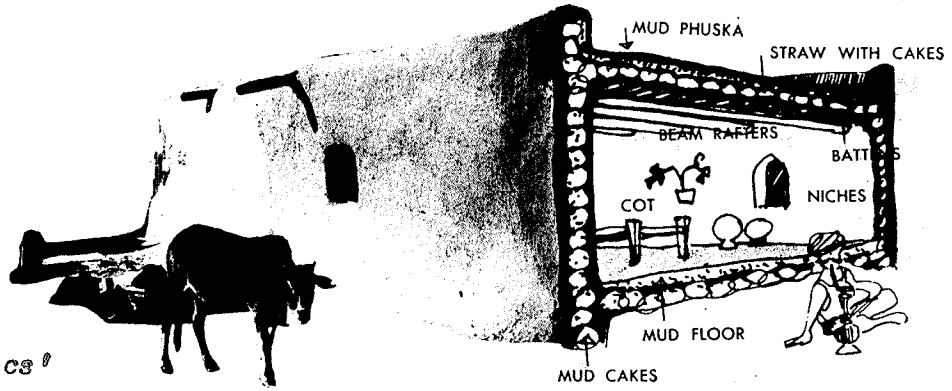
these simple shelters often out-perform the structures of many present day architects who are busy designing for more sophisticated needs in the urban areas of the region.

The chief limitation that seems to dictate most of the rural building activity is the impact of the region's environment and the building materials which this environment affords. In Panjab the climate is certainly not gentle. The building materials are appallingly meagre in quality as well as in quantity.

Broadly speaking, the summers are long, hot and dry, though a few weeks of monsoons do bring sufficient rainfall to cause warm, humid conditions. The dry winter season lasts about four months when the night temperatures at time can, and often do, go down well below zero. By and large, it is a healthy climate, the type that breeds vigorous, hardy and enterprising people.

In any under-developed community—under-developed in the industrial sense, that is — where even simple

Entrance to courtyards



Section through 'kacha' dwelling

Photograph from 'planning open spaces in the Tropics' Design July, 1958.

MATERIALS: Clay is the important indigenous building material. It is available locally and is the type of material that can be very conveniently handled by one or two individuals. Moreover the plastic quality of this material lends itself to interesting sculptural treatments. We see the evidence of it in various surface textures and patterns created by rhythmic pressure of the human hand, (refer page 19). "The rounded aris-parapet and vertical corners; an unlimited variety of niches in walls both internal and external, and at times even the stairs hollowed out of the courtyard will reveal the expressive qualities of clay and its moulder". (i)

Naturally this material has chiefly dictated both the construction and the design techniques of this region. With minor variations, the general method of construction is as follows:
Excavations for the walls are about 9" to 12" and the latter are built straight on this bed level. As such, for single storey construction, the part of walls below ground level acts as foundations. The most common use of clay is in the form of sunburnt bricks having no regard for their shape or size. Often, they ram the same pond soil in irregular shuttering consisting of two wooden planks (refer page 20).

(i) "Housing in Hot and Arid Tropics."
Design March, 1962.

The roofs are flat and they are constructed by placing wooden joists or 'ballies' roughly at 4 ft. centres. This is followed by a covering of planks or split battens closely spaced and twigs or leaves are then evenly spread with a final topping of mud which is tamped, screeded and plastered.

For floors, the ground surface is levelled, dressed and compacted by wooden 'thapies'. A final coat of wash of cowdung is then applied which is supposed to render the surface smooth, and acts as a general disinfectant. The primary drawback of clay as the building material is its instability. Everything gets eroded with the impact of rainfall and it is impossibile to keep any surface clean.

Despite this handicap these dwellings reveal a good knowledge of climatic conditions on the one hand and, on the other, an understanding of the performace characteristics of local materials.

Working, as they are, in an economy of general scarcity, the resources in both material and energy are severely limited. Yet there is little margin for error in coping with natural forces: heat, cold, wind and sometimes rain.

The traditional load bearing mud wall relies not only on its thickness to resist passage of heat but also on its greater heat storage capicity. In Northern India where diurnal temperature range is large, this extra heat storage capacity has considerable advantage in late morning and early afternoon, when the outdoor temperature exceeds desired comfort level. The degree of heat that succeeds in reaching the interior through the walls is not enough to heat the inside of buildings, especially in those hours. In the later afternoon and early evening hours, the outdoor temperature drops, but the indoor conditions do not improve right away. Heat that the heavy walls have stored during the day, is now discharged both outdoors and indoors. The people have traditionally answered this situation by coming to terms with nature - by using outdoors; courtyards, roofs and other open but private areas for the purpose of living and sleeping during these hours.

EXISTING CONDITIONS:

Rural redevelopment requires making efforts in many ways. The problem of housing in these areas is not an independent one but is inter-related with many other factors. These may be enumerated as:

LACK OF PUBLIC SERVICES:

Up to now, not enough attention has been paid to environmental sanitation and health. There are no proper arrangements of water supply. The wells are open and lack protection facilities. The water generally remains contaminated and often results in epidemic and endemic diseases. There is absence of even a very rudimentary drainage system The water keeps soaking into the soil, which after sometime becomes subject to waterlogging and stagnation. These places become the breeding ground of mosquitoes and insects.

INSUFFICIENT CIVIC AMENITIES:

It has already been pointed out that housing in rural areas lacks community services and facilities which has been causing the drift of rural population to urban areas. Civic amenities provide a stimulus to the developing community and are the backbone of their progress. Villages lack certain basic necessities. Education facilities, where existing, are not always adequate.

The main building material viz. mud as used presently is unstable and cannot stand the rigours of monsoon. Heavy rains wash it off and maintenance becomes difficult. Many of the houses have to be rebuilt each year.

The plan of the village as a whole lacks a more systematic pattern and it is difficult to make any expansion of the individual unit or of the whole village. At present these villages are the result of a slow accretion over a large number of years and lack co-ordination. As is evident from the plan on page 14, the 'shamilats' or the smaller areas seem to be the 'left over' spaces on the periphery rather than the enclosed rural spaces which could be more intensively used. The areas between the houses 'marked C' on page 14) are used by human beings and animals alike and there is always a large amount of filth lying all around. Moreover it is almost impossible to run the service lines of all the dwellings with their existing layout.

CHAPTER II

DESIGN CONSIDERATIONS: CLIMATE

Northern India is mostly hot and arid. A substantial area is influenced during summer by hot, dry air masses. The result is extremely high day temperatures of 90 degrees to 110 degrees F. or more in the shade. Nights are cool, the termperature dropping to the 60's, though there can be times when both days and nights stay persistently hot accompanied very often by hot, dusty and dry winds, of up to 15 to 20 mph. Exhibiting a wide diurnal range, often as much as 35 degrees F this region normally has fairly low relative humidity. It is classified as the poor rainfall region, with rainfall between 20" and 30". Here irrigation is essential for cultivation. Rice, millets and wheat are grown in the plains, while the Shiwalik hills are covered with sparse vegetation. During winter, however, which lasts from November to February, the temperatures drop down very often below freezing, and there is irregular and fairly low rainfall during this time of the year.

COURTYARD CONCEPT

In a typical Indian village we find that houses cluster very closely to protect themselves from the excessive heat. Moreover, they do not open onto the streets but to an inner court which is not only

a private garden but is also an extension of the living areas of the house. This concept is repeated to form communal areas between the houses and these act as cooling wells. The shade provided by walls all around or shrubs and the continuous flow of cool air bring down the temperatures effectively. These courtyards, which are an essential part of almost every house, not only provide useful open spaces but also create a manifold interest in the village-scape.

Use of the court design is not merely a theoretical hypothesis but its advantages are evident from so may practical instances. Residential palaces of Moguls invariably enclosed a garden cooled by water which not only delighted the eye on a hot summer day but also nourished the plants. These luxury courtyards of rulers were naturally imitated in the large dwellings of important court officials and upper class merchants and traders.

THE COURTYARD IN JAPAN

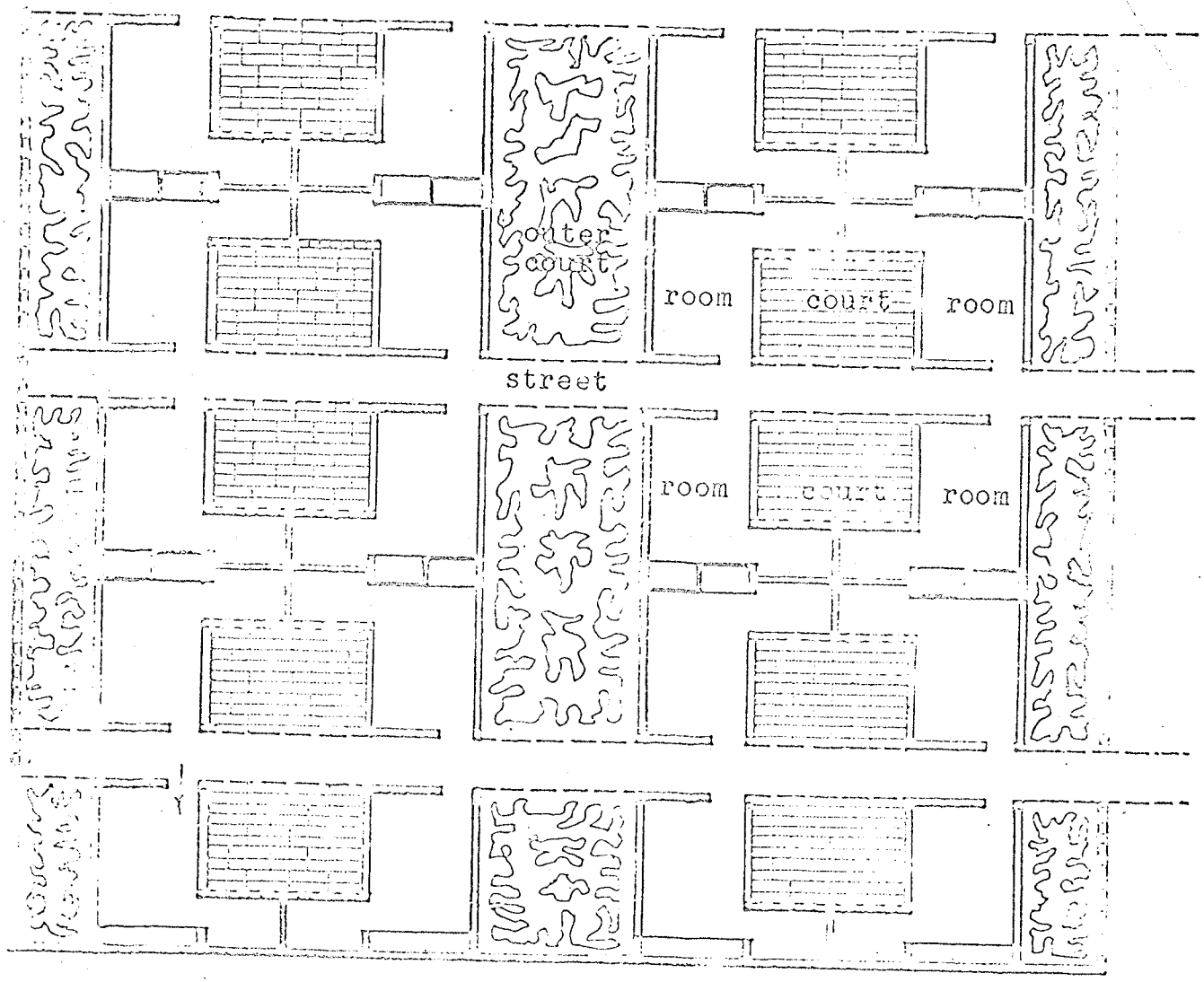
The Japanese courtyard has a great spiritual and philosophical basis of design. Conceived as a work of art and a piece of landscape design, it is intended for contemplation rather than purely

practical use. Small garden courts were popularized in every detail during the 18th and 19th centuries, in Japan.

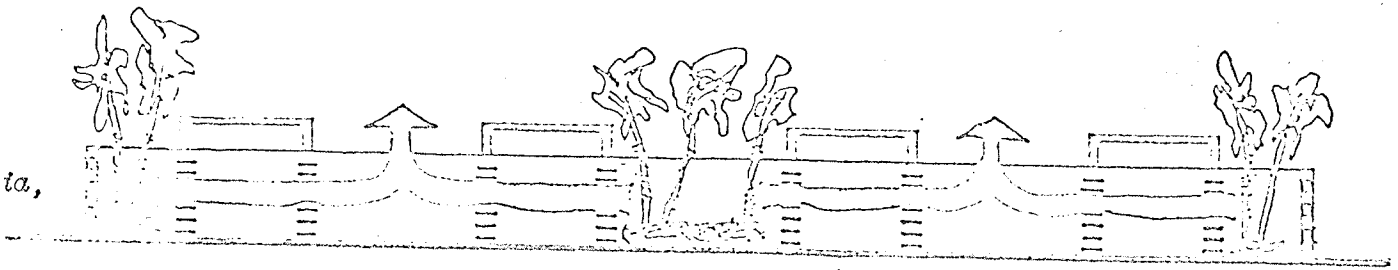
RESEARCH STUDIES AT COLUMBIA UNIVERSITY

In 1951 a group of research students at Graduate School of Architecture, Columbia University, carried out a number of experiemnts to study the influence of climate on planning and architectural forms. Investigations were made concerning natural air-flow from existing winds, if any, or if not, from artificially induced convection. A scheme was prepared to ventilate interiors where no breeze could be counted on. A system of living quarters (for scientific personnel) interlaced with courts was developed in Negeb, one of the world's hottest regions. "Trees are planted in alternate rows of courts which being shaded automatically have cooler air. This air at low temperature circulates from the shaded to the sunny courts where the rising hot air creates lower pressure. In its passage the moving cool air from the shaded courts ventilates the rooms which are located between the sunny and the shaded courts, via perforated gates and louvered walls." (i)

(i) Architecture in Australia, December, 1963.



Housing Layout in Negeb



Sketch from 'Tropical Architecture'
Architecture in Australia,
December, 1963.

NEW HOUSING DEVELOPMENTS

In many new housing settlements in North Africa, Iraq, and India, this basic concept used in individual houses, forms the basis of neighbourhood plans where open spaces extend from the private courtyard to larger parks and gardens shared by the entire community, thereby inducing a very satisfying social environment.

SUN CONTROL AND BUILDING DESIGN

Building design in hot dry regions presents problems where sun is a far more serious factor to deal with than breeze. A hot bright sun overheats practically everything - the roof, walls, exposed terraces and surrounding ground. The surfaces either reflect light and heat into the building or they transmit heat directly through the roof and walls into the interior. So the problem reduces itself to ways and means by which the building could be protected from the impact of solar heat.

Table No. II shows the effect of various types of shading devices upon instantaneous solar heat gain through single thickness of common window glass. Once direct sunlight is excluded, the ground and surrounding buildings are the main sources of light and radiant heat. To reduce glare and heat and, if need be, surrounding buildings and lower parts of the sky (which might

be bright and glary through dust-haze) is cut off by screens or by placing window sills above eye level.

ROOF SHADING: The problem of roof shading is certainly far more complex, particularly if it is necessary to achieve the objective through means that are inexpensive and foolproof. Owing to its orientation and comparatively large area, the roof can be one of the main sources of heat gain in a building. There are times of the year when the sun is at right angles to flat roof in which case the intensity of radiation falling on the surface may be nearly 350 B.T.U./ sq. ft. (hr).

The first objective should be to reduce the proportion of radiation absorbed by the outer surface of the roof. Here the color of the roof finish is of some importance. Figures in Table III indicate the effectiveness of white or light colors.

Generally in high day temperature areas, thick flat roofs with considerable heat storage capacity are ideal. Many other materials may also be possible and the list in Table IV gives some indications of the extent to which heat is transmitted through various forms of construction under certain conditions. There are many

examples of dwellings which achieve ideal results by topping the roof slab with a thick layer of earth - an excellent insulation material.

The practise of building walls in heavy weight materials is quite common where thick walls of high heat storage capacity provide excellent protection from heat of the day. Such construction cools down slowly. In the winter when the outside temperature is in the 50's, this is a considerable advantage.

SELF-HELP

"Although in tropical and semi-tropical regions of the world about 1,000 million people build their own houses, a very small portion of these families live in suitable dwellings." (i)
This is due to the fact that not enough study of the techniques involved has been done. By combining the initiative and resourcefulness of the people, the social advantages of group-work and the best use of technical knowledge available, considerable improvements could be made and new dwellings could be built to better standards.

The simplest and the most familiar form of aided self-help is the traditional 'one family approach,' best exemplified by the Eskimo's igloo, the nomad's tent or the earth and thatch hut.

(i) U.N. publication on 'Development Decade Proposals for Action'.

The family gathers its own materials, shapes and fits them and builds the house to completion. Outside skilled labour is not required. Money is not used or needed.

The other most common form is the 'group building approach.' This is usually associated with villages or farm settlements. Neighbours and friends help to build the house in return for reciprocal aid. Money is still not used if land and local materials are plentiful, but human interrelations are added to the process.

A different situation may arise when traditional materials become depleted or they become unsatisfactory from the point of view of maintenance or durability. At this stage the individual or family needs,

a. Financial resources to procure the materials.

b. Technical assistance to work with these materials if it involves certain changes from the traditional way of building construction.

To remove the existing shortcomings in the villages, the government of India anticipates to help the people as far as the above two factors are concerned, but they would have to rely on their own talent

and labour to make this rebuilding programme an economic possibility, both for the family as well as for the nation.

STANDARDIZATION

For reasons of long-range economy and in order that the basic unit can be repeated, consideration has to be given that the standardized units could be prefabricated. To start with there must be very limited number of repitittive mass produced units which can provide the desired range of dwellings. And the design of these units has to overcome the limitation that mass production may not lead to monotony. The most drastic measure to achieve standardization in house building is to produce a number of designs of houses which are suitable for identical repitition.

Also another important problem is to make the public understand and appreciate the forms of architecture which are more functional and typified without lacking aesthetic qualities. In semi-industrialized building methods, standardized constructional elements are used for the essential structure only which is then plastered or covered with traditional materials e.g. brick or stone or precast elements for roof.

The application of doors and stairs and windows as standardized constructional elements naturally influences architecture. The use of these standard elements creates the danger of excessive uniformity which can only be offset by giving even greater attention to the architectural composition.

TABLE I

REGION	Hot-arid Northern part of India
LAND CHARACTERISTICS	Alluvial Gangetic plains and semi-desert area of Rajasthan
TEMPERATURE RANGE Summer Temperatures	25 degrees to 35 degrees F between day and night: less in the East and more in the West. Maximum temp. in shade reaches 115 deg. F, at times. Average minimum temp. between 65 to 75 deg. (night)
Winter Temperatures	25 degrees between day and night. Average maximum temp. in shade 55 to 65 degrees F (day) Average minimum temp. 35 to 45 deg. F (night)
HUMIDITY Relative humidity	Relative humidity varies from 16% in May to about 80% in rainy season of summer and winter.
RAINFALL	Poor rainfall region, with rainfall between 20" and 40" for the whole year. It is less than 20" in the Rajasthan area.
GROUND CONDITIONS	Little vegetation in Rajasthan; Gangetic plains very fertile due to cultivation by irrigation. Water table high in the Gangetic plains.

AIR-MOVEMENT	Summer winds S-E to N-W, usually warm or hot. Winter breeze N-W to S-E.
OTHER CHARACTERISTICS	During summer, high sun temperature and rapid cooling at night may cause materials to crack and break up.

TABLE II: *Effect of shading upon instantaneous solar heat gain through single thickness of common window glass.*

Type of shade: finish on side exposed to sun	Percentage of heat gain occurring through unshaded window
Outside slatted shade, slats set to prevent direct sun falling on glass; white, cream.	15 percent
Outside commercial bronze shading screen, consisting of narrow metal slats; solar altitude above 40 deg. so that no direct sun falls on glass; dark.	15 percent
Outside canvas awning, sides open; dark or medium color.	25 percent
Inside venetian blinds, slats set to prevent direct sunshine passing through: diffuse reflecting aluminium.	45 percent

Ditto: white, cream	*55 percent*
Inside roller shutter fully drawn: dark	*80 percent*

TABLE III

Type of surface	*Fraction of solar radiation absorbed*
Asphalt	*0.89*
Bituminous felt	*0.89*
Blue-grey slats	*0.87*
Asbestos Cement White	*0.47*
White-washed surface	*0.21*

(Based on data in the American Society of Heating & Air conditioning Engineer's Guide).

TABLE IV — Transmission of heat through various forms of construction.

Construction	Coefficient of transmittance	Equivalent temperature difference	Heat Transmitted B. Th. U/ft (hr)
6" conc.	0.69	46	31.7
6" conc. with 1" cork	0.21	45	9.5
6" conc. with 2" cork	0.123	44	5.4
6" conc. with 2" cork air-space and plastered ceiling	0.107	44	4.7
1" wood	0.54	62	33.4
1" wood with 2" cork	0.118	62	7.3

TABLE V: Time lag in transmission of solar radiation through various structures

Type and thickness of structures	Time lag in hours
ROOFS	
1" yellow pine horizontal roof and water proofing and smooth black finish.	1
4" reinforced clay tiles horizontal roof and waterproofing and slab finish	$2\frac{1}{2}$
6" concrete horizontal roof and water proofing and slab finish	5

8" concrete slab, horizontally disposed.	6

WALLS

Wood siding, 1" sheathing, 2" x 4" stud, lath and plaster 13" brick plastered.	12

(Based on data in the Notes on Science of building S.B. 7 Commonwealth Experimental Building Station, Australia).

CHAPTER III

RESEARCH STUDIES IN INDIA

In the low cost housing exhibition held at New Delhi, in 1954, about 70 houses were built by architects and engineers from different parts of India. These houses varied in size, room heights as well as specifications and materials; limitation of cost was the only common factor in them. In order to arrive at a comparative assessment of the performance efficiency of the houses, investigations were conducted by the Central Building Research Institute, Roorkee (India). Investigations covered the aspects of thermal performance, moisture penetration, ventilation, daylighting etc.

THERMAL STUDY

The following conclusions emerged from the thermal study of the buildings:

(1) Heat capacity plays an important role in regulating the thermal performance of buildings, especially in hot arid zones.

(2) Where artificial cooling aids are not used, it is the thermal diffusivity of the materials which is more important than the thermal conductivity.

(3) *If windows are kept closed during sun up hours and open during sun down hours, there is an improvement in the behaviour of houses during summer.*

(4) *The presence of large permanent openings offset the advantages of high heat capacity structures in dry areas.*

(5) *As far as thermal comfort is concerned, the roof is the most important component of a building. Brick roofs are thermally better than concrete roofs of similar thickness and mud phuska is better than the lime concrete for roof insulation. Thin concrete roofs, stone slab roofs and bamboo roofs are not satisfactory. Asbestos Cement Sheet and corrugated G.I. Sheet roofing alone is not satisfactory but the addition of a false ceiling makes a considerable improvement. Ceiling temperatures can be brought down to quite an extent by white washing the exposed surface of the roof.*

VENTILATION

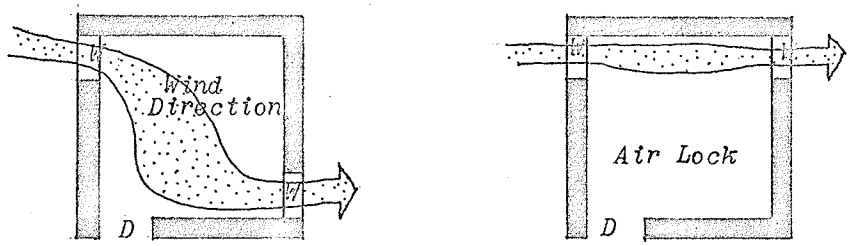
Even in a hot-dry region, ventilation is an important factor. A certain minimum rate of air change is required for health reasons and a reasonable amount of uniformly distributed air movement is necessary for comfort, especially in the monsoon season. Both of these factors depend on the area and location of openings provided in a house, together with its orientation in relation to the mean monsoon wind direction. As a result of the study of air movements, following suggestions were made:

(1) It is not sufficient to prescribe a window area as a ratio of floor area. The distribution and location of windows are also important and should be given due consideration.

(2) Openings should be provided on two walls which need not be opposite walls.

(3) If windows are provided only on one wall, one wide window or two windows at the corners should be preferred to one narrow window in the middle.

(4) *Windows should be located so that the line joining their mid points is almost parallel to the mean monsoon wind direction.*



(5) *To get a uniform distribution inside the room and to avoid air locks at the corners, the location of windows should be such that the direction of air flow passes nearest to the middle of the room.*

(6) *While fixing the relative dimensions of windows of a given area, it should be borne in mind that effective ventilation depends on total width.*

DAYLIGHT ILLUMINATION

In India, there is plenty of sunshine and the problem of daylight indoor illumination is not important except for some areas in winter. The ventilation openings provided for healty indoor living are found to be adequate for illumination.

DAMPNESS PENETRATION

Roofs and Floors: Houses having only two or three coats of bitumen on the roof showed some signs of dampness inside, after continuous heavy rains but tarfelt proved to be the most effective measure against dampness penetration. Similarly floors with low plinths became damp very easily.

Walls: 9" brick walls with plaster on both sides as well as hollow block walls and cavity walls behaved well.

For reasons of economy and thermal efficiency, soil will remain an important building material for houses in the rural areas. New scientific developments indicate broader application of stabilized soil in this field. The U.N. Committee for Housing, Building and Planning for Asia and Far East recommends that "it is essential for the wider economic use of soil that the principles of soil mechanics be made more widely

known among housing personnel by setting up suitable organizations for practical as well as theoritical training in the handling of soil as a building material". According to the research findings of Rural Housing Wing of Engineering College, Chandigarh (India), the most appropriate stabilizers are cement, lime, bitumen or tar. The quantity and type of stabilizer required for a soil depends on its nature.

SOIL BLOCKS

The system of construction with the use of soil stabilized bricks can be improved by employing machines. Except for stabilizers like bitumen which require lean mix for miscibility, the moulding of mixture at optimum moisture is done under the pressure with a machine.

The two most well known machines which have been evolved for making compacted bricks are,

a. Elson Block Master Machine,

b. Cinva Ram Block Press.

Both these machines are portable type and in case of damage, they can be readily repaired with equipment normally available in rural

areas. Thus the cost of the blocks, for a family that operates the machine itself, is reduced to the cost of stabilization. These bricks are uniform, having sharp, precise dimensions and smooth surface.

Solid wall blocks having laid up dimensions of 9" x $4\frac{1}{2}$"x 3", 12" x 6" x 3" and tiles having laid up dimensions of 12" x 6" x 2" can be made with these machines.

These compressed earth blocks are laid in ordinary mud mortar having a tar stabilizer mixed in it. Plaster is then applied to the walls to obtain complete protection and clean finish, internally and externally. Plastering the stabilized mud walls with cement mortar does not prove good, because after sometime, the bond between wall and plaster is broken, resulting in peeling of the plaster from background. This is due to the greater variation in the properties of two mixtures. Therefore soil mortars have been evolved, both for exposed surfaces and internal walls. These are made by adding bitumen, kerosene oil and paraffin wax in varying proportions, to the usual well cured 'bhusa' (straw) mortar of loamy soil.

The stabilized soil bricks can be produced throughout the year at the site of construction and are therefore not dependent on the coal supplies from long distances or carriage from kilns located at out of the way places.

Once the brick dries at the surface, it can withstand the impact of rain and does not get rain beaten like normal sundried bricks. Besides their use in walls, they have been tried on an experimental scale, in the flooring of open verandahs and they have given satisfactory performance.

CEILING HEIGHTS

It is a common conception that the comfort in a house in hot climates is increased by increasing the ceiling heights. Use of high ceilings is based upon the feeling that large volume of air in the room will absorb the heat; that thicker layer of air between the head of the occupant and the ceiling will provide insulation against the heat radiated from the ceiling to the man's head; and that the comfort in the room depends upon humidity and as the humidity in a close inhabited room increases due to respiration and perspiration, the comfort decreases correspondingly with the decrease in volume of air available in the closed room.

There is little scientific basis for all these beliefs. Experiments conducted have indicated that the increase in humidity caused by respiration and evaporation of the inmates within limits does not substantially contribute to thermal discomfort. Moreover, a layer of air of 3" or 4" below the ceiling provides the necessary insulation against further heat transmission from the ceiling to the occupant by conduction and a space of 3 ft. to 4 ft. is sufficient to reduce the discomfort due to radiant heat from the ceiling. The three main reasons to be specified when fixing the ceiling heights in dwellings are:

a. there shall be adequate head room in all rooms.

b. the proportions of all rooms shall be such that they will not cause mental discomfort to the occupant.

c. ceiling height selected shall not prejudice physical indoor comfort.

When ceiling height is considered in terms of head room; fittings of artificial lighting and ceiling fans are likely to be the limiting factors.

From a purely scientific assessment of research so far carried out by the Roorkee Institute, a ceiling height in excess of 10 ft. does not by itself materially contribute to thermal comfort. This allows for a minimum hanging height of 18 inches, thus leaving a clear head room of 8 ft. 6 in.

DESCRIPTION AND ANALYSIS OF THE PROPOSED SOLUTION

For the purpose of designing a prototype village, a site of about 60 acres has been taken near Ludhiana, a town quite centrally located in Punjab. It is intended to connect the village with Ludhiana as well as with other neighbouring villages. In the initial stage, this village shall consist of about 300 houses. As the increase in population in villages is only due to natural growth (about 2% annual at present), a total future expansion of 20% has been taken into consideration for a period of ten years, (although it is hoped that this much expansion may not take place even up to 20 years. With the increase in literacy and effective birth control methods, the rate of growth in population is liable to fall down appreciably or may even become static for many years to come).

The form of the village has been the result of the demands of functions, social as well as climatic. It has been the desire to improve the sanitation and mental and physical health of the people and not to disrupt the pattern of life present in the village.

HOUSE PLANS: A plot of 32 ft by 88 ft is allocated to every family. Main objective in the design of houses has been that, apart from satisfying the working needs of an average family, the layout should be such that it can be increased in size whenever the needs of the family increase or the financial resources of the individual permit. There are some fixed factors for the minimum house, which in the present case has been assumed to be a three-room dwelling and also includes a wash room, cattle shed and the courtyard.

The courtyard remains the main centre of activity with the principal rooms of the house (multi-purpose room, kitchen and verandah) on its one side and cattle shed, store and wash room on the other. The reasons for the location of different rooms are enumerated below:

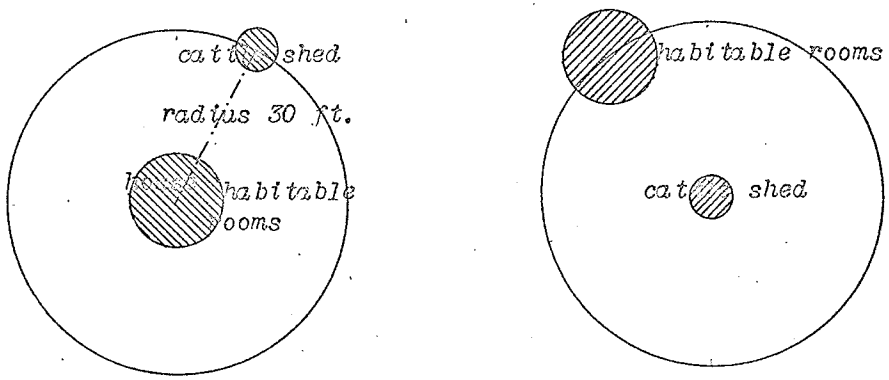
CATTLE SHED: First, for the purpose of sanitary requirements, the cattle shed has to be kept at a distance of about 30 feet from the habitable rooms.

Secondly, since cattle is the only main possession of the villager, he has always kept it next to his own room or at least under his

direct supervision so that nobody can steal it away.

It would be entirely wrong to break this old tradition and to try to keep the cattle in separate quarters. This basic function creates a form for the whole unit (the house). There are two possible alternatives:

a. The habitable rooms forming the core with the cattle shed on the circumference of a circle having a radius of 30 ft. (refer drawings below.)



b. In this case, cattle shed is at the centre and the habitable rooms are on the periphery.

In the next step, the most obvious form for a group of houses would be as shown schematically in diagram C. The cattle sheds surround the service court and thus not lie on the percinct of common areas between the houses. At a later stage we shall see that the dictates of the climate and economy in construction and service change this circular form into a linear pattern as shown in diagram D..

1. house
2. courtyard
3. cattle shed
4. service area

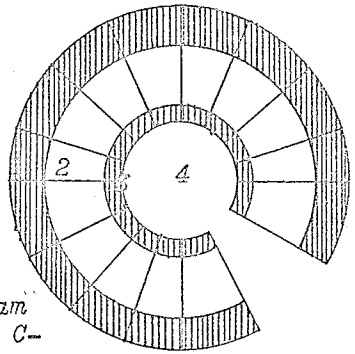


diagram C-

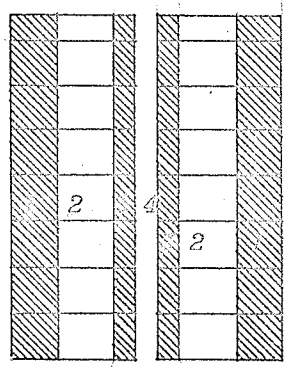


diagram D-

WASH ROOMS: At present, no sanitary conveniences of any kind exist in most of the villages. As first step towards improving the lot of these people, it is anticipated that every house will have a wash room and also the supply of clean drinking water will be assured to every family.

Service lines of four houses are combined together and common cesspools are made in the service lane. Each cesspool is at a distance of 40 ft from the habitable rooms. Assuming an average consumption of 40 gallons of water per head, the cesspool has been designed to contain at least three days' waste from the four houses. Thus each cesspool is 8 ft by 8 ft by 6 ft (deep) from inside and can hold 2400 gallons (384 cu. ft) of waste water. Sewage sludge from the cesspools shall be pumped out, taken to the sludge drying lagoons and eventually to farmland for manurial purposes. The cesspools have been preferred to septic tanks primarily because of the need for supply of fertilizer and waste water for controlled irrigation.

A platform for washing clothes is provided outside in the courtyard.

MULTI-PURPOSE RM, KITCHEN & VERANDAH: These parts of the house are very intimately connected to each other and they open on the courtyard which, in fact, is the main working area. The housewife is busy most of the time, either in the kitchen or in the verandah, cooking food, churning milk and looking after the children.

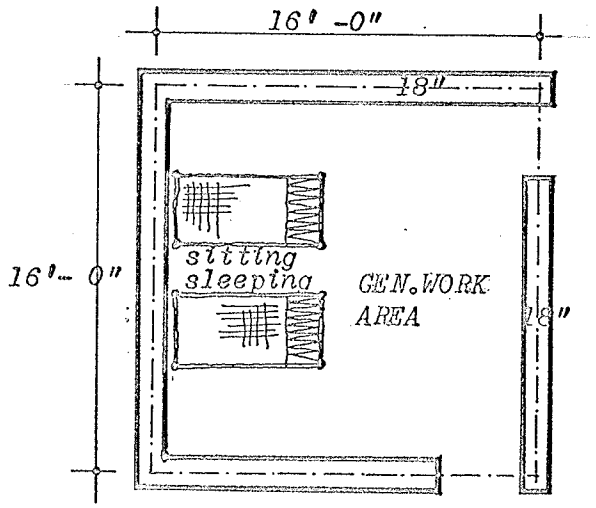
At the same time she looks after milch cattle in the courtyard. During a greater part of the year, children would spend most of their time in the courtyard if not outside in the street; the family would eat food in the open and sometimes cook also in the courtyard, in a makeshift oven (similar to barbecue).

Multi-purpose room is used during the inclement weather; also this is the main storehouse as well as the family room.

MEN'S ROOM: This part of the house overlooks the main street and is used for entertaining the male guests. An appreciable amount of privacy is maintained between this part of the house and the remaining part occupied by women and children.

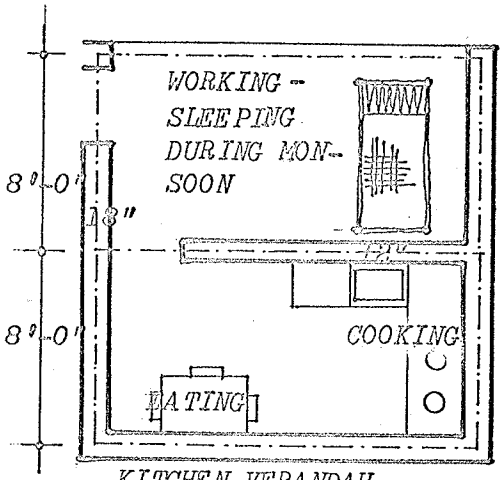
EXPANSION: The structural as well as the planning module is 16 ft. by 16 ft. This grid allows for a versatile use of the rooms viz. working, sleeping, storage, playing of small children, entertaining etc. (refer page 57A). At the same time it permits an economical construction for the roof.

Expansion of the house can be done in similar bays involving the same method of construction and formwork for making roofs. Two more rooms can be added on the main floor and two rooms can be

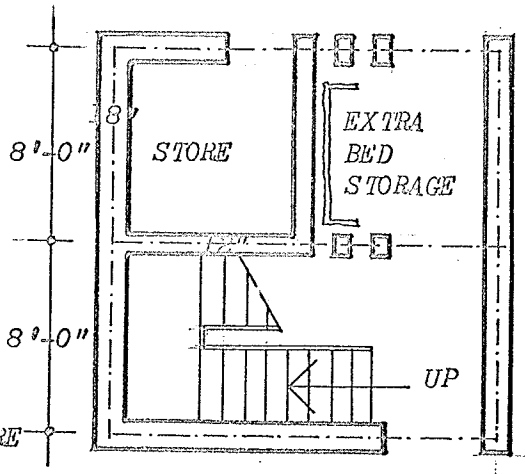


MULTI-PURPOSE

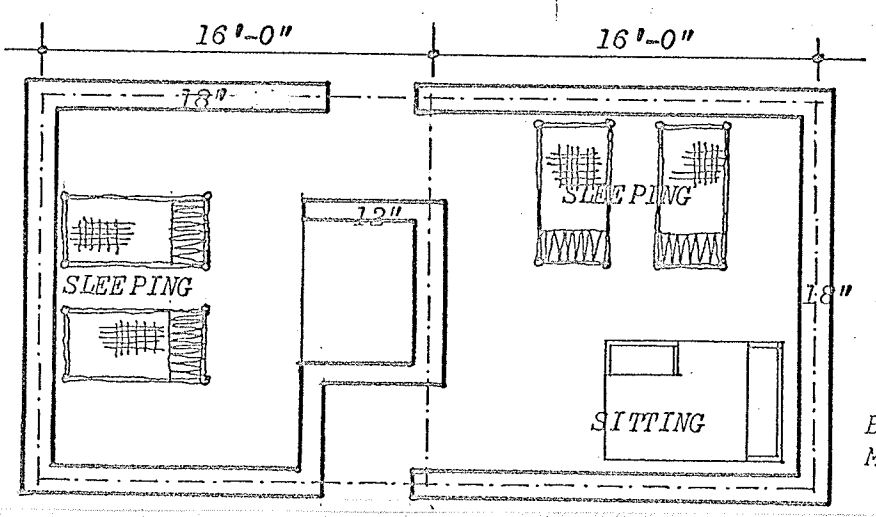
These diagrams indicate the use of a structural grid of 16 ft x 16 ft for various functional requirements of the house.



KITCHEN-VERANDAH



STAIRCASE -STORE



BED-ROOM

BED CUM
MEN'S LIVING RM.

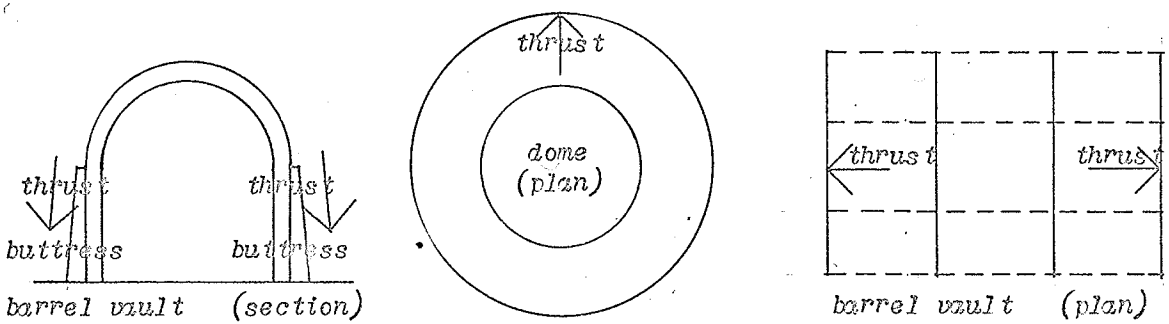
constructed on the second floor, thus allowing for a minimum three room house to be expanded to a seven room house. A number of combinations are possible e.g. no further construction may be done on the first floor but only a staircase may be built to utilize roof area for sleeping during summer or only one room may be built upstairs.

This expansion and flexibility in plan allows to suit the various needs of different people while working basically on just one grid. The latter factor allows for ease in construction and economy.

STRUCTURE: As pointed out earlier, as long as economy is the main controlling factor, then no other building material is cheaper than the present material in use viz. mud. The important change is its stabilization so that it can withstand the rigours of monsoon. Sun-baked bricks would be made as detailed out on page 47. They are used for making walls, flooring and pavements in the courtyard.

Since it was mandatory to use bricks for roofs also as the cost of using steel and concrete would be prohibitive, a roofing system has been worked out involving the use of brick only.

The main limitation of brick is that it is a compressive material, therefore it cannot be used as reinforced concrete where steel provides the tension. The only two possibilities are to use domes or barrel vaults. This further necessitates the use of a buttress to



counter the outer thrust in the end walls. In case of a dome, not only the construction is more difficult but it requires a support in all the directions. It is impossible to build only one segment of the dome which could support its own self. Whole of the dome has to be built in the same operation which requires a large amount of formwork.

In case of barrel vaults the construction is more simplified. A part of the arch can be built which will support itself and the same formwork can be moved further to build the next section of the vault. To meet the requirements of higher stresses, burnt bricks are used for roofing and supporting buttresses.

For the upper floors, since the size of the buttress increases too much and it is difficult to make addition to the buttress to take outer thrust of the roof of second floor, instead $1\frac{1}{2}$" dia m.s. rods are used to act as braces. No difficulty arises in the case of vertical loads.

CLIMATE: In the hot arid region of India, in order to have maximum protection from sun, the best orientation is to have window openings facing North and South. Only the end walls should face East or West as the angle of sun is low in these directions and it is difficult to protect any large surfaces, from the effect of solar radiations. Undoubtedly, this factor imposes a restriction of orienting the streets in only one direction and that is liable to result in a certain amount of monotony. In a project of this nature where cost is the main factor and no artificial cooling aids can be counted upon, the comfort of the inhabitants has been given the primary consideration. For that, two factors have been taken into account:

a. Attempt is made to mintmize the effect of heat due to direct exposure of sun's rays on the walls and roofs. All the rows of houses are in the East-West direction. Plantation is done in front of all other end walls facing East or West and this would help to bring down the intensity of heat.

For maximum reflection of heat, all roof surfaces are painted white.

b. To protect the swellings from the hot winds in summer and sand storms (which are in the direction of SE to NW), an artificial berm has been planned on the SE side of the village. This, together with heavy plantation on that side would check the flow of hot winds. Secondly, in order to induce local currents, the principle stated on page 30 has been applied to the plan of the village as a whole. Alternate paved and green enclosures would help to keep the interiors cool.

STREETS AND OPEN SPACES: As in the existing village, next to courtyards, importance is given to the life pattern in the streets.

Though linear, the street varies in depth and character and thus provides pleasant outdoor enclosures. Unhampered by any type of vehicular traffic (bicycle, bullock carts etc.), it is in the street where life exists in all its facets; the neighbours meet, the children play, the shoe-maker mends the shoes, the peddlar sells his goods from door to door.

These streets terminate on one side with the periphery road which gives access to emergency vehicles like ambulance and fire brigade. On the other side, a large open space acts as a "collector" of people from the streets. This area is meant for the use of community as a whole. With the help of plantation it is divided into smaller enclosures and there is enough shade provided by the trees, for the afternoon siesta of old people who, at present, are always seen together in village "shamilats" (common areas). This green enclosed space, protected from the hot winds and sand storms, can be used by people of all ages alike; it is another place to bring the people close to each other, so naturally. This space is continued throughout the breadth of the village and is the main link to the temple, school, lake and also the village centre.

PUBLIC BUILDINGS: It is anticipated that construction of all the public buildings shall be the responsibility of the community as well as the government, greater in case of the latter as far as finances are concerned. Due to their intensive use they have to be more permanent in character and built to superior specifications. All the construction shall be of kiln-burnt bricks. Since the roof spans are large therefore reinforced-brick roof construction is preferred to the barrel vault. In case of latter another objection is the production of echo which is a disturbing factor in public areas, particularly in the school and temple. The cost for correcting this noise defect may be much more than the extra cost involved in the construction of flat slab roofs.

A brief description of different public buildings is given below:

VILLAGE CENTRE: This is the main activity area of men where business is conducted, the 'panchayat' (village elders) meetings are held, complaints are filed with the local administrator or daily news are read in the library or just a walk in the cloister is enjoyed for its own sake. Bus terminus is also located here, as well as the dispensary.

Both these functions require an immediate connection with the main road connecting the village to the other neighbouring villages or the nearest urban centres. So, in a way, village centre acts as a transition between the main road and the residential area.

Dispensary or the local health unit will have a visiting doctor and a family planning adviser. Emergency cases will be given the preliminary treatment here before they are transferred to any big hospital.

Reading room is provided to encourage people to keep in touch with the latest news and also develop an interest in other literature pertaining to agriculture etc.

The local administrator keeps an account of all the land holdings and he acts as the main representative of the government in the village. Apart from this 'patwari' there is a council of the village elders which looks into the minor disputes between different parties and is also responsible for the general cleanliness of the village and welfare of people.

Besides shops, a large covered area is kept for ambulant vendors. This would help to preserve the existing atmosphere of open-air fruit and vegetable market which is held once a day in the village 'chowk' (square).

A generously planted area adjoins the village square on the North side. It is hoped that this 'outside' will act as a pleasant counterpart of 'inside' i.e. the village square. This would also help to change the micro-climate to quite an extent. Future expansion of the village centre will also take place on the North side.

TEMPLE: Temple dominates the 'villagescape'. It is maintained as the physical and spiritual centre of the village. Away from the traffic of the main road it is 'snugged in' a thickly planted grove of flowering trees. The excavated earth from the lake is used to raise the temple about six feet above the road level. An approach by ramp is provided from the West side. Also it is linked with a large open area on North side which would be used for religious gatherings and functions.

A fountain is provided at the entrance level where people will wash their hands or face, before they enter the prayer hall. After the prayers, everyone goes around the altar and gets out through the exit doors provided at the far end on both sides of the hall. One walks back through the verandah to the entrance area.

SCHOOL: In the initial stage, the school is expected to be built up to junior level i.e. up to 6th class. Children studying in the senior classes would either attend high schools in the nearby towns or go to schools built at appropriate places, for five or seven villages.

This school is also expected to grow up to Matriculation stage, therefore enough space is left for its future expansion.

A large playground is planned by the side of the school which shall be used by the children and also by the community for their games or weekend wrestling matches.

VILLAGE WORKSHOPS: As already stated, some oil presses or grinding mills exist in every village, either worked by electricity or

driven by bullock contrivances. It is intended to introduce few more rural industries so that there can be some job openings during the part of year when there is no work on the fields.

These workshops are planned across the village centre and they have an immediate service access from the main road. Apart from the flour grinding and rice husking mills a greater part of the area shall be used for packing fruit or other produce from the fields. The village ironsmith and carpentar shall also work here as they require a large outdoor work area.

Depending upon the indigenous raw materials, appropriate manufacturing plants shall be built on a small scale. It is hoped that this would provide some balance to present rural economy which is purely agrarian.

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