Development of Design & Technology Package for Cost Effective Housing in Gujrat

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Submitted to the Department of Architecture, on May 10, 1996 in partial fulfillment of the requirements for the degree of Master of Science in Architecture; Architecture and Urbanism.

ABSTRACT

Purpose
Improve quality of life in rural areas through intervention of infrastructure and housing improvement.

Provide methods of building better and cost-effective houses at a quicker pace.

Devise strategies of withdrawing support to avoid dependency by the villagers on the program, while transferring skills and technology to facilitate self-administration.

Procedure
List observations from field studies and available reports.

Identify built form, building types, materials of construction, skilled labor and environmental conditions.

Analyze space utilization patterns and structural efficiency of major systems and building types in selected villages.

Assess the priorities and affordability of households of different economic classes.

Summarize the problems and potentials.

Recommendations
Strategies for improvements in housing and infrastructure.

Develop a design and technology package for cost-effective housing to improve quality of life.

Thesis Supervisor: Attilio Petruccioli
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Pyarali I. Firasta, for his spirited inspiration and commitment for improving rural architecture and life of people in Gujrat.

I am grateful to my mother for making me what I am. Last but not the least: Nini, for her help, support and patience at every stage of the development of this thesis.

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SUMMARY MATRIX (with reference page numbers)

BUILDING ZONES	LOCATION	SETTLEMENT TYPE	BUILDING SYSTEMS WALLS	MATERIALS USED		PROPOSED MATERIALS		PROPOSED BUILDING SYSTEMS
				ROOF	WALLS	ROOF		
Northern-arid	Kuchh peninsula, part of Gujrat plains and part of northern Saurashtra peninsula (Surendranagar and Rajkot districts)	-Compact linear clusters -Narrow streets -Inner courts -Few openings	-Massive walls -Shared/ adjoining east- west walls	-Soil -Rubble stone -Burnt bricks	-Thatch -Sandstone slabs	-Stabilized soil blocks	-Jack arches -Filler slabs	-Walls-rat-trap bond -High ceiling -Clerestory window -Slit windows -Ventilation band
30	30	30	43- 47	33- 63	33- 63	94- 99, 112	104, 110	92, 94, 96, 99
Semi-arid hot dry zone	Northern plains Saurashtra peninsula (Mehsana and Ban-askantha districts)	-Compact linear clusters -Porous houses -Facilities for out-door sleeping	-Shared/ adjoining east-west walls	-Soil -Rubble stone -Burnt bricks	-Sandstone slabs -Tiles	-Stabilized soil blocks -Burnt bricks	-Jack arches -Filler slabs	-Walls-rat trap bond -High ceilings -Large windows
30	30	30	48- 51	33- 63	33- 63	94- 96, 112	104, 110	91, 92, 94
Composite hot humid/ dry	Eastern hilly regions Saurashtra peninsula (Surendranagar and Bhavnagar districts)	-Linear dwellings with open space in between for air movement. -Upper floor used for thermal gain/ lag and storage.	-Pitched roof -Composite load bearing frame structure.	-Soil -Rubble stone -Burnt bricks	-Mangalore tiles -Clay tiles blocks roofing	-Stabilized soil blocks -Molded stone -Micro-concrete tiles	-Jack arches -Filler slabs -Country tiles	-Pre-cast beam/ post -Pre-cast filler slabs -Jack Arches -Clerestory window
30	30	30	34- 41	33- 63	33- 63	94- 96, 110	104- 112	91, 92, 112, 121
Hot humid plains	Southern plains parts of Bharuch, Valsad and Surat	-Loose, detached clusters with large open spaces arou-nd them, usually enclosed with low hedges or walls. -Long verandahs	-Pitched roofs -Framed structure with loft spaces	-Wattle and daub -Stone	-Thatch -Mangalore tiles -Clay tiles	-Stabilized soil blocks -Molded stone blocks	-Country tiles -Micro-conc. tiles	-Bamboo post-beam structure -Tiled roofs -Clerestory window -Ventilation band
31	31	31	61- 61	33- 63	33- 63	94- 99	107- 109	91, 113, 114, 121

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SECTION I: ANALYSIS

Chapter 1
Introduction

OBJECTIVES

The objectives of this thesis are to:
Identify the major building zones in Gujrat based on built form, material of construction, skilled labor and response to environmental conditions.

Identify the major building types in the state in rural areas and the trend of changes in housing stock.

Undertake a detailed analysis of space utilization patterns and structural efficiency of major systems and building types in selected sample districts.

Assess the priorities and affordability of households of different economic classes.

Develop a design and technology package for cost-effective housing in the state that integrates the above mentioned parameters.

Identify the areas of technological and administrative intervention and suggest ways to improve delivery system of aid.

PROJECT STRATEGY

Gujrat is a large and diverse state, hence a comprehensive study across all districts of the state is neither pragmatic nor economically viable. Therefore a sample of representative districts has been chosen, based on identified building zones.

Within these districts four classes of settlements have been investigated based on the following population sizes:
less then 1000
1000- 5000
5000- 10,000
above 10,000

Detailed investigations of the structure of housing stock, house types, building systems and their material and labor utilization were done through village, settlement, and household level study done by BMTPC/ TARU in 1991. Some of the data from this study has been used.

Based on this data and the study done by myself and others in Gujrat Workshop (MIT Spring 1996), a design brief for a portfolio of cost-effective building systems for both traditional and conventional building practice has been developed. It is based on the criteria of economic viability, resource efficiency and availability of infrastructure.

Building techniques and components will be proposed and the design of a unit and cluster shall be developed based on these observations.

MAJOR RESEARCH QUESTIONS

The project will attempt to address the following broad questions at state level, through the aggregation of district level data.

Housing Stock

What is the current need for housing?

How will these houses be constructed (upgradation, addition, new construction or routine maintenance)?

Who will construct these houses?

What materials can be used for construction?

What are the mix of skills that can be used for construction of these houses?

Resources

How many types of building materials will be used for construction?

How much labor will be utilized in the construction of these houses?

Infrastructure

What is the level of local control over the house construction process?

Who will pay for the construction of these houses?

How many workers of various categories need to be trained to undertake a planned housing intervention?

Where will the production and training facilities be best located?

DATA SOURCES AND METHODOLOGY

The bulk of the data that will be utilized in the estimation of material requirements and housing trends, will be derived from secondary sources i.e., from Central, State and District Government sources and also from research and academic institutions. The trends and changes observed from secondary sources will be investigated and qualified through spot field investigations, in sample settlements across the study districts of the state.

Secondary data

A mix of secondary sources including the Census of India, NSS, State Statistical reports, plan documents, research reports and program review publications of relevant departments have been utilized. The bulk of this data has been examined as a time series over 1961-1996 period (wherever available). In addition a number of independent studies and publications from academic institutions and the Anthropological Survey of India, have been examined and relevant sections utilized.

Primary data and field studies

Intensive field studies have been undertaken in the three identified districts of the state, to enable the ground verification of trend identified from secondary data. The housing conditions, materials and technology of construction of selected building types have been documented.

Field surveys were done as a part of the Gujrat Workshop (MIT Spring 1996) and some of the documentation is a part of this exercise. Within the settlements three types of buildings have been selected based on materials- traditional, upgraded and conventional.

Data has been collected in schedules described below:

State overview and district profile

This has been prepared to get an outline of the demographic characteristics, employment structure, settlement pattern, resource utilization and agricultural practice in studied districts.

Settlement schedule

This has been utilized to collect information on demographic changes, land holding and utilization patterns, agricultural practices and output, socio-economic and occupational structure of the settlement and its basic resources. The major resources that has relevance to housing are stone, timber, bamboo, thatch and agricultural residues. Data has been collected on village institutions and their role in promoting change.

Household schedule

Detailed measured drawings have been done along with analysis of material, labor and space utilization patterns. Emphasis has been given to collating information on bio-mass, earth and stone use in buildings. Household socio-economic information on consumption, expenditure, asset holdings, housing problems and aspirations has been recorded along with the perception of Government and Aga Khan Housing Board programs.

Chapter 2
Context

PROFILE AND BACKGROUND OF GUJRAT STATE

India, as the often quoted cliche goes, is a land of great diversity. Unfortunately there are two facts which are ignored or glossed over. The first is the presence of inherent common strains of the human environment and culture. The second, is that change is continuous as one passes through the land. As a result, there are very few area/ states in the country which are definite contiguous homogeneous entities. Specific criteria such as a common language, become only reference points. Often, areas related to each other by a reference frame such as language have stronger linkages with another not related by the same criteria. This leads to situations where development within a state is a diverse and often unbalanced.

Gujrat is a part of India in which these characteristics are fairly apparent. As a result the task of analyzing the context, designing of development programs becomes very difficult. In the following, certain basic patterns pertaining to development in Gujrat are introduced as a reference frame for this study on rural habitat issues.

The unique geo-physical and socio-economic location of the state has resulted in a wide range of different physical-cultural-socio-economic environments to be found within its boundaries.

PHYSICAL LOCATION AND ENVIRONMENT

The state is located between 20' 01" N and 24' 07" N latitudes, with the Tropic of Cancer passing through it. The southern region of the state has a tropical climate.

Gujrat is a maritime state with a long Arabian Sea coastline defining its western edge. A broad belt along the sea, particularly the southern tropical region has heavy rainfall and dense vegetation.

In the north west and the north of the state lies the "Rann of Kutch"- a swampy marshy area, and the sub-continental desert (Thar) beyond it. Naturally the adjoining northern areas of the state are semi arid.

The eastern edge of the state is physically defined by low hilly tracts forming a north-south range. This region of the state is also characterized by plentiful rain and vegetation. Many sedimentary and metamorphic mineral deposits are located in these areas.

Another major system of highlands is located in the south western peninsular region of the state. A large portion of this region is forest which is protected and is famous for its 'Gir Lions, Wild Life Sanctuary'.

The central region of the state consists primarily of plains draining south or west towards the sea and its gulfs. Numerous rivers flow through the state to the sea of these the major ones are the Narmada and Tapti in the southern region of the state. The plains in the central region are tropical or semi-arid in character depending on the location.Gujrat can be therefore theoretically divided into four major physical environments:

Semi-arid plains
Tropical- coastal
Tropical- hilly
Tropical- plains

GEOLOGY AND SOILS

In Gujrat, eight groups of soils are found, though a large part of arable land is covered with black and alluvial soils.

The northern part is composed of recent alluvium and blown sand which comes from Rajasthan during the pre-monsoon period. The southern part of the plain is covered with deep black soil with very high clay content.

The eastern hilly region can also be classified into two parts. The northern part (Panchmahals districts) has Aravallis, Erinpura Granite, Gneiss and the Deccan Trap. The southern part (Dangs district) with the hills of the Sahyadri range is basically Deccan Traps.

The Saurashtra Peninsula has a widespread occurrence of Deccan trap with the presence of numerous Trap dikes.

The soils can be broadly classified into:
Black soils
Mixed red and black soils
Residual sandy soils
Alluvial soils
Saline alkali soils
Desert soils
Lateritic soils
Hilly soils and
Forest soils

CULTURAL-ECONOMIC: LOCATION AND ENVIRONMENT

Historical background

The history of this area goes back to the early days of human civilization. This region was part of the area covered by the Indus Valley Civilization dating back to approximately 2500 BC.

Following the Indus Valley Civilization, was the Aryan age with a succession of Hindu and Islamic eras of political dominance. Both of these eras saw remarkable developments and achievements in the socio-economic environments particularly architecture, crafts, industry, trade and commerce.

The colonial era with British political dominance followed the Islamic. During this period, indigenous vassals of the British ruled over territories varying in scale from a settlement to the size of present day districts. This era was also characterized by continuing of the traditional crafts, industry, trade and commerce. Major developments in the built environment took place during this period.

The rulers of the princely (vassal) states undertook a great deal of building work to express their status, at times with a genuine desire for improvement. The building activity ranged in scale and type from an entire settlement to campuses and individual buildings such as palaces, government office buildings and colleges. A large quantum of these works and buildings still exist and are being used, often for different purposes than originally intended. The new towns, streets, complexes and structures built by these vassals and their courtiers display a combination of indigenous and european influences. Typical among these were grid-iron layout for new towns or the reconstructed sections of the old

town; geometrical and similar formalization of spatial configuration and volumes of: the main avenue of the town, the new buildings and other similar structures. Another major influence was in the field of construction technology, particularly timber joinery and resultant changes in roofs, doors and windows.

After independence of the country in 1947, began the process of consolidating hundreds of small princely states which the present area of the Gujrat state was divided into. Finally the present state was established on 1st May, 1960, based on the Indian Governments policy of Linguistic States as political- administrative territories.

Political situation

Gujrat besides being a maritime state, following the partition of India at Independence shares an international border in the northwest with Pakistan. To the north, east and south it shares interstate borders with Rajasthan, Madhya Pradesh and Maharashtra.

The state is divided into 19 districts which have further subdivisions/ Talukas. A group of towns and villages compose a Taluka. The state capital is the city of Gandhinagar.

Economy, industry, trade and commerce

Gujrat is one of the most rapidly developing states, specially in terms of economy, industry and infrastructure. Specially the eastern and central parts of the state fall within the belt that stretches from Maharashtra in the south to Mehsana and Palanpur in the north. Rapid economic, industrial and urban growth with highly developed infrastructure, particularly transportation is characteristic of this belt.

LAND USE

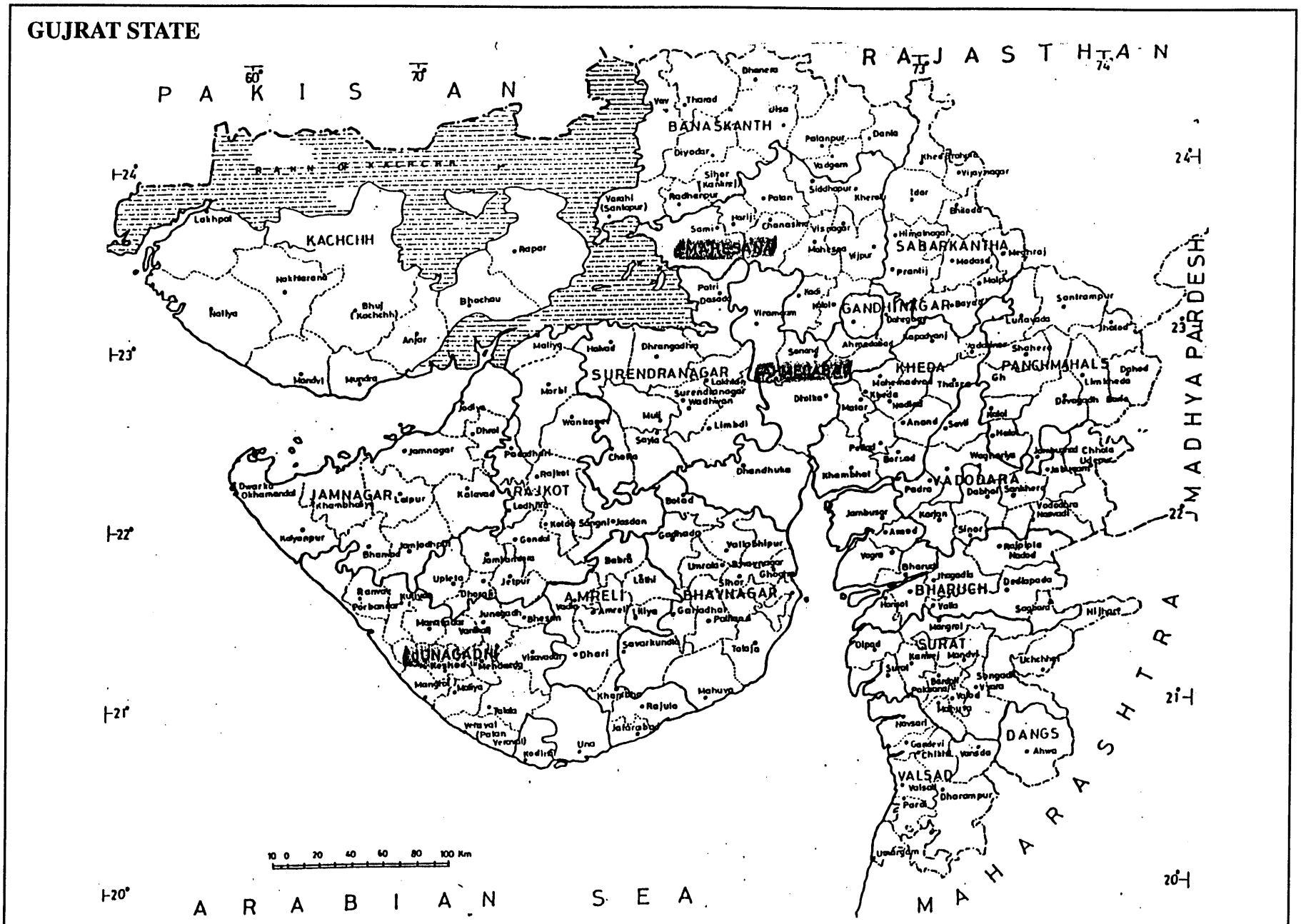
Landuse	Area (million ha.	Geographical area
Total area	19.6	
Forest	1.97	10%
Non agricultural use	1.08	6%
Unculturable land	2.00	10%
Permanent pasture	0.85	4%
Culturable waste lands	1.99	10%
Current fallows	0.73	4%
Other fallows	0.08	0%
Cropped area		
Net area sown	9.58	49%
Area sown regularly	1.36	7%
Total cropped area	10.94	56%

Source: Directorate of Agriculture, Gujrat state, Ahmedabad

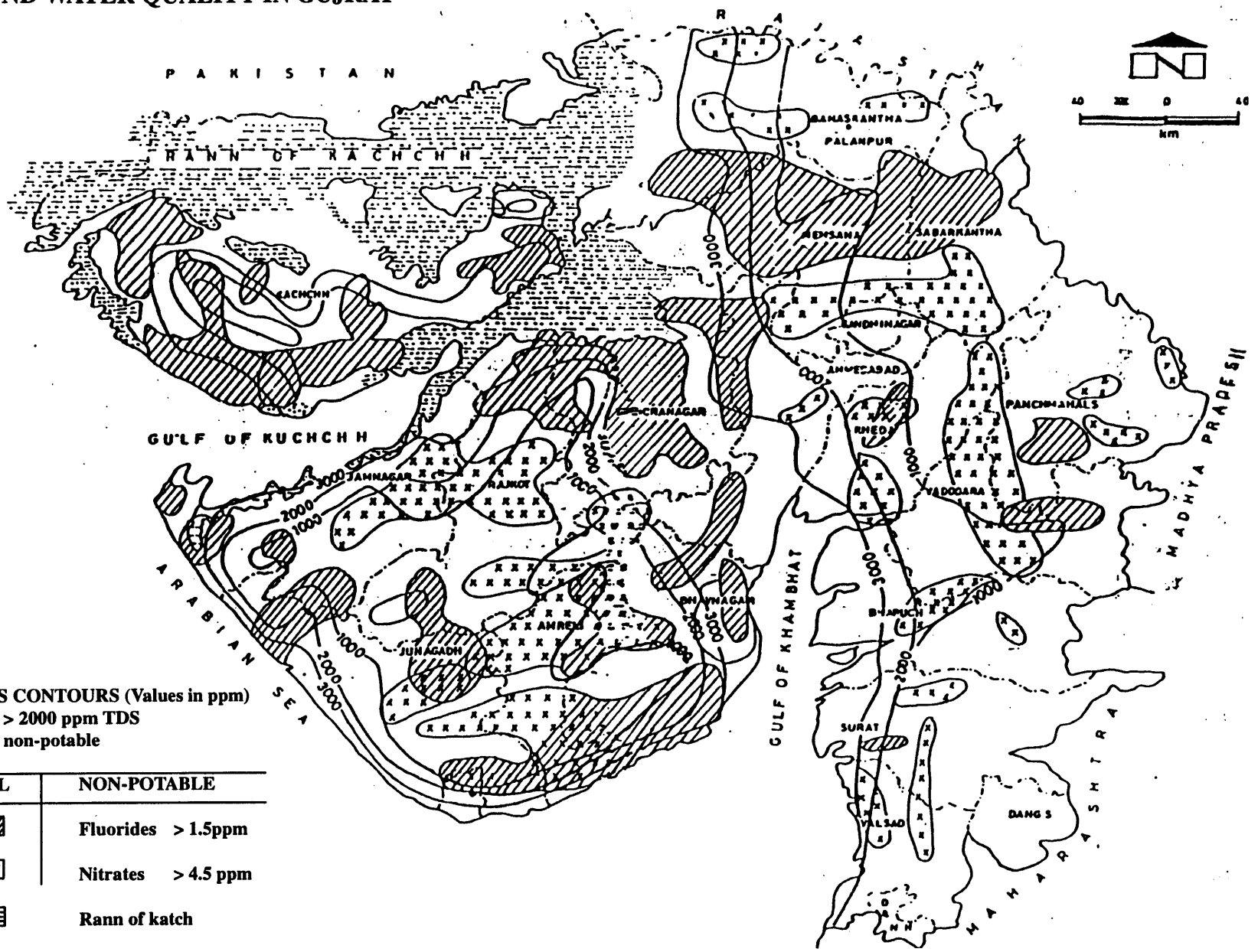
DEMOGRAPHIC AND CULTURAL CHARACTERISTICS

The State has an area of 1,95,984 sq.km representing 6% area of the country and a population of 41.2 million. accounting for 4.9% of the countries population (Census 1991). According to the Census 69% of the population lives in 18,574 villages.

The gender ratio in state is 936 females per 1000 males and the literacy rate is 61%. A continuous increase in the rural population has been observed.


GUJRAT STATE
PAKISTAN
RAJASTHAN
MADHYA PARDESH
MAHARASHTRA
ARABIAN SEA
BANASKANTH
KACHCHH
SABARKANTHA
GANDHINAGAR
MEHSANA
PATAN
SURENDRANAGAR
KHEDA
PANCHMAHALS
JAMNAGAR
RAJKOT
AMRELI
BHAVNAGAR
JUNAGADH
VADODARA
BHARUCH
SURAT
DANGS
VALSAD
Rann of Kachchh
10 0 20 40 60 80 100 Km

GROUND WATER QUALITY IN GUJRAT

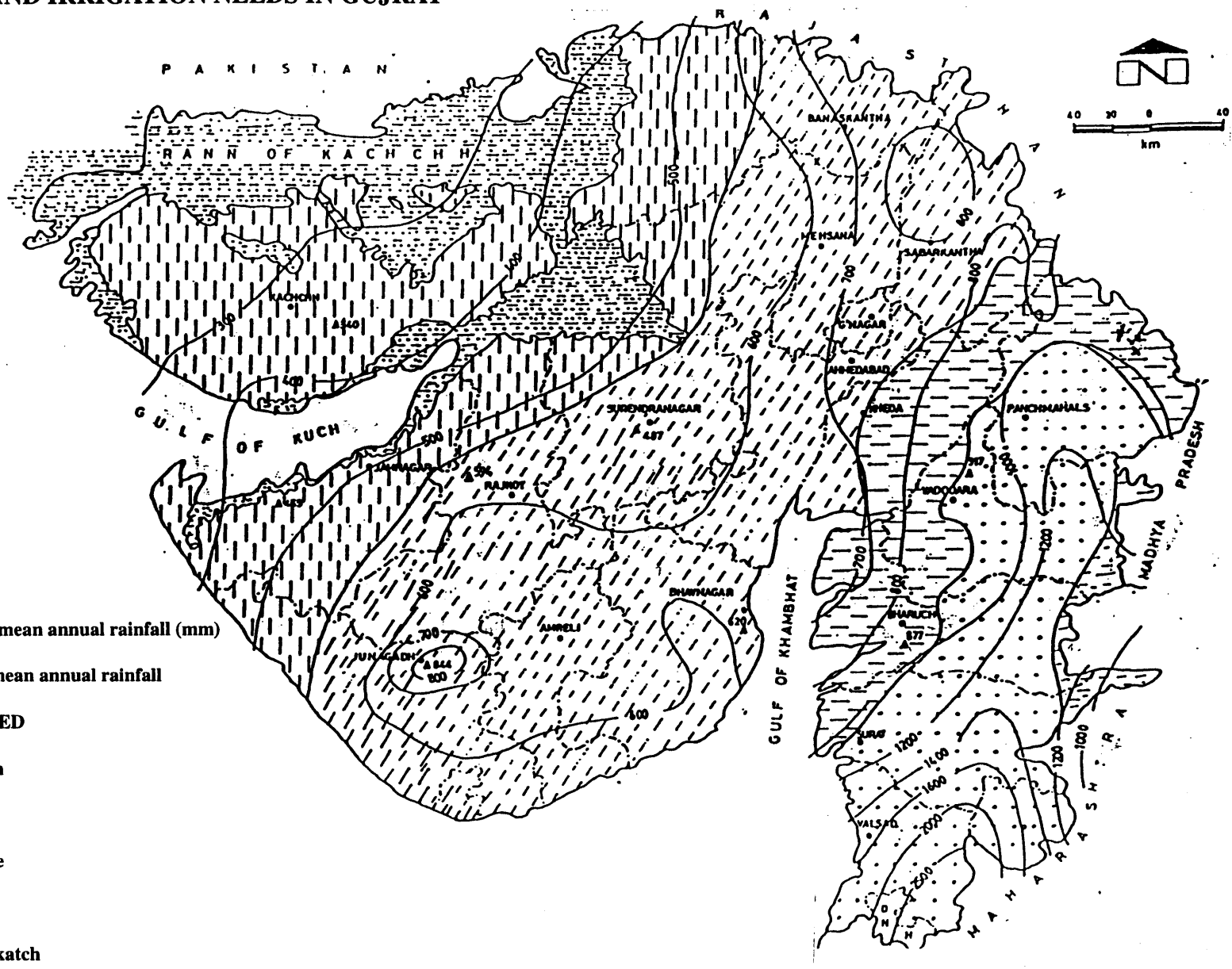


ISO- TDS CONTOURS (Values in ppm)

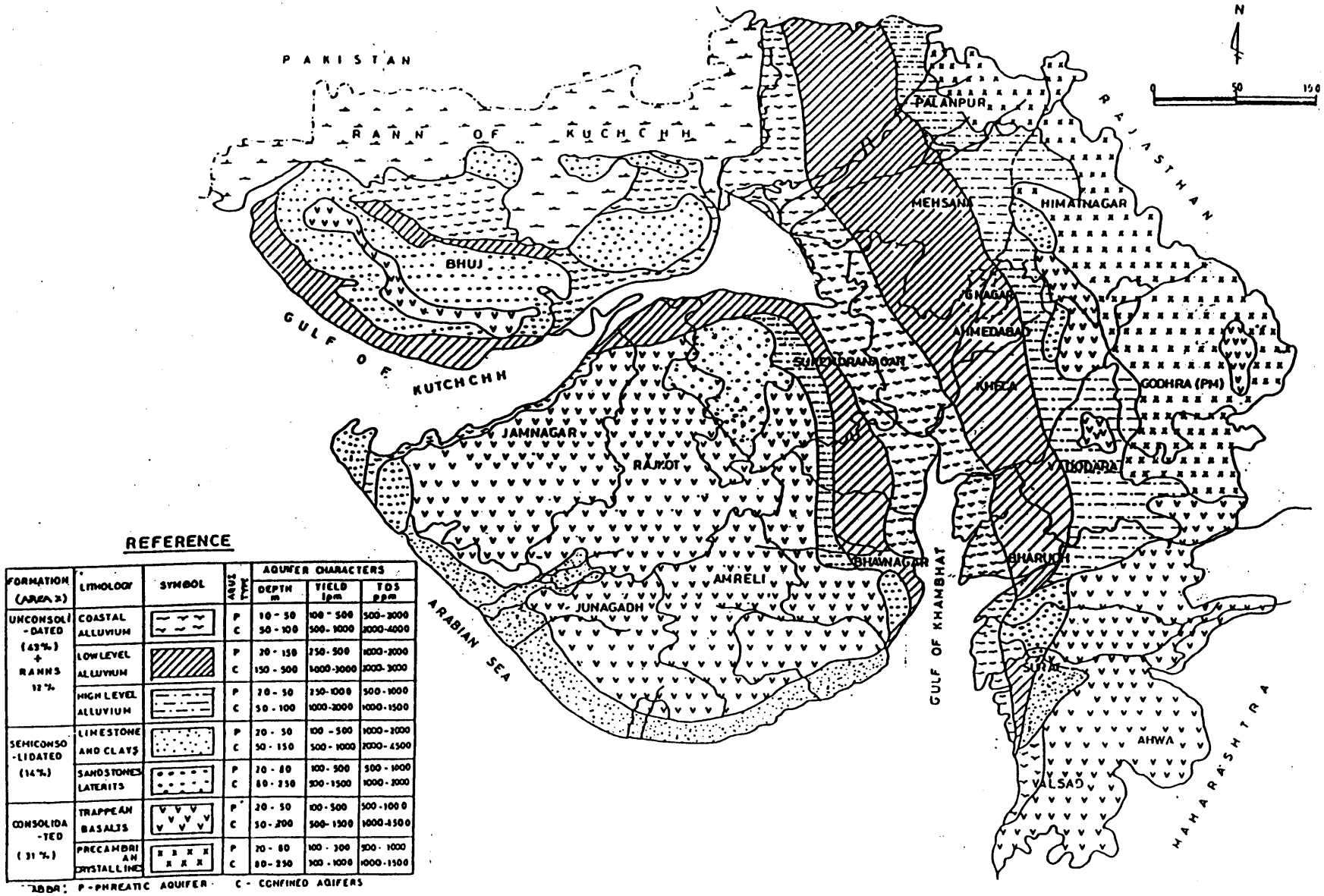
200 > 2000 ppm TDS non-potable

SYMBOL	NON-POTABLE
	Fluorides > 1.5ppm
	Nitrates > 4.5 ppm
	Rann of katch

ISOHYETS AND IRRIGATION NEEDS IN GUJRAT



HYDROGEOLOGY OF GUJRAT

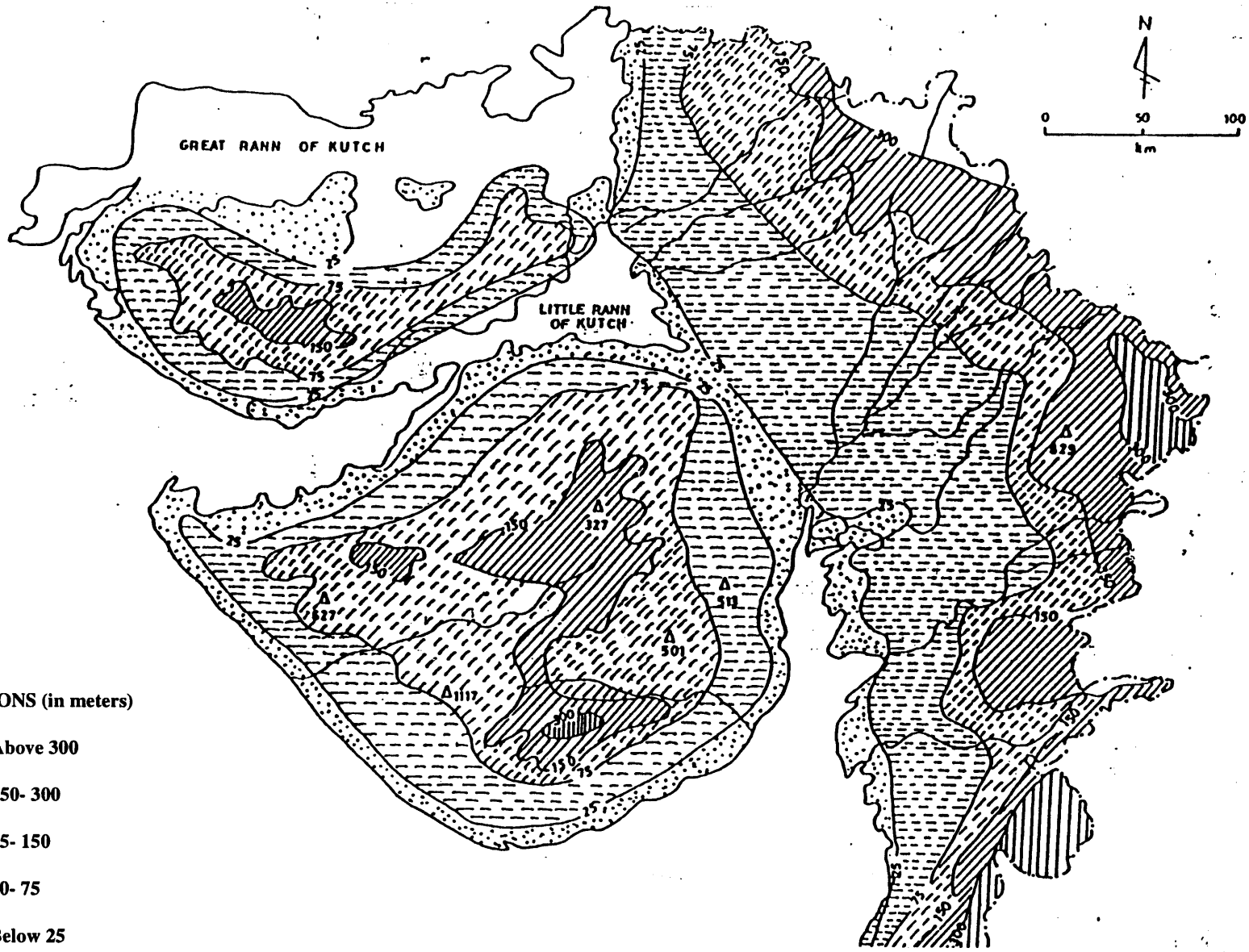


REFERENCE

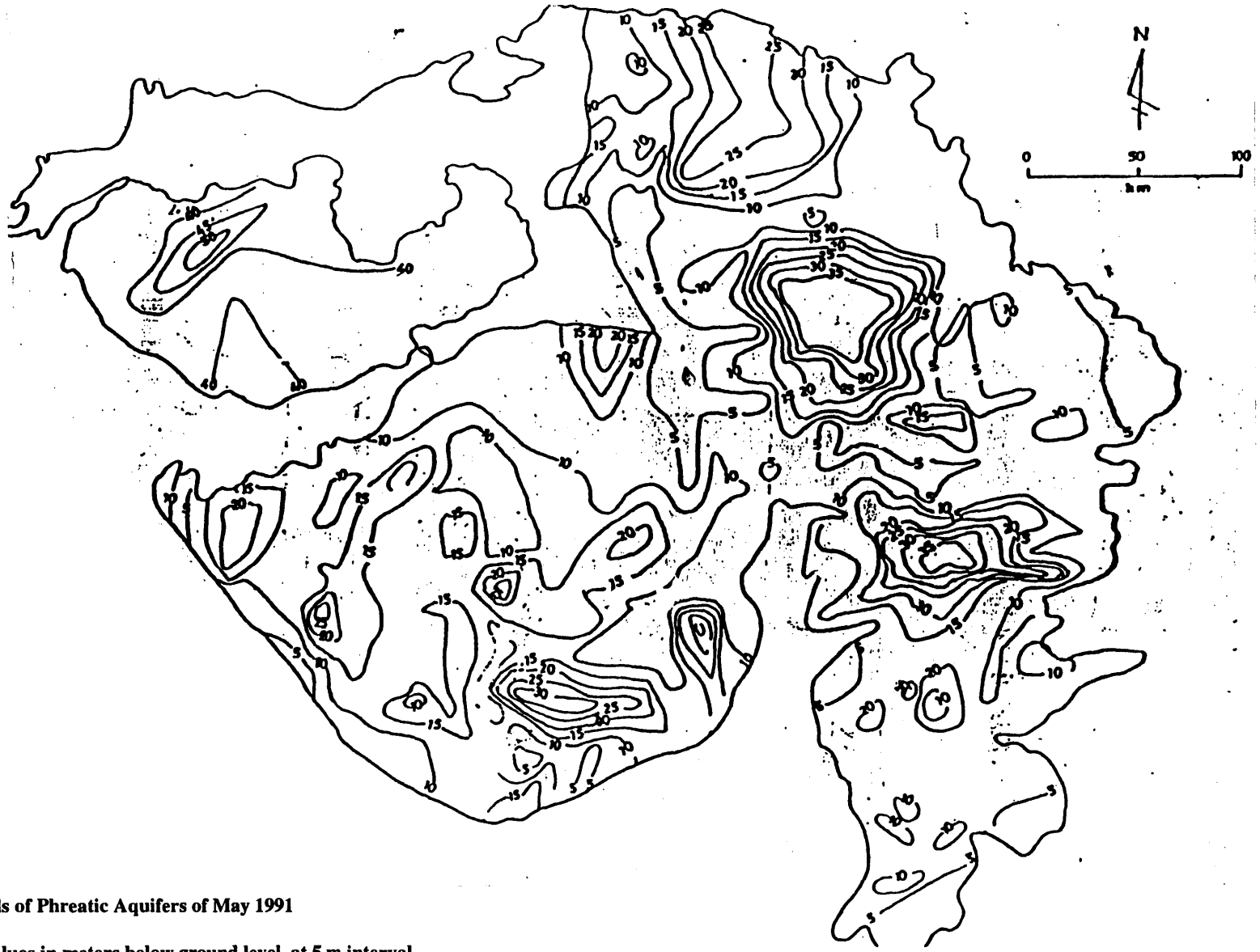
FORMATION (AREA %)	LITHOLOGY	SYMBOL	AQUIF TYPE	AQUIFER CHARACTERS DEPTH m	YIELD lpm	TDS ppm
UNCONSOLI-DATED (43%) + RANNS 12%	COASTAL ALLUVIUM		P	10 - 50	100 - 500	500 - 2000
			C	50 - 100	500 - 1000	2000-4000
	LOW LEVEL ALLUVIUM		P	20 - 150	250 - 500	1000 - 2000
			C	150 - 500	1000 - 3000	2000 - 3000
	HIGH LEVEL ALLUVIUM		P	20 - 50	250 - 1000	500 - 1000
			C	50 - 100	1000 - 2000	1000 - 1500
SEMICONSO-LIDATED (14%)	LIMESTONE AND CLAYS		P	20 - 50	100 - 500	1000 - 2000
			C	50 - 150	500 - 1000	2000 - 4500
	SANDSTONES LATERITS		P	20 - 80	100 - 500	500 - 1000
			C	80 - 250	500 - 1500	1000 - 3000
CONSOLIDA-TED (31%)	TRAPPEAN BASALTS		P	20 - 50	100 - 500	500 - 1000
			C	50 - 200	500 - 1500	1000 - 4500
	PRECAMBRIAN CRYSTALLINES		P	20 - 80	100 - 300	500 - 1000
			C	80 - 250	300 - 1000	1000 - 1500

ABBR: P - PHREATIC AQUIFER C - CONFINED AQIFERS

PHYSIOGRAPHY OF GUJRAT



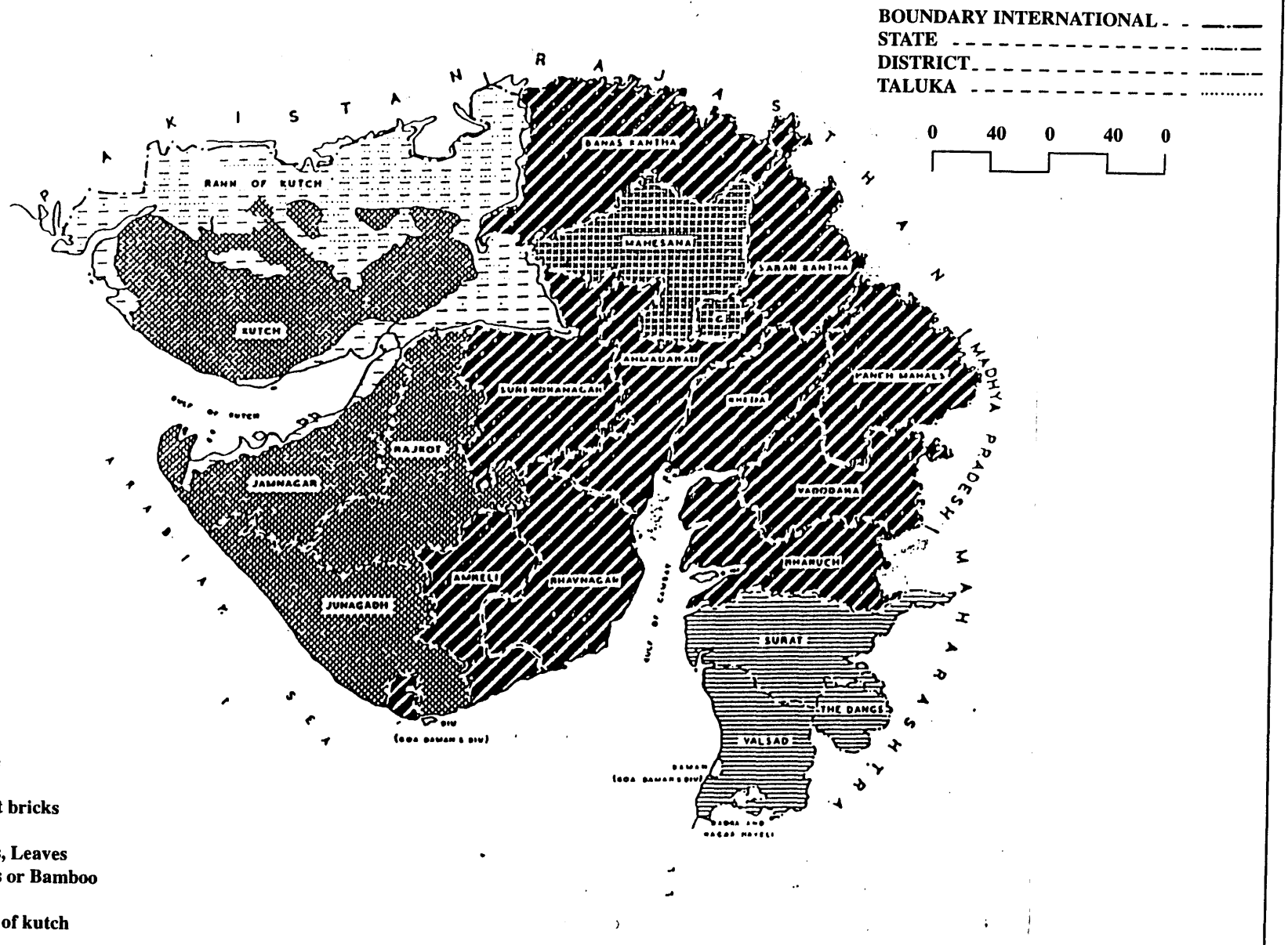
WATER TABLE CONTOURS IN GUJRAT



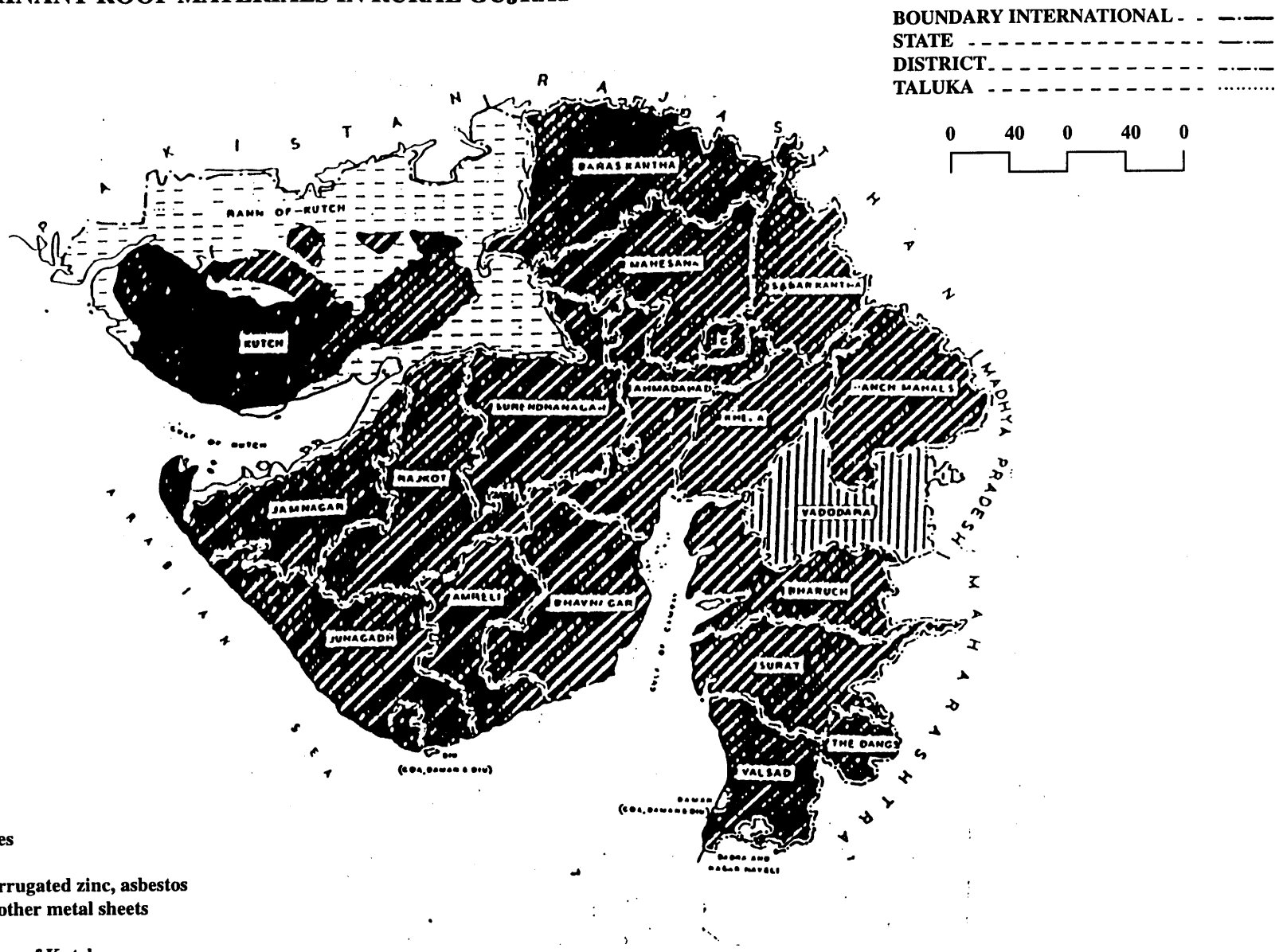
Water levels of Phreatic Aquifers of May 1991

Contour values in meters below ground level, at 5 m interval

PREDOMINANT WALL MATERIALS IN RURAL GUJRAT



PREDOMINANT ROOF MATERIALS IN RURAL GUJRAT



STRUCTURE OF HOUSING STOCK

State/ District	1971		1981		1991	
	Rural	Urban	Rural	Urban	Rural	Urban
Gujrat	3,201	1,296	3,675	1,855	4,683	2,531
Rate of growth	-	-	14.8%	43.1%	27.4%	36.4%
Bhavnagar	146	74	191	103	236	141
Rate of growth	-	-	30.8%	39.2%	23.6%	36.9%
Kachh	121	41	149	52	173	74
Rate of growth	-	-	23.1	26.8	16.1	42.3
Panchmahals	248	36	313	45	416	56
Rate of growth	-	-	26.2%	25.0%	32.9%	24.4%

Source: Census of India

Ownership of Dwellings

	Gujrat		India	
	Rural	Urban	Rural	Urban
Own	94%	58%	91%	55%
Hired	2%	37%	3%	40%
Others	3%	5%	5%	8%

Source: NSS 4th Round

Distribution of Households by Plinth Area

Sqm	Gujrat		India	
	Rural	Urban	Rural	Urban
< 30	42%	37%	39%	34%
30-50	36%	31%	27%	21%
50-75	13%	10%	15%	13%
75-100	5%	5%	7%	8%
> 100	4%	16%	12%	22%

Source: NSS 4th Round

Source of drinking Water

Percentage distribution of households by source of drinking water:

Tap	well	Tank	River	Spring	Others	
Gujrat	49%	46.8%	1.2%	2.7%	0.3%	0.4%
All India	15%	78.2%	2.2%	2.4%	1.4%	0.3%

Source: NSS 4th Round

Distance to Drinking Water Source

Percentage distribution of households by distance to the source of drinking water:

	Distance in km				
	Within premises	< 0.5	0.5-1.0	> 1.0	Total
Gujrat	31.3%	63.2%	4.2%	1.0%	100%
All India	23.2	72.4	3.5	0.7	100%

Source: NSS 4th Round

The preceding tables indicate that the drinking water remains a major problem for majority of households.

Sanitation

Percentage distribution of households by type of Latrine and Facility of Latrine:

	None	Flush	Septic tank	Service latrine	Total
Gujrat	40.7%	18.5%	40.6%	0.2%	100%
All India	42.5%	9.2%	33.6%	14.7%	100%

Source: NSS 4th Round

Percentage distribution of households by type of Drainage:

	No drainage	Open-built	Open-unbuilt	Covered/ Underground
Gujrat	-	80%	13%	0.6%
All India	1%	67%	29%	3%

Source: NSS 4th Round

Lighting Sources

Percentage distribution of households by type of Lighting:

	None	Electricity	Kerosene	Others	Total
Gujrat	8.2	49.4	42.2	0.1%	100%
All India	3.2%	27.0%	69.2%	0.5%	100%

Source: NSS 4th Round

Structure of Rural housing in Gujrat

Wall material	Earth	Tile	GI sheet	AC sheet	Brick	RCC	Others
Biomass	6%	-	-	1%	-	-	9%
Earth	3%	39%	4%	-	-	-	-
Wood	-	-	-	-	-	-	-
Burnt Bricks	-	12%	8%	1%	2%	-	-
GI sheet	-	-	-	-	-	-	-
GI sheet	-	-	-	-	-	-	-
Stone	-	11%	-	-	-	1%	-
Cement conc.	-	-	-	-	-	-	-
All materials	10%	62%	13%	2%	1%	3%	10%

Census of India, 1981

STRUCTURE OF HOUSING STOCK

Structure of Housing Stock in Rural Bhavnager

Materials of Walls	Materials of Roofs						
	Earth	Tile	GI sheet	AC sheet	Brick	RCC	Others
Biomass	-	-	-	-	-	-	-
Earth	4%	52%	-	-	-	-	-
Burnt Bricks		25%	-	-	6%	-	-
Stone	-	10%	-	-	-	-	-
Cement conc.	-	-	-	-	-	-	-
All materials	5%	87%	13%			7%	1%

Census of India, 1991

Structure of Housing Stock in Rural Kachh

Materials of Walls	Materials of Roofs						
	Earth	Tile	GI sheet	AC sheet	Brick	RCC	Others
Biomass	4%	-	-	-	-	-	-
Earth	4%	12%	-	-	-	-	-
Burnt Bricks	-	7%	-	-	-	2%	-
Stone	3%	58%	-	-	-	5%	-
Cement conc.	-	2%	-	-	-	-	-
All materials	11%	79%	-	1%	-	8%	-

Census of India, 1991

Structure of Housing Stock in Rural Panchmahals

Materials of Walls	Materials of Roofs						
	Earth	Tile	GI sheet	AC sheet	Brick	RCC	Others
Biomass	4.5%	-	-	-	-	9.8%	-
Earth	3.1%	69%	2%	-	-	-	-
Burnt Bricks	-	5%	2%	1%	-	2%	-
GI sheet	-	-	-	-	-	-	-
Stone	-	1%	-	-	-	-	-
Cement conc.	-	-	-	-	-	-	-
All materials	8%	75%	4.3%	-	-	-	10.3%

Census of India, 1991

DISTRICT BHAVNAGAR

Village: Rajpara
Gram Panchayat: Rajpara Khodiyar
Block: Sihor

Location
Village Rajpara has a semi-compact settlement pattern and is located near a river.

Population and occupational structure
Rajpara has a population of 3,500 people and about 450 households. One third of these families work in diamond factories and another third in plastic factories. 5% of village population is involved in trade, 3% as masons and another 3% are carpenters.

Land holdings
There are 5% households without any land, more than 50% own less than 2 hectares of land, 5% have 1-2 hectares and 0.6% have 2-5 hectares.

Infrastructure
The village has a metaled road. A hospital, bank, cloth shop and public telephone are located at Sihor which is 7 kms away, also its own primary school, ration and provision shop and a bus stop. There are no street lights, no paved streets or proper drainage. There is a well and a handpump, less than 1km away.

Building material prices and wages
Earth costs Rs. 100/- per tractor, stone costs Rs. 300/- per tractor while the sand costs Rs. 100/- per tractor. Materials are available for free only transportation costs. Mangalore tiles cost Rs. 1500/- per 1000 pieces.

DISTRICT KUCHH

Village: Nani Vamoti
Gram Panchayat: Vamoti
Block: Abdasa

Location
Village Nani Vamoti lies about 20 kms. from Naliya town in Abdasa Taluka. It has a semi-compact settlement.

Population and occupational structure
Nani Vamoti has a population of 700 people and about 136 households, out of this 80% stay in Bombay, working as grain store merchants or accountants.

Land holdings
Most of the households own land between 0.2- 2 hectares. 5 people own land between 5- 10 hectares, while 3 occupy more than 10 hectares. There are 2 masons, one carpenter and one doctor.

Infrastructure
The village has a metaled road as well as a hospital, bank, post office, provision shop and cooking-fuel shop within. Banking facilities and telephone are available in Bitta, which is 11 kms. away. The village has no drainage system. Water is available from 29 wells throughout the year.

Building material prices and wages
Earth costs Rs. 100/- per tractor, stone costs Rs. 300/- per tractor while the sand costs Rs. 150 per tractor. Mangalore tiles cost Rs. 1350/- per 1000 pieces, Cement bag costs Rs. 120/-, Sag wood is available for Rs. 15,000/- per cum (transportation from Nakhatrana costs Rs. 300/- for a truck.

DISTRICT PANCHMAHALS

Village: Jokha
Gram Panchayat: Navi Signali
Taluka: Lunawada

Location
Village Jokha is located about 15 km. from Lunawada, on an undulating plain.

Population and occupational Structure
There are 184 people staying in 29 households. The predominant cast is Kshatriya. Farming is the main occupation.

Land holdings
There are 60% households without any land, the size of the land holding is small with only one household owning land up to 4 hectares. The majority has land between 0.8-2 hectares.

Infrastructure
The Village has a bus stop on the metaled road and a hospital, bank, cloth shop and public telephone are located at Makhalia which is 5 kms away. It also has its own primary school, ration and provision shop. There are no street lights, no paved streets or proper drainage. The village has a well and a handpump which provide water throughout the year. It faces acute water shortage.

Building material prices and wages
A bag of cement costs Rs. 121/- inclusive of transportation. 1000 bricks cost Rs. 850/-, while its transportation costs another Rs. 150/-. Mangalore tiles cost Rs. 1700/- per 1000 pieces, while Rs. 300/- is charged for its transportation. Country tiles made locally cost Rs. 350/- per 1000. Unskilled laborers get Rs. 20/- per day.

DISTRICT JUNAGARH

Village: Chitravad
Gram Panchayat: Rajpara Khodiyar
Block: Talala

Location
Village Chitravad is located 9 km. east of Talala town.

Population and occupational Structure
Chitravad has a population of 3,215 people and about 568 households. Ismailis count for 47% of the population.

Land holdings
92 farmers have up to 5 acres of land, 60 have 5-10 acres, 50 have 10-20 acres and only six Ismaili families have above 20 acres of land.

Infrastructure
The village has a metaled road. Basic educational facilities such as day care centre, primary and secondary school exist within the village. 75% of land is under irrigation, with hand pumps and wells as major source of water. The nearest bank and post office are in Talala town. Some essential food and grocery shops exist within the village. Electricity is available for both domestic and commercial usage.

Building material prices and wages
Earth costs Rs. 100/- per tractor, stone costs Rs. 300/- per tractor while sand costs Rs. 100/- per tractor. Materials are available for free, the costs are for transportation. Mangalore tiles cost Rs. 1500/- per 1000 pieces. The village has 20 semi-skilled masons, 4 carpenters, 2 blacksmiths and 1 potter.

Chapter 3
Built Environment Characteristics

CHARACTERISTICS OF BUILT ENVIRONMENT

Profile of Building Zones

The natural environment characteristics of the various parts of Gujrat, as well as certain socio-cultural and economic characteristics, can be the basis of dividing the state in to six built environment zones:

1. The northern arid zone

   This zone covers the Kutchh peninsula abutting the south of Thar desert. In addition, the adjoining parts of Gujrat plain as well as a part of the northern Saurashtra Peninsula (parts of Surendranagar and Rajkot districts) also comprise this zone.

   The settlements here are characterized by very compact linear clustering, narrow streets which minimize exposure to solar radiation. They also often have high walls and hedges for protection against hot dusty desert winds. The dwellings generally have shared/ adjoining east-west walls with a linear configuration of interior spaces parallel to these walls. They normally have inner courts with very few openings, small windows and massive walls.

2. The semi-arid hot dry zone

   This extends from the northern part of Gujrat plain to the central part of Saurashtra Peninsula in south-west (parts of Banaskantha Mehsana districts).

   The settlements, clustering and dwellings are similar to the Northern Arid Zone. These dwellings are more porous, with larger number of open spaces including facilities of outdoor sleeping during summers. Within this zone, there is a marked difference between spatial and construction technology patterns of the northern Gujrat plain and Central Saurashtra.

3. The composite hot humid/ dry zone

   This zone is basically a part of the Gujrat plain as well as the western fringes of the eastern hilly region and the eastern fringes of the Saurashtra Peninsula (parts of Surendranagar and Bhavnagar districts).

   The settlements, clusters and dwellings while retaining the basic characteristics of arid and semi-arid zones have a further degree of porosity. The linear dwellings have enough open spaces to allow air movement. These open spaces have more squarish proportions in plan. The dwellings generally have shared/ adjoining east-west walls with a linear configuration of interior spaces parallel to these walls. Small openings on north-south are protected by verandahs. They have generally more than one floor, with the upper floor being used as thermal gain/ lag zone and is primarily used for storage. They continue to have pitched roofs and load bearing or composite bearing frame structural system, partially due to lower clay content of the soil.

4. The hot humid- low rainfall zone

   The zone comprises of Saurashtra thus also a plains terrain. The settlements retain definite clustering of row houses. The degree of porosity is very high with large number and frequency of open spaces. The streets and the open spaces are broader and squarish in proportions to allow for air movement. The width of the units are larger, with larger and more openings, longer verandahs and facilities of outdoor sleeping. They also continue to have pitched roofs and load bearing structural system, using stone to withstand corrosion by salt.

5. The hot humid plains zone

This zone primarily covers the southern part of the Gujrat plain (parts of Bharuch, Surat and Valsad districts). The settlements are characterized by loose, detached clustering, which have large open spaces around them, enclosed by low height hedges or walls. The dwellings are mostly single storeyed but often have partial lofts for storage. They also have long verandahs on more than one side, both for semi-sheltered living spaces and protection against rains. This zone has frame structure and wattle and daub walls due to high rainfall, and black cotton soils of high clay content.

6. The hot humid- hilly zone

This zone comprises the southern parts of the Eastern Hilly region i.e., parts of Valsad and Dange district. The settlements are characterized by very loose, detached clusters located on terraces of hill sides. The spatial configuration within the dwellings is also loose, with large spaces and few internal walls to allow free air movement. The dwellings are generally single storeyed pitched roof structures, with deep verandahs and eaves to protect the walls from rains. The shorter side normally faces the wind direction. Tribal concentration is high in this area hence the dwellings are unshaped timber structures with wattle and daub walls.

Building Systems Identified in Studied Districts

MANGALORE TILE ROOF ON BRICK WALLS (DISTRICT BHAVNAGAR)

Location

This house type is located mainly in Bhavnagar district in Savarkundala, Gariyadhar and Umrala talukas. The house type is usually confined to settlements, which fall on the roadside.

Cluster layout

These houses are laid out in a planned settlement having well defined streets. Most of them share a common wall with other houses.

Building Systems

Roof

The double pitched Mangalore tile roof is supported on a ridge beam and timber purlins which further rest on a tie beam and the brick wall. Bamboo battens spaced at 250- 300 take the load and support the Mangalore tile roofing. These tiles (400 x 240 mm) rest on timber and bamboo understructure.

Walls

The stone foundation of the 350 mm thick wall is 0.9 m to 1.2 m deep. Bricks are laid in English bond using mortar. They are not plastered by cement. Interior walls are painted once a year. Brick walls are 350 mm thick, reaching a maximum height upto 5 m in a double storeyed structure.

Intermediate floor

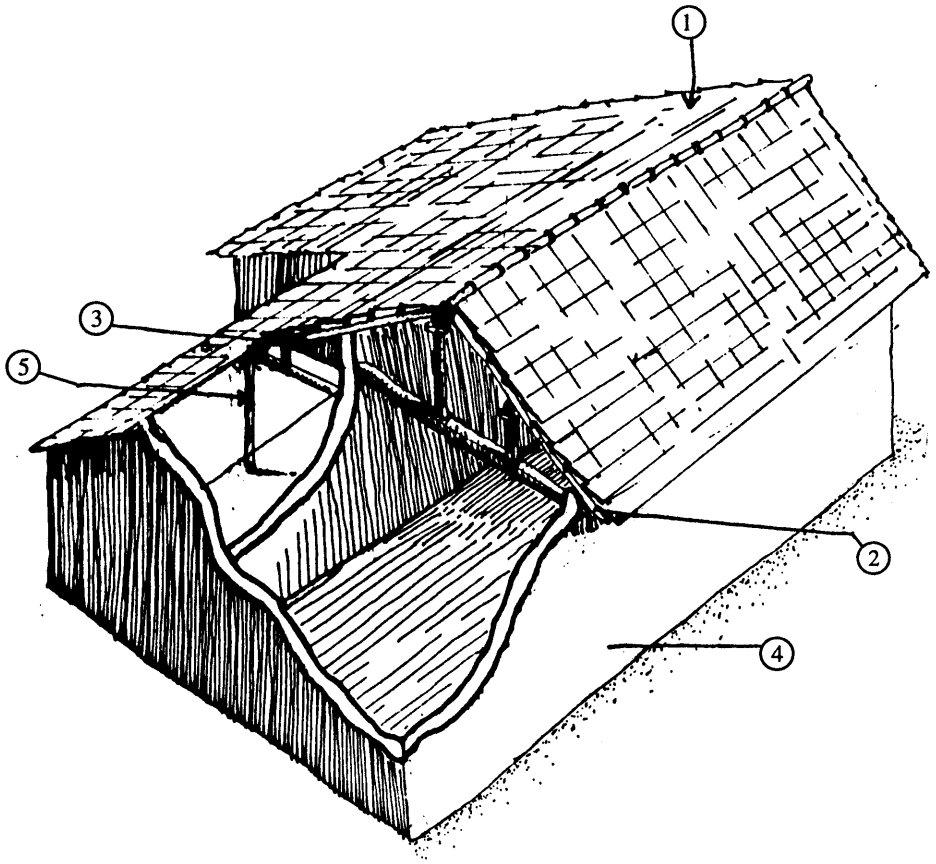
Timber (Eucalyptus) beams spaced at 1.2- 1.5 m form the basic substructure of the intermediate floor. Beams rest on 350 thick brick walls. The timber beams are supported by a wall plate. The flooring is also of timber planks.

Timber planks 750 x 50 with a maximum length of 2 m rest on 150 dia. timber beams (1800- 2000 c/c)

Maintenance

Roof cladding takes two days for repairs. The wall finish (mud and cowdung) takes about 10 days for the entire house.

MANGALORE TILE ROOF ON BRICK WALLS

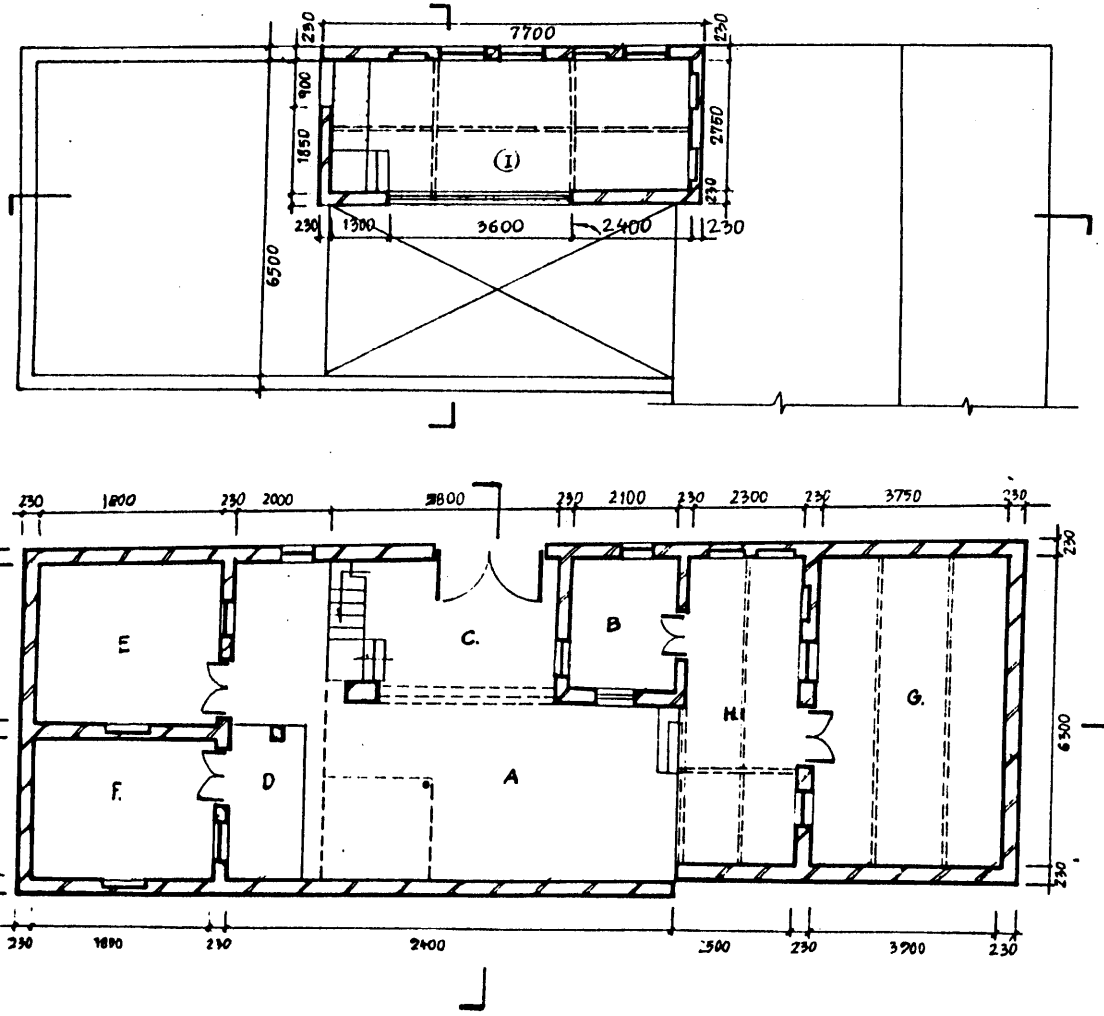


Perspective view

1. Cladding: 400 x 200 Mangalore tiles.
2. Rafters: 100 dia. timber @ 1200 c/c.
3: Purlins: 120 dia. timber posts @ 1200- 1800 c/c.
4. Walls: 350 tk brick walls.
5. Post: 150 dia. timber.

All dimensions in mm.

MANGALORE ROOF ON BRICK WALLS



Plan

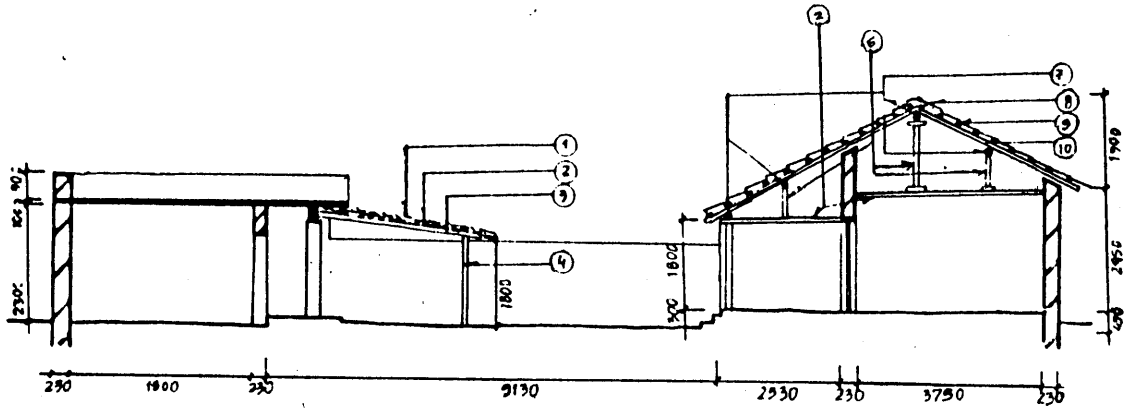
A.Court.
B.Kitchen.
C.Dalhi.
D.Verandah.
E.Store.
F.Sleeping cum storage.
G.Bedroom.

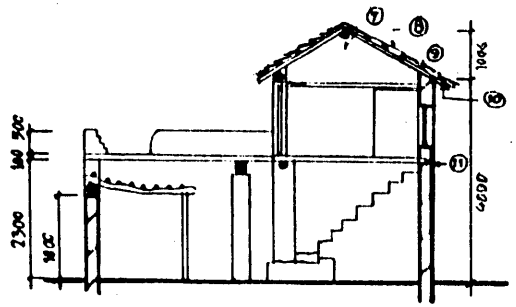
Total Area: 107 sqm.
Covered area: 71 sqm.
Semicovered area: 36 sqm.

All dimensions are in mm.

District Bhavnagar.
Taluka: Savarkundla.
Village: Giniya.

MANGALORE TILE ROOF ON BRICK WALLS





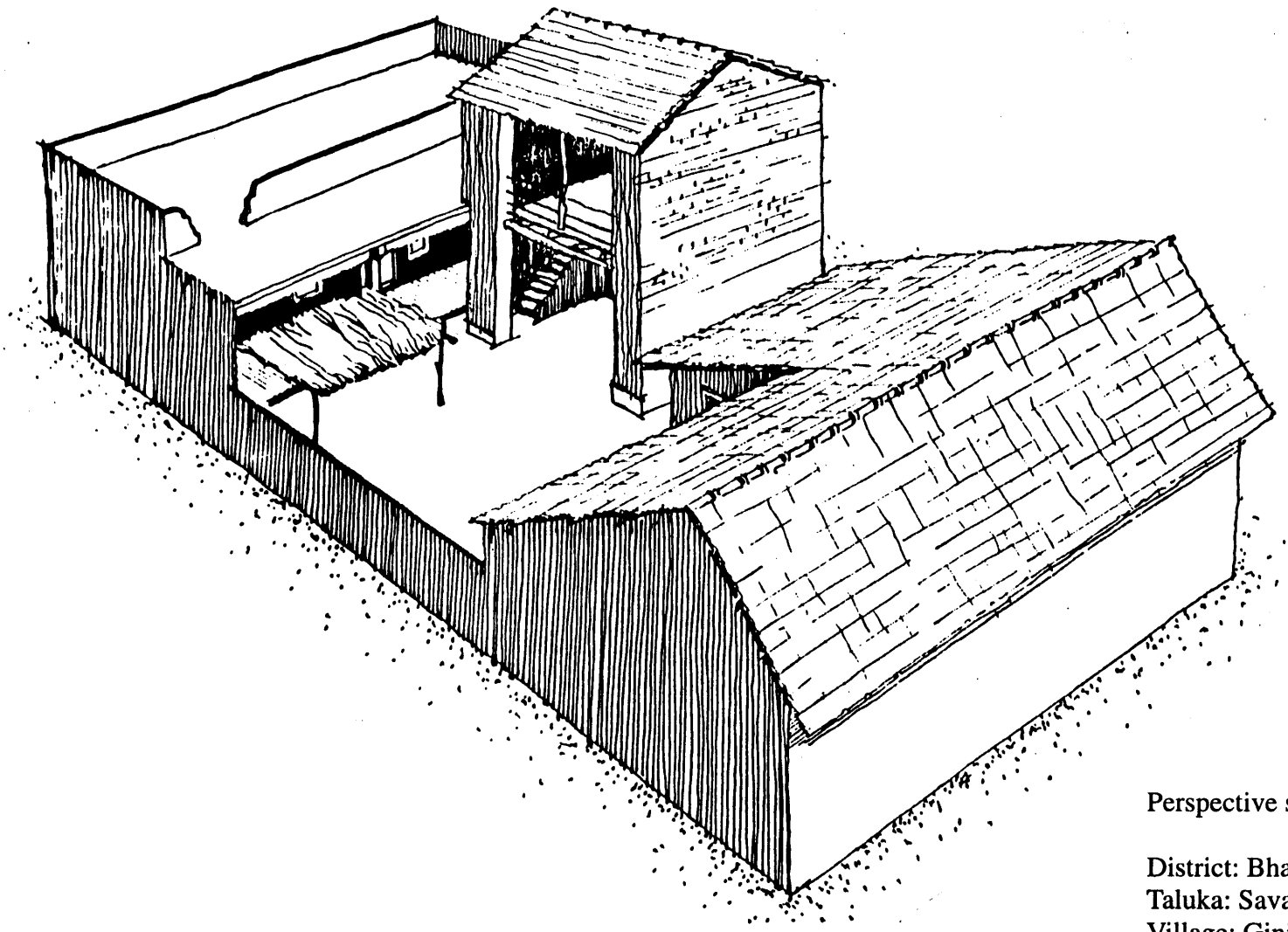
Sections

1. Thatch.
2. 20 dia. timber batten.
3. 100 dia. timber rafter.
4. 150 dia. timber post.
5. 120 dia. timber post.
6. 100 dia. timber king post.
7. 100 dia. timber ridge post.
8. 400 x 240 Mangalore tiles.
9. 40 dia. timber battens.
10. 150 dia. timber rafter.
11. 350 thick brick wall.

All dimensions are in mm.

District: Bhavnagar.
Taluka: Savarkundla.
Village: Giniya.

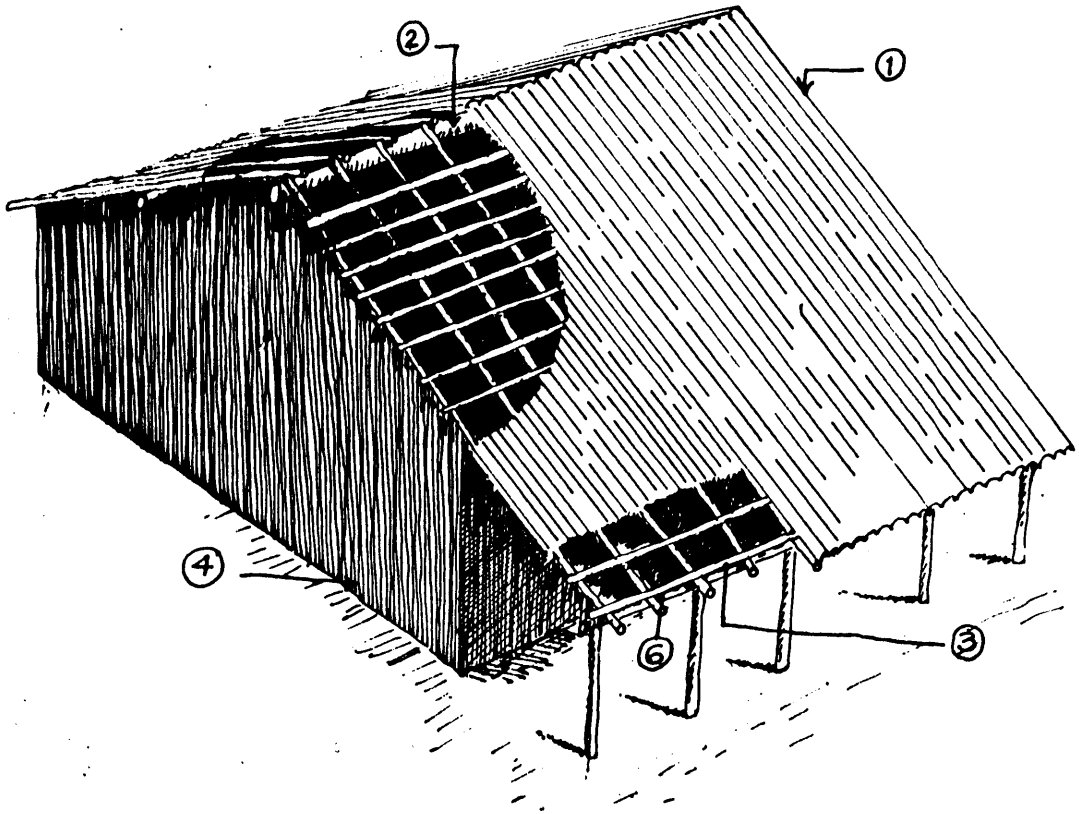
MANGALORE TILE ROOF ON BRICK WALLS



Perspective sketch

District: Bhavnagar.
Taluka: Savarkundla.
Village: Giniya.

COUNTRY TILE ROOF ON COB WALLS

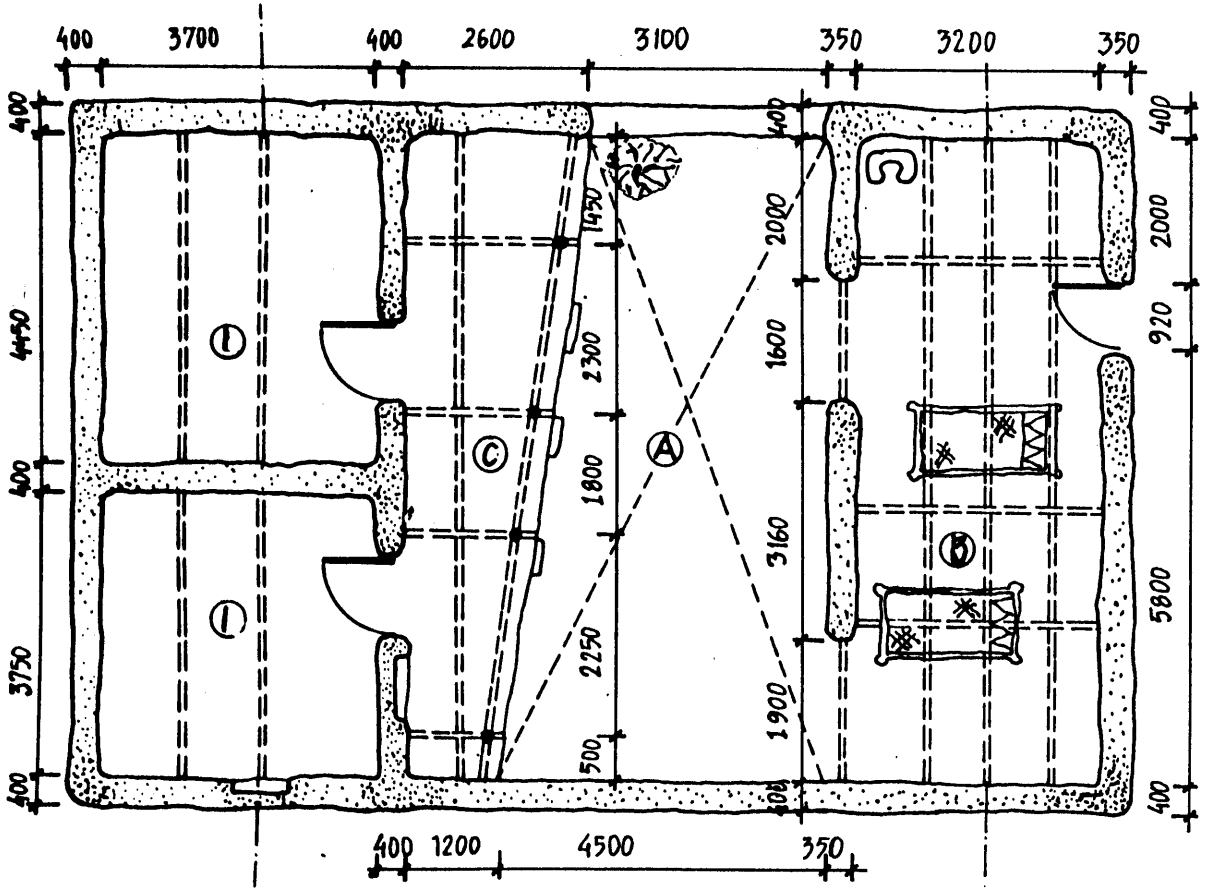


Perspective sketch

1. Cladding: 600 x 80 Mangalore tiles.
2. Ridge: 150 dia. timber (eucalyptus)
3. Purlins: 100 dia. timber posts @ 1200- 1800 c/c.
4. Walls: 450 tk. cob walls.
5. Post: 150 dia. timber.
6. Tie members: 150 dia. timber (eucalyptus).
7. Battens: 50 dia. bamboo @ 300 c/c.

All dimensions in mm.

COUNTRY TILE ROOF ON COB WALLS



Plan

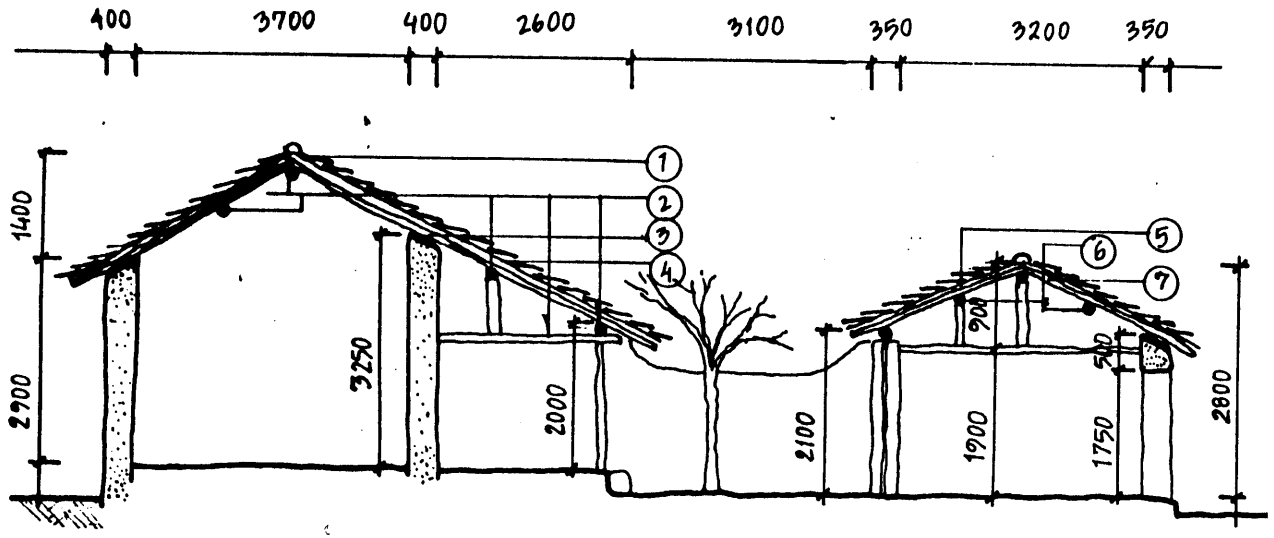
A. Court.
B. Sitting and sleeping.
C. Verandah.
D. Living room.

Total Area: 77 sqm.
Covered area: 57 sqm.
Semicovered area: 20 sqm.
Household area: 13 sqm.

All dimensions are in mm.

District: Bhavnagar

COUNTRY TILE ROOF COB WALLS



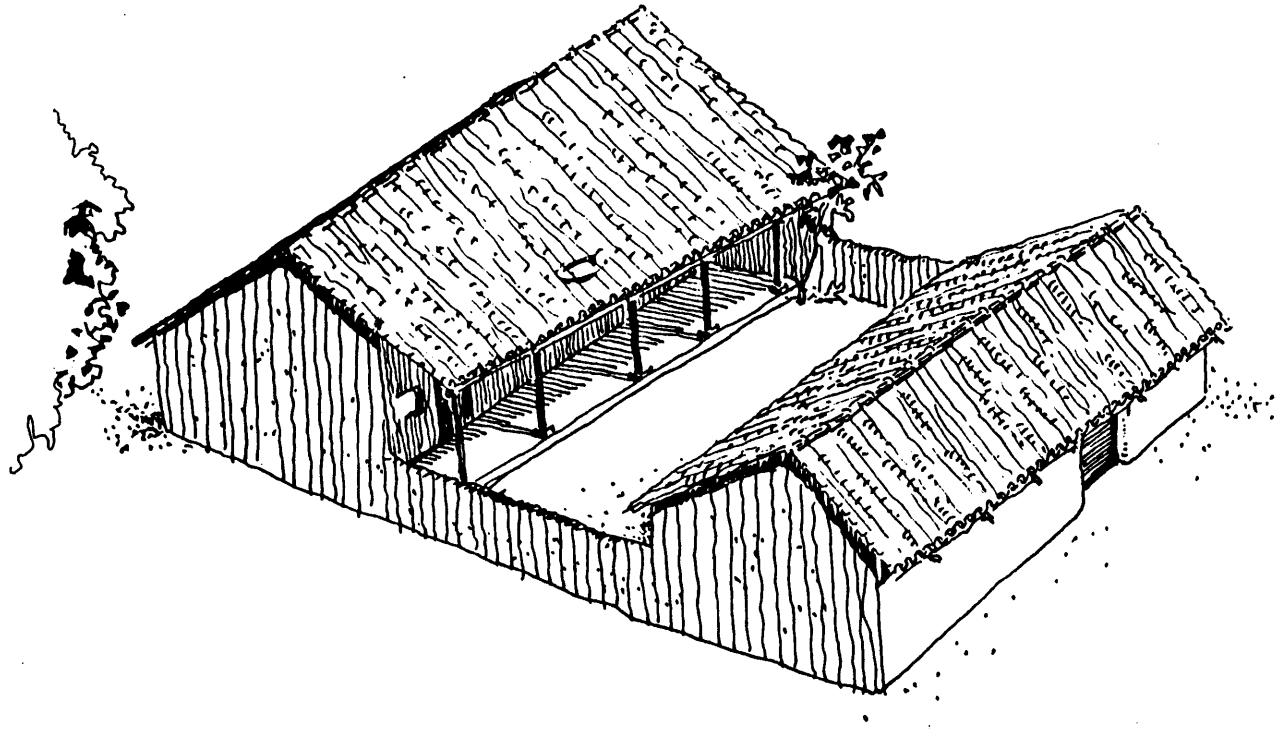
Section

1. 600 x 75 country tiles.
2. 100 x 100 timber ridge.
3. 30 x 20 timber battens.
4. 70 x 20 timber rafter.
5. 100 dia. timber rafter.
6. 100 dia. timber joist.
7. Split bamboo battens @ 200 c/c.
8. 400 thick cob wall.

All dimensions are in mm.

District: Bhavnagar.
Taluka: Umrala.
Village: Thonda.

COUNTRY TILE ROOF COB WALLS



Perspective sketch

District: Bhavnagar.
Taluka: Umrala.
Village: Thonda.

PITCHED MATT ROOF ON MATT WALLS (DISTRICT KACHH)

Location

This building system is the most common in Nikhtrana tehsil of Kachh district.

Cluster layout

A cluster of "Bhungas" and pitched matt house structures (with square or rectilinear plan) form the most common layout pattern.

Building Systems

Walls

Posts 50 mm- 75 mm in dia. form the wall frame. These are infilled with 1- 2 cm dia. stalks. The front and rear walls are 1- 1.4 m high. The apex of the gable wall is to 3- 5 m higher than the front and the rear walls.

There is no foundation for the Acacia posts (50- 100 mm dia.) The thickness of the wall is provided by the wooden sticks, 10- 20 mm dia. with an average spacing of 1 cm. They are tied together by the local rope defining the periphery of the whole house. The front and the rear walls have a height upto 1.4 m and gable walls upto 1.7 m.

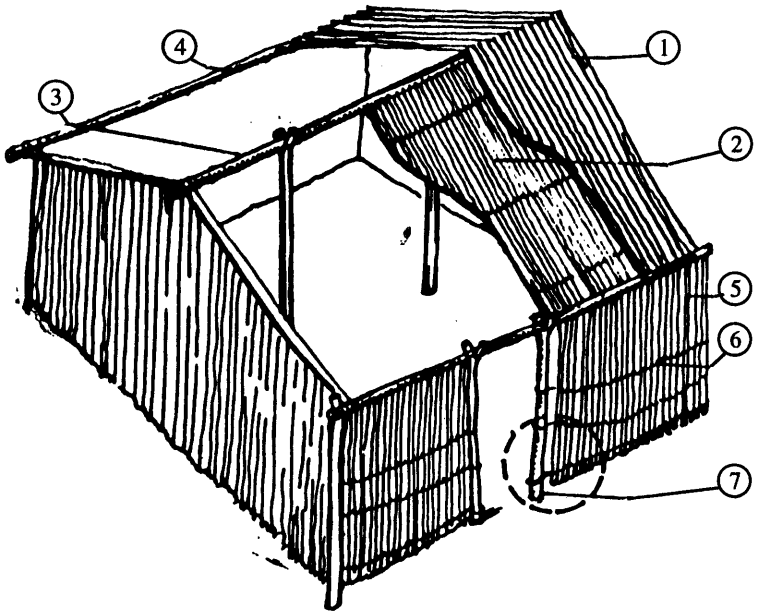
Roof

Stalks are sandwiched above the timber understructure from the roof cladding. The roof substructure consists of ridge piece, horizontal beams and rafters framing the roof. Sticks are tied to each other with rope and rest on the ridge and the beam. The distance between them is hardly 1cm. Sacs and waterproof sheets are placed over the Akadu (wooden tie sticks) above which Kanybi (wooden sticks) are laid.

Method of Construction and Maintenance

Posts of Acacia/ Aakad are erected at a distance of approximately 1 m on the periphery and below the ridge.The height of the posts below the ridge is 3- 5 m more than the front and the rear posts. Ridge beams are placed and tied over the shaped top of the post. The understructure is completed by placing the kanyu stick of 10 mm dia. (which are tied together) on the beams. They act as secondary rafters. Waterproof sheets/ sacks are placed above the secondary rafters which are further sandwiched by placing Kanya, on top of them. The gap between the posts are filled by tying them with the Kanyu/ Aakad sticks. These form a continuous peripheral partition.

PITCHED MATT ROOF ON MATT WALLS



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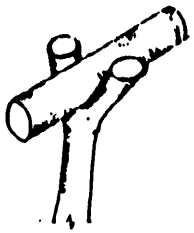
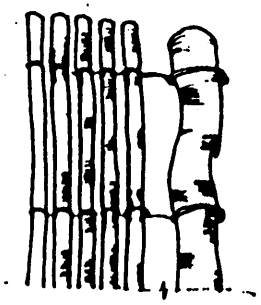




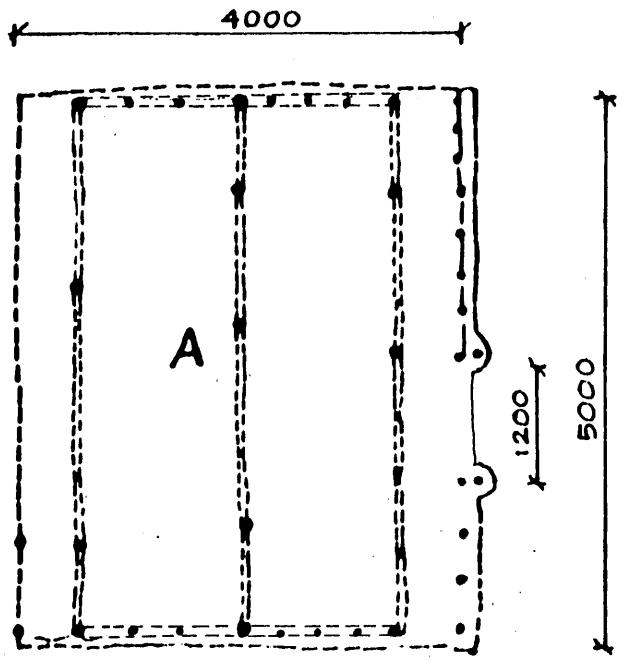
Perspective sketch

1. Cladding: 10- 20 dia. stalks (kanyu) @ 10 c/c.
2. Rafters: 10- 20 dia. wood.
3. Ridge: 75 dia. timber.
4. Walls: 10- 20 dia. stalks.
5. Rafter: 50- 75 dia. timber.
6. Rope: 5 dia. rope for binding the stalks.
7. Post: 50- 75 dia. timber.

Detail A of water proofing: sacks or polythene sheets.

All dimensions in mm.

MATT ROOF ON MATT WALL



Plan

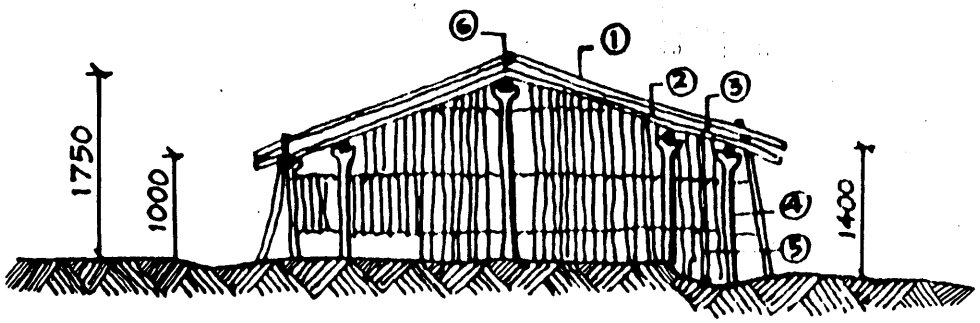
A. Store/ Living.

Total area: 20 sqm.
Covered area: 20 sqm.

All dimensions in mm.

District: Kachh.
Taluka: Nakhatrana.
Village: Laiyari.

MATT ROOF ON MATT WALL



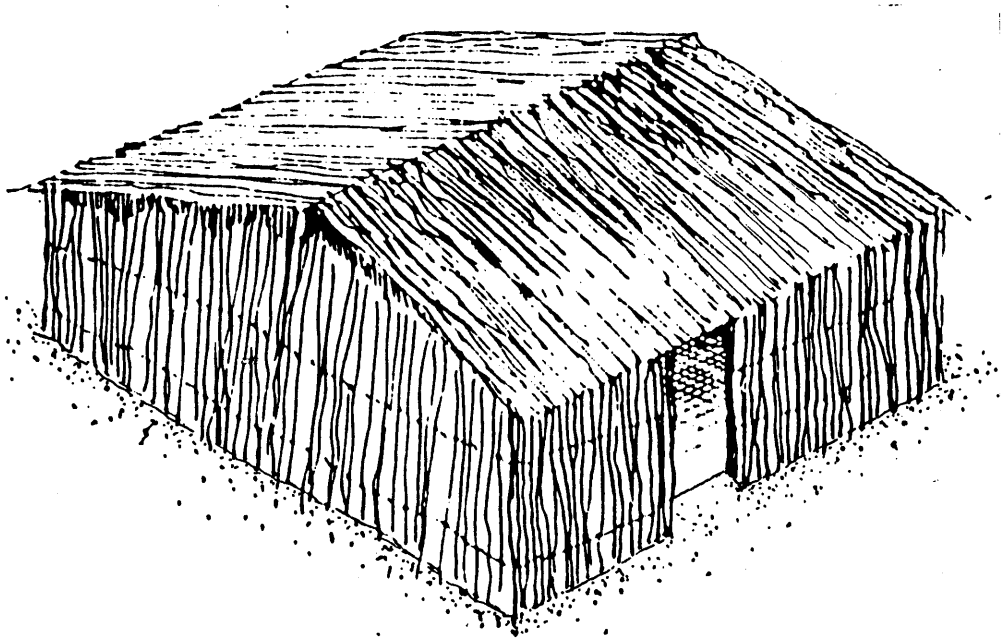
Section

1. 15 dia. stalk matt (Kanyu).
2. 15 dia. stalk matt (Aakad).
3. Water proof sheet.
4. 50 dia. timber post.
5. 10 dia. stalk matt wall.
6. 75 dia. timber ridge.

All dimensions in mm.

District: Kachh.
Taluka: Nakhatrana.
Village: Laiyari.

MATT ROOF ON MATT WALL



Perspective sketch

District: Kachh.
Taluka: Nakhatrana
Village: Laiyari.

BUNGA THATCH ROOF ON COB WALLS (DISTRICT KUCHH)

Location
This type is most common in the Bani area of Bhuj taluka.

Cluster layout
A compact cluster of Bhungas and Chokis around an open space forms the most typical house types which incorporates this building system. The cluster is situated on a raised platform (0.6 m-0.75 m high) which serves as a connecting element and protects the occupants from snakes.

Building Systems

Walls
The Bhunga has cob walls 25- 30 mm thick, rising from the foundation built along a circular plan with internal diameter ranging from 3.5 m -5 m. Vertical members 'Arana or Akada' plants held together by rope made from local Bhari plants (reeds) are placed at regular intervals.

Roof
Roof supporting methods:

1. Understructure consists of central wooden (acacia) post with radial joists set in four directions supported on a circular wall.
2. Spars radiating from the center (without central support) supported on a circular wall. Roof cladding consists of 2 layers of thatch which are bundles of grass (Dir and Khejadi).
   The entire cladding is secured to the understructure using locally made ropes. A spiral bundle of rope is laid from the top, and is radially stretched in all directions by means of longer ropes tied to the purlins towards the bottom and the circular rope towards the top. A special network of ropes starting from the top, connecting the radial ropes at different levels is tied to the purlins towards the bottom.

Method of Construction

Bhunga is built by the inhabitants, the process of construction is described below:

Walls
A circular plan of a desired size is demarcated on ground with a rope. Cob walls are built along the circular plan with a foundation depth of 0.45- 0.75 m and height of upto 2 m.

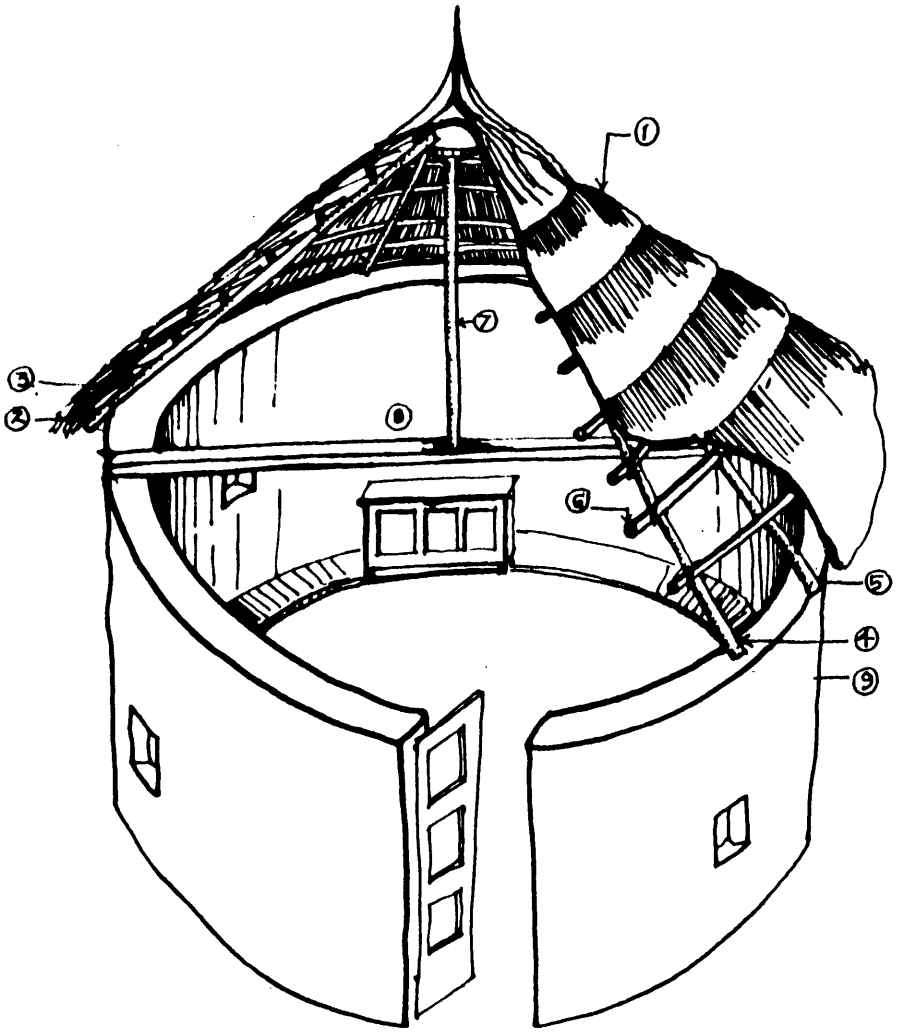
Roof understructure
Height of the Bhunga is equal to the dia. of the house. The central post is erected in the structure, depending on the diameter of the Bhunga The post (Suyo) rests on the tie beam which rests on the wall. In some cases the post rests on the ground itself. The main rafters are nailed to the apex, 10 acacia rafters of 50 mm dia are used for a 4.5 m dia. bhunga. These purlins are tied by a rope to the rafters at an average distance of 30 cm.

Roof cladding
Conical form is achieved by spanning the radial purlins with 'Tankar' stalks laid closely along the slope. 10 cm of 'Dhrab', a local shrub is laid over these and is topped with a min. of 10 cm tk. layer of Jowar or Bajra stalks. Final cladding is done with a 2-5 cm tk. layer of 'Dir', the local grass.

Maintenance

Cladding is re-done annually, the roof sub-structure lasts 6-7 yrs. and the walls are plastered every month with mud and cow dung.

BHUNGA (THATCH ROOF ON COB WALLS)



Perspective sketch

1. Thatch I: 75- 125 tk. layer of local grass.
2. Thatch II: 100 tk. layer of Bajra or Jowar stalks.
3. Thatch III: 75- 100 tk. layer of fine thatch.
4. Rafters: 40- 80 dia. Aakad members @ 700 c/c.
5. Stiffeners: 20-30 dia. Aakad members.
6. Timber purlins: 10- 20 dia. Tankara members.
7. Timber post: 100- 200 dia. Tankara members.
8. Timber tie member: 100x 200 Acacia member.
9. Mud wall: 250- 400 tk. Cob walls.

All dimensions in mm.

MANGALORE TILE ROOF ON STONE WALLS (DISTRICT KUCHH)

Location
This type of construction is most common in the rich villages of Bani area of Bhuj taluka.

Cluster layout
A compact cluster if 5 or 6 Bhungas raised at a plinth of 60 cm is the most typical system. The raised element platform acts as a connecting element and prevents snakes from entering.

Building systems

Walls
Stone walls 400- 500 tk. rising to a height of 2.25 m built along a circular plan with internal dia. of 4- 5 m.

Roof
The roof understructure is of timber (Acacia or Eucalyptus) and the cladding is done with Mangalore tiles from Morbi.

Method of Construction

The house is built by masons and laborers. A 4.5 m dia. house is completed in 30 days with the help of 4 masons and 6 laborers. The process of building this type of Bhunga is:

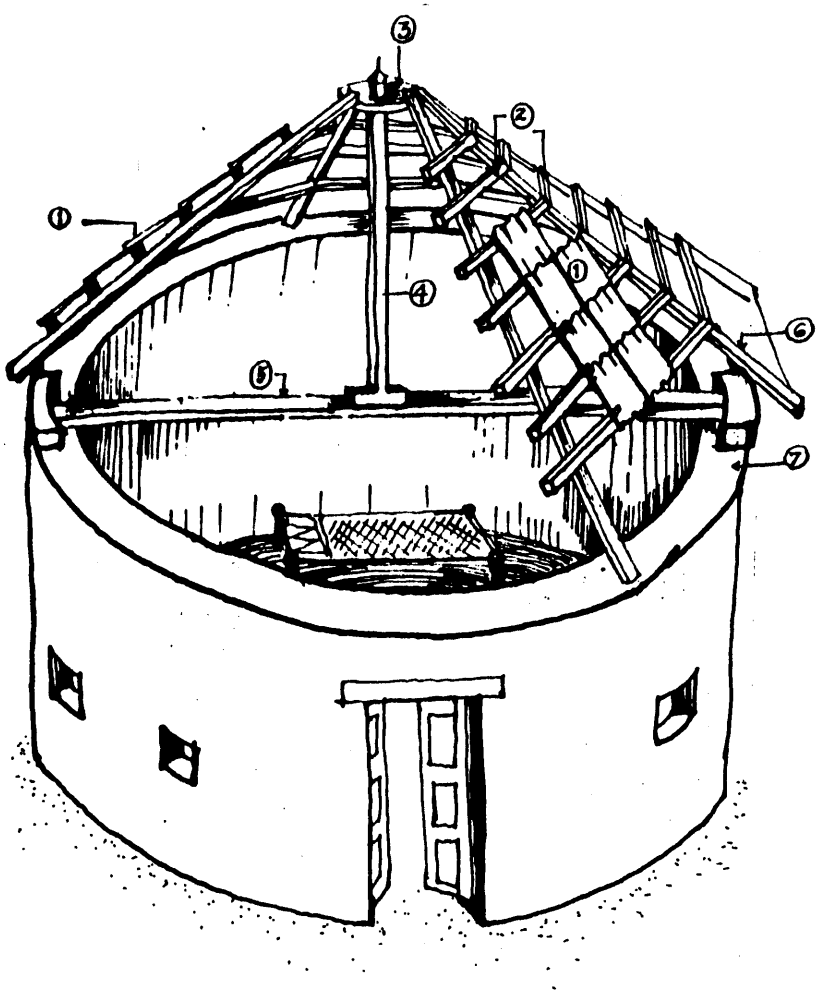
Walls
A circular plan of desired diameter is demarcated on the ground with a rope. The stone wall is built along the circular plan with a foundation depth of 0.45- 0.75 m and height of upto 2.3 m. Stone is queried from the rocky belt in Kachh. Mud mortar is used for binding the masonry walls.

Roof understructure
Height of the Bhunga is equal to the internal diameter of the house. The central post is erected in the structure, depending on the diameter of the Bhunga. The post (Suyo) rests on the tie beam which rests on the wall. In some cases the post rests directly on the ground.

The height of the apex is decided and then 8- 10 principal rafters are distributed from the top of the apex to the wall. This creates 8 triangles which are further stiffened by secondary rafters (40 x 40 mm- 50 x 50 mm thick) The principal rafters are fixed to the wall by timber brackets (Acacia). Above the rafter timber, battens (Acacia, 25 x 25 mm- 30 x 30 mm thick) are nailed with rafters, spaced according to the size of the Mangalore tiles.

Roof cladding
Mangalore tiles are placed on top of the battens, this makes the house hot. The traditional thatch Bhunga maintains its coolness.

BHUNGA, MANGALORE TILE ROOF ON STONE WALLS

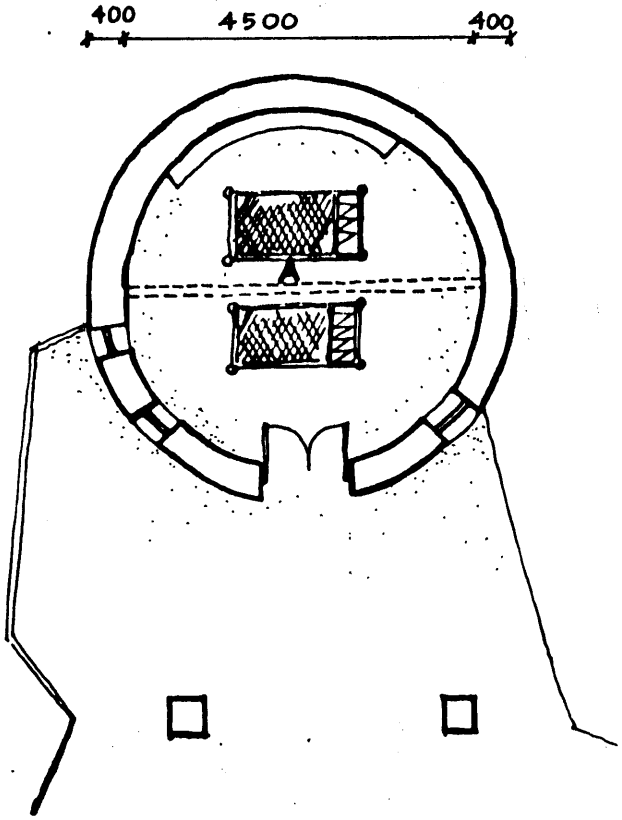


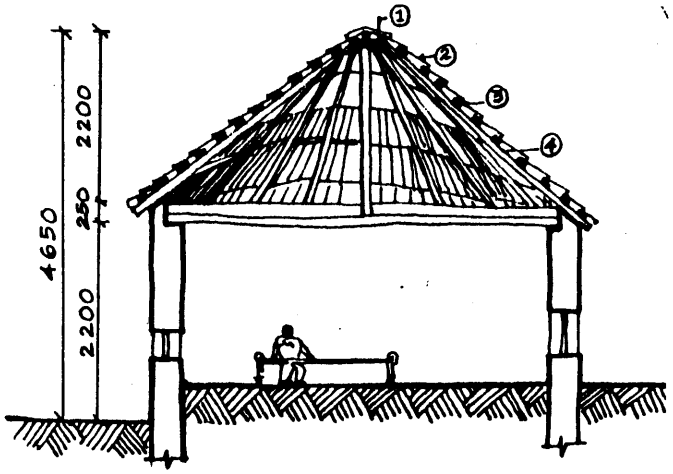
Perspective sketch

1. Cladding: Mangalore tiles.
2. Battens: 30 x 30 timber members.
3. Apex: 400x 500 dia. timber disc.
4. King post: 125x 125 timber member.
5. Tie beam: 200 x 200 dia. timber member.
6. Rafter: 45 x 45 timber member.
7. Stone wall: 400 tk. with 900 deep foundation.

All dimensions in mm.

MANGALORE TILE ROOF ON STONE WALLS





Plan

A: Multi- purpose room.

Section

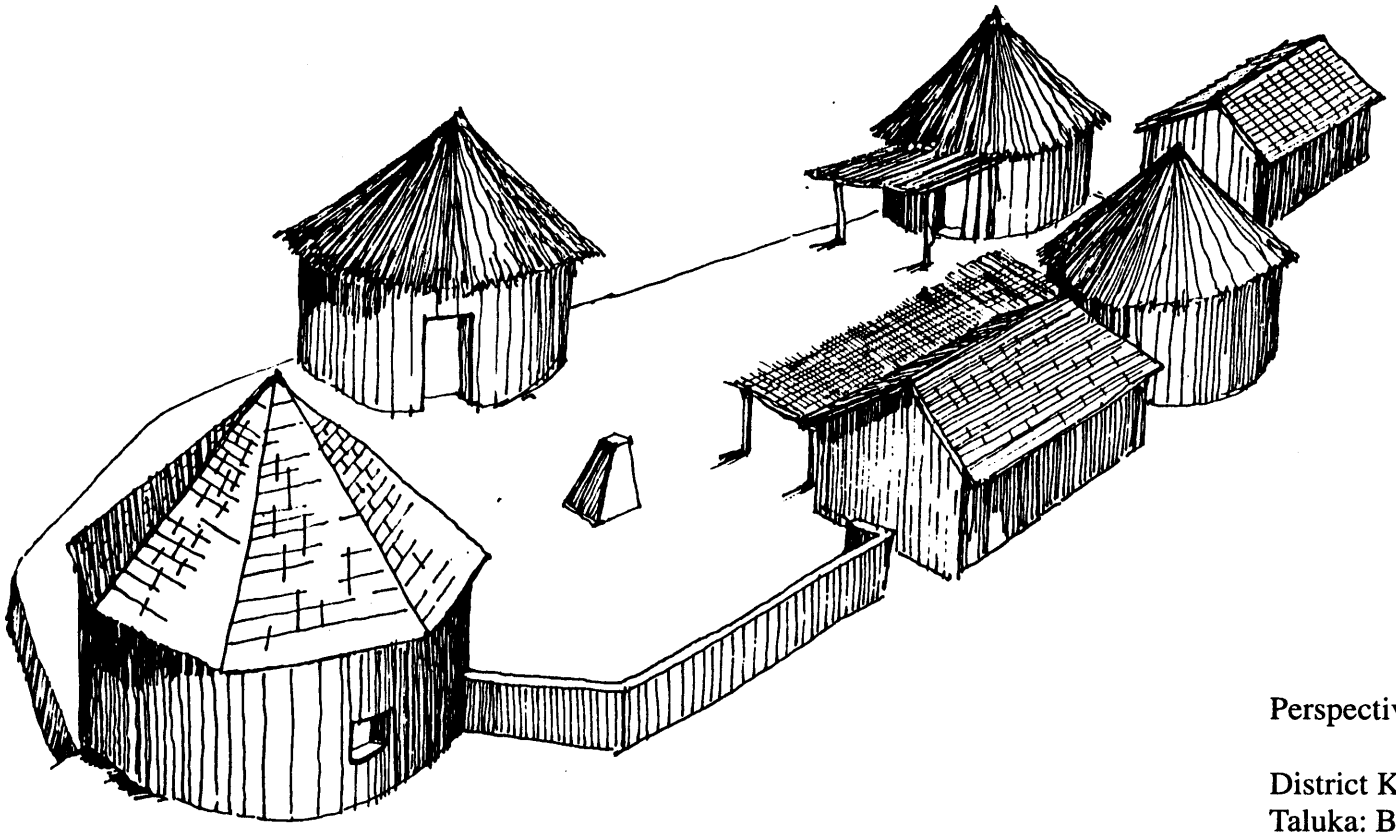
1. 450 dia. timber disc.
2. 400 x 240 mangalore tile.
3. 25 x 25 timber battens.
4. 50 x 50 timber rafter.
5. 40 x 40 timber rafter.
6. 100 x 100 timber post.
7. 250 dia. timber tie beam.
8. 400 tk. stone wall.

All dimensions in mm.

Total area: 16 sqm.
Covered area: 16 sqm.

District Kuchh.
Taluka: Bhuj.
Village: Ludia.

MANGALORE TILE ROOF ON STONE WALLS



Perspective sketch

District Kuchh.
Taluka: Bhuj.
Village: Ludia.

MANGALORE TILED TRUSSED ROOF ON STONE WALLS (DISTRICT KUCHH)

Location
This building system is very rare in Gujrat, it is found only in Ahir Patti area of Bhuj taluka of Kachh district.

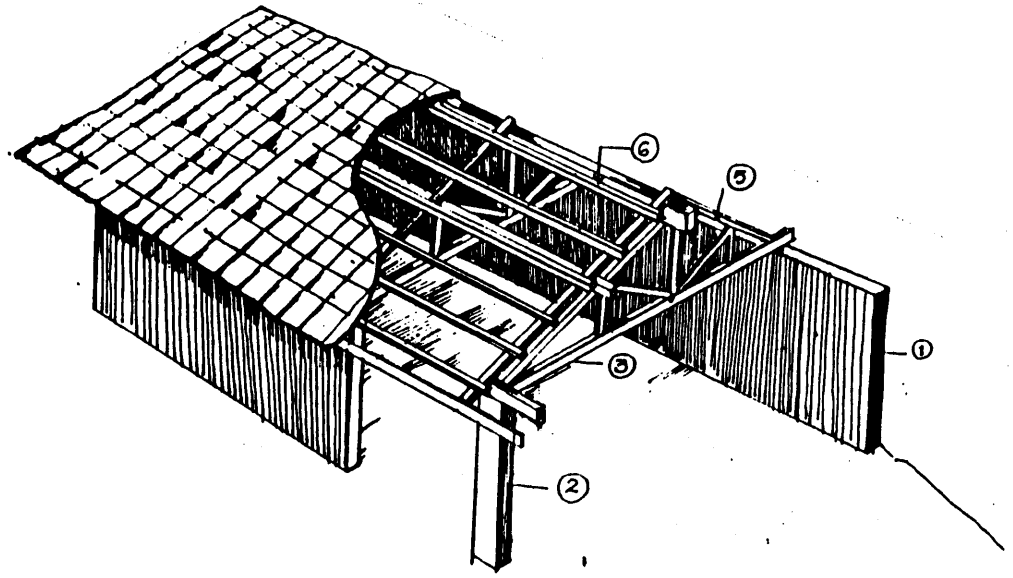
Building systems

Walls
Walls are erected by using locally available stone 400- 500 mm in width. The maximum height of the wall is 4 m. These are plastered with cement. The stone foundation is 900- 1200 mm deep with a width of 500 mm.

Roof understructure
The truss understructure has a tie beam, king post, queen post, principal and common rafters, purlins and battens. The tie beam of 250 x 100 mm rests on the stone wall or the column. Principal rafters 100 x 40 mm are fixed on the tie beams. The 100 x 100 mm king post is nailed to the tie beam at the bottom and to the ridge purlin on top. The width (4.5-5 m) is spanned by fixing a 100 x 100 mm queen post between the stone wall and the king post. A strut further strengthens the structure. Purlins 75 x 75 mm are nailed to the principal rafter spaced at 1.5 m, a timber stopper is nailed next to the purlin in the principal rafter towards the wall to stop the purlin from sliding down. Battens 50 x 10 mm are nailed on to the common rafter. A common rafter 50 x 50 mm spaced at an interval of 350 mm rests on the stone wall at one end on the timber wall plate at the other. This rafter extends 300 mm on both sides, to which 200 x 4 mm timber eaves boards are nailed.

Roof cladding
Mangalore tile cladding is laid from the lowest edge of the roof. The tile usually extends 150- 200 mm ahead of the eaves board and is kept in place by a stopper moulded in the tile.

MANGALORE TILE TRUSSED ROOF ON STONE WALLS

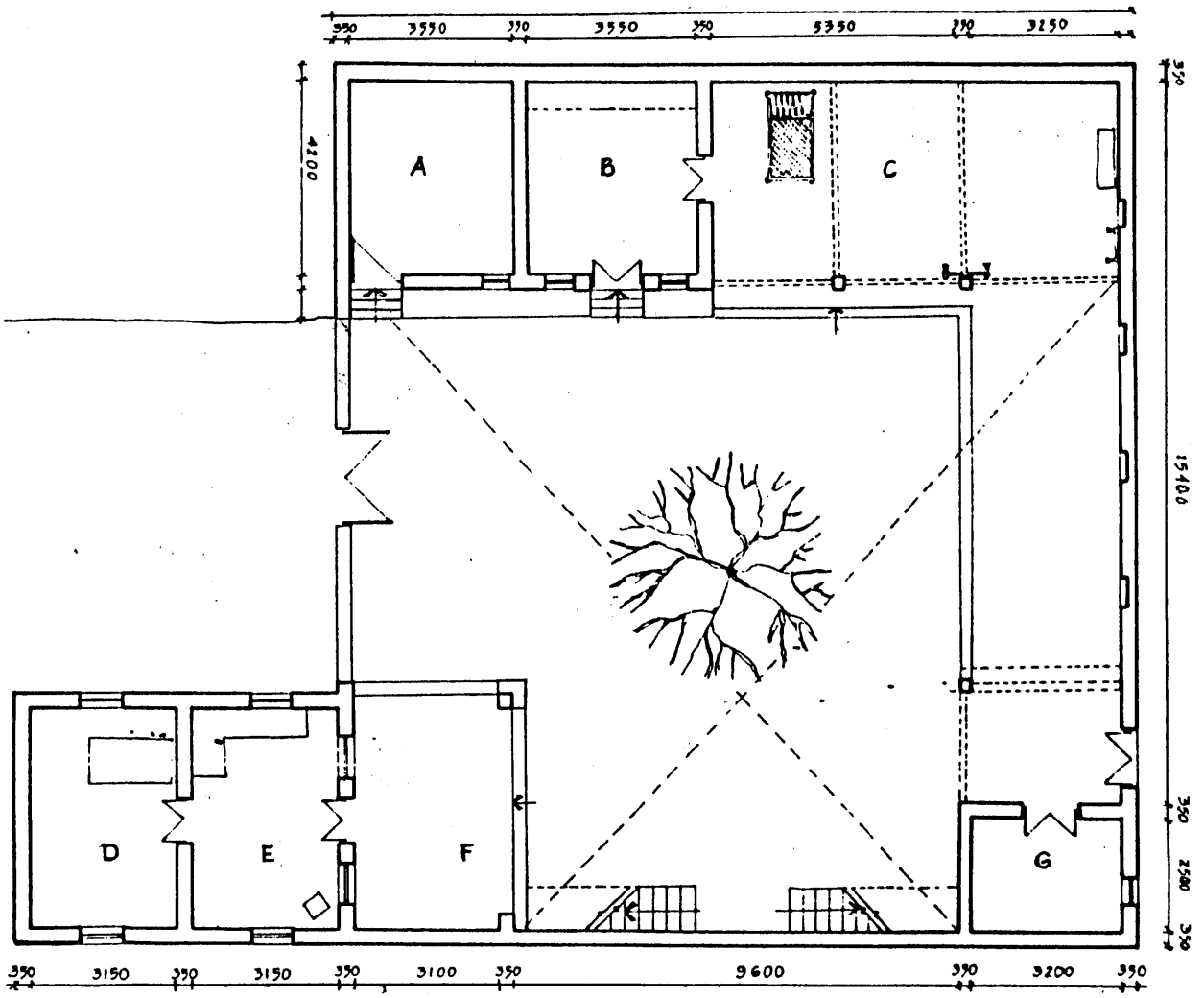


Perspective sketch

1. Walls: 400 tk. load bearing, coarsed stone wall.
2. Columns: 400 x 200 tk. load bearing stone column.
3. Main tie beams: 250 x 100 dressed timber @ 2500-2800 c/c.
4. Rafter truss detail.
5. Rafters: 50 x 50 timber beam @ 350 c/c.
6. Purlins: 75 x 75 timber @ 1000- 1500 c/c.

All dimensions in mm.

MANGALORE TILE ROOF/ R.C.C. SLAB ON STONE WALL



Plan

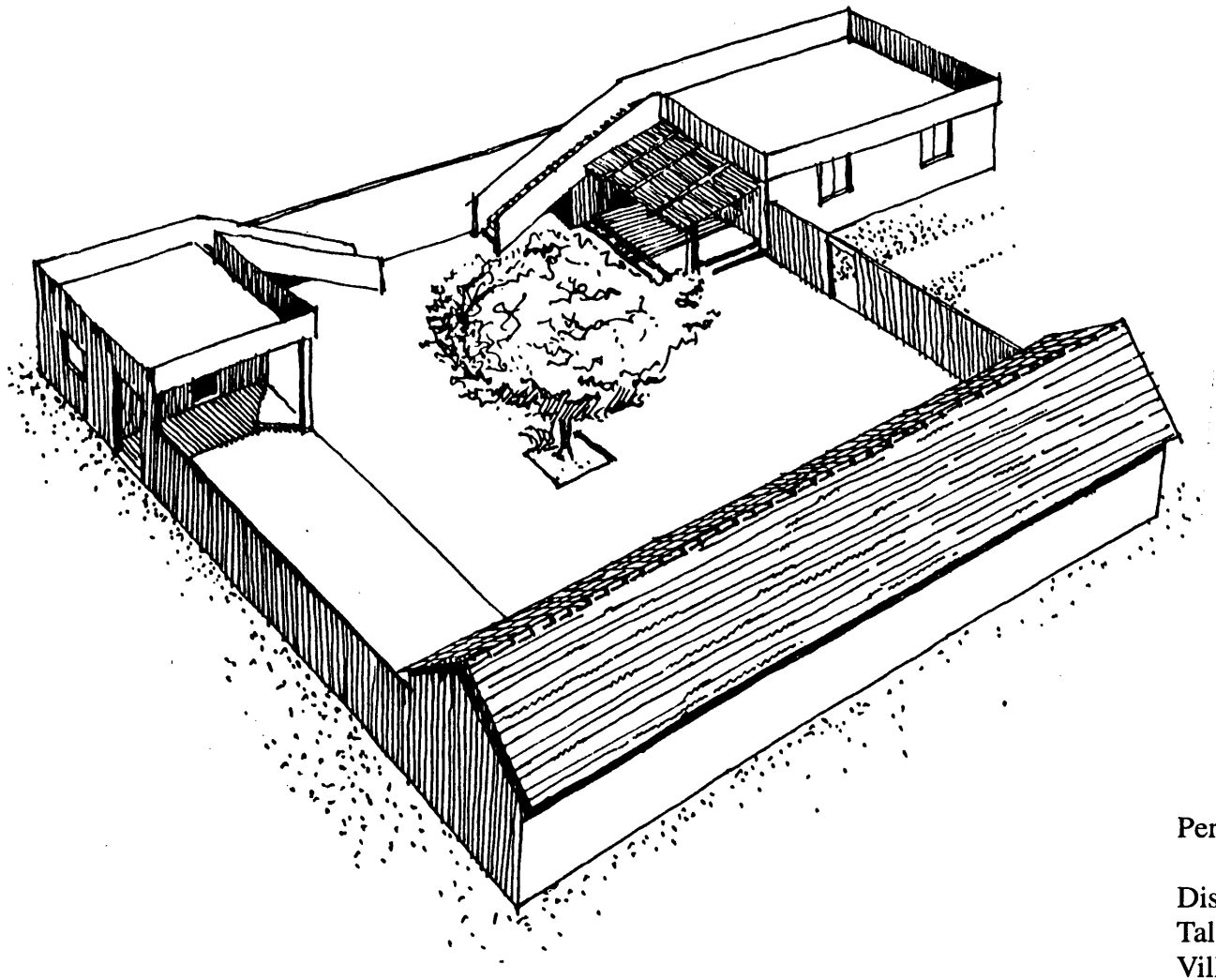
A. Grain store room.
B. Kitchen.
C. Verandah.
D. Room.
E. Living.
F. Store.

Total area: 132 sqm.
Covered area: 65 sqm.

All dimensions in mm.

District: Kutchh.
Taluka: Bhuj.
Village: Kotay.

MANGALORE TILE ROOF/ R.C.C. SLAB ON STONE WALLS



Perspective sketch

District: Kutchh.
Taluka: Bhuj.
Village: Kotay.

COUNTRY TILE ROOF ON TIMBER POSTS (DISTRICT PANCHMAHALS)

Location
This technique of construction is prevalent in the tribal regions of Panchmahals district of Gujrat.

House form

Plan form of these houses vary from square to rectangular in the tribal areas of the district. These houses have no plinth and are built with shallow foundation. Some houses have a semi- covered verandah used for used for storage and cooking while others have no verandah but just a cattle shed next to the house.

Building Systems

Walls
The roof is supported on 15- 25 cm diameter timber posts (Mahuda). Walls are made of 75 cm thick wattle and daub using jowar stalks (1 cm dia.) and mud plaster of 1cm. The timber posts have a diameter between 150- 250 mm and are buried 750 deep in the ground. The height of the post varies from 1.9- 4.1 m, according to the height of the roof.

Roof
Locally made country tiles (Desi Naliya) 500 mm long and 50 mm dia. are laid over sloping bamboo and timber understructure.

Roof understructure
The roof understructure is constructed of timber purlins, rafters and battens. Teak timber (Sag) purlins of 100- 150 mm diameter rest on the timber posts, either nailed from above or supported on a fork shaped post. Purlins are spaced at 2 m with a running length of 5- 7 m. Bamboo is spaced at 300 mm and the rafters (100 mm dia.) are nailed to the purlins. Battens are 300 mm split bamboo members spaced at 150 mm c/c. Country tiles are laid on top of it.

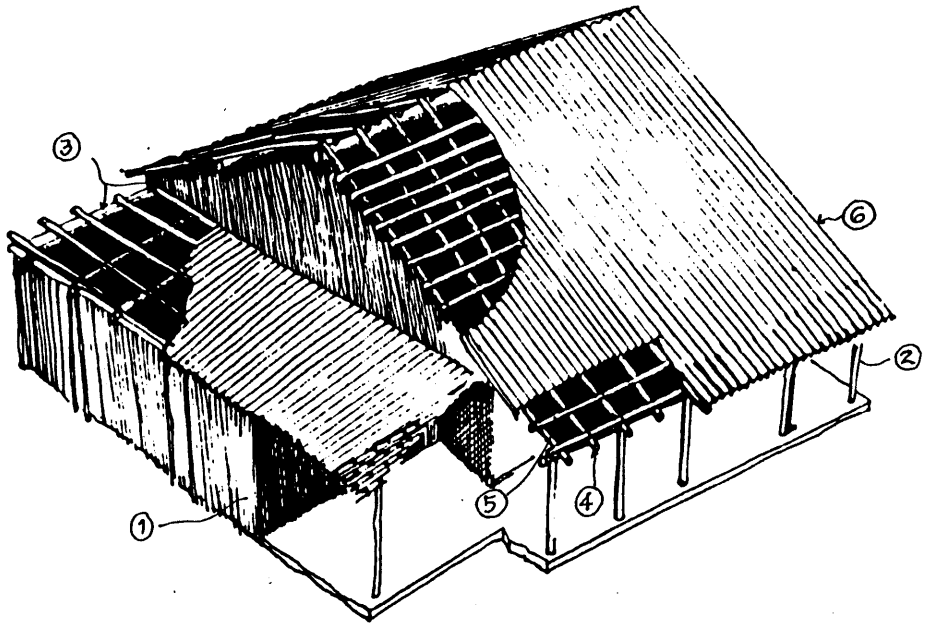
The cob wall foundation of the partition wall is 250 mm deep. There is no plinth and no base layer for the foundation. Walls are 40- 60 mm thick. Front and rear walls have a height upto 2.2 m and gable walls upto 4.1 m.

Roof cladding
The hollow semi- cylindrical country tiles (upto 600 mm) are made of local clay and are laid on bamboo battens. Laying is started from the lower edge of the pitched roof.

Maintenance

The roof cladding and the sub- structure of the roof needs to be repaired every monsoon. Jowar stalks which form the wall are replaced annually. Fresh mud and cow dung is applied to the jowar stalks every month.

COUNTRY TILE ROOF ON TIMBER POSTS

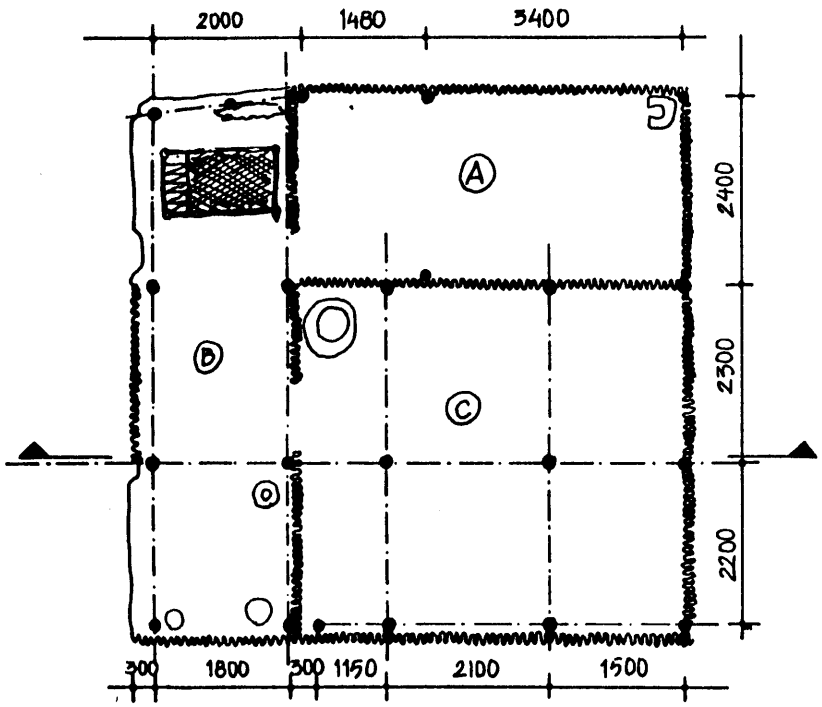


Perspective sketch

1. Walls: wattle and daub non-load bearing walls of 10 dia. Jowar stalks (Sarthi) and 40- 60 mm mud finishing.
2. Posts: 250 dia. timber.
3. Main beams: 150- 200 dia. timber.
4. Rafters: 100 dia. Bamboo.
6. Roof: 600 x 10 dia. hollow semi- cylindrical country tiles.

All dimensions in mm.

COUNTRY TILE ROOF ON WATTLE AND DAUB WALLS



Plan

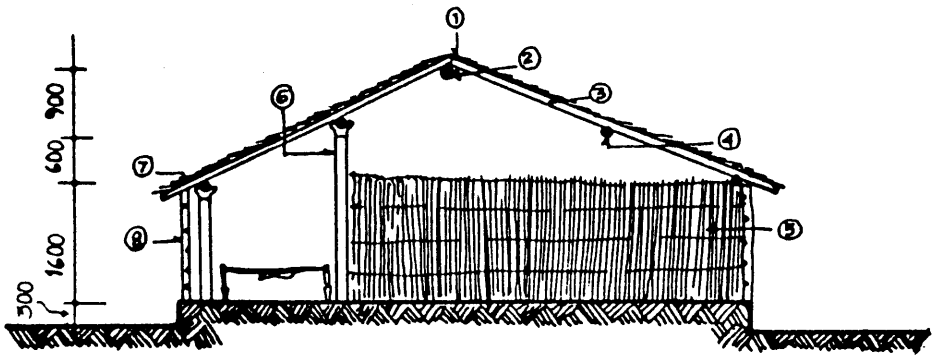
A.Kitchen.
B.Living/ bedroom.
C.Store.

Total area: 44 sqm.
Covered area: 32 sqm.

All dimensions in mm.

District: Panchmahals.
Taluka: Limkheda.
Village: Jamandra

COUNTRY TILE ROOF ON WATTLE AND DAUB WALLS



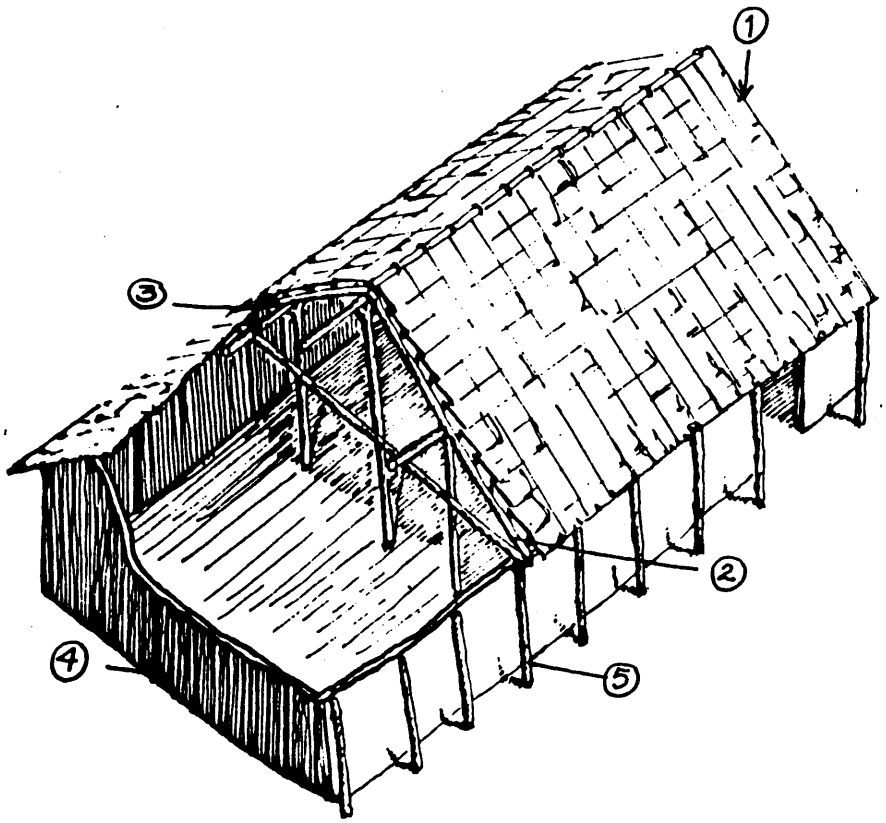
Section

1.480 long country tils.
2.150 dia. timber ridge
3.100 dia. timber rafter.
4.150 dia. timber purlins.
5.1300 high Jowar stalks.
6.250 dia. timber post.
7.30 dia. half bamboo.
8.Jowar stalk binders.

All dimensions in mm.

District: Panchmahals.
Taluka: Limkheda.
Village: Jamandra

MANGALORE TILES ON TIMBER POSTS

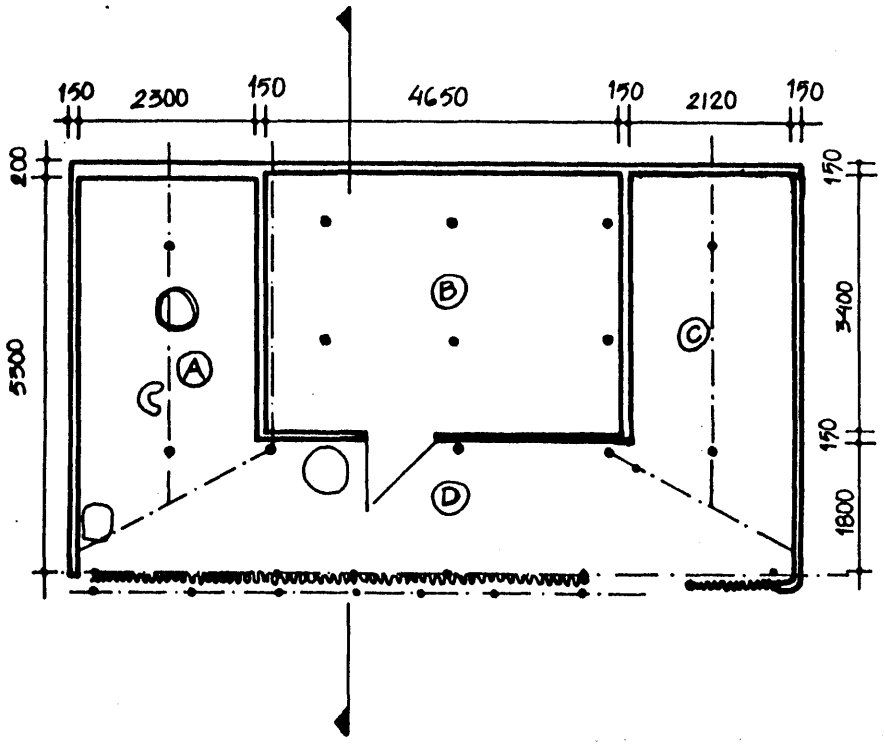


Perspective sketch

1. Wall: 300- 400 tk. non-load bearing cob wall.
2. Posts: 150 dia. timber.
3. Rafters: 100 dia. timber @ 1200 c/c.
4. Purlins: 30 dia. bamboo @ 300 c/c.
5. Battens: 30 dia. half bamboo @ 300 c/c.
6. Cladding: 400 x 240 Mangalore tiles.

All dimensions in mm.

MANGALORE TILES ON TIMBER POSTS



Plan

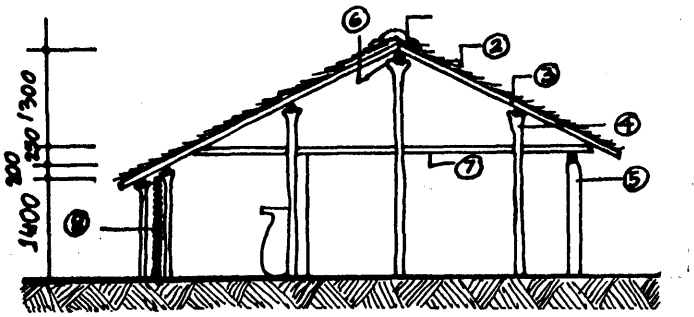
A.Kitchen.
B.Store.
C.Grain storage.
D.Verandah.

Total area: 48 sqm.
Covered area: 48 sqm

All dimensions in mm.

District: Panhmahals.
Taluka: Godhra.
Village: Sankali.

MANGALORE TILES ON TIMBER POSTS



Section

1. Mangalore tile ridge piece
2. 400 x 240 Mangalore tile.
3. 100 dia. timber rafter.
4. 100 dia. timber post.
5. 230 tk. mud wall.
6. 150 dia. timber ridge.
7. 150 dia. timber tie beam.
8. Wattle and daub wall.

All dimensions in mm.

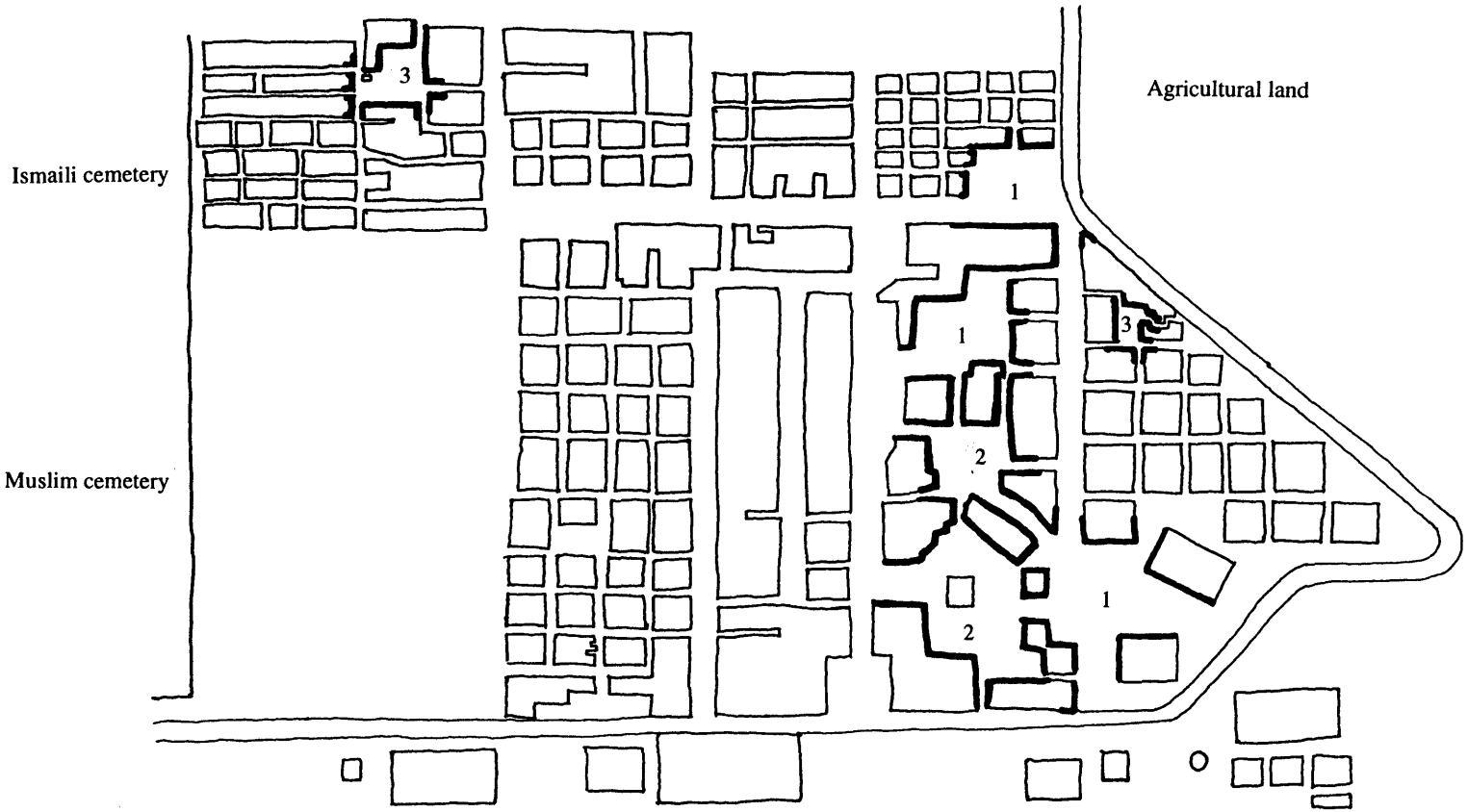
SECTION II: PROPOSAL

Chapter 5
Design Criteria

PUBLIC SPACES

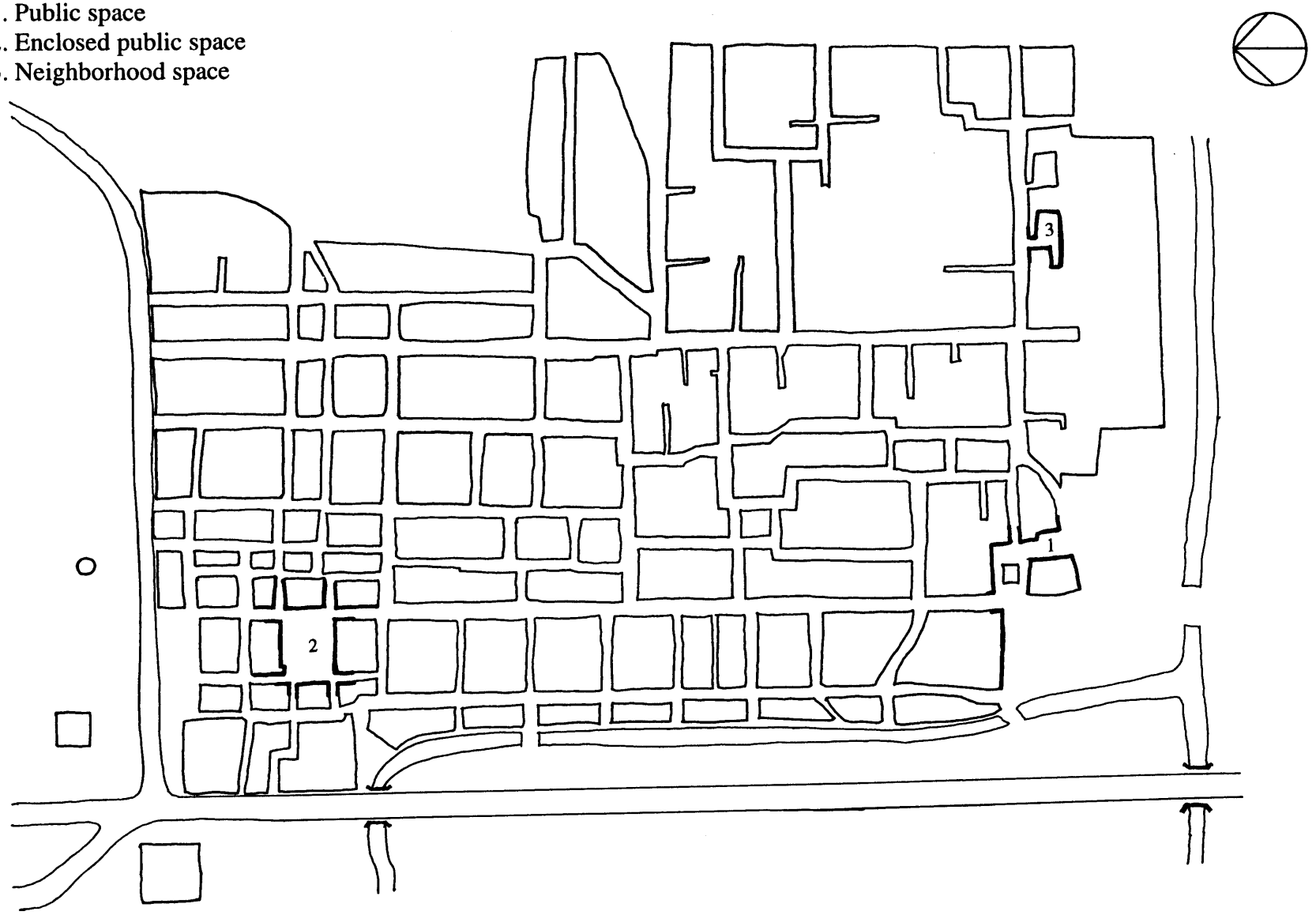
Village Chitravad

1. Public space
2. Enclosed public space
3. Neighborhood space



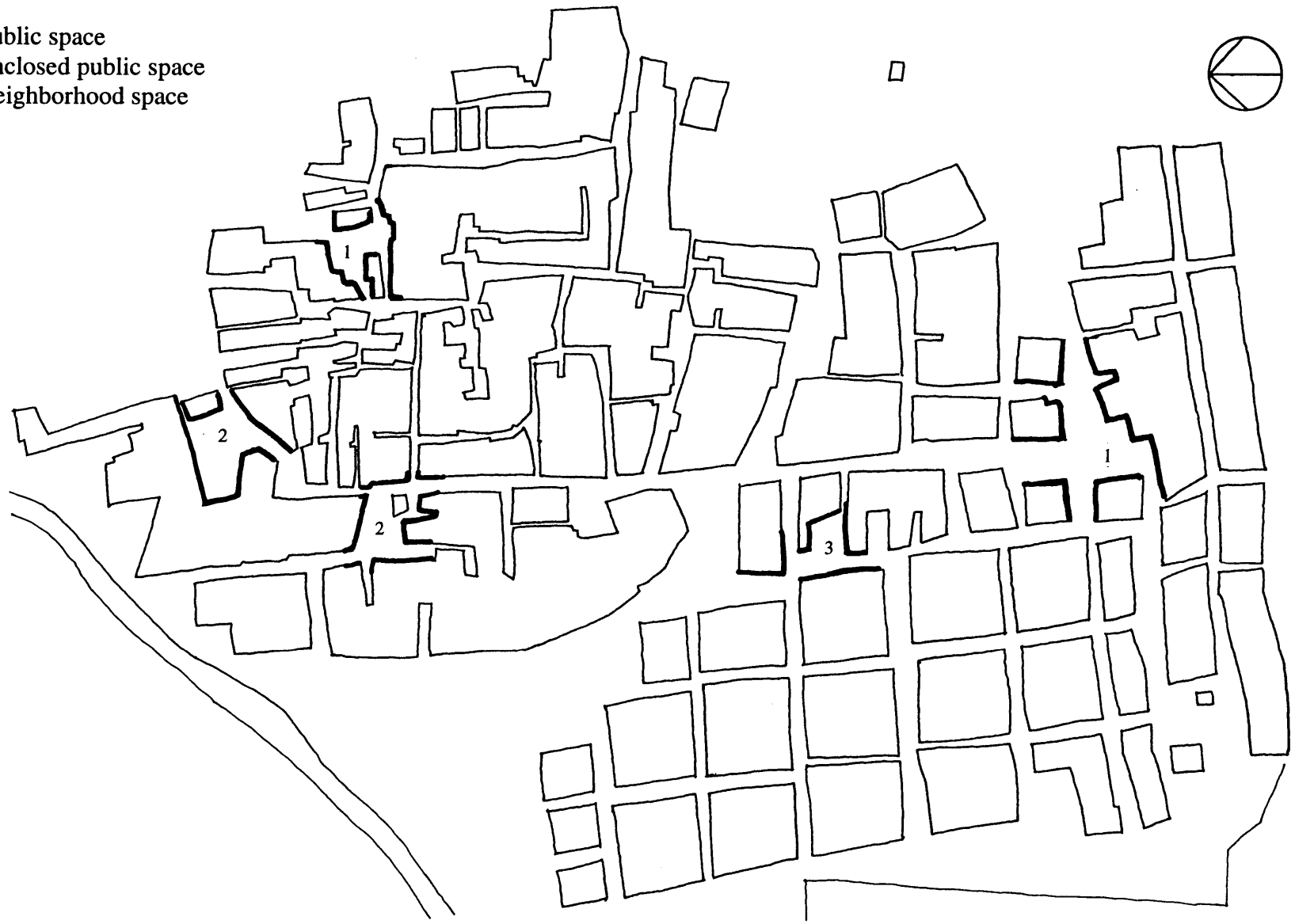
Village Amrapur

1. Public space
2. Enclosed public space
3. Neighborhood space



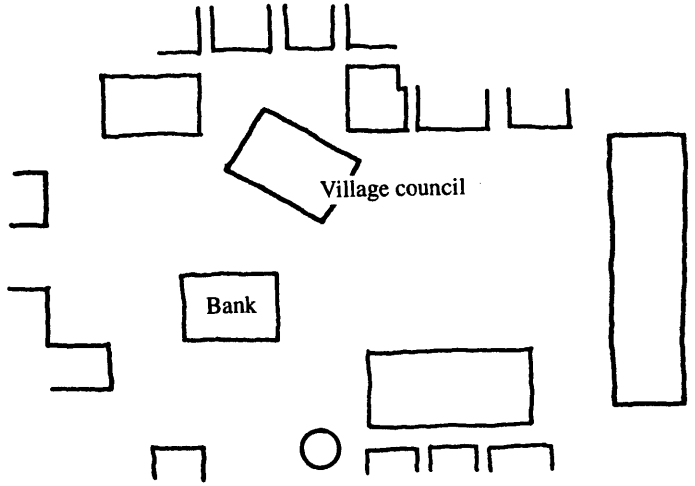
Village Lathodra

1. Public space
2. Enclosed public space
3. Neighborhood space

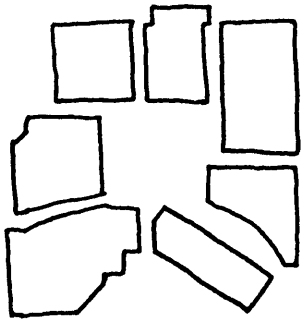


Hierarchy of Spaces

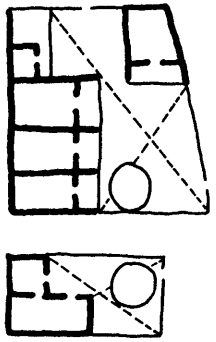
Public space- undefined



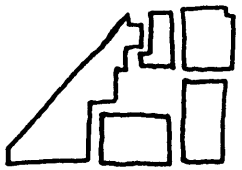
Enclosed public space



Courtyard space



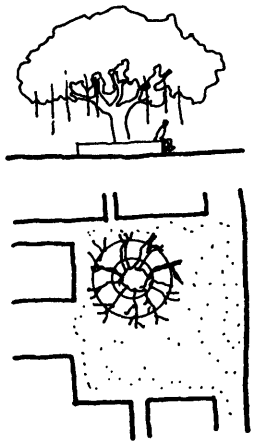
Neighborhood space



Elements

Platform

This effectively transforms the space by providing a place to sit and rest, specially if shaded. Provision of sitting space gives incentive to the people to relax and encourages informal meetings and activities.

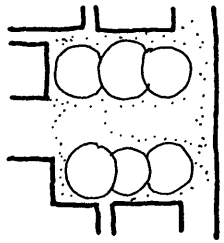


Verandah

This is the transitional space between interior and exterior. Informal activities within tend to spill over to this space. The fact that it has a direct link with the outside (street mostly) makes it an important space.

Trees

Trees are an effective element that can transform a space. The fact that they are the best and inexpensive source for shade, makes them the obvious choice for most public spaces.



Design Criteria for Public Space

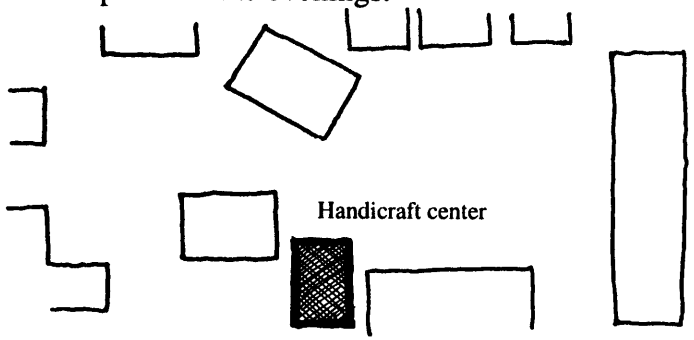
Location

All public spaces should be neutral i.e., non-religious, and should be designed for usage both for day and night. Ideally it should be located at a prime space e.g., close to existing markets or any other existing space with public activity.

Functions

In view of the current needs and circumstances in the villages, this space could be a recreation/ handicrafts center, which could be located within an existing space (schools, day care centres) or can be developed as a new center.

This could provide women with the opportunity for education and encouragement to work and take part in various activities (sewing, knitting, small scale industry, etc.) in the handicrafts center. Besides this indoor games and sports facilities can also be located here, along with a library/ reading room. The timings of these activities can be regulated for optimum use of the space e.g., women's center can work in the late morning or noon and the games can be opened in the evenings.



Maintenance

The village council could act as caretakers, supported by users.

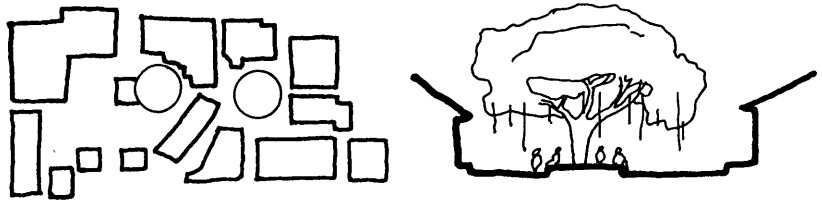
Design Criteria for Neighborhood Space

Location

This is normally located off the main street as a courtyard shared by a particular community, or people with same economic status.

Functions

Activities performed here are recreational, residential and religious. Planting trees, providing platforms and street furniture, can enrich the space and make it more usable.



Plan Section

Design Criteria for Courtyard Space

Location

Within houses or other buildings.

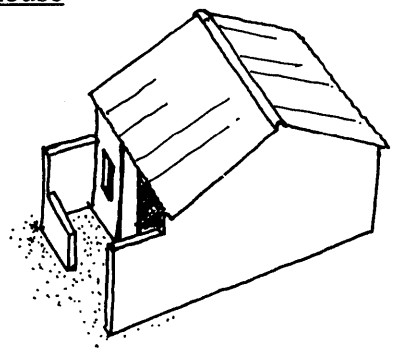
Functions

Extended living space used for a variety of functions varying from shelter for animals to drying clothes, food items. Informal activities tend to spill over to this space. Platforms can be introduced for multiple usage as sitting, as counter top or storage.

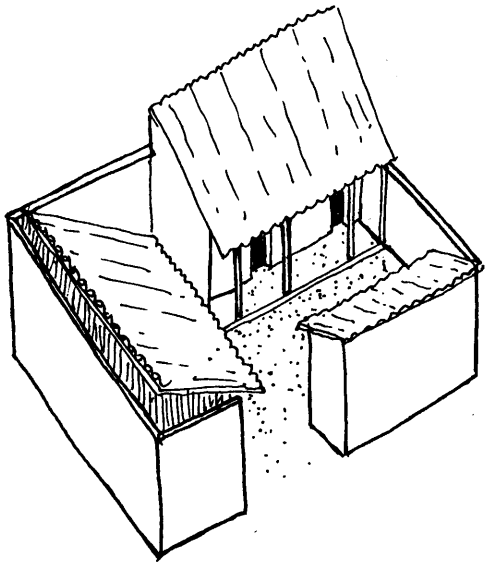
SPACE ORGANIZATION

Design criteria for house organization should address issues of light, ventilation, expansion and thermal comfort. Other issues of sanitation & hygiene are related to location of toilet and animals.

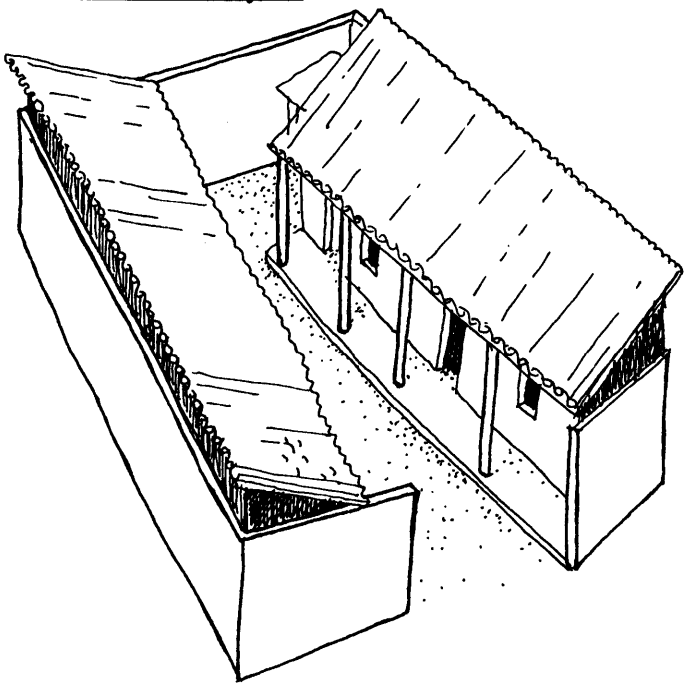
Single family house



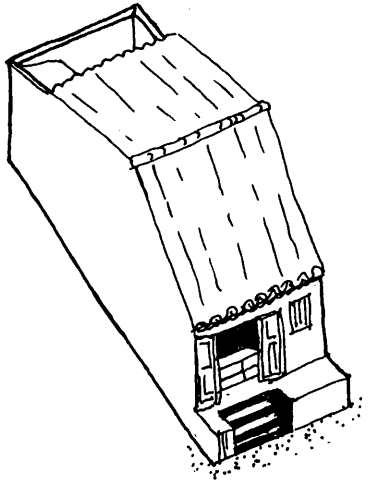
Two family house



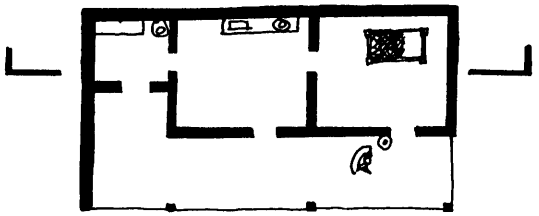
Houses with shared courtyard



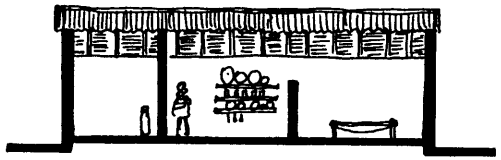
Shop-front house



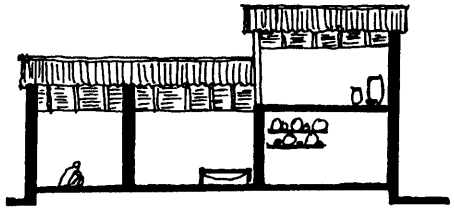
Single Family House



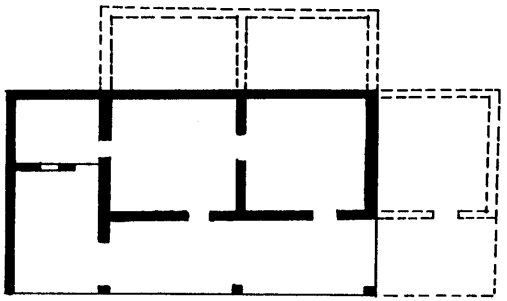
Plan



Section

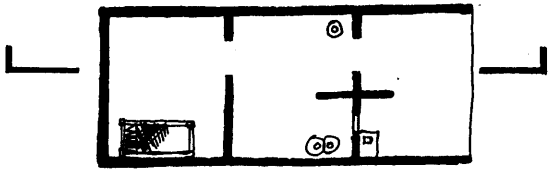


Section: possible vertical expansion

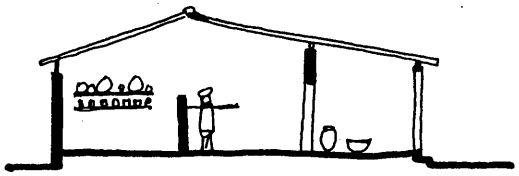


Variations in plan showing possible expansion

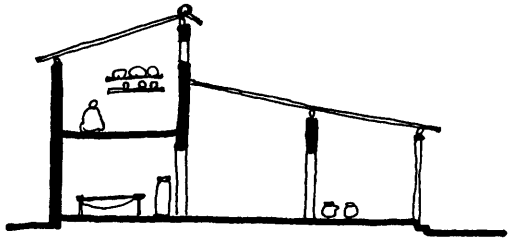
Single Family House- Elongated Plan



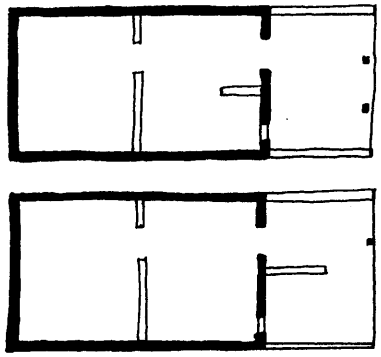
Plan



Section

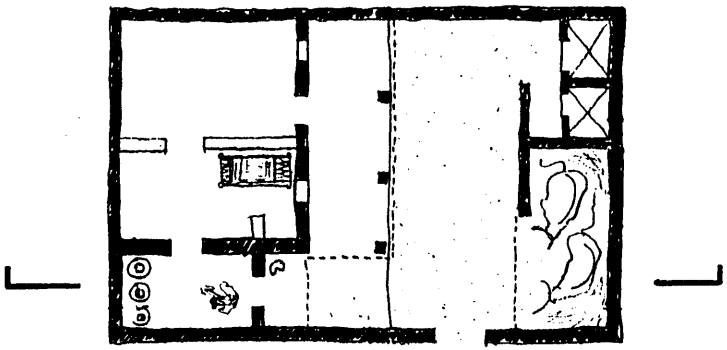


Section: possible vertical expansion

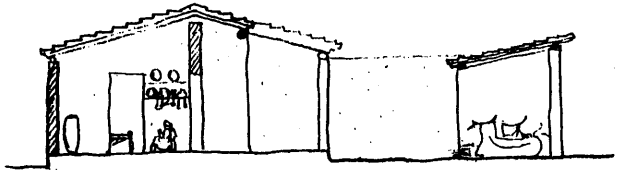


Variations in plan showing possible expansion

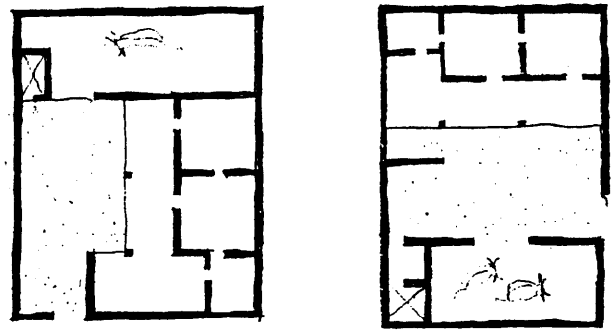
Single Family Courtyard House



Plan

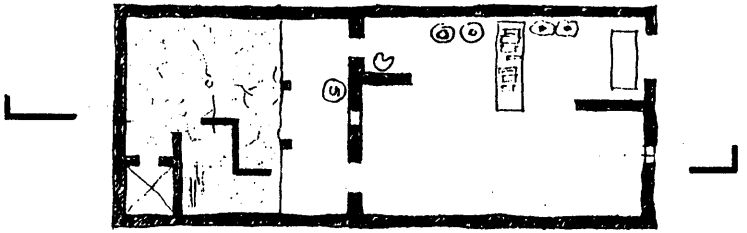


Section

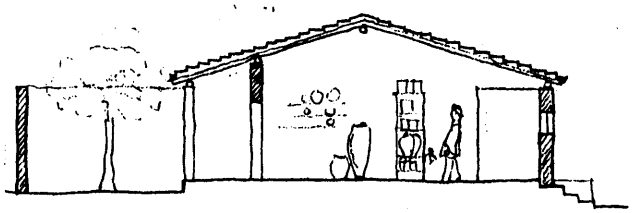


Variations in plan

House with Shop-front



Plan



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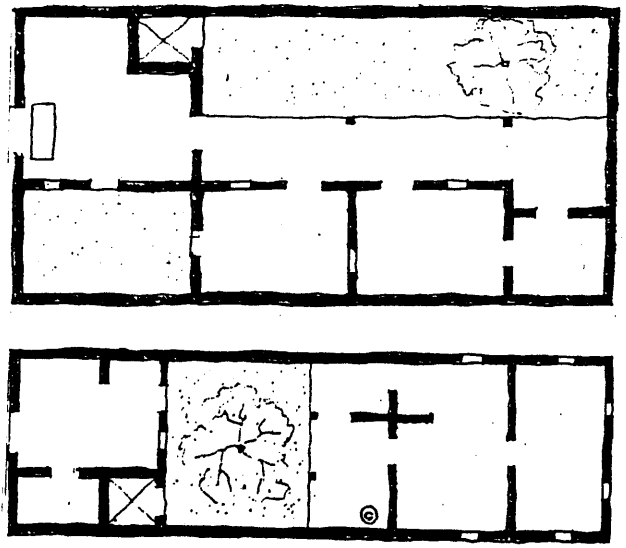
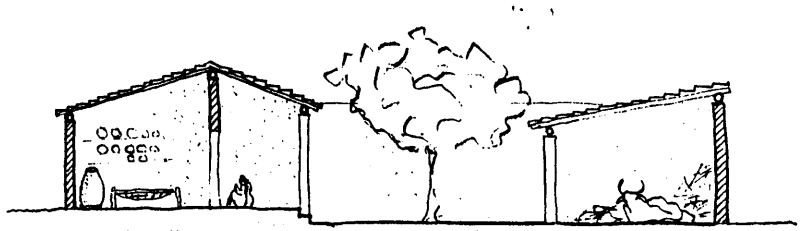


Variations in plan

Two Family House



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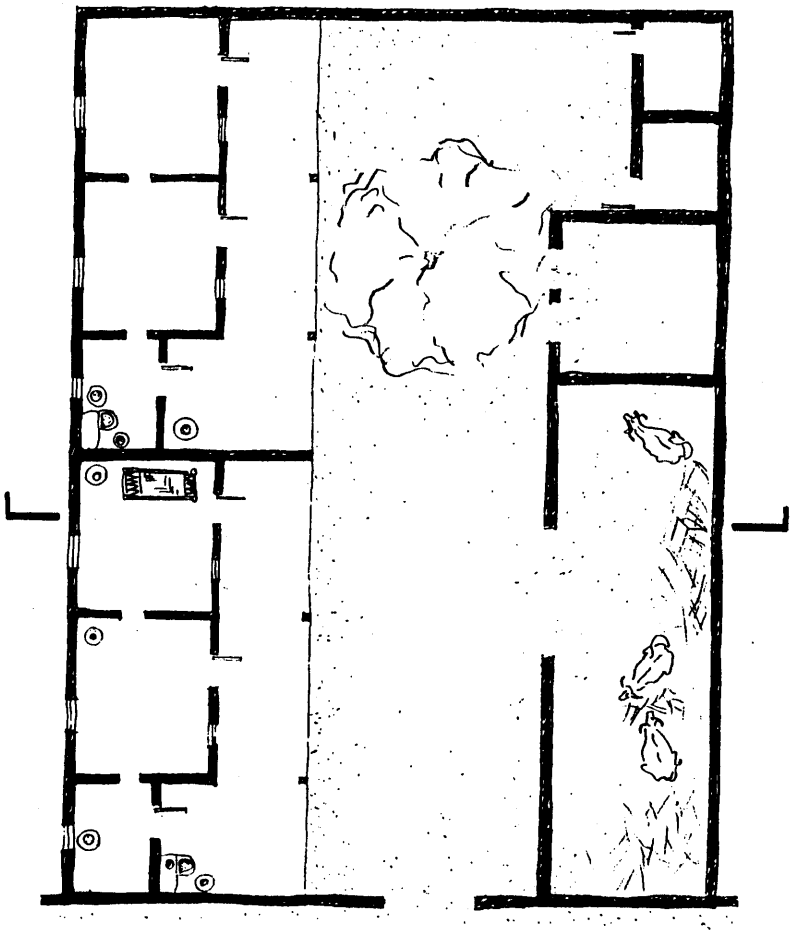

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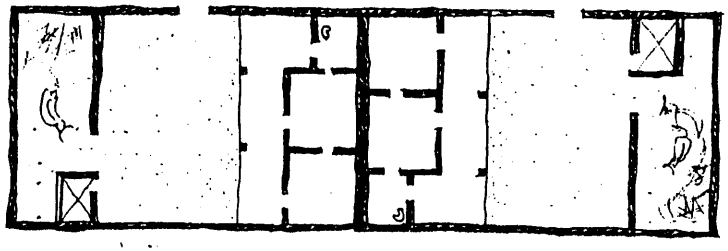
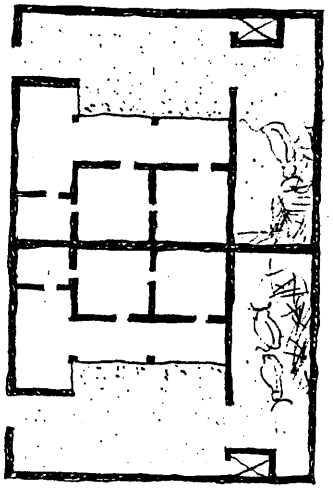
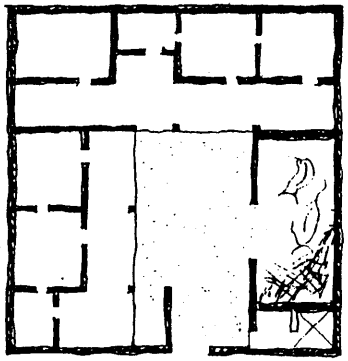
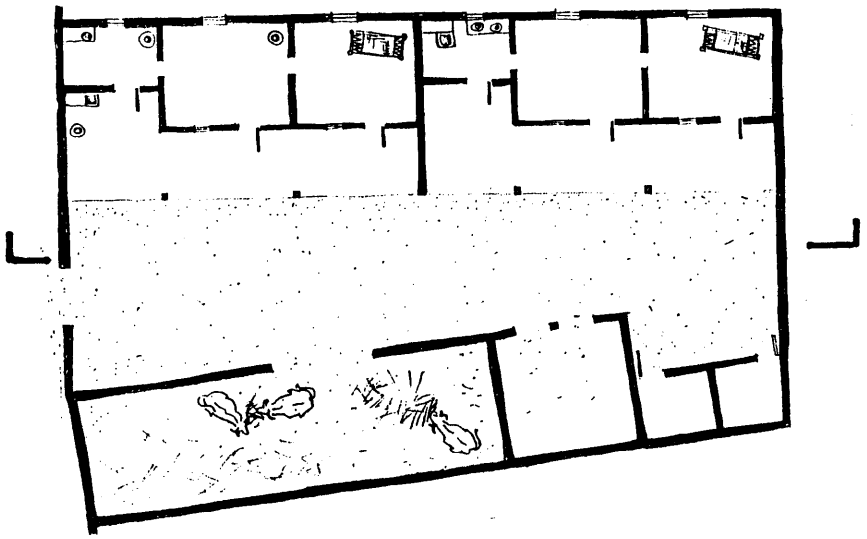






Variations in plan

Houses with Shared Courtyard



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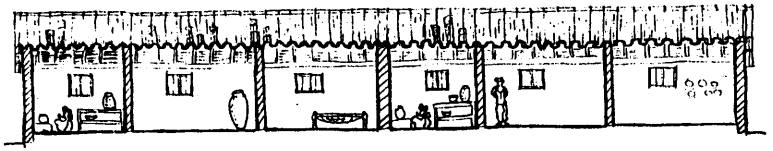

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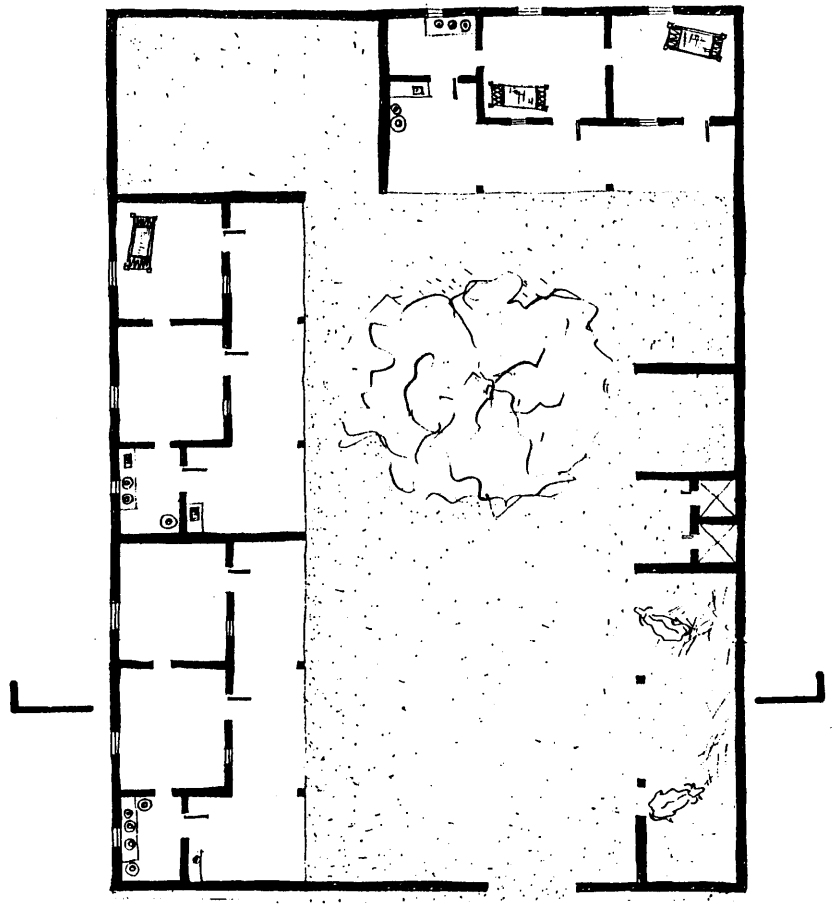

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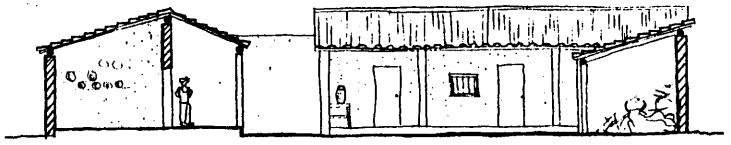
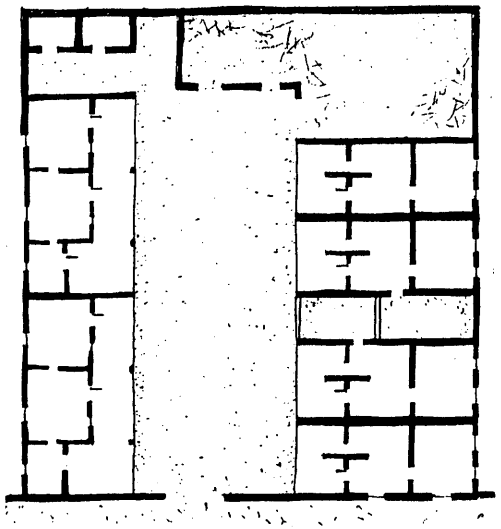
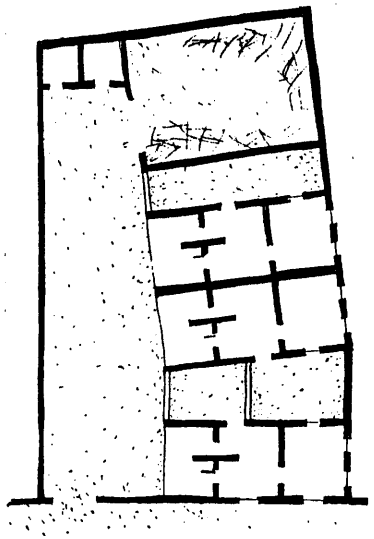
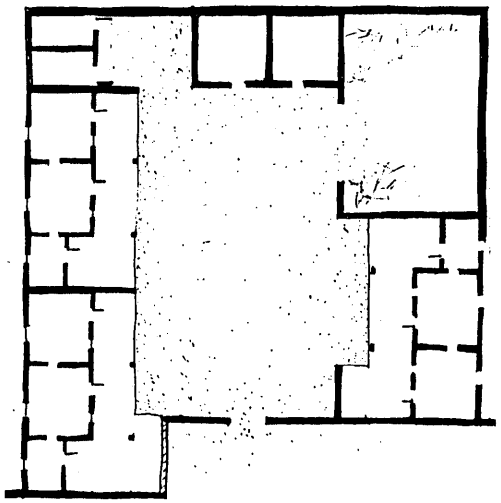


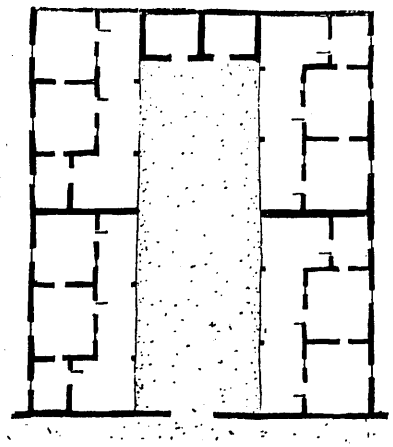
Section

House with shared courtyard- variations in plan









Sanitation and Drainage

Most of the villages have a lack of proper drainage and sewerage. Where there *are* drains, they are open, causing serious health and hygiene problems.

Due to a lack of education and awareness, the villagers do not consider proper sanitation as a priority, since it does not affect them directly.

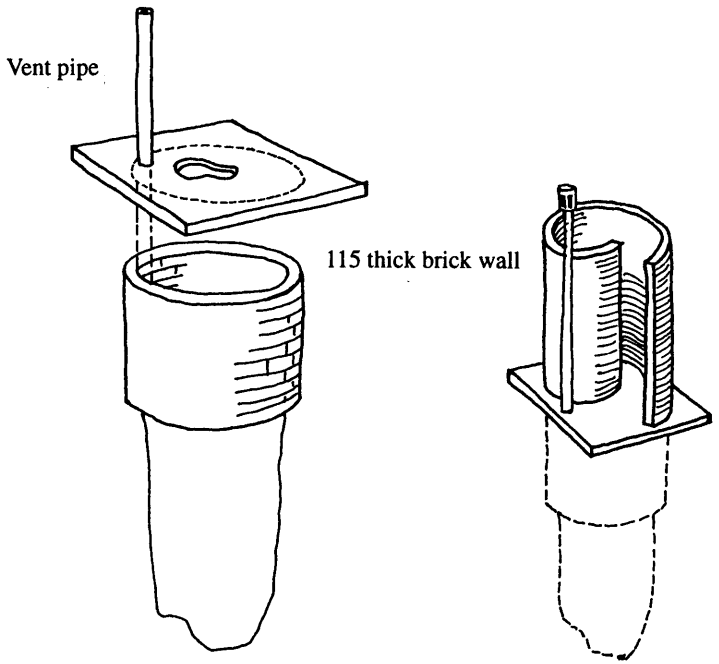
One way of dealing with the situation, till such time as an adequate drainage system is laid out, is to have individual or group soak pits. The soak pits will take care of the drain water and enable water recycling, there by giving relief to villages with water shortage.

Similarly sewage can also be collected in pits located under the latrines within the house. This can be further used for producing bio-gas and the waste can be used as manure for agricultural land.

Latrines and other wet areas should be grouped for the convenience of maintenance, servicing and establishing infrastructure. This would also reduce the cost price considerably.

The deep pit latrine is effective in all but rocky sites. The pit is about 3 feet in diameter and as deep as possible (minimum 15 meters).

A reinforced concrete filler slab with a latrine pan set in to it, and a hole for the vent pipe, is placed above the hole or pit. If soil is sandy or loose, the top 2- 3 feet is lined with 115 thick brick wall. A screen wall and vent pipe are built above the latrine slab.



KITCHEN ORGANIZATION

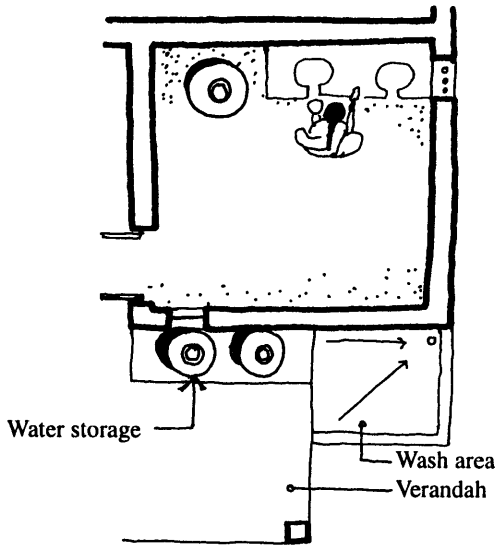
The kitchen, in Indian social and family life holds the center stage around which all the other functions are performed. Cooking, by itself, is a small part of the whole process. Typically the preparation is done in a social atmosphere, mostly outside the kitchen in verandah or the courtyard. Storage of water and grains is also an external affair due to lack of proper light and ventilation within the kitchen. The model that exists in these villages suggests that the cooking area therefore is a small room, mostly used by only one person at a time.

These observations were done as a part of the Gujrat workshop (MIT spring '96) the goal here is to improve the light and ventilation in the kitchen and to reorganize them for maximum space utilization. This study documents the shortcomings and suggests design criterias for better layouts of more efficient kitchens.

Activities

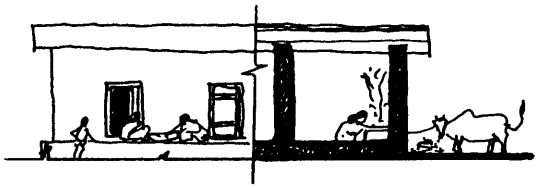
Preparation

The process is social as it involves women working together and talking to each other as they cut, chop and prepare food. This is outside the kitchen, most of the time.



Cooking

This remains the main activity which involves just one person (women of the house, mostly) since it is the main function, all other facilities, like grain and water storage must be related directly to it.



Section

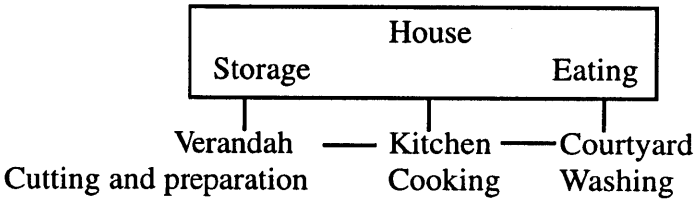
Storage

Adequate space is needed to store grains, spices, water and even vegetables at times. While cookware stays in the kitchen crockery and Plates are kept elsewhere, mostly as prized possessions.

Washing

Dish washing is done mostly outside in the courtyard. Water shortage leads to drainage problems.

Space usage in preparation



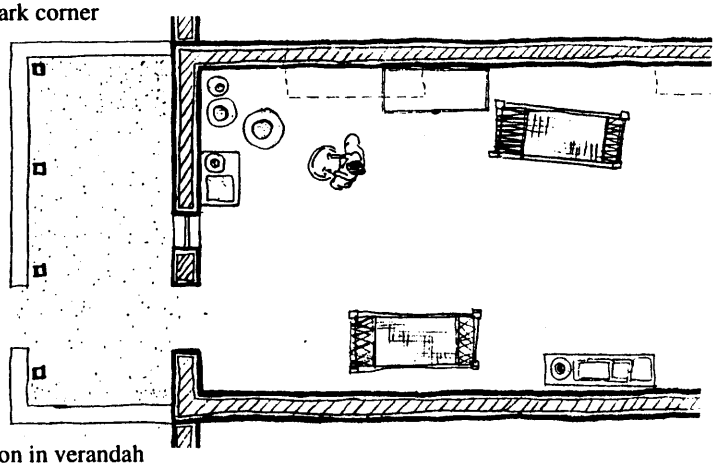
Existing Examples

One room house

In order to maximize space utilization no partition walls are made and the cooking area is placed in a corner closest to the opening for light and ventilation and preferably towards the front. This allows the verandah in front to be used as the spill over space for preparation and washing.

The obvious problem with this layout is the lack of privacy and problems of smoke and odor within the house, which are exacerbated at times with the absence of proper light and ventilation.

Cooking in a dark corner

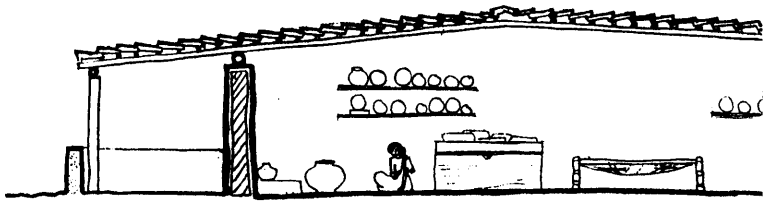


Small opening

Food preparation in verandah

No ventilation from the roof

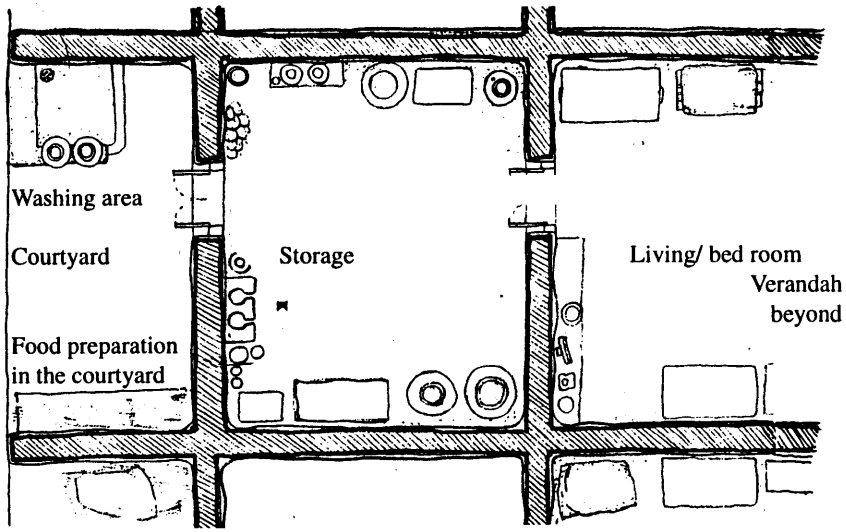
Utensils on display



Kitchen/ storage room separated from the house

The house is divided into two rooms, i.e., the living/ bed area and the storage area which has cooking area in one corner. Cooking is also done outside at times.There is a verandah in front and a rear courtyard also in several houses.

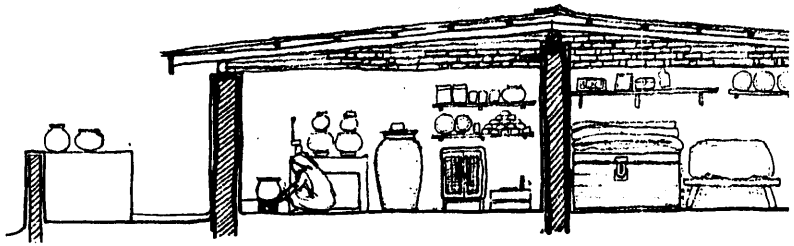
The problem of light and ventilation exists with insufficient openings in several cases.



Convenient grain and water storage

No ventilation from the roof

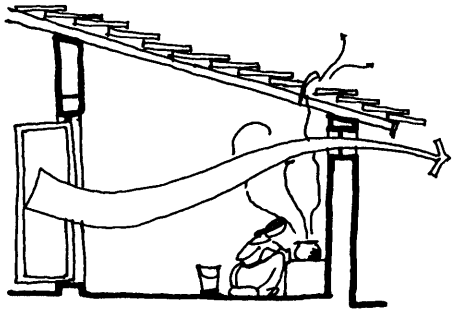
Utensils on display



Ventilation

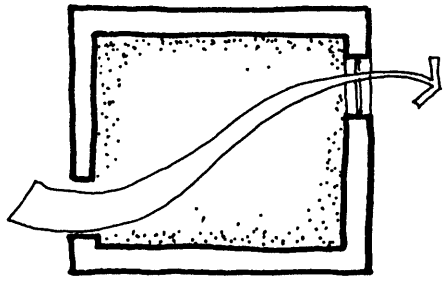
Both light and ventilation are discussed later in greater detail. Kitchen exhaust remains a major issue specially in houses that use firewood or coal for cooking. The smokeless stove is an effective solution but it needs to be advertised more and should be easily available.

Organizing windows to create draft for cross ventilation and exhaust the smoke can help, but requires flexibility in terms of placement of openings. Placing openings closer to the roof will help in ventilation by reducing smoke build up. When affordable, an exhaust fan for mechanical ventilation can be very effective, however this should not be the primary method for exhaust.



Ventilation band for cross ventilation

Section



Openings placed across to create draft

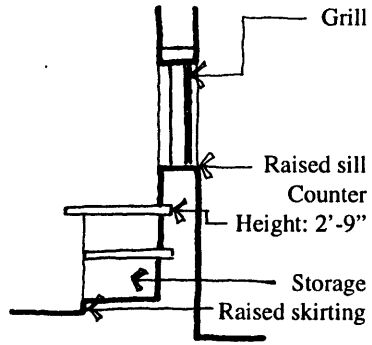
Plan

Cooking

Most of the cooking is done on the floor using firewood/ coal in earthen stoves or kerosene/ gas stoves. Since squatting and cooking has been followed through the ages it will be difficult to convince people to start cooking on raised platforms.

Squatting leads to all kinds of medical problems such as arthritis and back problems. Educating people to use kitchen counters will help, at the same time the use of counters is likely to be an aspiration for the younger generation. So, the layout should be made flexible with the possibility of cooking on the counter as well as squatting. The counter can be made of pre-cast concrete slab or Ferrocement. Ferrocement counter is a better option as it can be cleaned easily, is lightweight and more economical.

Problem of bad posture



Drainage

Kitchens should be located next to a court or a verandah which can be sloped easily for drainage to the street. Adequate drainage must be planned to avoid the problem of standing water. Kitchen gardens can be planned so that the water drains to the advantage of plants.

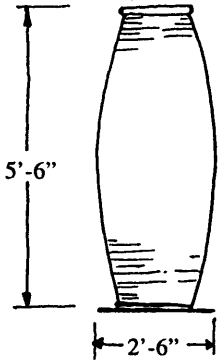
Storage

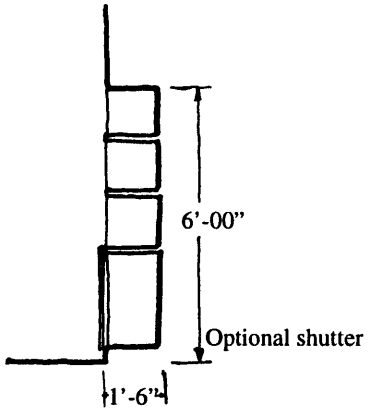
Water and grains are the essential things that need to be stored in large quantities. Water is scarce and has to be carried over large distances at times. Large earthen pots are used for storage which are kept in the vicinity of the kitchen for drinking, cooking and washing.

Grains, too, need to be stored and protected from rats and insects. They are typically stored in large urns within the house, close to the kitchen.

Other things that need storage are spices which are stored in small jars, mostly within the kitchen. Cooking utensils remain in the kitchen either on shelves or on the ground.

Crockery and plates are kept within the house, mostly as a display of family status.

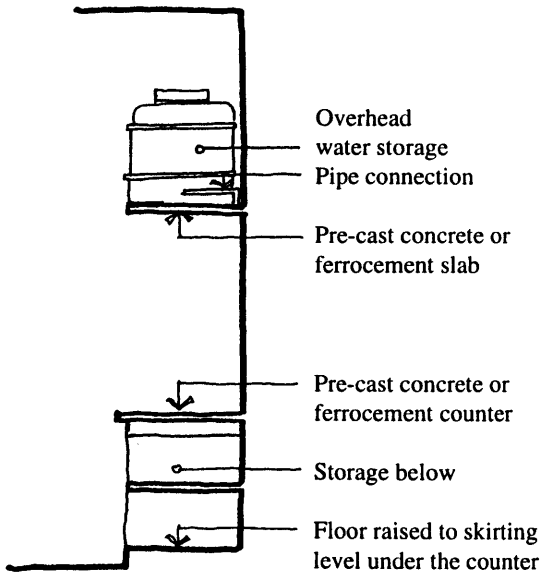




Design options

Water can be stored in overhead tanks which can be of Fiber glass or can be pre-cast in ferrocement. Placing the tanks overhead will create the necessary water pressure for good water supply over longer distances. This can be located within the kitchen or just outside in verandah or the court. Water can be supplied through G.I. pipes.

Storage space can be increased by providing niches within the walls and also by making shelves using pre-cast concrete or ferrocement slabs. Additional space can be generated in kitchens with counters, as the space below the counter can be utilized.



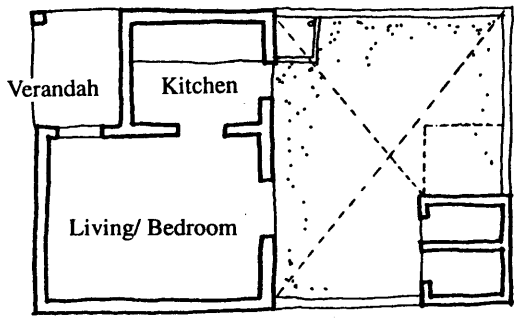
Maintenance

The cooking activities performed in the kitchen demand high maintenance. The surfaces i.e., walls and floor need to be wiped and cleaned regularly. Presence of grease makes this difficult.

So, a surface that does not corrode easily and can be wiped clean is desirable. Walls can have ceramic tiles if the client can afford it. The plastered wall can be simply white washed too, as it is cheap and can be redone easily at very little cost. Another possibility is to make the wall surface next to cooking area with ferrocement or IPC. These can be cleaned easily and are not very expensive.

Floor should be laid to slope for proper drainage. Ideally, verandah and kitchen should be a level higher to the court. IPC floor is inexpensive, aesthetically pleasing and is easy to maintain. The floor surface can also be used on the wall where cooking is done for easy maintenance.

Plan



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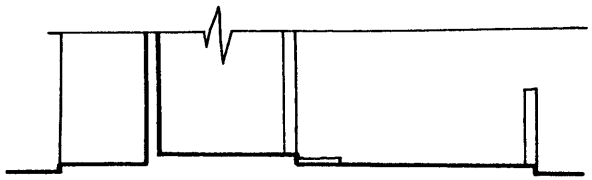
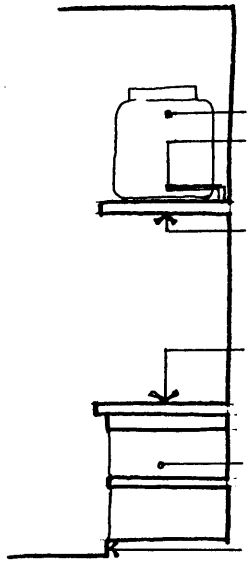
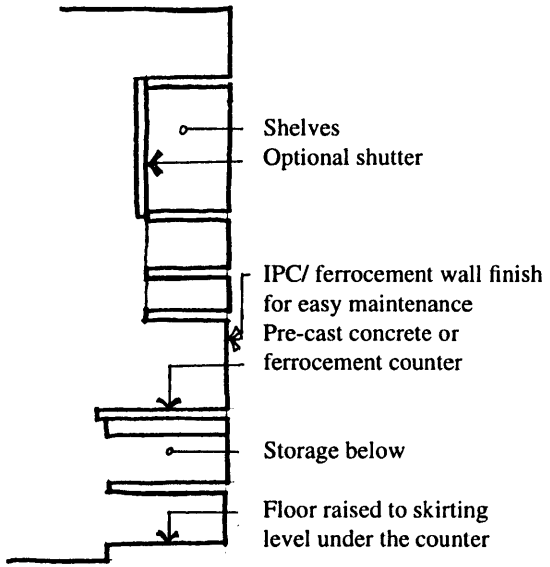


Level of kitchen higher than the court

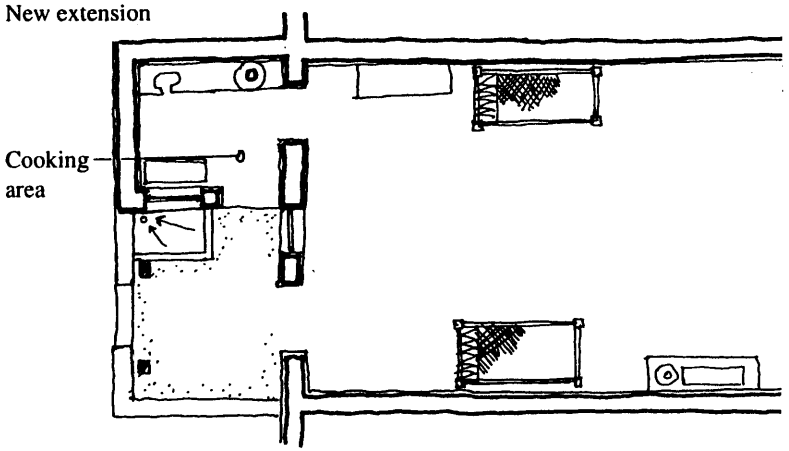




Design Solutions to Existing Problems

One room house

A small kitchen can be added just outside the room in one part of the courtyard. This can be directly connected from within, or accessed only from exterior. This will isolate smoke and odor from the rest of the house, will provide privacy, and create more storage space. Light and ventilation can be provided by making adequate openings in walls and roof.



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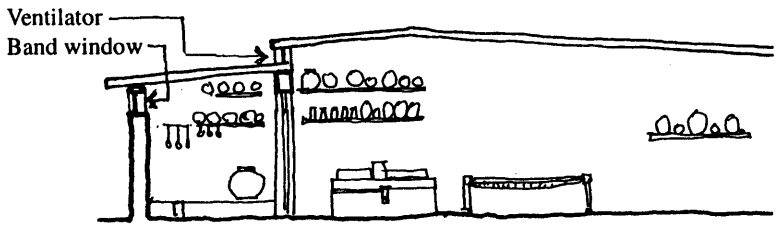
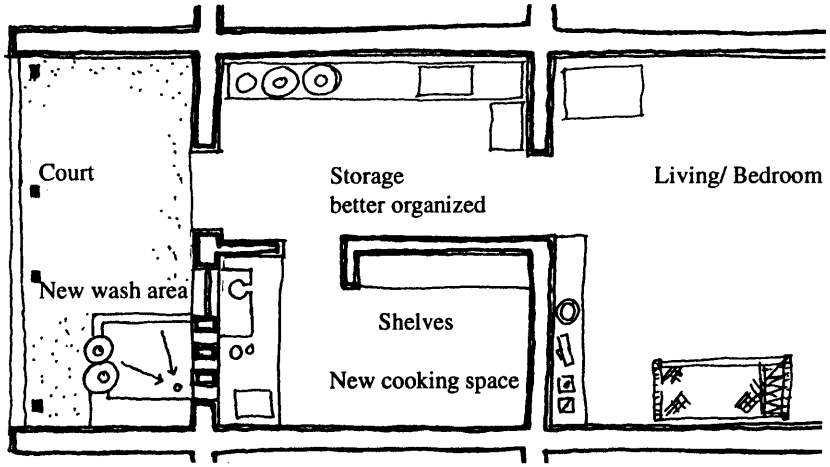


Section

Kitchen/ storage room separated from the house

The existing large storage space can be sub- divided to create a new cooking space. The new wall can be equipped with niches and shelves for storage. Wall should go up to the ceiling to isolate the kitchen from the rest of the house. This would prevent smoke and odors from entering into the living areas. A new window and the ventilation band will improve the lighting and ventilation considerably.

Storage space reduced but better organized



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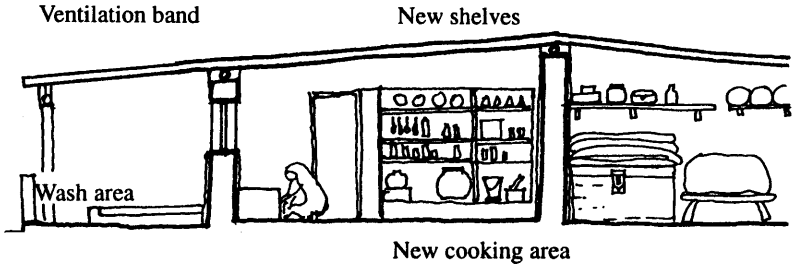


Section

Proposed Design for New Kitchens

The observations made in all the villages lead to the design of a kitchen unit which has to be supported by a verandah and a court for ideal cooking conditions. Further the kitchen may, or may not be directly connected to the house for retrieving supplies and serving food. A groove is provided in the wall for insertion of a slab, if required for a counter top. The space below the counter can be used effectively for storage.

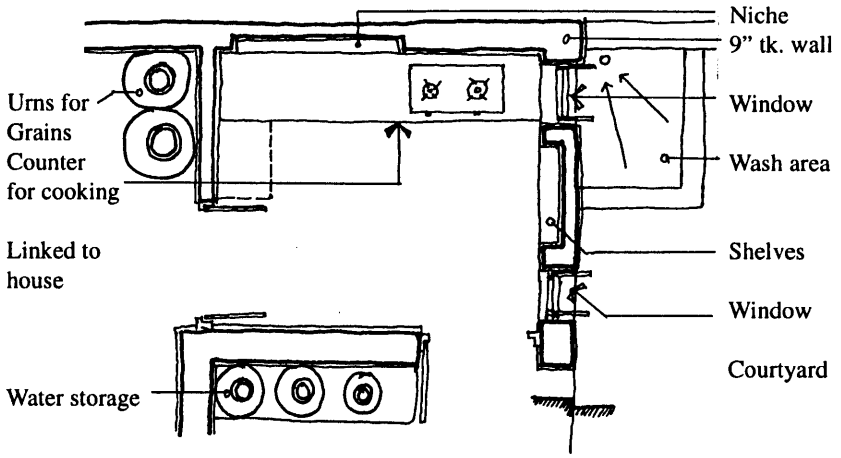
Other improvements include storage of water in a raised tank and the provision of an optional cooking slab. The storage can be better organized in shelves and niches. water can be supplied directly through pipe connections from the tank. An optional dishwashing space can be provided in the courtyard, which can also be used for washing clothes.

Lighting and ventilation are major considerations. The provision of a ventilating band along with the window can provide the required light and ventilation. This ventilating band will remove the smoke and provide better diffused light.

Wall finish in front of the cooking area can be done with IPC or ferrocement for easy cleaning. The floors can also be done in IPC.

Kitchen can share the verandah and the courtyard for spillover activities such as cutting and drying food items.

Layout plan



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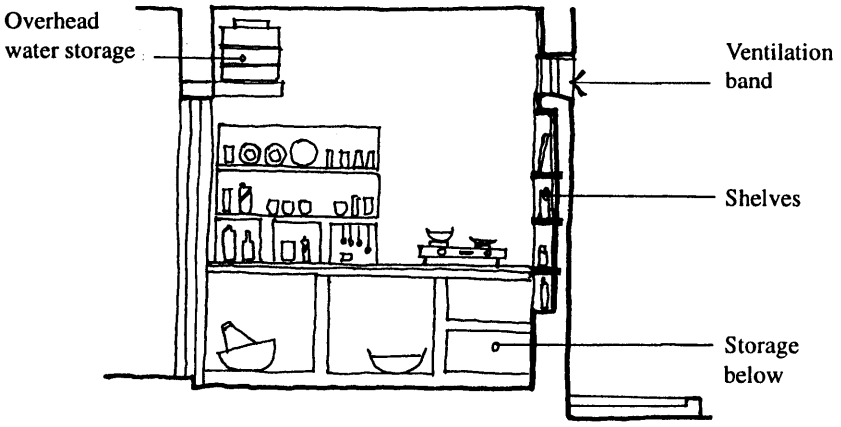


HOUSE EXTENSIONS

There are various reasons for the extension and modification of existing structures from faulty construction, to increase in family size. These are addressed with varying degrees of success depending on the means available.

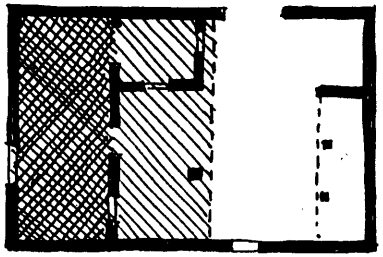
The traditional social structure often dictates a joint family system. It is common that at least for a few years after marriage, sons continue to live in the parents house. As the family is extended, more room is needed, and this is a common reason for the extension of the house.

Five case studies show possible solutions, and their spatial implications.It is necessary to go upwards, where length wise, or lateral extension is not possible. This introduces new technical issues.The sketches are diagrammatic representations of plan arrangements in:

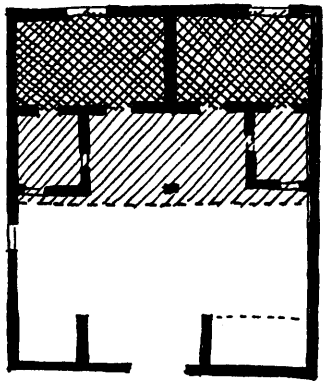
1) Typical Single family house

Private/ dark spaces

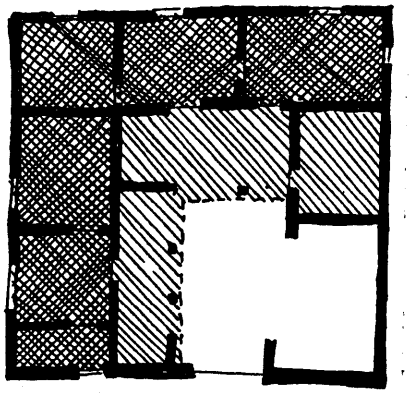
Public/ lighter space



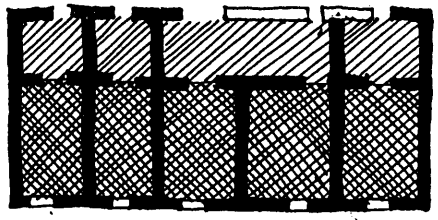
2) Typical two family compound



3) Typical multi-family house



4) Actual five family house



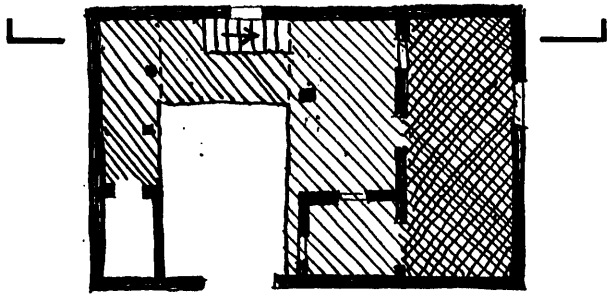
Many of the construction materials and techniques currently used in Gujrat are capable of accommodating additional loads introduced by a new second level. Finished stone and concrete block walls, precast concrete beams, and even wood frame roofs, are in current use. It is necessary to integrate this technology and material with new applications of similar fabrication, transportation, and assemblage processes.

The new processes should aim to expand the formal capacities of precast technology and its ability to reduce construction time, effort, and material.

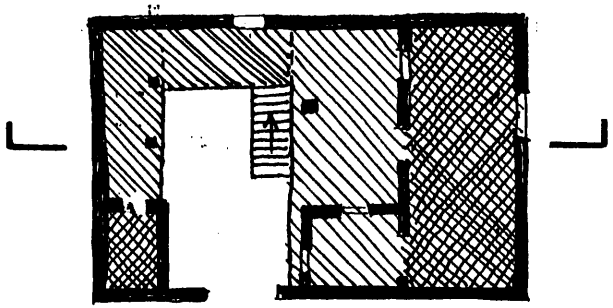
Single Family House

Second floor plan- stairs located in different positions.

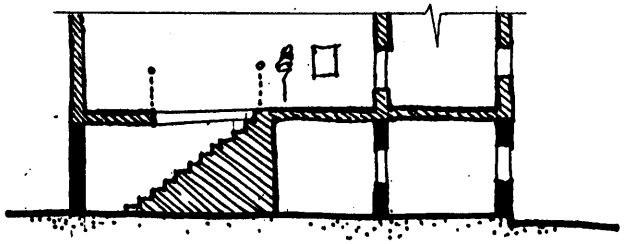
A. Against the boundary wall for support and maximum utilization of the courtyard.

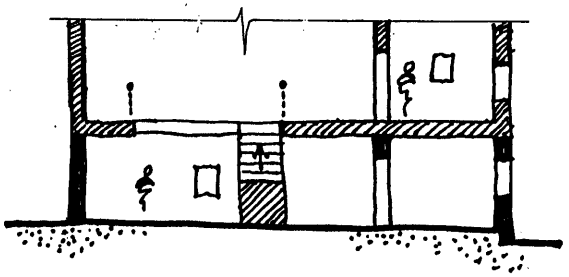


B. In the direction of movement, provides privacy to verandah.



Sections- Stairs land in the connection between verandah space and toilets.

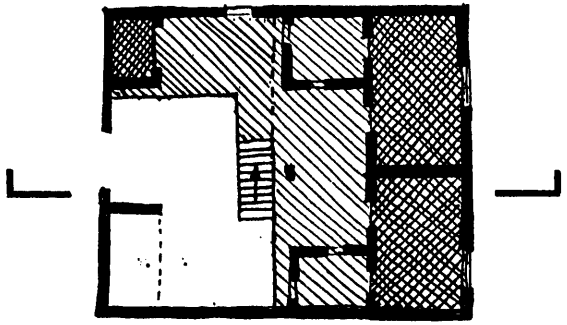




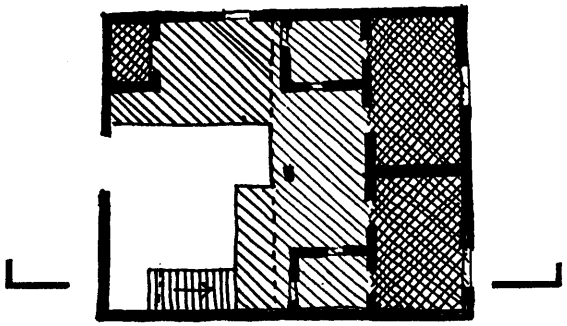
Two Family House

Second Floor Plan- Stairs located in different positions.

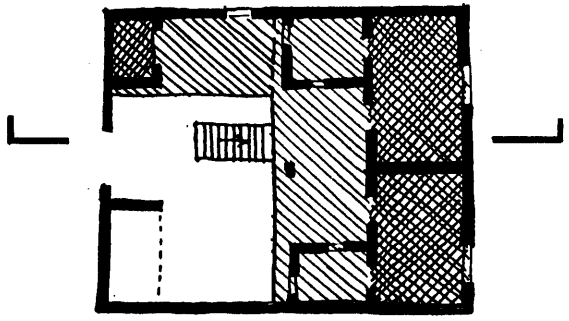
A. Adjacent to the verandah space for additional privacy.



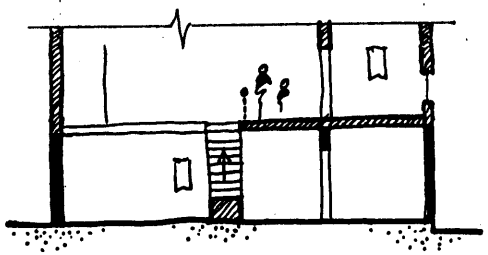
B In the direction of movement, against the boundary wall for support and court size.

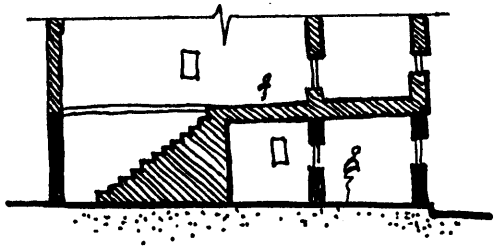


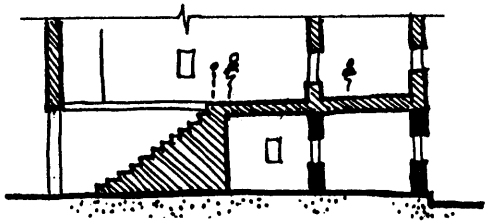
C. Stair positioned in the direction of movement into the court, towards the center.



Sections- Stairs land in the connection between Verandah space and toilets. Verandah is partially shaded.





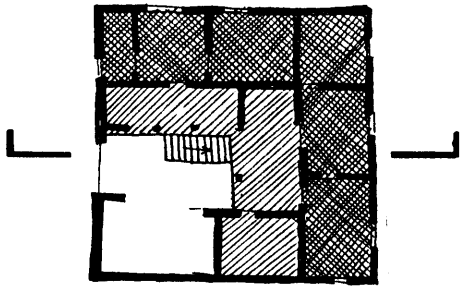


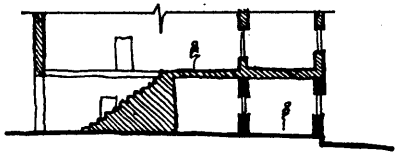
Multi- Family House

Sections- Possibility of using space under the stairs.

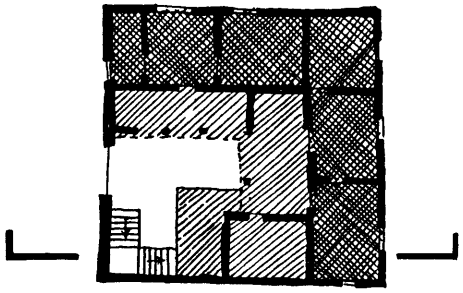
Second Floor Plan- Stairs located in different positions.

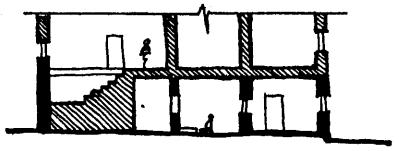
A.Stair positioned in the direction of the movement into the court for privacy.



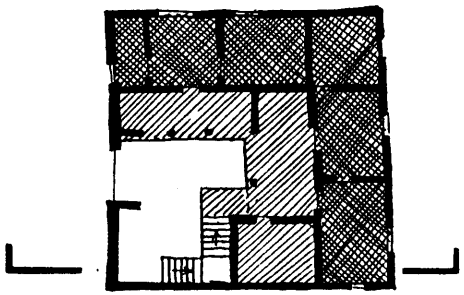


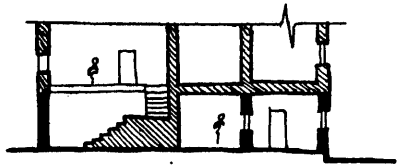
B.Dog- legged, positioned next to boundary wall, for support and better court dim.





C.Dog- legged stair to maximize the court area.

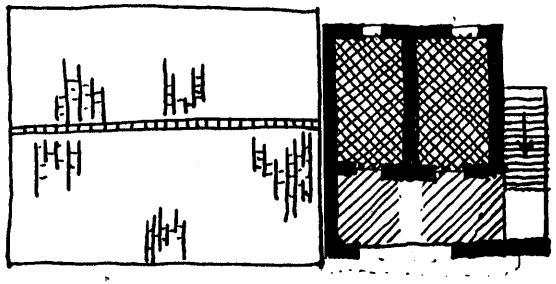




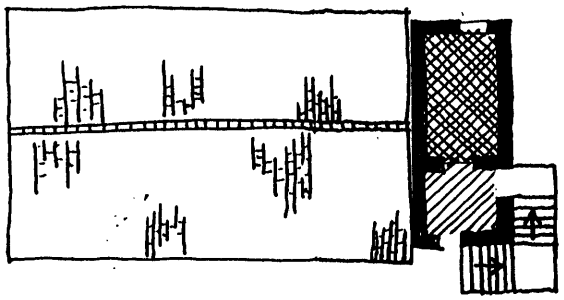
Five Family House

Second Floor Plan- Stairs located in different positions.

A.Only two rooms are extended and stairs positioned in the direction of the movement.

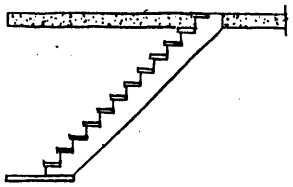


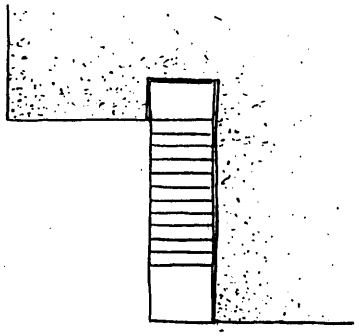
B.Only one room is extended, dog- legged stair is positioned adjacent to the entry.



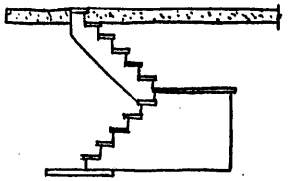
Staircase Variations

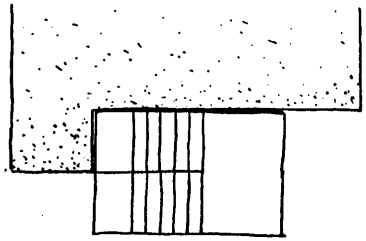
Type A



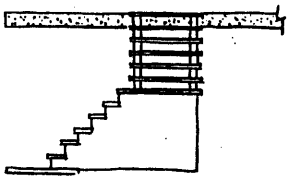


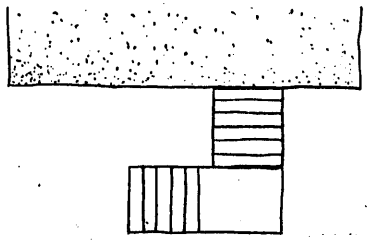
Type B



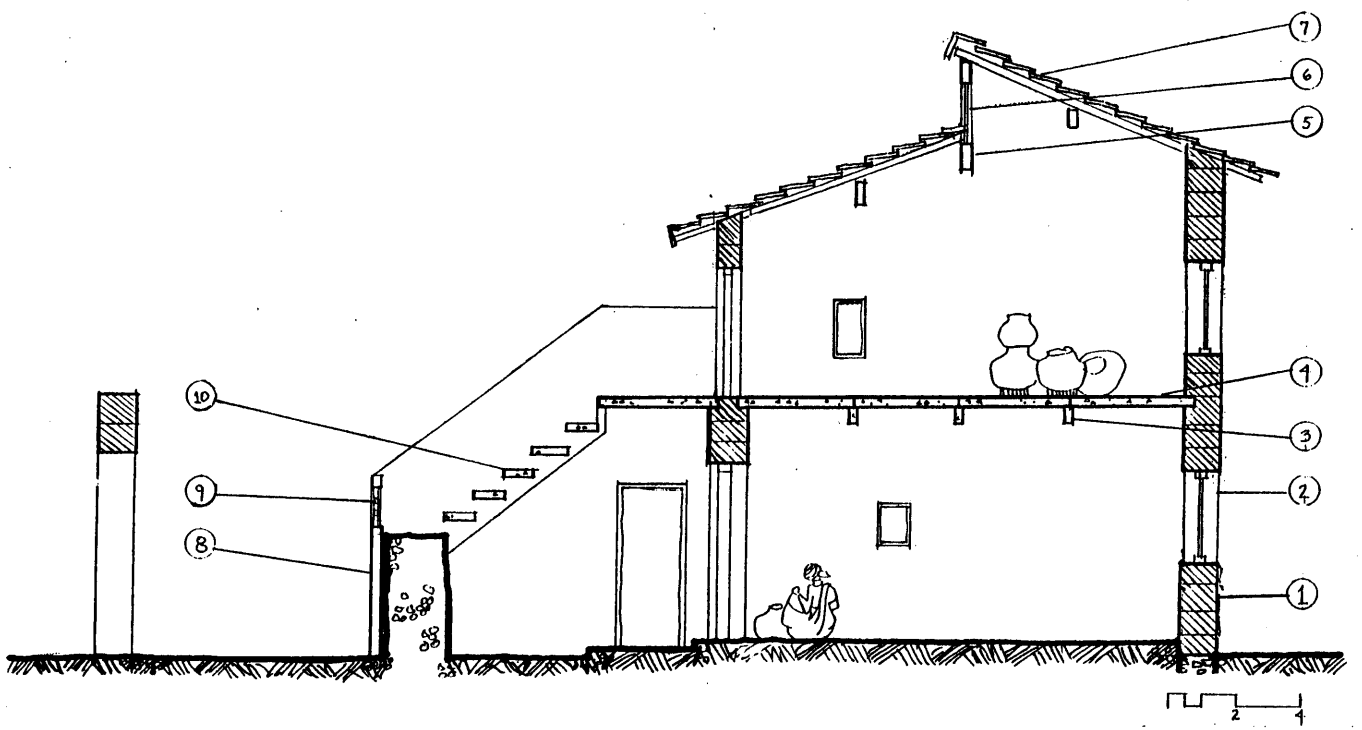


Type C





PROPOSED DESIGN FOR HOUSE EXTENSION



1. Finished stone provides stable base for extension of the wall.
2. Window.
3. Precast concrete beams.
4. Precast concrete/ ferrocement or dressed stone slabs.
5. Precast concrete/ ferrocement, timber or bamboo beam or purlins.
6. Clerestory opening for maximum light and ventilation.
7. Tiled roof.
8. Stairs: precast concrete or ferrocement members on a load bearing wall.
9. Precast railing member.
10. Stairs: precast concrete or ferrocement treads.

LIGHT AND VENTILATION

Most of the villages have a common problem of lack of proper light and ventilation on one hand and the need for protection against the harsh unrelenting sun, hot winds and dust on the other.

Present situation and problems

LIGHT	VENTILATION	BUGS
Poor light conditions in kitchens and living areas causes all kinds of eye problems as the rooms are not conducive to reading or working even in the daytime. The problem is slightly overcome by removing roof tiles or keeping doors open.	Insufficient ventilation due to lack of openings and sometimes because of improper arrangement of rooms. Kitchens are not properly ventilated which causes accumulattion of smoke. This results in cooking outdoors, in some cases roof tiles are removed for exhaust.	Flies and mosquitoes are a problem as a result of insufficient drainage and high levels of humidity inside the houses.

Possible Solutions

LIGHT	VENTILATION	BUGS
Light conditions can be improved by making openable skylights. More openings can be provided with some thought given to the sizes for privacy and better diffused light.	Mechanical ventilation is possible, though not the most energy efficient solution. Kitchen can have smokeless stoves and chimney. Windows can be located according to the wind direction.	Removable plastic mesh can be used along with grills for security. Level of humidity & light to be controlled.

Optimum lighting levels

Light conditions can be improved by making the openings that provide sufficient light according to the following table:

TYPE OF ACTIVITY	ILLUMINANCE RANGE (in lumens/ sqft)
Storage	5-10
Kitchen	50-100
Living/ Reading	100-200
Workspace/ Embroidery	200-300

Materials

Frames

Frames can be made in pre-cast concrete or ferrocement to reduce cost and conserve wood. Besides this the conventional materials such as wood, steel and aluminium can be used.

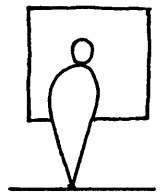
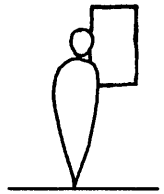
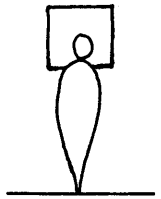
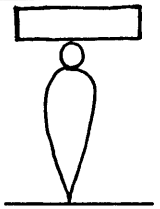
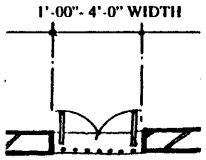
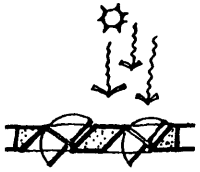
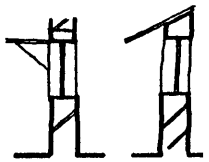
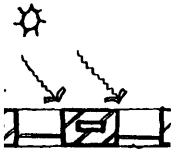
Shutters

The shutter cost can be reduced by using pre-cast ferrocement panels, with mesh or glass, wherever required. Besides this the conventional materials such as wood and steel can be used.

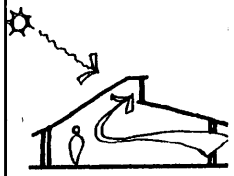
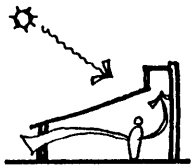
Mesh

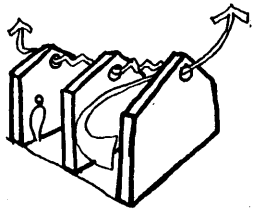
Steel, aluminium or plastic (removable).

Openings

NORTH	SOUTH	EAST	WEST
			
Larger openings	Slit windows		
			
Wider openings	Avoid direct sun	Overhangs	Cavity walls

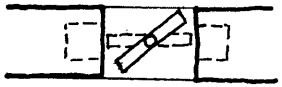
Ventilation

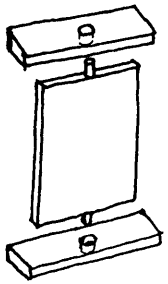
NORTH	SOUTH	EAST	WEST
			
Clerestory	Along the wall	With overhang	diffused light



Ventilating band running under eaves for diffused light and ventilation.

When a window is necessary but an expensive item, the simplest window consists of a vertical plank set in two holes or pivot hinges, at the top and the bottom. A 9" wide opening is sufficient for a window.



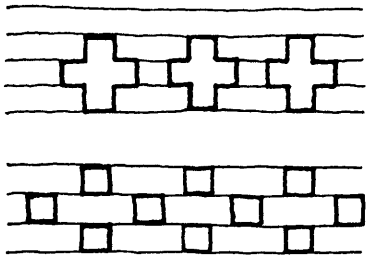


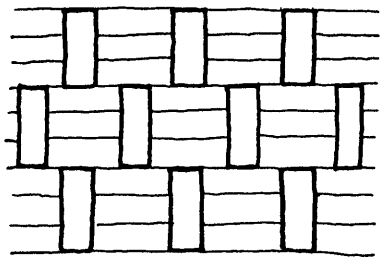
Chimneys

Smokeless stoves should be made available, but wherever cooking gas is available, openings proper openings are sufficient for ventilation.

Screens

Windows are costly and can cost upto 10 times the simple stone or brick wall that it replaces. A window has varied functions- to look out of, to let the light and fresh air in or to exhaust stale air. In most of the case the; "Jali" or the honeycomb wall, is as effective, and is less costly than the walls itself (in brick).
Some examples:





Chapter 6
Building Techniques

BUILDING TECHNIQUES

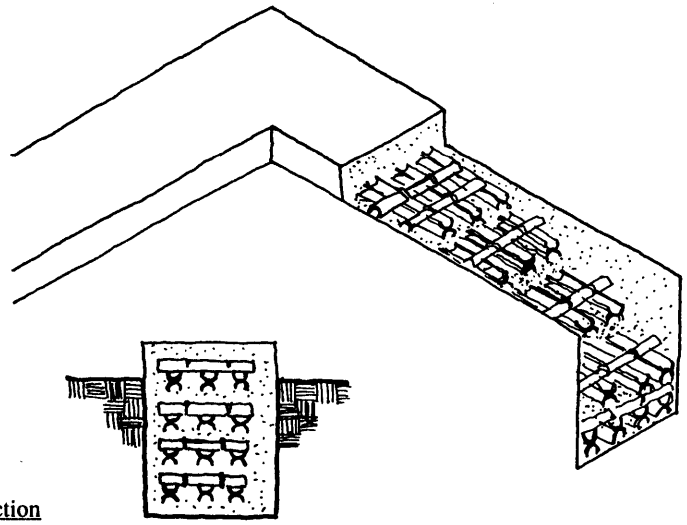
Foundations

For small single and double storeyed houses an 18" wide foundation is usually adequate on most soils and often there is no need for the wider concrete base beneath the basement wall.

If stone is available, the ordinary 18" thick wall is perfectly adequate to carry the load of a single storey or double storeyed house unless the soil is very poor or loose or of different consistencies.

If stone or bricks are unavailable, the soil can be excavated, the soil moistened with a little water and then replaced with layers of bamboo reinforcement inserted, as shown below.

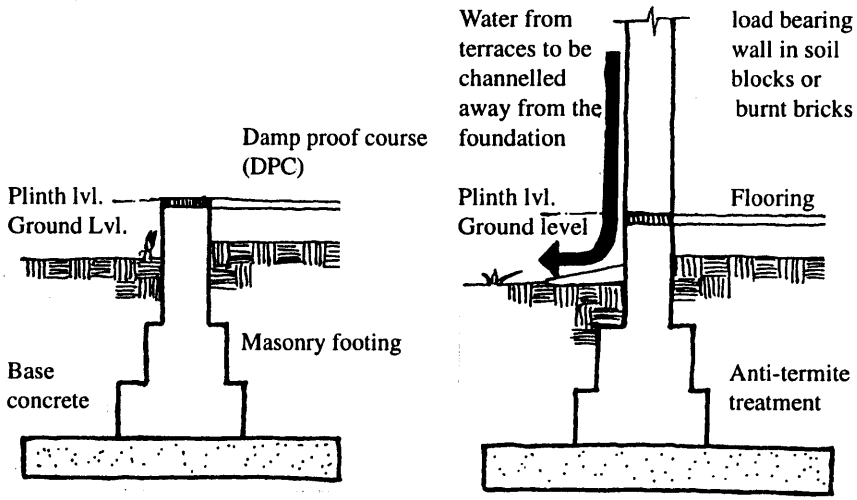
Reinforced Bamboo Foundation



Section

Burnt Brick Foundation

Components



Compatibility with other sub-systems

Sub- system

Continuous strip foundation in burnt brick masonry that runs under each load bearing wall. Masonry footings are laid over base concrete of cement or lime. A damp proof course is laid on top to protect the super structure from dampness rising from soil.

Appropriate for

Most singe and double storeyed buildings except on-
Black cotton soil
Soils with very low bearing capacity and on hard rock.

Improvements over traditional systems

Traditionally foundations of rammed earth and stone or bricks in mud or lime mortar had depths and widths often exceeding 1m due to thickness of walls they supported.

Comparison with other materials

Characteristics	Burnt Brick	Random Stone
Stability	Medium	High
Cost range (Rs./ m)	260- 320	240- 350
Unskilled labor (%)	14	18
Level of skill required	Medium	High
Resistance to water/ Moisture penetration	Medium	High
Resistance to Termites	Low	High
Stage of acceptance	Widely used	Widely used

Building Method

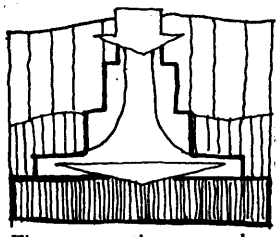
Materials required

For 1 running meter of foundation with lime concrete base 1:2:6 and footings of burnt brick Class II in lime surkhi mortar 1:4.

Material	Quantity	People (Mandays)	Tools
Lime	44 kg	Mason- 0.24	Masonry tools
Surkhi	0.38 cum.	Labor- 0.09	Water level
Brick bats		0.09 cum.	Ramming rod
Burnt bricks	140 nos.		

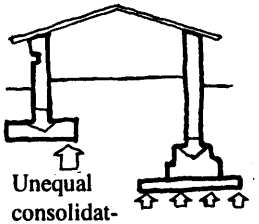
A foundation is required to

Distribute load of the building over a wide area

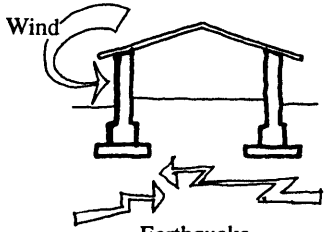


Firm supporting ground

Prevent differential settlement of the building



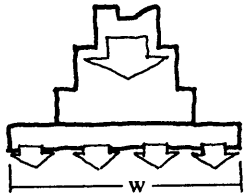
Anchor the building against lateral forces



Earthquake

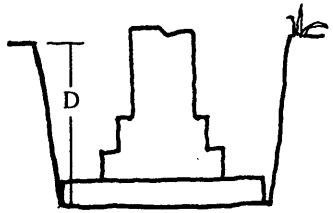
Its dimensions can be determined by

a) load



Higher load-Broader width

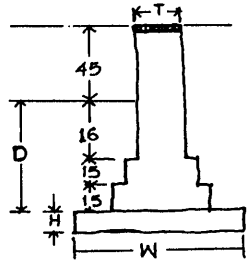
b) soil bearing capacity



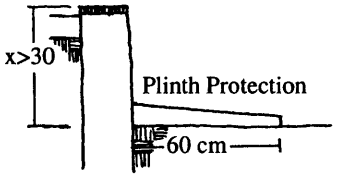
Higher soil bearing capacity- lower depth

For residential buildings upto 2 storeys on firm ground use these dimensions

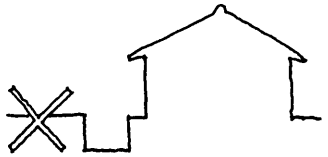
T= 23cms
W= 2T + 30 = 76 cms
H= 5/ 6T = 20 cms
D= 2T = 46 cms
The depth depends upon local conditions



DPC should be at least 30 cm above Ground level

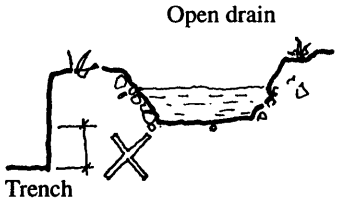


Do not dig next to an existing building



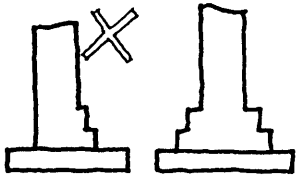
If unavoidable consult an expert

Do not dig a foundation below the level of an existing drain



Trench

Do not make an eccentric foundation without consulting an expert



WALLS

Walls can be constructed using various materials such as mud, bamboo, stone, brick and concrete blocks.

Compressed Soil Block Walls

Sub- System

Soil is compacted in manual press to form high strength blocks. Resistance to water is provided by stabilizing with cement or lime

Appropriate for

All areas where soil is available except black cotton soil, deserts and silty areas. Compressed soil blocks can be made where the soil composition is:

Clay	-	15 - 22%
Silt	-	15 - 25%
Sands	-	40 - 60%
Gravel	-	10 - 10%

Improvements over traditional systems

Compaction of soil increases its compressive strength and hence its capacity to carry load.

Stabilization with cement or lime increases resistance to erosion by water.

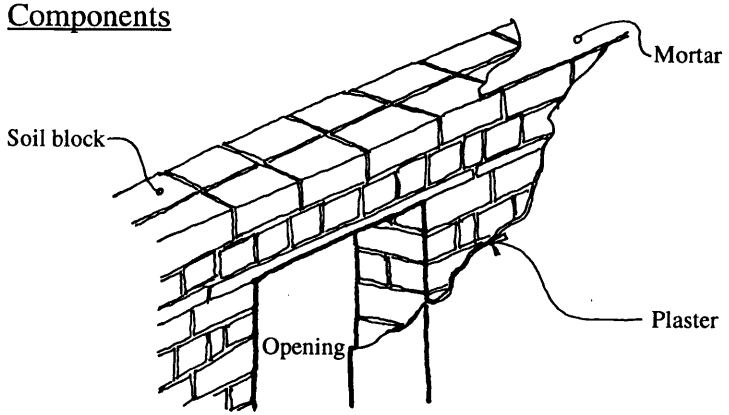
Soil blocks enable rapid construction.

Comparison of masonry costs

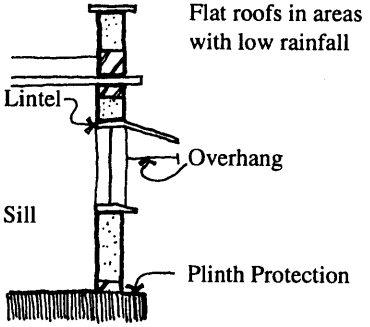
Stabilized block masonry is less expensive than burnt brick masonry using different mortars.

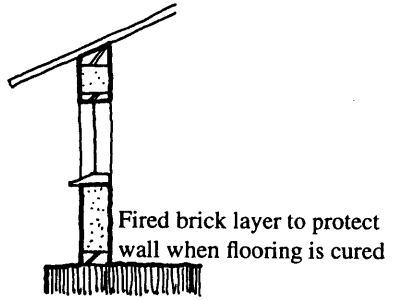
Cement stabilization beyond 6% is more expensive than burnt brick masonry.

Components



Compatibility with other sub- systems





Comparison with other materials

Characteristics	Soil Blocks	Burnt Brick	Random Stone
Compressive strength (kg/ sq.m)	25- 45	50- 70	80- 110
Slenderness ratio	16	18	15
No. of storeys (load bearing)	2	3	3
Cost range (Rs./ Cum)	400- 875	700- 900	650- 750
Unskilled labor (%)	44	11	16
Resist. to water without plaster	Low	Medium	High
with plaster	Medium	High	-
Transportability	Low	High	Medium
Stage of acceptance	Initial	Widely used	Widely used

Building Method

Materials required

For 10cum of 4% cement stabilized masonry with 6% stabilized mortar

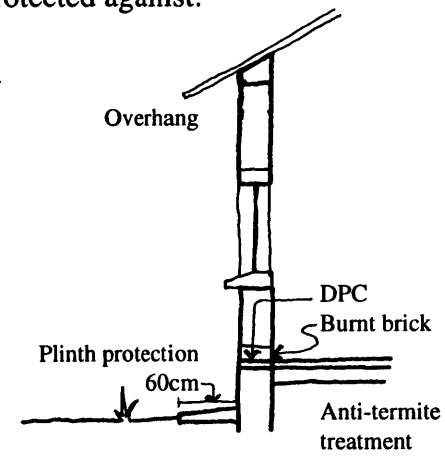
Material	Quantity	People (Mandays)	Tools
Soil Blocks Soil for mortar Cement for mortar	4400 nos. 2.85 cum 182 kg	Mason- 10.5 Labor- 21	Masonry Tools Scaffolding

Soil block walls have to be protected against:

a) Water by-
- adequate roof overhang
- proper roof drainage & water run off
- plinth protection
- plaster

b) Dampness by
- DPC
- Sill/ Coping
- Flooring

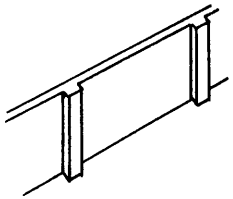
c) Termites by
- Chemical treatment
- Using sand in foundation

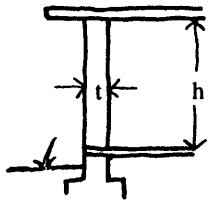


Use wall thickness of 23 cm up to two storeys of building

Do not make long walls without intermediate supporting piers

Slenderness ratio of wall (allowable) h/t < 16 for a 23 cm thick wall the height of each floor > 3.68 m





Clean DPC surface with a nylon brush and damp cloth. Blocks should be stacked near the plinth and should not be thrown.

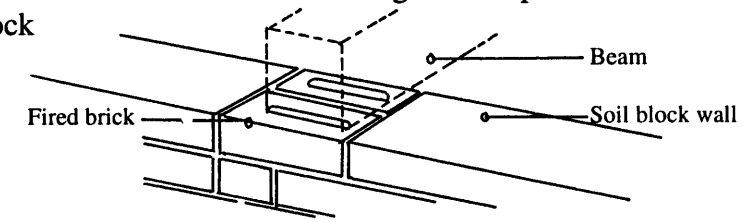
Mud mortar is to be used for construction, if the mud block is stabilized with x% of cement or lime stabilize mortar with 1.5x% cement or lime.

First two courses above DPC should be laid in fire bricks to protect the soil block wall when flooring and skirting is cured.

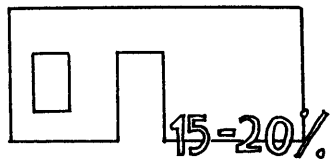
Ensure proper bonding of blocks for strength of the wall no vertical joints should be laid.

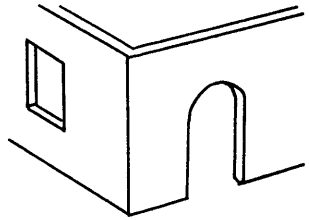
The soil block wall has to be cured for 7 days by lightly spraying water.

For concentrated load on wall e.g. beams provide fire brick bed block

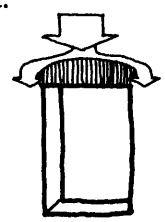


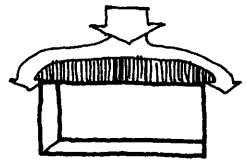
Area of the opening should not be greater than15- 20% of wall area, and the opening should be at least 60 cm away from the corner.



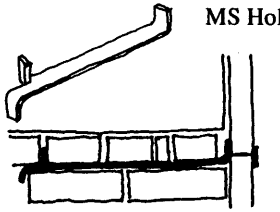


Vertical openings are stronger than horizontal opening of the same area.



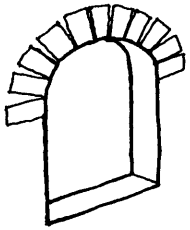


Door and window frames should be fixed as the wall comes up, avoid breaking later.

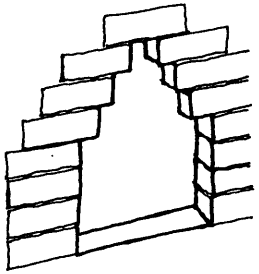


Openings can be of various types:

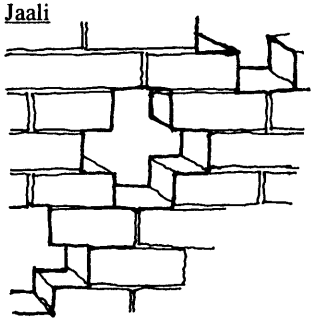
Arch



Corbel



Jaali



Use soil based plasters with cement, lime, bitumen or cow dung. Do not use sand plasters, they tend to separate from the walls.

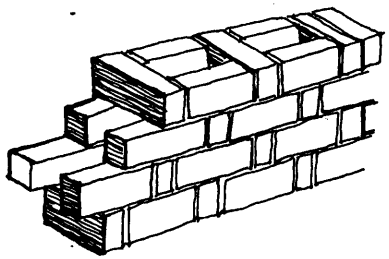
Comparison of masonry costs

At low degrees of stabilization upto 1%, choice between cement or lime have no significant effect on cost.

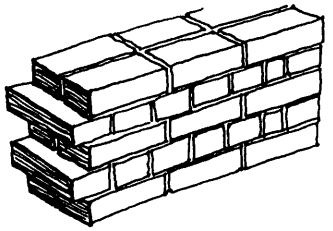
Beyond 6% Cement stabilization is uneconomical compared to using burnt bricks.

BURNT BRICK WALLS

If burnt bricks are available, and if 9" thick wall is required, 25% of the total number of bricks and of the cost of the wall can be saved by using a "Rat- Trap" bond. It is easy to build, is aesthetically pleasing, has better insulation properties and is as strong as the ordinary 9" thick walls.



Rat Trap bond



English bond

Structurally a 4.5" thick wall is often adequate for single storey structures and certainly for interior partition wall. An isolated 4.5" wall is weak but it can be made strong enough to carry the load of roofs if it has either thin buttresses every five or six feet or if recesses are created.

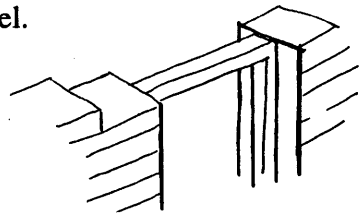
STONE WALLS

Sometimes stone is available but only in small irregular shaped lumps. These make poor walls that usually crack or crumble. Wood or metal moulds can be made of suitable sizes (e.g. 12"x 8"x 6") and these lumps are placed in moulds and the spaces filled in with weak lime or cement concrete. This produces neat rectangular blocks with which walls can be easily constructed.

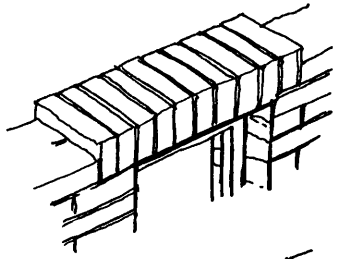
LINTELS

Lintels are usually made of reinforced concrete. If large stone blocks are available they can be used as lintels.

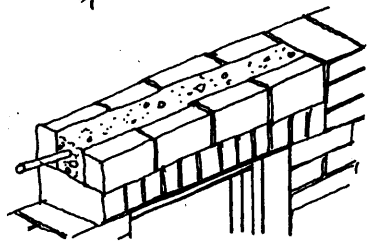
Often lintel is unnecessary over openings upto 4 ft. wide. Ordinary brick on edge is all that is required to span the opening. If something stronger is necessary, a hollow arrangement of brick on edge, filled with one or two steel bars in concrete will carry large weights of wall and roof above. This costs less than half of the cost of orthodox RCC lintel.



Opening to be spanned



Ordinary brick on edge



Brick on edge with RCC inside

Brick arches cost much less than reinforced concrete lintels but are just as strong and are more aesthetic than concrete, and it is possible to build them in various shapes and sizes.

Arched Openings

Sub- systems

Arched openings in masonry walls transmit load in compression through masonry. Semi- circular arches impose the least possible thrust on the adjacent walls.

Soil block arches with 4% cement stabilized blocks using 6% cement stabilized mortar.

Appropriate for

All masonry structure including soil blocks.

Improvements over traditional systems

Arches have been traditionally used where masonry is used for construction.

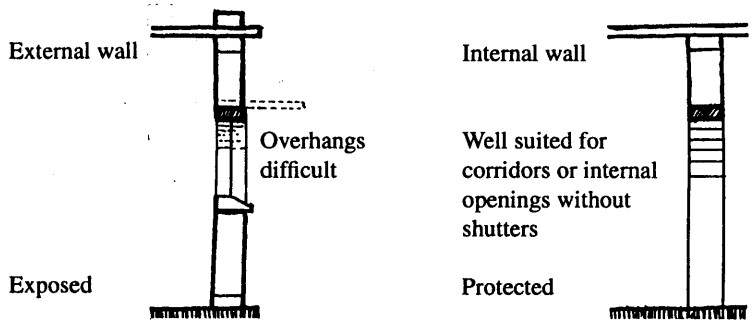
Re- usable wooden formwork reduces cost and time required for arch construction.

Comparison of lintel costs

Segmental Arches are less expensive than RCC lintels at all spans.

Beyond 1.4m span, RBC lintels are more expensive than segmental arches.

Compatibility with other sub- systems



Comparison with other Materials

Characteristics	SSB Arch	RCC beam	BB Arch
Structural stability	High	Medium	High
Cost range (Rs./ sqm)	40- 130	65- 150	30- 90
Unskilled labor (%)	38	8	10
Level of skill required	High	Medium	Medium
Degree of acceptance	Initial	Widely used	Widely used

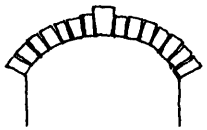
Building Method

Materials required

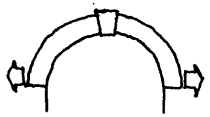
For a semi- circular arch of 1m span built in 4% cement stabilized blocks with 4% cement stabilized mortar.

Material	Quantity	People (mandays)	Tools
Soil blocks	46 nos.	Mason- 1.35	Shuttering
Soil for mortar	0.009 cum	Labor- 0.198	Masonry tools
Cement for mortar	1.17 kgs	Bhisti- 0.09	Scaffolding

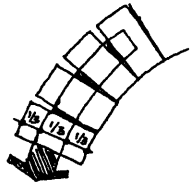
Arches are made of units in compression



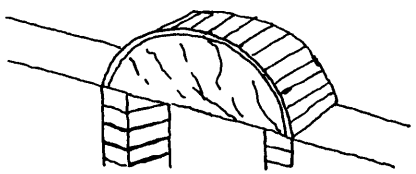
Semi- circular arches impose least thrust



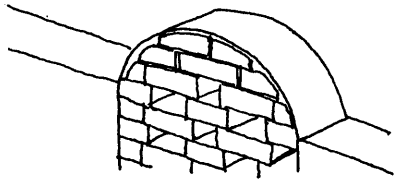
The forces travel through the middle third of section



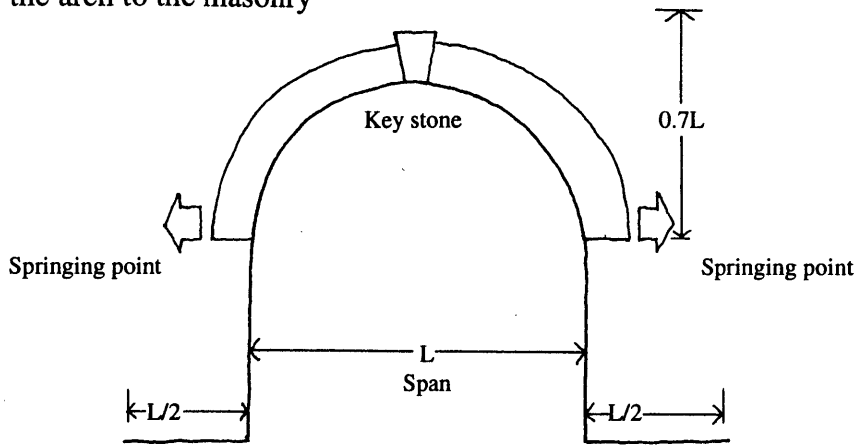
Erect formwork on temporary masonry



Alternatively make a formwork of brick inmudmortar



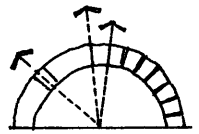
The load supported by the arch is transmitted through the units of the arch to the masonry



To ensure stability:

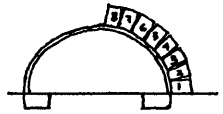
a) Build the roof only above 0.7L of masonry above the springing point.
b) Build at least L/2 of masonry to counter thrust.
c) For spans upto 4.5 m use 23 cm thick arch.

Lay each block radially from the center of the arch

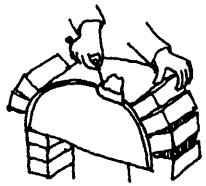


Begin from both ends

Count the number of blocks needed by measuring on formwork



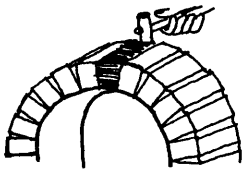
Fill wedged joints with mortar



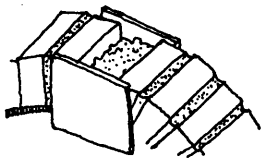
Bottom edge of the blocks should touch each other

Do not cut bricks next to if needed use them at the springing point

Gently hammer a slightly oversized keystone or of shaped firebrick in place



Make a keystone by pouring plain cement conc. mix 1:2:4

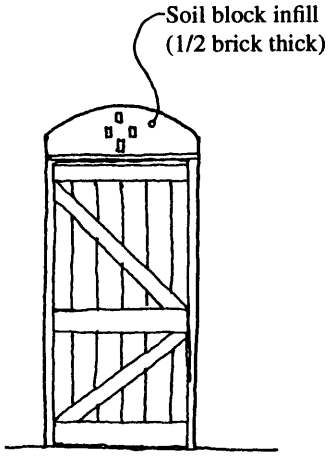


Formwork should be kept for atleast 24 hours and masonry should be completed around the arch before loading.

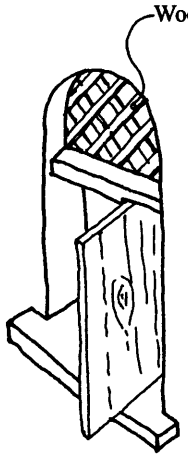
Curved doors and windows should be avoided as they are expensive and waste a lot of wood.

Some options:

Segmental arched opening



Frameless pivoted shutter



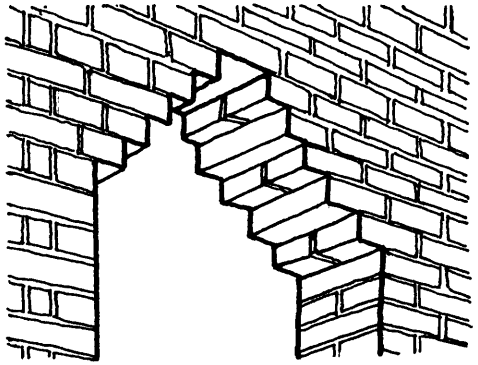
Cost variation with span

Cost of arch increases with span and the rise of arch from L/5 to L/2.

Critical factors

Rise of arch
Span of arch
Cost of unit block
shuttering used

The inexpensive way of spanning an opening is the simple corbel arch. Each row of brick is projected 2.25 inches beyond the course below until the bricks meet together in the middle. No formwork or shuttering is necessary with burnt bricks.



SANDSTONE ROOFING

Sub- systems

A flat roofing system with sandstone slabs resting over beams. Beams can be of steel or slender RCC or ferrocement sections. Stone slabs are laid over with terracing for insulation and to provide slope for rain water drainage.

Appropriate for

All areas where sand stone is available.

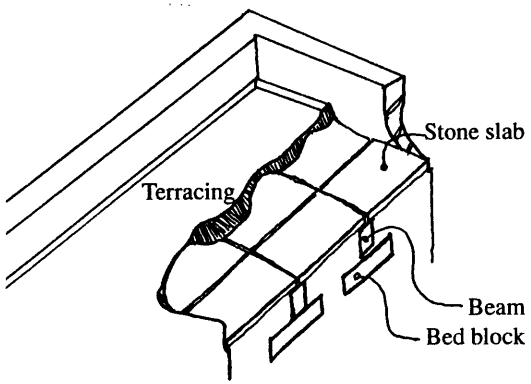
Improvements over traditional systems

Traditionally stone slabs are used over wooden beams which may or may not be sawn.Wood is now scarce and expensive and also uneven beams cause roofs to leak in rains.
Use of steel sections and slender RCC beams permits engineering design of roof and optimal use of materials

Cost comparison of flat roofs

Sandstone roofing on RCC beams is more economical than RCC slabs at all spans and is comparable to jack arch roofing.
Sandstone roofing on mild steel I beams is more economical than RCC slab beyond 2.4 m.

Components



Compatibility with other materials

Characteristics	sandstone	Jack roof	RCC slab
Cost range (Rs./ sqm)	140- 190	190- 250	290- 350
Unskilled labor (%)	7	27	6
Level of skilled required	Medium	High	Medium
Resistance to water	Medium	High	Medium
Stage of acceptance	Initial	Widely used	Widely used

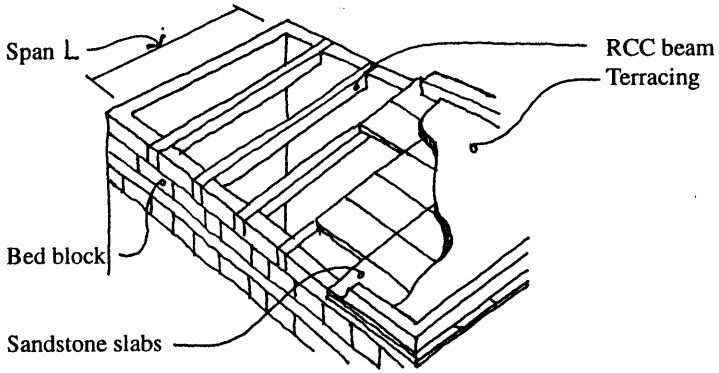
Building Method

Materials required

For 10 sqm of roof of sandstone slabs (60 cm x 90 cm) laid over precast RCC beams (1:2:4)

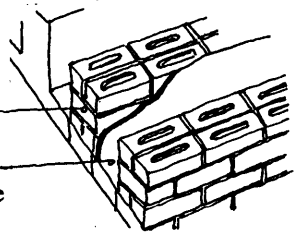
Material	Quantity	People(mandays)	Tools
Stone	12.72 sqm	Mason- 0.02	Shuttering
Cement	83.3 kg	Labor- 3.2	Scaffolding
Coarse sand	0.07 cum	Bhisti- 0.05	Masonry tools
Aggregate	0.23 cum		
Steel	14.93 kg		

Load of the roof is transferred to the soil block walls through the sandstone slabs resting on equally spaced precast RCC beams

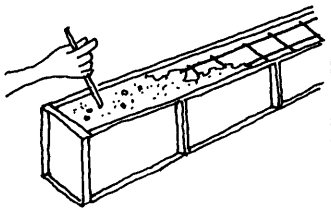


Prepare reinforcement as per design. Beams up to 150 kgs can be precast and lifted.

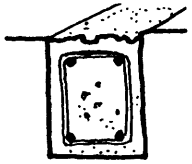
Option 1
Temporary masonry shuttering



Option 2
Steel shuttering



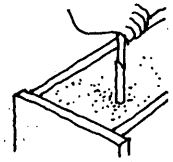
Use 1:2:4 conc. and tor steel for beams



Ensure that bottom bars are thicker

Use water i.e., suitable for drinking

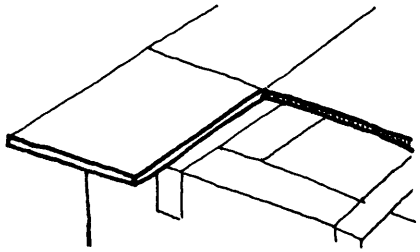
Ensure proper Compaction of concrete



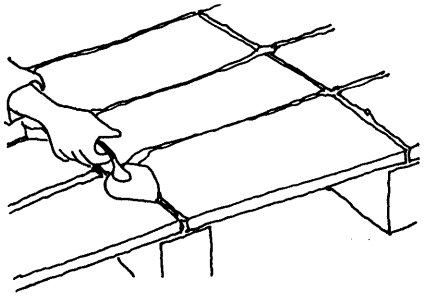
Cure upto 14 days from the casting

Use stone slabs which are at least 4cm thick even at the thinnest section. Levelling can be done by using stone chips. Sandstone panels should be laid on beams with a minimum bearing of 4 cm.

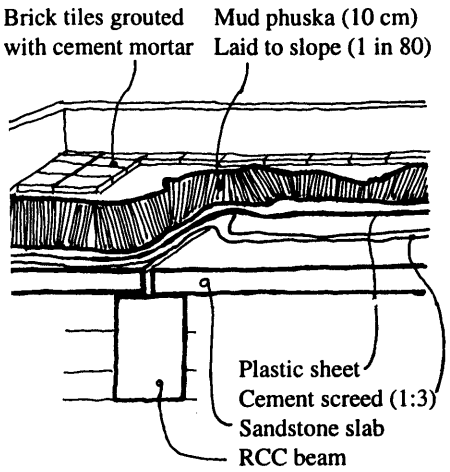
The stone slab can be projected outwards as roof overhangs to protect the soil block wall.



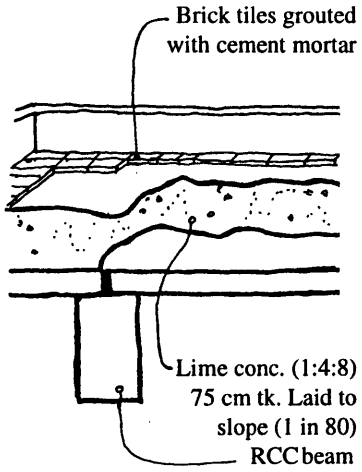
Fill the joints properly with cement mortar



Finishing Layer Option 1



Finishing layer option 2



Cost variation with span of the room

Sandstone roofing on RCC beams is less expensive than on steel I beams for spans upto 4.5 m

The cost of the roofing increases as the size of stone decreases.

Critical factors

Span of the room

Size of stone slab (width 60 cm, 75 cm or 90 cm)

Material of beams

Terracing used

JACK ARCH ROOFING

Sub- systems

A flat roofing system with segmental arches of stabilized soil blocks built over RCC beams. The roof is relatively flat and can be used as intermediate floors.

The beams can be precast or cast in situ.

Terracing can be of mud phuska or lime concrete finished with brick tiles.

Appropriate for

All areas where flat roofs are required

Areas where suitable soil for compressed soil blocks is available

Low rainfall areas

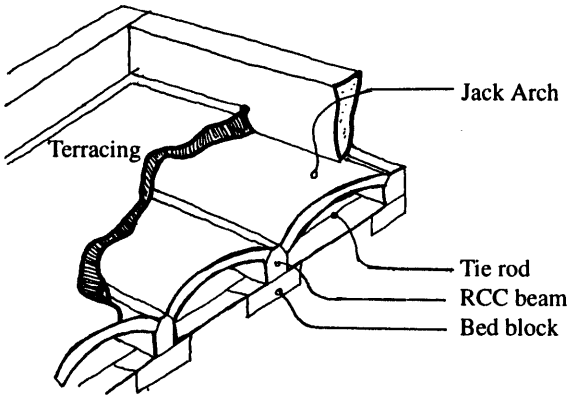
Improvements over traditional systems

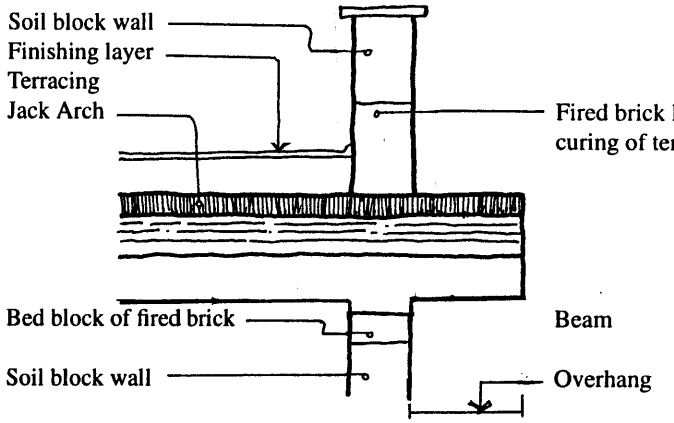
Use of slender RCC beams, continuously re- usable sliding form-work and soil blocks allows speedy construction and reduces cost.

Cost comparison of flat roofs

Jack Arch roofing is less expensive than RCC slab at all spans. It is comparable to sand stone roofing on RCC beams.

Components





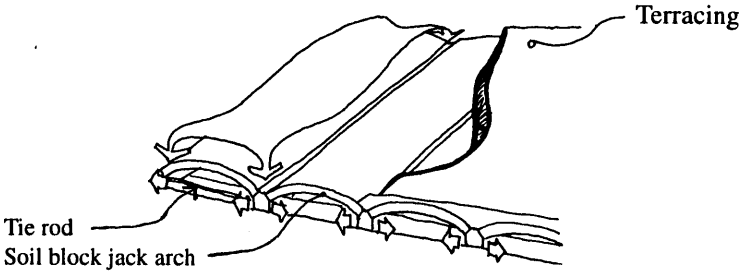
Building Method

Materials required

For 10 sqm of Jack arch roof over RCC beams (1:2:4)

Material	Quantity	People (mandays)	Tools
Soil blocks	63 nos.	Mason- 2.2	Shuttering
Soil for mortar	0.1 cum	Labor- 4.5	& Scaffolding
Cement	87 kgs	Bhisti- 1.6	for Jack arch
Coarse sand	0.1 cum		& RCC beams
Aggregate	0.2 cum		Masonry tools
Steel	32.9 kg		

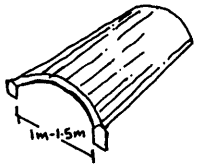
Load of the roof is transferred to the soil block wall through the segmental jack arches built on RCC beams



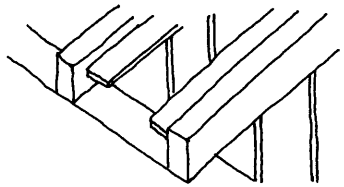
Horizontal thrust of the end bay is contained by providing steel rods

Load transfer takes place through the soil blocks to the beams

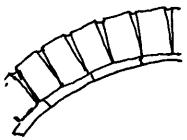
Optimal dimensions



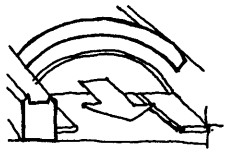
Put up wooden support for the jack arch support to slide on



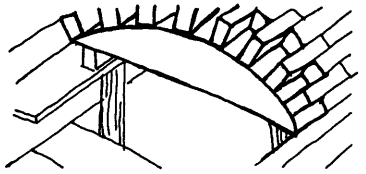
Lay the blocks so that the bottom edges touch



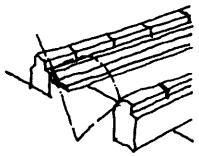
Move the shuttering and continue the arch



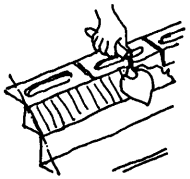
Hammer stone keys between blocks to ensure tight fit even when mortar dries and shrinks



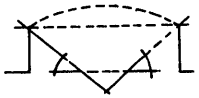
Place the fire brick layer on the beam to prepare a skewed face for the springing of jack arch



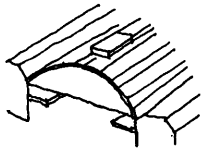
Fill the triangular space with cement mortar (1:3)



Make skew backs with exactly the same angle and lvl.

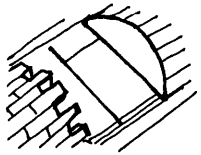


Make the shuttering 1cm smaller than the openings

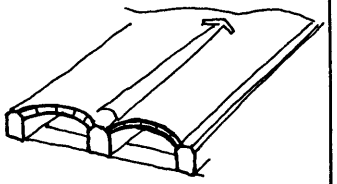


Insert MS tie rods thr-eaded on both sides

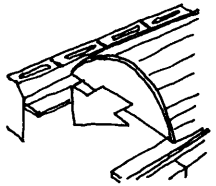
Insert the tie as the arch progresses



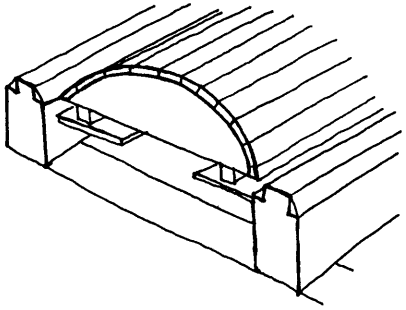
Apply heated bitumen in valleys



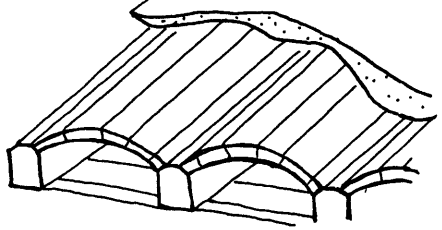
Ensure that the shuttering slides easily



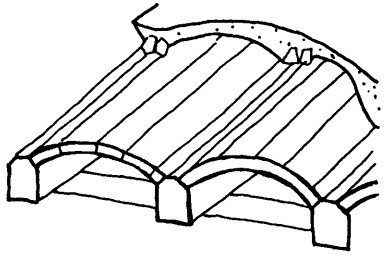
Place the formwork



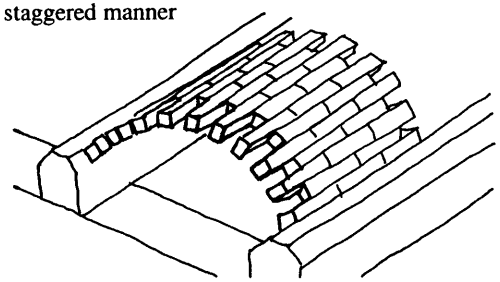
Finish with a layer of lime concrete (1:2:6) 5 cm tk. laid to slope (1 in 80) over which brick tiles may be laid grouted with cement mortar (1:3)



For intermediate floors use brick bats or inverted pots to fill the valleys



Place the blocks in a staggered manner



Use wooden wedges to adjust level

Cost variation of jack arch roof

The cost increases with the span.

Cost decreases with the increase in bay size from 0.5- 1.5 m.

Critical factors

Span of the room and Jack Arch (bay size)

Material of terracing

COUNTRY TILE ROOFING

Sub- System

A pitched roofing system with burnt clay tiles laid on timber understructure

Appropriate for

All areas where:
Pottery skills exist
Timber or alternative understructure costs are low
Strong winds or cyclone are not frequent

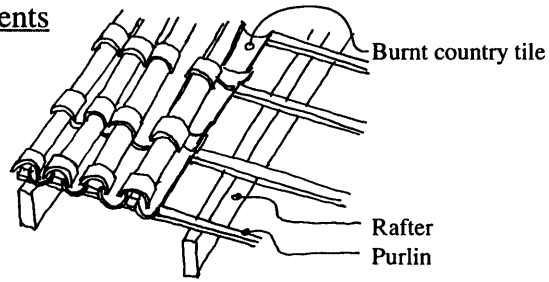
Improvements over traditional systems

Traditionally tiles produced by village potters are laid on a wooden or bamboo understructure in multiple layers which makes the cost of the understructure expensive.
Moulded tiles are fired at temperature > 800 C to reduce permeability.
Increase in the length reduces the roof cost.

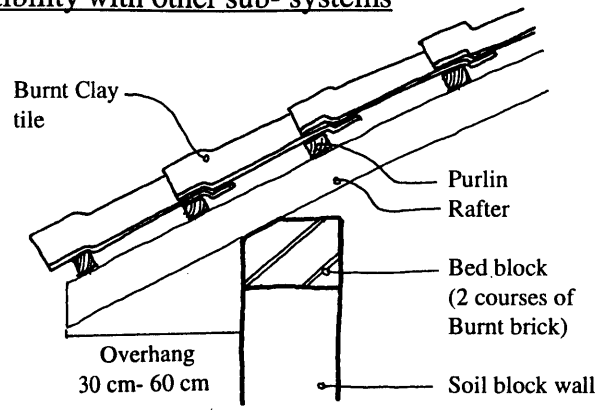
Cost comparison of sloping roofs

Burnt country tiles (BCT) are expensive than Mangalore tiles on wood upto 4.5 m span.
BCT roofing is expensive than micro concrete roofing.

Components



Compatibility with other sub- systems



Comparison with other materials

Characteristics	Country tile	Mangalore tile	Micro-conc. tile
Cost range (Rs./ sqm)	290- 370	230- 270	105- 170
Unskilled labor (%)	12	13	18
Level of skill required	Medium	High	Low
Resistance to water	Medium	High	High
Resistance to wind	Medium	High	Medium
Thermal capacity	Medium	Medium	Low
Stage of acceptance	Widely used	Widely used	Initial

Building Method

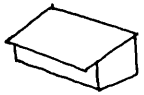
Materials required

For 10 sqm tile area of Burnt country tiles with wood understructure:

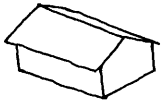
Material	Quantity	People (mandays)	Tools
Tiles	1125 nos.	Carpenter- 2.2	Carpentry tools
Wood	4.36 cuft	Labor	1.1
Paint	2 liters		
Nails	0.55 kg		

The type of pitched roof needed depends upon climate and span

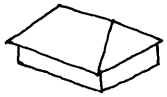
a) Lean-to roofs for spans upto 3.9 m



b) Gable roof for spans above 3.9 m



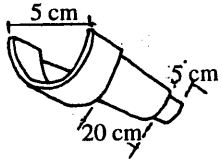
c) Hipped roof for cyclone prone areas



Provide an overhang atleast 60 cm to protect the wall

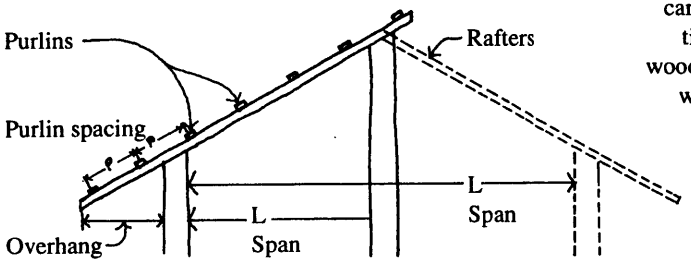
Provide slope prevalent in the area to run-off rain water and counteract air pressure

Size of the tile



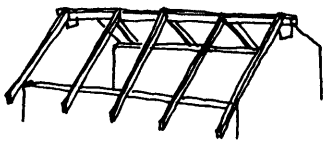
Lean- to roof

Gable roof



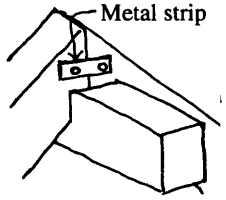
The support structure can be of seasoned timber section or wood section treated with anti- termite chemicals

Place rafters in position. If using ballies, use only straight ones

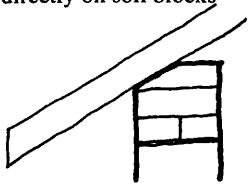


Rafters should be in one plane

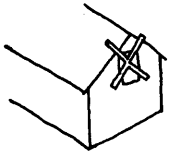
Fixing detail at ridge



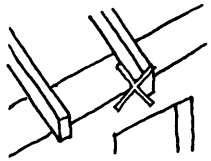
Do not place timber rafter directly on soil blocks



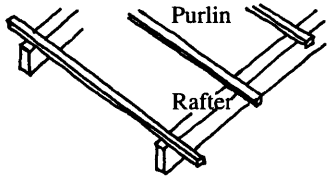
Do not make openings under the ridge piece in gable roof



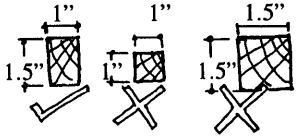
Do not place rafters directly over openings



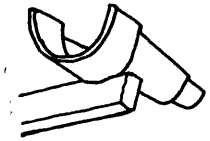
Use timber sections of 5 cm x 3 cm for purlins
spacing of purlins depends upon the tile length



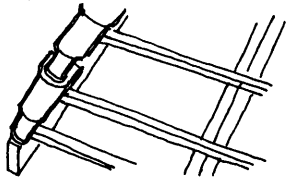
Do not use timber purlins less than 2.5 cm x 4.0 cm (1" x 1.5")



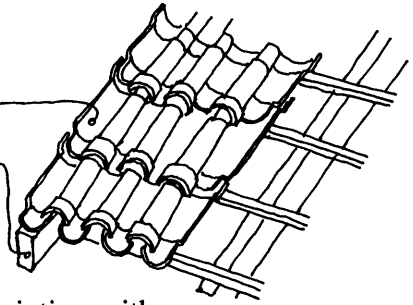
Each moulded tile rests on a purlin



Start laying the tiles from bottom upwards



Overlap the laying pattern to ensure the water run-off



Grout ridge tiles with cement and sand mortar 1:3

Use GI sheet gutters in hipped roof and valley junctions

Cost variation with span

Roof costs do not increase significantly with the span.
Burnt country tile roof is more expensive.

Critical Factors

Span/ slope of the roof and cost of unit tile.

MICRO CONCRETE ROOFING

Sub- system

A pitched roofing system with micro concrete tile cladding on timber or 'balli' understructure.

Appropriate for

Areas where local production is desirable.
All areas where pitched roof is prevalent.
Areas with low or medium wind velocities.

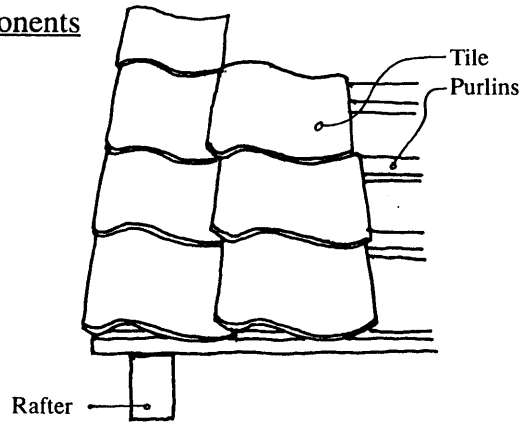
Improvements over traditional systems

The tiles are lighter and larger, thus use less understructure.
This system gives greater flexibility with uneven understructure like ballis.
Tiles can be made locally by micro enterprises.

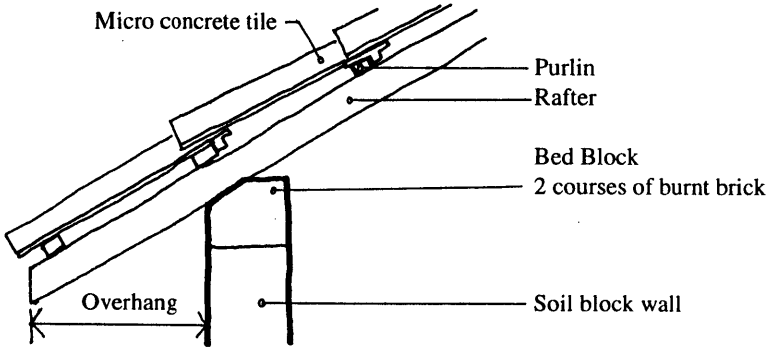
Cost comparison of sloping roofs

MCR is less expensive than ACC on steel and BCT roofing upto a span of 4.5 m.
MCR on balli is the least expensive than BCT and ACC roofing.

Components



Compatibility with other sub- systems



Comparison with other materials

Characteristics	MCR	Country tile	ACC
Cost range (Rs./ sqm)	105- 170	290- 370	220- 280
Unskilled labor (%)	18	12	7
Level of skill required	Medium	Medium	Low
Resistance to water	High	Medium	high
Resistance to wind	Medium	Medium	Low
Thermal capacity	Medium	Medium	Low
Stage of acceptance	Initial	Widely used	Widely used

Building Method

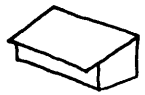
Materials Required

For 10 sqm of plan area of MCR tile roof on balli understructure

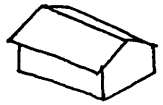
Material	Quantity	People (mandays)	Tools
MCR tiles	144 nos.	Carpenter- 2.2	Carpentry tools
Wood (understructure)	2.3 cuft	Labor- 1.1	
Balli	2 nos.		
Paint	2 liters		
GI wire	4.08 kg		
Nails	0.55 kg		

The type of pitched roof needed depends upon climate and span

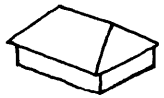
a) Lean-to roofs for spans upto 3.9 m



b) Gable roof for spans above 3.9 m



c) Hipped roof for cyclone prone areas



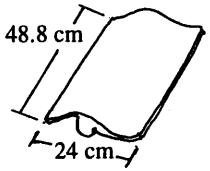
Provide an over hang at least 60 cm to protect the wall

Lean- to roof

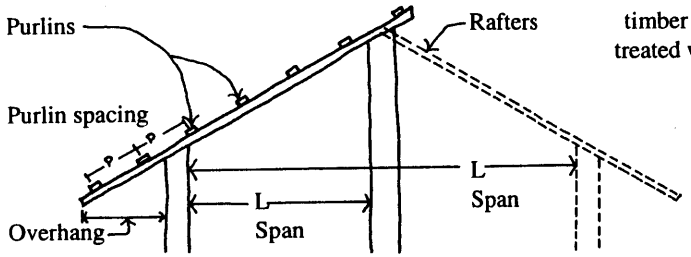
Provide slope prevalent in the area to run-off rain water and counteract air pressure

Gable roof

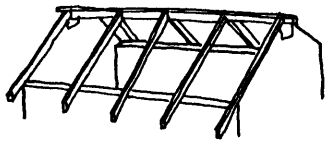
Size of the tile



The support structure can be of seasoned timber or wood section treated with anti-termite chemicals

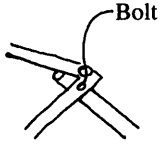


Place rafters in position. If using ballies, use only straight ones

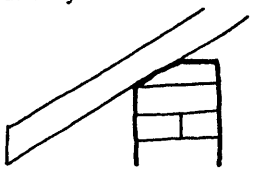


Rafters should be in one plane

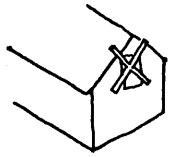
Fixing detail at ridge



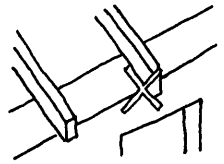
Do not place timber rafter directly on soil blocks



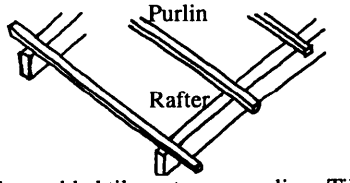
Do not make openings under the ridge piece in gable roof



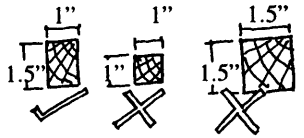
Do not place rafters directly over openings



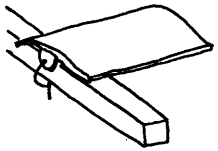
Use timber sections of 5 cm x 3 cm for purlins
spacing of purlins depends upon the tile length



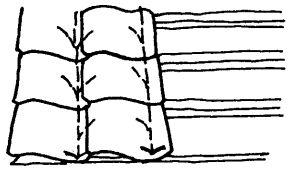
Do not use timber purlins less than 2.5 cm x 4.0 cm (1" x 1.5")



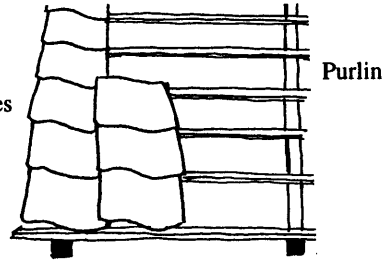
Each moulded tile rests on a purlin



Tile overlap/ laying pattern ensures water run-off



Lay tiles from bottom left corner



Grout ridge tiles with cement and sand mortar 1:3

Use GI sheet gutters in hipped roof and valley junctions

<u>Cost variation with span</u>

Roof costs do not increase significantly with the span.
The roof cost reduces considerably if balli understructure is used.

<u>Critical factors</u>

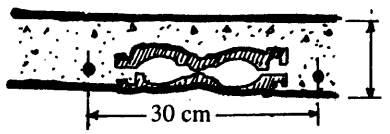
Span/ slope of the roof and cost of unit tile.

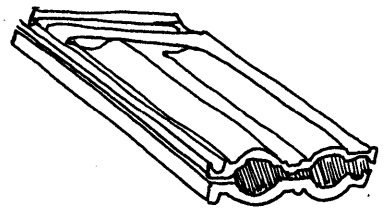
FILLER SLAB

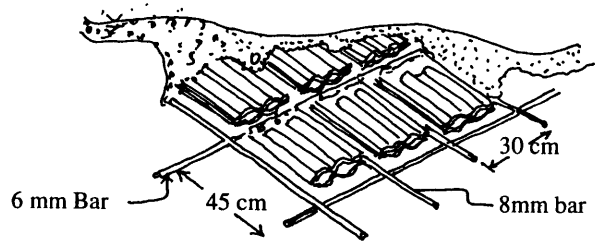
Galvanized iron and asbestos cement sheets use less timber, but iron rusts and is hot and uncomfortable to live under, while those who work in asbestos factories and those who live and work under ACC roofs run the risk of developing lung cancer. Therefor it makes sense to discourage its manufacture and use. As there is a lot of redundant concrete in an orthodox concrete slab, it can be replaced with any light weight cheap materials in order to reduce the overall cost of the slab. This alternative RCC roof is called the filler slab. For fillers light weight bricks, Mangalore or country tiles, etc. can be used. This reduces the cost of the RCC slab upto 35%.

Damaged or broken Mangalore tiles can be used for making excellent light weight filler slab. These can be placed in between steel reinforcement rods creating a grid of RCC ribs or beams.

Section



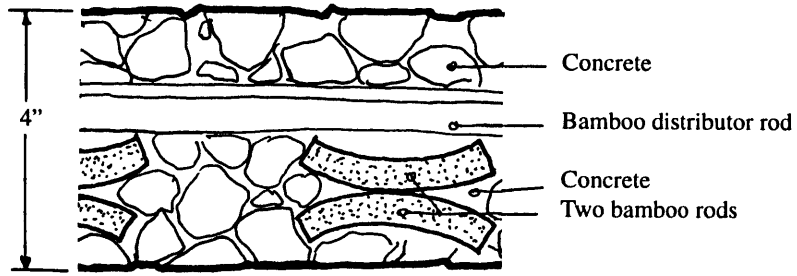




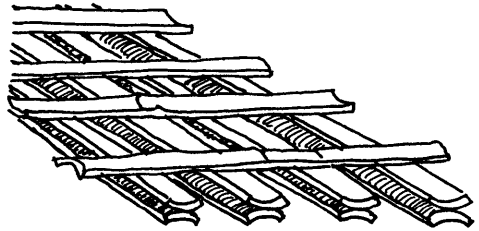
In areas where strong mature bamboos are available, the steel reinforcement bar in conventional reinforced cement concrete can be replaced by bamboo. This is possible because the tensile strength of a good bamboo is similar to steel.

Though extreme caution has to be maintained in the selection of the right bamboos. This system is perfectly adequate and safe for small roofs, lofts, shelves, work tables, stairs treads etc.

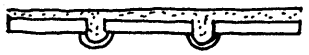
Section through a bamboo reinforced slab

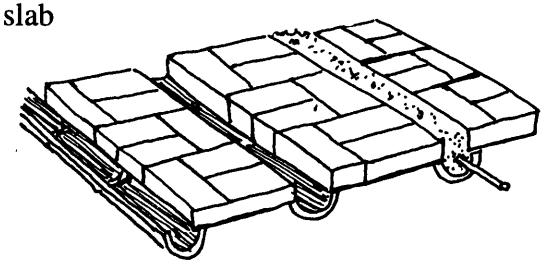


Strips of bamboo tied by wire to be used as reinforcement in a concrete slab



A good mature bamboo can also be split in half an used as a permanent shuttering for reinforced cement concrete ribs between brick units (three burnt bricks) previously joined together with mortar to form a small slab





Section

Chapter 7
Building Components

COMPRESSED SOIL BLOCK

Masonry blocks are made by compressing loose soil with optimum water content in a manual machine and then sun-dried. Stabilizers like cement or lime are added to increase the resistance of the blocks to erosion by water. These blocks are used with mud mortar in walls. They have a low resistance to abrasion or impact unless adequately stabilized. These blocks need to be treated against termites and rodents.

Soil should be tested for suitability before use. Since stabilizers react with clay in the soil to form a binder, the degree of stabilization depends on the amount of clay. Cement (3- 6%) is used with low clay soils with lime (4- 8%) is used with soils with higher clay content. The correct proportions can be determined by making sample blocks and testing them for strength.

Appropriate for

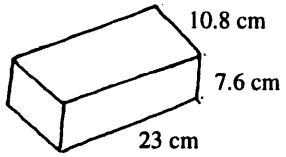
All areas where suitable soil is available. Soil should consist of:

Clay	-	25%
Sand	-	40- 75%
Silt	-	15- 25%
Fine gravel	-	0- 10%

All areas in which fired bricks are relatively expensive
Efficient and renewable energy utilization.

Improvements over traditional techniques

Compaction increases the compressive strength of the block and hence its capacity to carry loads as compared to traditional techniques of cob and adobe.



Building Method

Materials required

For 1000 soil blocks stabilized with 4% cement

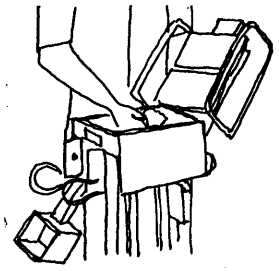
Material	Quantity	People (Mandays)	Tools
Soil Cement	3.35 cum 212 kgs	Labor for: Digging & sieving- 3 production- 5 Curing- 1.5	Balram Block testing equipment

Quality of the soil block depends on: the mix of soil used, moisture content of the mix, compaction and the rate of production

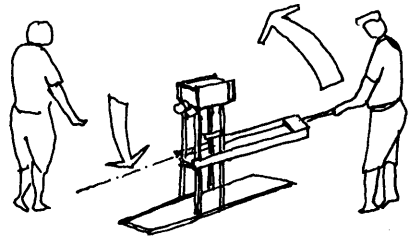
Prepare soil in batches 0f 36 cuft. Break lumps Sieve soil through 5mm sieve. Add stabilizer

Ensure thorough mixing of stabilizer. Lime requires more care as it tends to form lumps

Lightly coat the inside of the machine with oil. Fill prepared soil into the mould to the top, close lid and lock.



Move the yoke through 180 for compaction



If the soil is difficult to compact: check for pebbles, water content may be less
If the soil compacts easily: put more soil into the mould

Measure the block, if properly compacted, it should have dimensions: 7.6 +.01cm
Its weight should be 3.6- 4.0 kgs

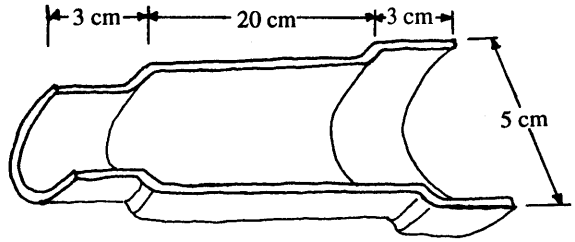
Blocks should be laid in rows for an initial drying period of 5-7 days. Stack and cure blocks at regular intervals for 14 days. Lime blocks should be cured for 24 days. A sample of blocks should be tested by loading them.

BURNT COUNTRY TILE

A roofing tile made of common clay pressed into shape with a wooden mould and fired in a kin. These tiles can be used on a wooden or balli understructure.
Country tiles are traditionally made by village potters in various ways ranging from the wheel to the wooden moulds.
Traditionally these are laid in lairs over heavy wooden or bamboo understructure. The rising cost of timber and bamboo and their competing use by contractors and paper mills at subsidized rates has helped push tile roofs out of existence at places. Tiles are prone to breakage under impact loads.

Appropriate for
All areas where pottery skills exist traditionally and clay is available.
Areas where pitched roofs are common.

Improvements over traditional techniques
The tiles are lighter and longer than the traditional tiles and therefore use less understructure.
These are less permeable than traditional tiles. Hence a single layer is adequate for moderate rainfall areas.
The grooves ensure better interlocking of tiles.

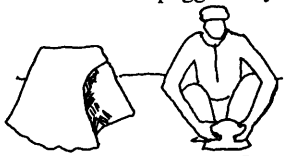


Building Method

Materials required
For 1000 burnt country tiles

Material	Quantity	People (Mandays)	Tools
Pugged clay Sawdust Fire wood	14 cuft 400 kgs. 90 kg	Potter- 2 Labor- 6	Mallet Wooden mould Country kiln

Take a mass of pugged clay

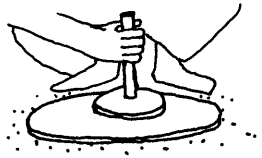


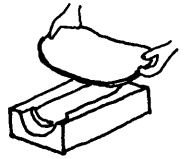
Roll it on a dry surface on which sand has been sprinkled

Flatten the mass with a flat wooden mallet to about 5mm

Do not flatten with a roll

Place the processed clay on The bottom mould

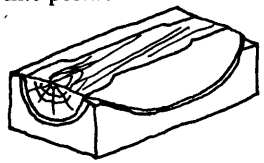


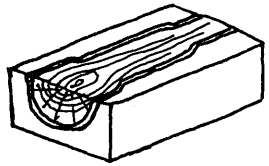


Press the top mould firmly into position

Trim off the excess clay with a sharp metal blade

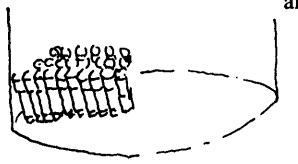
Remove the tile from the mould by inverting the mould directly where the tile is to be dried





Dry the tiles initially in shade transfer to a sunny area for final drying

Stack the dried tiles vertically in the kiln and fire



Well burnt tiles that have no cracks give a ringing sound when struck lightly

MICRO CONCRETE TILE

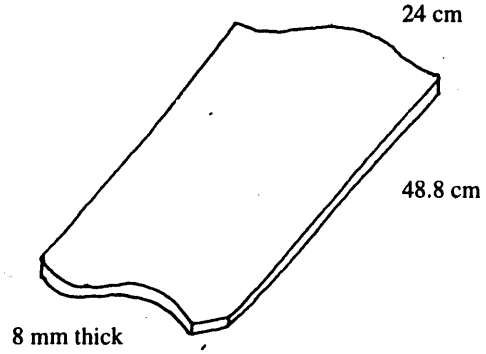
A roofing tile made of cement mortar vibrated on a table at a controlled frequency and set on a mould to shape. The mortar used is a mix of Cement, Fine sand, Coarse sand and Fine aggregate. Care is needed at all stages of production to ensure quality of the tile. The production has to be carried out in a shed with electricity connection and a flat floor near the curing tank. These tiles can be used with wooden or balli understructure. They provide greater flexibility with uneven understructure in comparison to ACC sheets.

Appropriate for

All areas where pitched roofs are common.
Areas which are not prone to strong winds or hailstorm.
Efficient and renewable energy utilization.

Improvements over traditional techniques

These tiles are water proof, fire proof and insect proof. Therefore are much more durable than thatch roofs.
They provide a durable, low- cost and thermally more satisfactory option than ACC sheets.
Can be manufactured locally with low investment using materials available locally and cement.



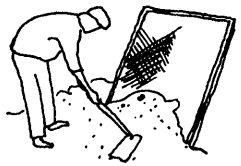
Building Method

Materials required

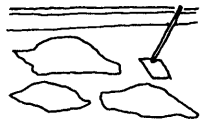
For 150 micro concrete tiles.

Material	Quantity	People (Mandays)	Tools
Cement Fine sand Coarse sand Fine aggregate	90 kgs. 0.028 cum 0.084 cum 0.041 cum	Mason (B Grade- 1) Labor- 2	Tara vibrator and accessories 150 moulds

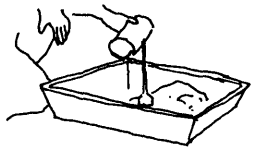
Sieve sand and aggregate through a 5 mm sieve



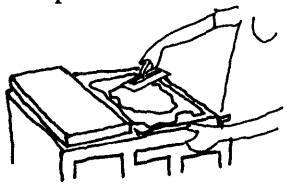
Mix with cement in dry state on a clean floor or in trough



Add 4lit. of water for a mix of 32 kg and mix. Use mix within 30 min.

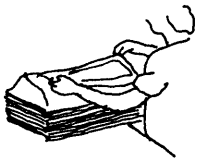


Wipe the surface clean, place plastic sheet in position and lock the framed

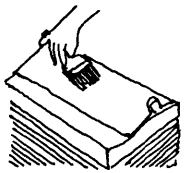


Start the vibrator and spread the mortar flat and smooth, taking care to spread it into corners. Vibrate for 35- 40 sec.

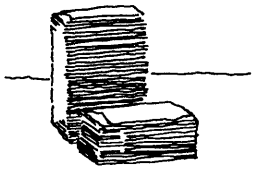
Pick up the plastic sheet, place correctly in a mould



Lightly brush the tile to close cracks

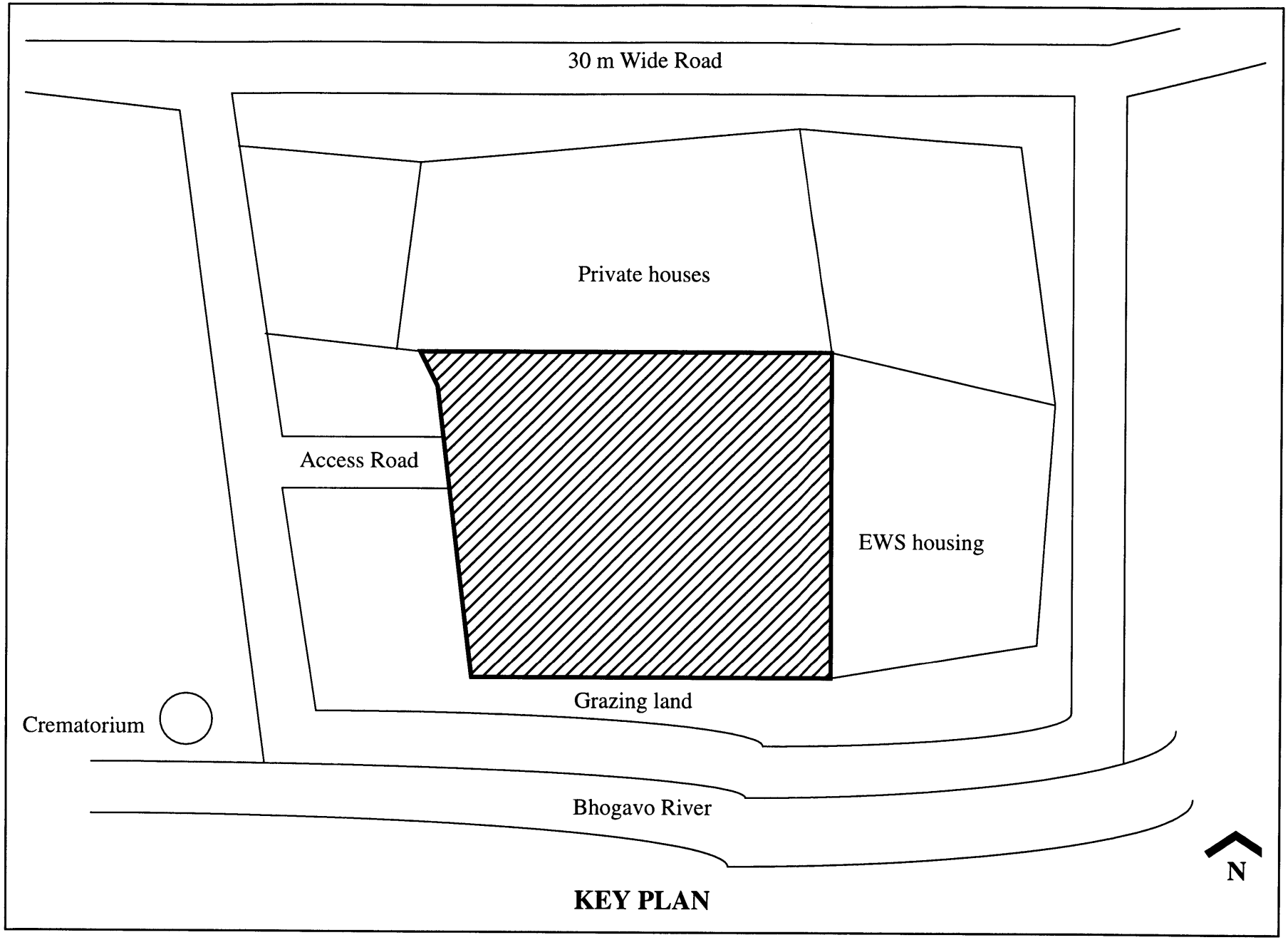


Place all moulds in stacks upto 1m high for a day.



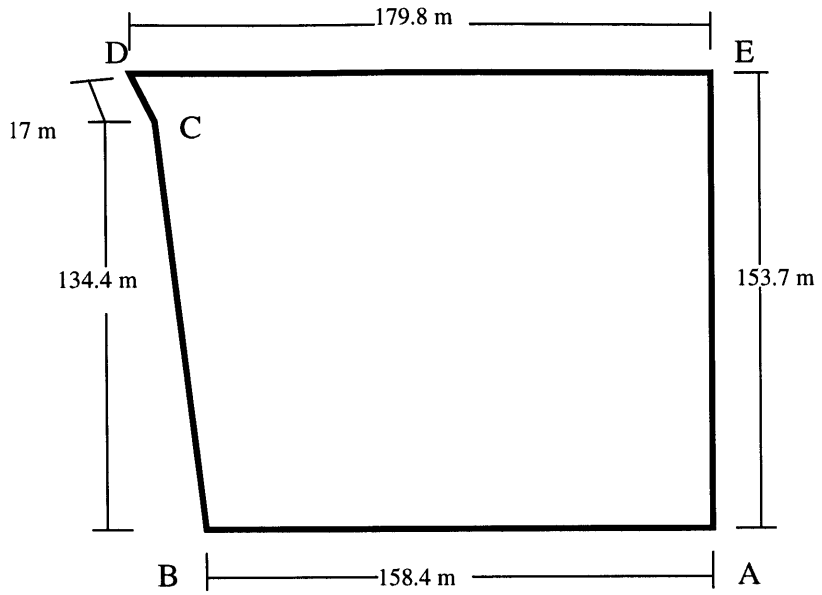
Stack the tiles vertically in a tank and cure for 10 days.

Chapter 8
Design Proposal


30 m Wide Road
Private houses
Access Road
EWS housing
Grazing land
Crematorium
Bhogavo River
N

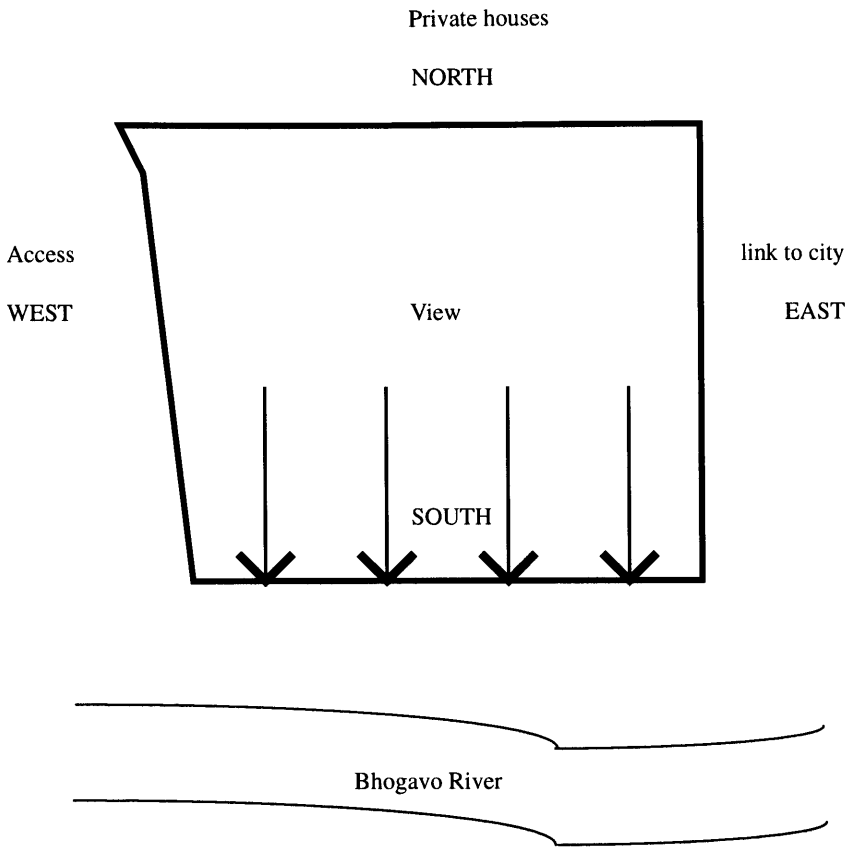
KEY PLAN

SITE ANALYSIS



Site Area = 24185 sqm.

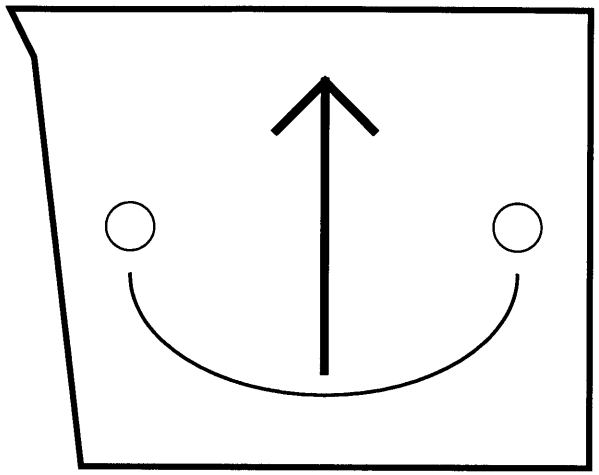
Lengths	Angles
AD= 224.5 m	A=90
AC= 206.0 m	B=95
BE= 220.0 m	C=127
CE= 170.0 m	D=56
	E=89



Surroundings

Site access from west only
South edge is open for view with no possibility of future development.
Internal link possible towards east for optional access and interaction.

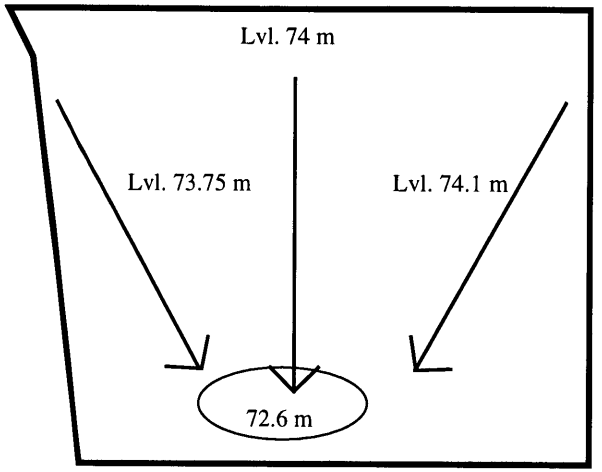
CLIMATE



Hot dry, desert like climate.
Location: 123 kms south of Ahmedabad
Mean annual rainfall: 500- 600 mm
Temperature in Winter: 24 C- 10 C
in Summer: 41 C- 28 C
Water Resource
Average rainfall per year= 50 cm = 500/ sqm
Site area= 24000 sqm, rain water on site = 24000 x 500
= 12,00,00,000 liters
Assuming 50% collection = 6,00,00,000 liters

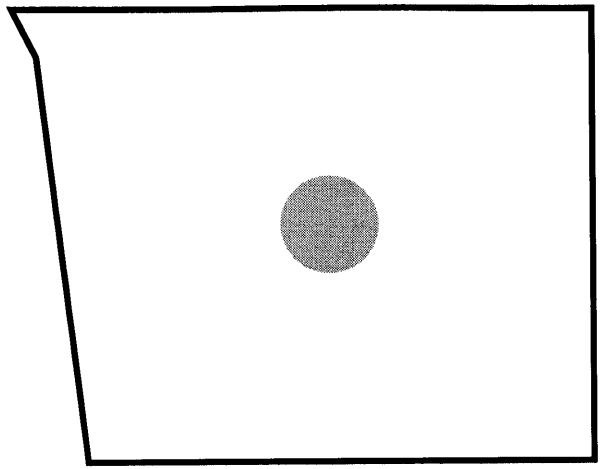
Daily consumption/ person / day = 135 liters
Total population= 1000 Daily water consumption=1,35,000 liter
Total water available for settlement = 6,00,00,000/
1,35,000 = 44 days

LAND SLOPES

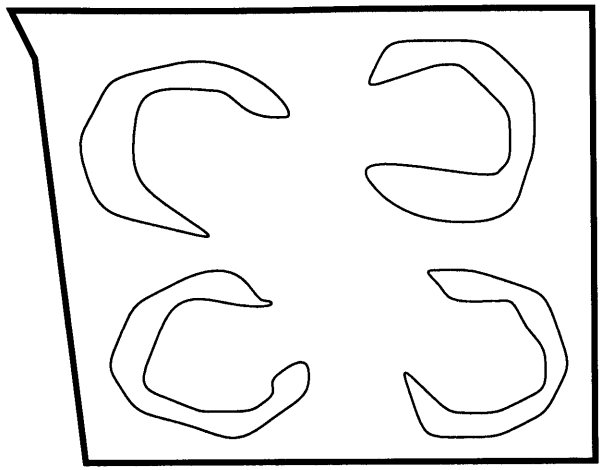


Land slopes gradually towards the river.
View and breeze direction corridors with the land slope.
Depression towards southern edge can be used as catchment pool.

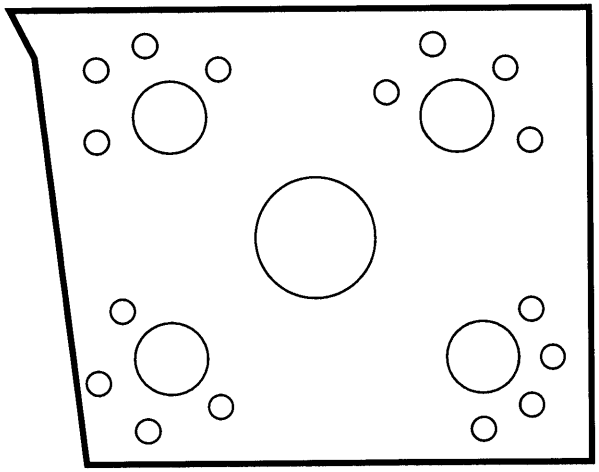
DESIGN CONSIDERATIONS



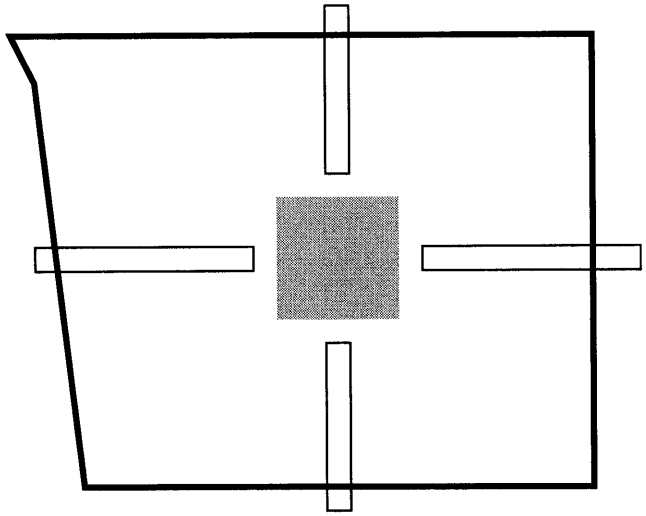
Community facilities such as Jamatkhana, day care canter, women's handicrafts center or cultural center to be developed as focal point for community interaction and landmarks.



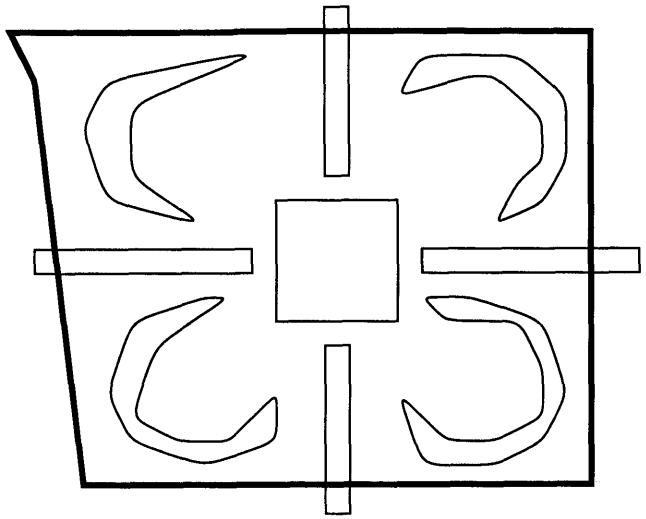
Informal/ casual residential fabric for rural settlement



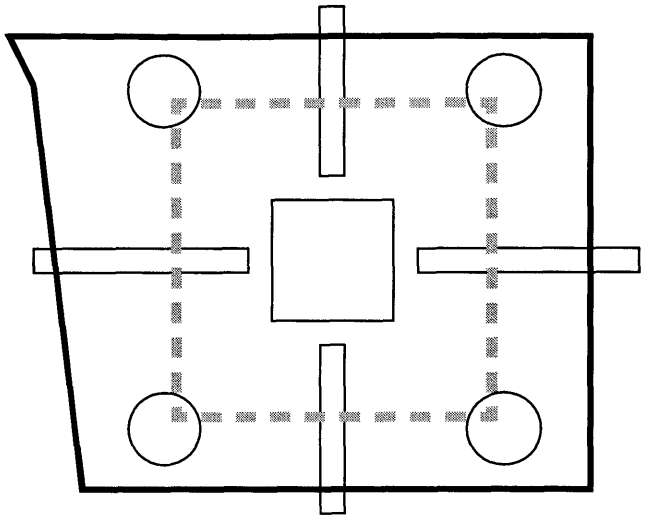
The local shops and group facilities to be dispersed



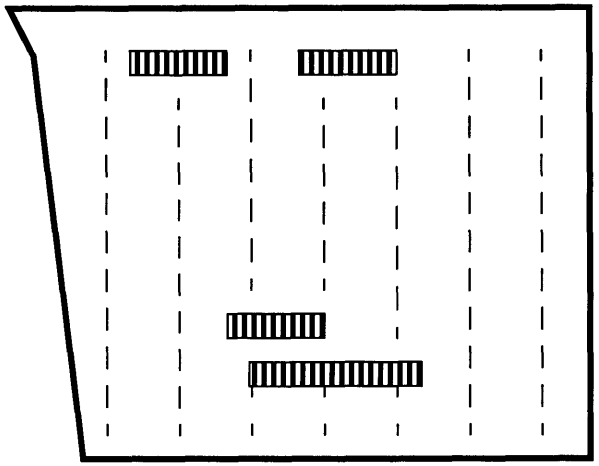
Formal/ cardinal reference of islamic monuments



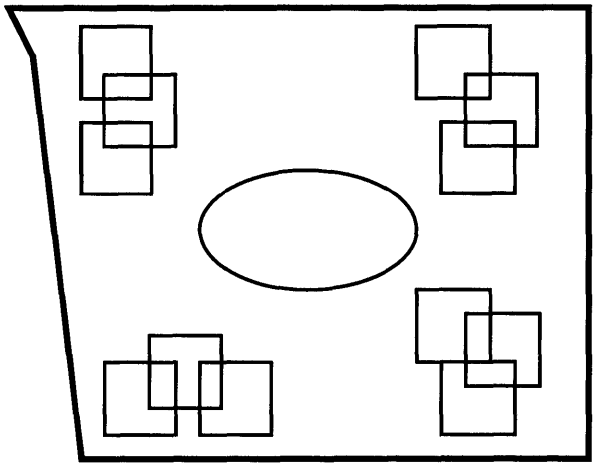
Juxtaposition of the two, formal with informal



Network of pedestrian cross links to connect the center with the peripherals.



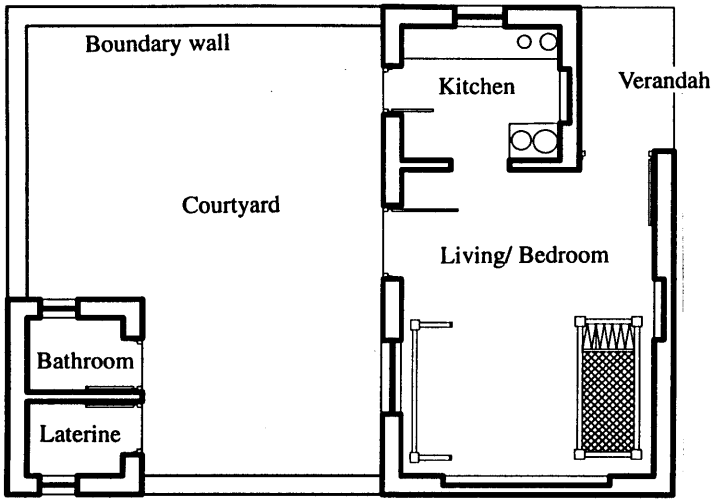
Dwellings to orient preferably North/ South



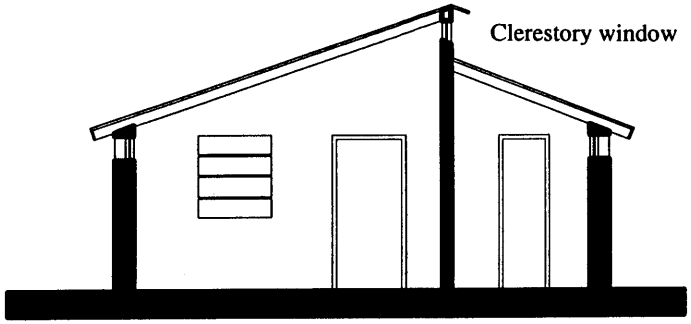
Smaller clusters for intense neighborly interaction.

UNIT PLAN

Plot size- 48 sq. mts. (8m x 6m)
Ground coverage- 30 sq. mts.

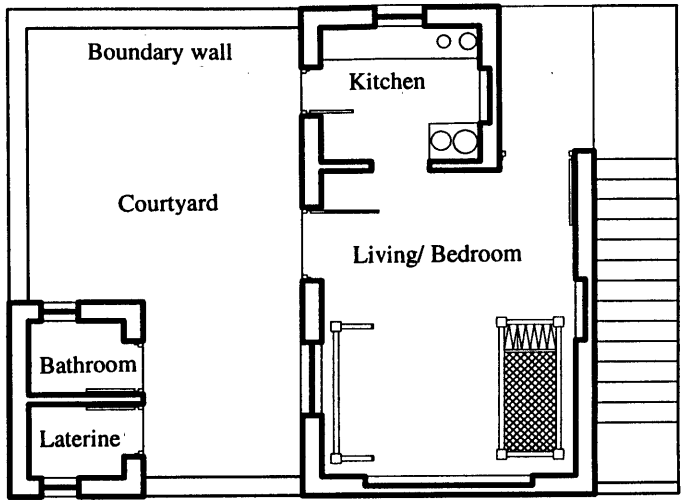


Plan



Section

Layout showing location of staircase, for possible expansion upwards. Though the present trends suggest that the initial encroachment is done laterally.



Plan

The plan has been developed after careful examination of existing single family houses and their evolution patterns. The living/ bed room is accessed indirectly through the verandah, which acts as a transitional space between the interior and the exterior.

Kitchen size has also been derived from the analysis of the existing kitchens. The proposed space is more functional, as it takes advantage of the verandah and the courtyard, which is used as the extended kitchen. It is equipped with niches, shelves, overhead water tank and other elements discussed earlier in the design criteria section.

Bath and kitchen are connected to the septic tank and the latrine and have a deep, well ventilated pit. Community participation should be sought in creating bio-gas plants at neighborhood level. At the same time water may be recycled and the waste from the septic tank can be used as manure for the agricultural land.

Courtyard is designed to be used as a spill over space by the kitchen and the living/ bed room. Activities like, washing/ drying of clothes, cutting/ chopping of vegetables, drying food items and spices, are carried out in the court. This space may also be partly covered with a temporary structure to be used as cattle shed. The courtyard has a 5'- 0" high boundary wall to demarcate the property, and act as protection against dusty winds.

When the family expands, the space can be used for a lateral expansion at ground level, or the staircase can be located here for vertical expansion.

Toilets have been located on one corner of the plot to keep the unpleasant odors away from the house. Soak pit and septic tank can be located in one corner of the courtyard and an access can be provided for maintenance.

This layout has the possibility of expanding according to individual needs (vertically and horizontally)

Materials of construction

Walls can be 9" thick load bearing, made of cement stabilized soil blocks set in "Rat-trap bond". The roof can be spanned with bamboo or precast concrete purlins and rafters as discussed in detail in the chapter on building techniques, and can be covered with filler slabs or burnt country tiles (depending on the choice of roof structure). Mud plastering can be done with some stabilization, a coat of silicon will help make it last longer and will protect it from rains.

Clerestory window can be created with openable shutter laterally hinged on pivot for easy operation. This will provide with required diffused light and necessary cross ventilation. This can be supplemented with slit windows with pre-cast ferrocement frame and shutters and a removable plastic mesh.

Additional light and ventilation is provided with the band windows at 7'- 0" height. These are equipped with bamboo members as grill, places at 4" spacing. The opening height should not exceed 1'- 6".

Doors also have pre-cast RCC or ferrocement frames and ferrocement shutters. These can also be used as shelves or treads for staircases.

Flooring is done with IPC in various colors and designs, this keeps the floor cool and does not require maintenance.

CLUSTER PLAN

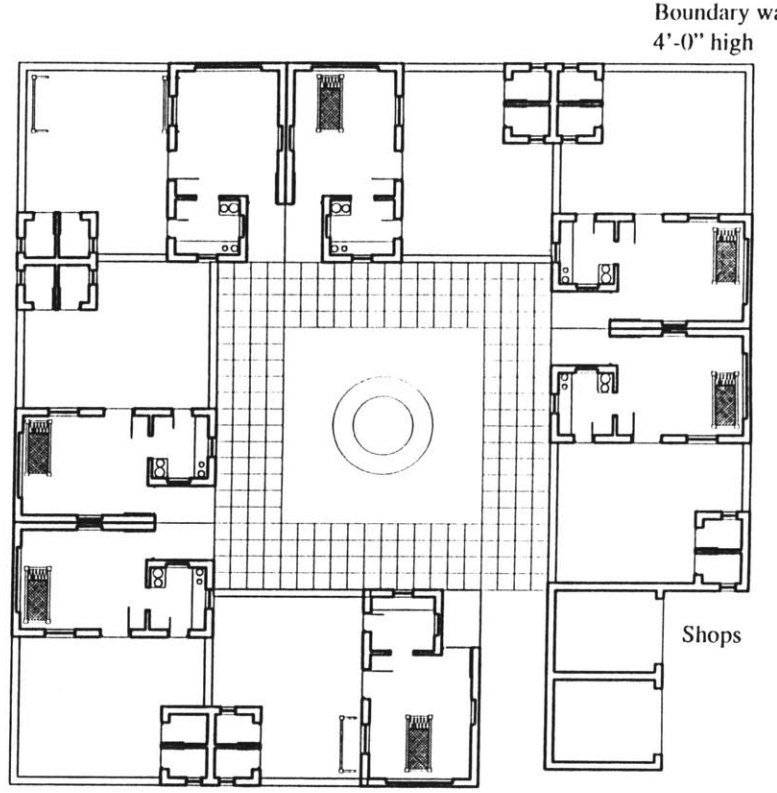
The clusters have been designed keeping in mind the cost of infrastructure i.e., the cost of laying water and drainage pipes, street lighting, roads etc. The toilets and the septic tanks have been grouped together to reduce the cost of laying infrastructure and better servicing.

The public space in the center of the cluster has an underground water tank which will be used for rain water storage and can function as an effective community space, specially in hot- dry months. As the calculations indicate this should be able to provide for almost 2 months of water supply. The excavated soil will be used for making stabilized soil blocks for the construction of houses around the court/ tank.

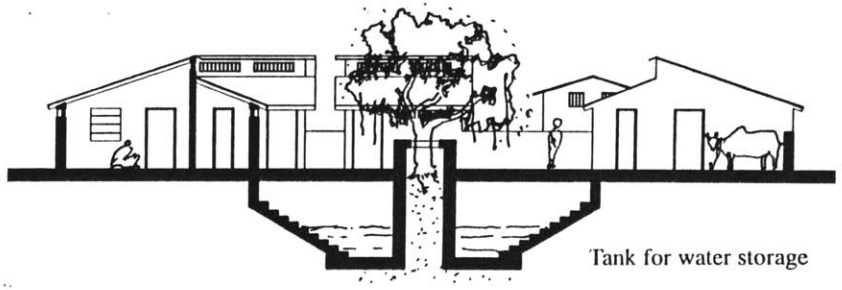
Planting a tree in this central space with a platform around it, will provide shade and opportunity for neighborhood interaction.

Shops are located at the entrance to the cluster for reasons of privacy within the cluster, and at the same time to scatter the public infrastructure evenly throughout the community.

The units have been arranged in such a way, that additions are possible and the cluster can expand in any direction depending on site conditions.



Plan



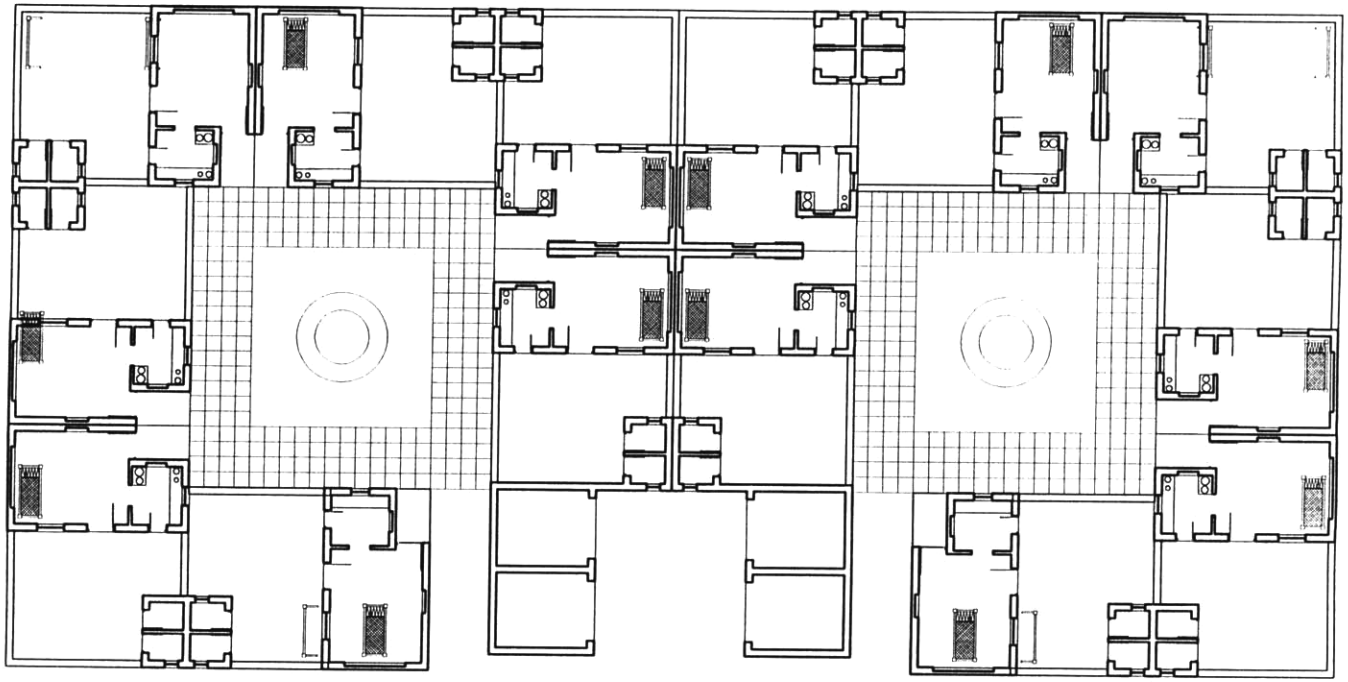
Section

Cluster Layout

The cluster layout has been done with emphasis on servicing and infrastructure development. Grid layout will facilitate grouping of pipes and avoid unnecessary expenditure on piping and cables. This will also allow for better distribution of bio-gas.

Shops are scattered throughout the community. There is a possibility of creating animal sheds in place of shops according to the needs of the community.

Boundary wall
4'-0" high

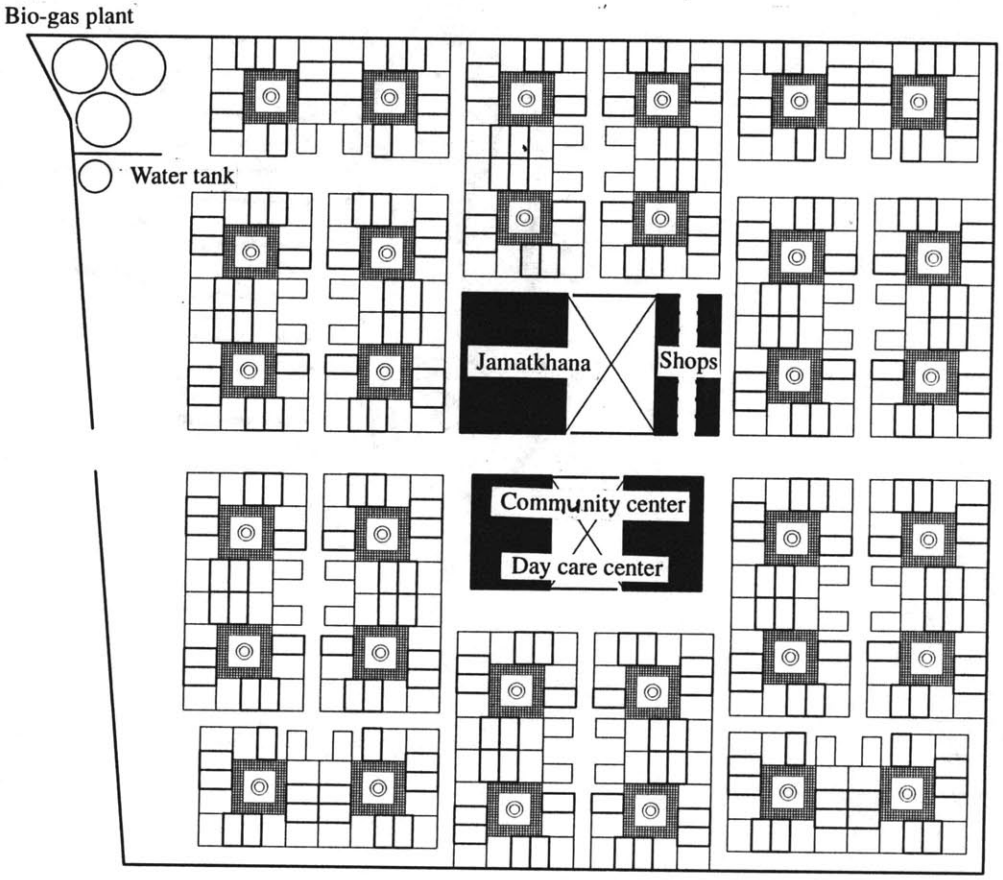


Plan

PROPOSED LAYOUT

The layout has been done according to the site contours. Water tank and bio-gas plant have been located at the highest point to facilitate distribution.

Community facilities like the Jamatkhana and the welfare/ cultural center have been located in the center on an axis as land marks for the community. Besides the scattered shopping, a main shopping area has been developed right in the center which will have the public distribution shops, the kerosene/ firewood depot and other important facilities like bank and post office.



SECTION III
REFLECTIONS

ANALYSIS

Change is inevitable. If Gujrat has to grow and prosper, it will have to keep pace with the demands and changes in available technology. This thesis puts across proposals of building and construction technology that have been tried and tested elsewhere in India.

The systems and materials suggested will not only make the construction simpler and save time, but will also be cost-effective. The proposed "Rat-trap" bond uses 25% less bricks than the conventional brick bonds, which is a major saving on material, and will reduce the total cost of construction.

These new techniques will not only create new job opportunities, but also revive dying arts and crafts, like pottery. This can be achieved by setting up materials workshops and vocational centers/ training institutes, to train villagers/ workers in these areas.

The study also sets up the stage for the use of appropriate technology and materials in these areas, to change current (expensive) methods of construction, improve the quality of life by seeking desirable changes in current life-styles.

This has to be followed up with detailed, on site investigations of religious and social structures and making appropriate adjustments, before implementation.

The design suggested is conceptual, and obviously needs critical analysis and refinement before being used as a prototype.

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Illustrations

Page 16- 23 ..... Survey of India
Page 66- 92 ..... Gujrat Workshop, MIT Spring 1996

All other illustrations are by the Author.