LOW-INCOME HOUSING: ALTERNATIVE STRATEGIES FOR BUILDING CONSTRUCTION AND PROJECT CONTROL

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ABSTRACT

Housing low-income groups, who cannot afford even the most minimal shelter, remains a dominant issue in most developing countries. However, all the solutions advanced so far depend on large investments, either by the Government or by the individuals concerned, which neither of them can afford. This thesis examines squatter settlements in Aurangi, Karachi (Pakistan) and identifies issues related to housing and the policies currently being implemented. The results of that investigation indicate that housing the low-income, given the economy and housing policies in most developing countries, can most effectively be realised by encouraging self-help methods. However before self-help methods can be realised construction techniques have to be simplified. This thesis proposes an alternate construction method which promises to simplify some of the building tasks in construction of low-rise dwellings, and hopes to reduce the overall material costs in construction. This method relies on using fabrics as formwork in construction. This fromwork is used in making walls, beams, and domes. A cost comparison is made with the current construction techniques in the country and the proposed building strategy is found to be highly competetive.

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If you give a man a fish, you feed him for one day.
If you teach him to fish, you feed him for many days.

Glossary of Terms

Bustees: Squatter or unauthorized settlement

Baldia: Municipality

Charpoy (Charpai): Bed made of twine or bamai

Chatai: A mat of straw reeds or dried palm leaves

Goth: Subdgu village (within the city perimeter)

Juggi: Squatter area; also, a temperary shelter made from reed mats, mud, etc.

"Katchi Abadi": Unauthorized settlements

Kutcha: Temporary, new, a house made of mud, reeds, mats, etc.

Mistri: Craftsman, a mason; also contractor

Pucca: Permament

Ruppee: Pakistan currency; 100 paisa make a Ruppee; US $1.00 - 11.50 Rs (1981)

Semi-Pucca: Having a non-permanent roof (i.e., asbestos, aluminum roofing sheets)

Sarkanda: Reeds

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CHAPTER 1

1.0 Introduction:

1.1. Background

One of the more immediate concerns of most developing countries is to provide shelter and other support institutions for the massive influx of migrants to urban centers. The situation has not only strained the limited resources of most of these countries but so far escaped a convincing resolution. The problem looms large and threatens to remain one of the dominant impediments to the socio-economic development of most of these developing countries for the rest of the century.

The problems and issues that have been generated are manyfold. There are inadequate standard housing units and those that are being produced, through public or private intervention, serve only a limited number and only the few fortunate enough to afford them. The scenario is more of production targets not being met, land and construction costs being higher than that assumed, and most dwellings units designed for the lower income groups going to those with much higher incomes.[1] Continuing inflation of land values and speculation in the housing market make the situation worse. Most of the migrant population, a major portion of the growing urban population, resort to impromptu improvisation of shelters and squatting on any available land. Lack of tenure negates any sense of security of shelter and often results in alienating the individual socially and economically from the rest of the urban population.[2] As a rule, the conditions in the squatters need environmental upkeep.

1.2 The Global Situation.

The population of squatters compared to city population varies from 15% to as high as 80%, in case

TABLE 1

Per Cent of Increase in Total World
Population and in World Urban Population
1800-1850, 1850-1900, 1900-1950

Years	Total World population % increase	World population living in agglomerations of 20,000 inhabitants or more % increase	World population living in agglomerations of 100,000 inhabitants or more % increase
1800-1950	29.2	132.3	76.3
1850-1900	37.3	193.5	222.2
1900-1950	49.3	239.6	254.1

Source: United Nations Secretariat, Bureau of Social Affairs in cooperation with International Labor Office, Food and Agriculture Organization, United Nations Educational, Scientific and Cultural Organization, and World Health Organization, Report on the World Social Situation Including Studies of Urbanization in Underdeveloped Areas (New York: United Nations, 1957), p. 114, Table 2, as compiled in Breese.

of Jakarta[3] and as high as 30% in case of Karachi, Pakistan.[4] Different criteria used for defining "slum" in different places makes statistical comparison difficult. However, all studies indicate that low-income housing problems have been aggravating at a faster rate than the rates of growth of cities.[5] In Karachi a population of 1.6 million out of 6 million live in "Katchi Abadis."[6] About 80% of Jakarta's population lives in Kampungs. An estimated 70% of Jakarta's new growth continues to be absorbed by unplanned Kampungs on the periphery of the city.[7] In the case of Phillipines out of Manila's population of 4.9 million almost 2 million or 40% are estimated to be either squatters or living in sub-standard housing. Over 30% of greater Bombay's population is estimated to be living in squatter settlements and almost 80% city's housing stock consists of huts and chawls.[8] Between 50 and 60% of Colombo urban population lives in "slums" and shanties.

1.3. Housing Policies.

Past Public Policies:

The existence of large numbers of squatters is a manifestation of inadequate housing, and inappropriate policies at the metropolitan and regional level. The problem is complex and most governments are incapable of initiating any comprehensive improvement program, as resource limitations make such attempts prohibitive. However public policies toward squatter has shown a gradual transition. In the past, demolition and clearance of squatter settlements by owners, whether public or private, was the norm. Clearance often met voluntary or forced relocation to less obvious outskirts. While the Government saw these settlements as eyesores and inconveniences, to the slum dweller it represented shelter, close to job opportunities in the city. Appropriate policy approaches became exigent only after enormous increases in both the scale and rates of growth in recent decades. In most cities of the developing world, eviction had been practiced at one time or another. Often in these cities policy changes were made, but eviction was still practiced under one pretext or another and continues even today. The justifications for such actions have been forwarded as a desire to remove the ugly blotches from the city's social fabric; to either arguments that the land under occupation is needed for more desirable, albeit, profitable uses; to arguments that these settlements are marginal to the formal economy.[9] On a regional level constraints to inter-city migration has been practiced by imposing restrictions on new-comers.[10] These policies, as a whole, have contributed to lack of growth to outright depletion of housing stock, causing over-crowding in existing housing and proliferation of less developed, mostly inner city,[11] housing stock.

Present Policy Trends.

In most cities of the world the current policies are more positive in outlook, generally demolition of housing is avoided, and policies of forceful prevention of growth or relocation has been replaced by policies stressing the need for environmental improvement by dwellers involving socio-economic upgrading. However, specific tactics to achieve these goals, given the lack of resources, have not materialized in most cases. Some projects like the Kampung Improvement Programme in Jakarta," and programs of National Housing Authority of Bangkok and Manila, testify to the change in policy. Many of the cities have initiated in site improvement of infra-structure and services while dwelling improvement is left to owner occupants through mobilization of household labor and savings. The advantages of such a policy are a minimum disturbance to existing communities; an improvement of existing housing stock rather than its depletion; low per capita costs to the Government compared with building standard houses; negligible management costs; intensification of labor and resource utilization in these areas; the political advantages of social stability derived from spreading the benefits of scarce resource among a larger section of the population; and generation of communal interaction through reinforcement of collective enterprise.

However enlightening such policies are they have only achieved limited objectives harnessing of the skilled and unskilled manpower resources has not been fully investigated. Much work, generating specific programs which would combine public policies with collective enterprise remains to be done.[5]

1.4. Traditional and Environmental Approach.

There are a number of specific approaches but they can be basically clustered under two categories: the traditional and the environmentalist approach.

Traditionalists see the problem as quantitative, i.e., the number of sub-standard housing. The environmentalists have a broader perception of the problem. They see housing as a symbiotic process closely appendaged to the socio-cultural and economic aspiration of the squatters. Traditionalists evaluate housing on the basis of (i) access to areas where family activities occur daily (ii) its adequacy in dealing with the hostile environment (iii) degree to which security of tenure is assured.[12]

Until now, much to the chagrin of the squatters, government planning policy was dominated by the traditionalist approach. Its validity has been questioned on the following grounds.[13] Deficits are calculated arbitrarily without taking into consideration values or preferences of the people to be housed. Secondly, some calculations of housing deficits show traditional solutions to be well beyond the current capital investment rates of most developing countries.[14] This results in the housing sector competing with other sectoral investments. Inevitably housing gets a lower priority in developing countries with scarce capital resources "because its desirability is minor in economic terms compared with productive activity investment."[15] Thus, housing shortages in developing countries continues unabated.

The environmentalists on the other hand are more concerned with the improvement of what exists,[16] with the help of whatever solutions are available now instead of waiting for new technical solutions, and thus waiting for new resources to materialize in order to meet some fancy standard. These solutions rely heavily on talents of the dwellers themselves and attempt to maximize their enterprise, initiative and resourcefulness. These resources can be utilized more effectively if there is a better resource inventory and management through neighborhood community organizations. The failure of traditional design methods can be attributed to lack of interest by professional bodies, i.e., architect, engineers, to investigate potentials for low-cost housing. This neglect is partially due to all education being oriented along the lines of western countries, with very little applied technology investigation. Most countries maintain building codes - standards imposed by the colonalists who were more concerned with controlling rather than generating growth.

The reaction of the people is only natural, they disregard codes which are beyond their ability to afford and implement. The crux of the environmentalist argument is a greater degree of self-help; use of local materials and indigenous manpower; and emphasis on lowering of minimum standards for housing and a demand for more communal facilities and services.

To the traditionalists the views of environmentalists are suspect. Traditionalists counter that to lower the housing standards is to turn the clock back on progress and lose faith in human ingenuity. They advocate seeking higher standards and actively advocate standards achievable through mass industrialized housing.

These arguments are parochial and pernicious and are not circumspect of conditions in developing countries.

The first question is who sets the standards. Very often these standards are a legacy of the colonial past and arbitrary in nature. Secondly lowering the standards will absorb more of the housing stock, considered presently sub-standard and hence ready for demolition. This will permit the squatter to use his ingenuity and skill and apply it to housing production rather than invest his limited savings on a sub-contractor to perform the same job.

Thirdly, the argument that lowering standards will increase social tensions is untenable and unsound as all the squatters want is a secure shelter.

Lowering of the standards will generate self-help, mutual help, and establishments of co-ops which will figure out ways to mobilize local capital and manpower resources. This will stimulate craftsmanship, and develop social and political consciousness - by providing grass root participation from dwellers. If the Government wants to help subsequently it has to merely consider ways of marketing the resources, human and material, that are generated from these locales.

1.5 Conclusion.

We can summarize our discussions as being:

1. The current attitude of Government in terms of squatter housing treats housing merely as a means of shelter and does not view it as serving other socio-economic needs of the dweller.
2. The efforts should be concentrated on upgrading existing stock and providing services to the squatter areas.
3. Security of tenure is a crucial issue in mobilizing self-help potentials of the squatters.
4. Encouragement of self-help housing and environmental development will have very strong positive impact on self-employment and communal self-reliance and capital creation.

1.6 Methodology: Thesis Proposal

The objective of the thesis is to investigate the urban squatter condition in the context of Aurangi, Karachi and determine how squatters may mobilize their resources, in the context of overall squatter upgrading process - with particular emphasis on delivery of the housing unit. The other objective is to identify the socio economic issues that must be considered while designing squatter housing programme.

The solutions however are not unique to Karachi and can be applied to most developing countries.

The research was conducted in two parts. The first part consisted of a field trip to Karachi, visiting the various squatter settlements, conducting informal interviews to assess the needs and issues that the squatters considered relevant. This was complemented with discussions with the Governmental agencies and assessment of their views and policies on squatters.

The second part consisted of laboratory work at the university to investigate certain housing systems which would reduce cost of construction. Two systmes were finally chosen and developed more extensively. These systems were only investigated to a limited degree and their true potentials can only be realized after more research, which limitation of time and funds has made it prohibitive at this stage.

1. Sarin, Madhu. "Policies Toward Urban Slums: Slums and Squatter Settlements in the Escap Region," United Nations, 1980, p. 7.

2. Breese, Gerald. Urbanization in Newly Developing Countries. Prentice Hall, Inc., New Jersey, 1966, p. 5.

3. Sarin, op. cit., p. 9.

4. Directorate of Katchi Abadis, Karachi Metropolitan Corporation, "A Place to Live: Katchi Abadi Improvement in Karachi, Pakistan (Karachi, January 1979), p. 3.

5. Sarin, op. cit., p. 9.

6. Directorate of Katachi Abadis, op. cit., p. 3.

7. Sarin, op. cit., p. 67. "The new Kampungs on the periphery have developed after 1950 and are the main response to the housing needs of the city's rapidly growing population. Growing at 15 percent they housed 32% (1.6 million) of Jakarta's population in 1973.

8. Ibid., p. 9.

9. Peattie, Lisa and Haas, A.A., Jose, "Marginal Settlements in developing countries. (Department of Urban Studies and Planning, M.I.T., Cambridge, MA 02139). These informal settlements are treated differently by different groups. One school of Morris Juppenlatz writes (1920), "As the political control of cities with an urban squatter problem passes from the presently established urban society, who have little or no heritage of city dwelling, and who at present have no training or administrative knowledge of city maintenance, it can be expected that essential services will diminish until they finally break down and collapse." (p. 171) He views them as an invading group who threaten to pollute the city. However another perspective, Margin sees them as "a process of social reconstruction through popular initiative." He does not see them as pathological but as creative, city builders, and creaters of new institutions. (Mangin, 1967 b)

10. Sarin, op. cit., p. 9.

11. Harst, D.J. van der. "Low Income Housing." JRP Project IV, Institute of Business Adminsitration, University of Karachi, 1774.

12. UN Department of Economic and Social Affairs. "Improvement of Slums and Uncontrolled Settlements," (Repast of the Inter-region Seminar on Improvements of Slums and Uncontrolled Settlements, New York, 1971), p. 17.

13. Schmitz, Gunter. "Lower Cost Housing Re-
search": Proceedings of the Second International
Symposium on Low Cost Housing Problems. (ed. Oktay
Ural, University of Missouri-Rolla, 1972. p.43)

14. Ibid., p. 43.

15. UN Improvement of Slums, op. cit., p. 45.

16. Chandrasekhara, S.C., "Problems of Low
Cost Housing in Asia: An Overview."
(ed. Dieter Bielenstein, Tokyo, 1973),
p. 19.

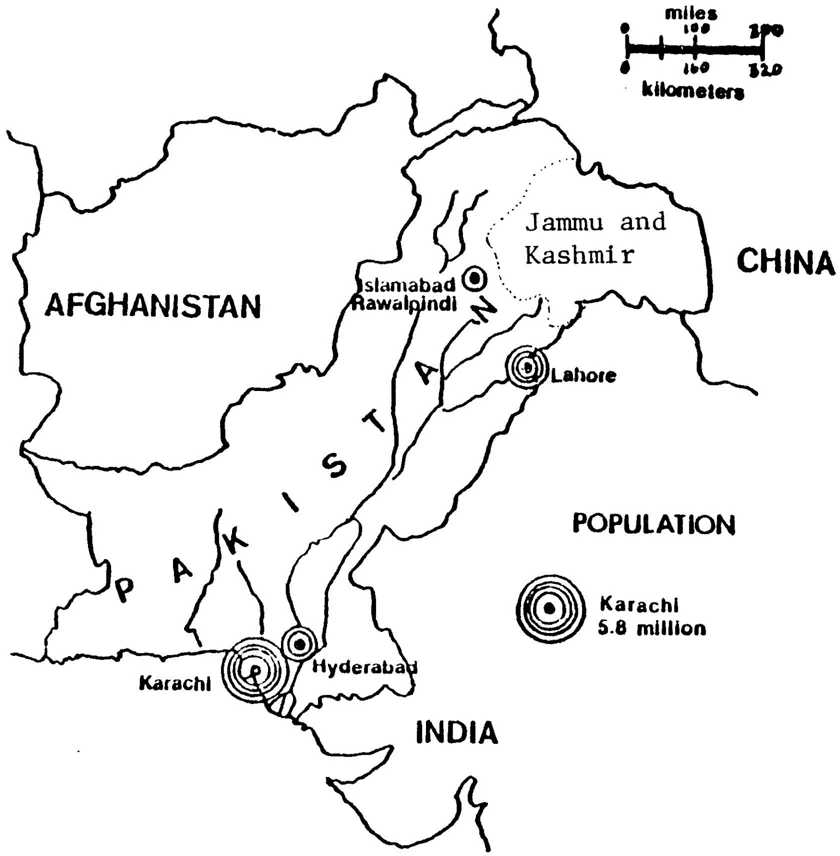


Fig. 1

Karachi Development Authority, Master Plan Department. Master Plan for Karachi Metropolitan Region, p.5

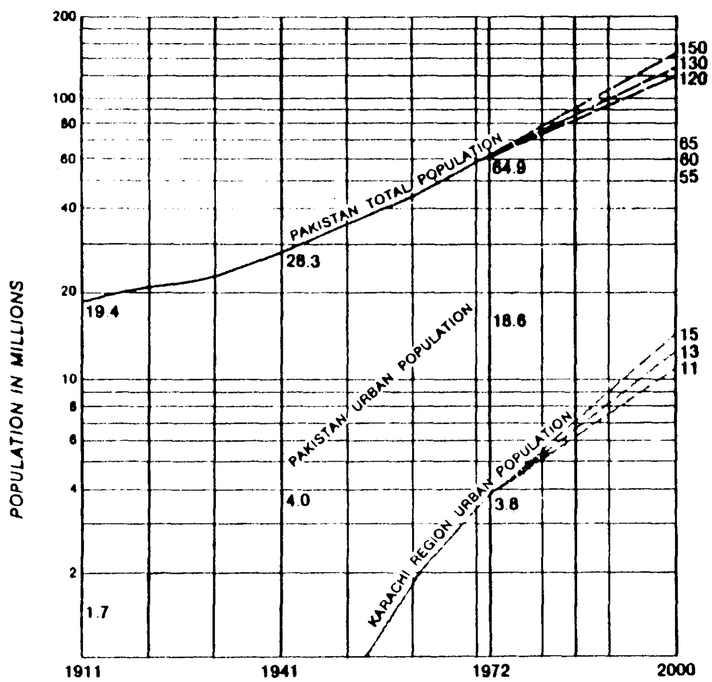
Chapter 2

2.0. PAKISTAN: The National Context

This Chapter hopes to introduce the country and its people and the current policies on housing on the national and metropolitan scales.

2.1. PAKISTAN: Primary Information[1]

Country:	Islamic Republic of Pakistan
Capital:	Islamabad
Population:	77.3 million
Growth rate	3.1%
Density	96 persons/square kilometer
Urban	28%
Urban growth rate	6.0%
Area:	804,000 square kilometers
Geography:	Six regions: northern mountains, sub-montane plateau, Indus Plain, Baluchistan Plateau, western bordering mountains, and desert areas. Major river system: Indus River
Climate:	Hot dry summer, monsoon season, moderately cool winter



POPULATION GROWTH • 1911-2000
PAKISTAN TOTAL, PAKISTAN URBAN, AND KARACHI REGION URBAN

Fig. 2

Languages:	Punjabi, Urdu, Baluchi, Sindhi, Pashtu, Brahui, and English
Religions:	Islam 93.6%, Hindu 5%, and Christian 1.4%
Currency:	Ruppee. 1 ruppee = US $ .10
Per Capita Income:	GNP/capita US $ 230
Major Cities:	Karachi, Lahore
Production:	Industry 24%, growth rate 4.8%, Agriculture 32%, Services 44%

Geography[2]

Pakistan, situated in south Asia, is bounded on the north by Afghanistan and the U.S.S.R., to the east and southeast by India, and to the west by Iran. It lies at the western end of the Indo-Gangetic plain, with the mountain wall of the great Himalayan ranges to its north. Its major rivers are the Indus and its four tributaries, the Ravi, the Sutlej, the Chenab, and the Jhelum. The areas served by these river systems are fertile and intensively cultivated.

1. Karachi Development Authority, Master Plan for Karachi Metropolitan Region, (Final Report, August, 1974) p. 10

The country is divided into six natural regions: the northern mountains, the sub-montane plateau, the Indus Plain, the Baluchistan plateau, the western bordering mountains, and the desert areas. The characteristics of different areas are determined by variations in rainfall and irrigation, rather than by temperature. Although the country is dominated by monsoon winds, it is extremely arid with an average precipitation of less than 20 inches in all areas except for the southern slopes of the Himalayas and the sub-montane tract which receive an average rainfall of 30 to 35 inches.

There are essentially three seasons: summer, winter, and the monsoons. The hot, dry summer lasts from March to July. The monsoons begin in July and last until late September. The moderate winter runs from November through February.

2.1.3. Historical Background

Pakistan gained independence in 1947 when the former British India was partitioned into India and Pakistan. From 1947 to 1971, Pakistan consisted of two regions: West Pakistan in the Indus River basin and East Pakistan, located more than 1,000 miles away in the Ganges Delta. However, in 1971 due to grave internal problems, East Pakistan became the independent autonomous state of Bangladesh.

2.1.4. Administration

The political system of Pakistan has undergone several changes since 1947. The first Constitution was enacted in 1956 and brought a presidential form of government. However, the basic administrative structure has remained virtually unchanged since colonial times. Provinces are subdivided into divisions, districts, and "tahsils," which are governed by a hierarchy of administrators.

2.1.5. Economy

The economy relies heavily on the agricultural sector. The major crop is cotton. Pakistan's economic performance compares favorably with most developing countries. By 1980 the country was self-sufficient in staple food crops. Progress has also been made in diversifying the manufacturing sector. Agriculture accounts for 45% of the gross domestic product (GDP) and provides employment to about 50% to 60% of the work force. Industry accounts for about 20% to 25% of GDP and employs about 15% of the work force.[3]

Some 20 different types of minerals have been identified in Pakistan. There are deposits of natural gas, as well as limestone to serve a growing cement industry. There are several hydroelectric projects which have started fueling its expanding industries.

Until late, economic development has been concentrated in the provinces of Punjab and Sind, which contain about 75% of the rural population and produce 75% of the country's wheat, more than 95% of its rice, and 100% of its cotton. Most of the industrial development has occurred in these two provinces. The remaining two provinces, Baluchistan and the Northwest Frontier, are poorer by comparison.

Throughout the country there is a concentration of land-ownership, although successive governments have pledged land reforms. Until recently, most of the country's industries were owned by a few individuals, but this has changed with the nationalization of major industries in the 1970's.

2.1.6. Demography

Over recent decades, Pakistan has experienced dramatic population increases due to internal migration and to a high rate of population growth. Between 1901 and 1961, the population increase was 158%. From 1951 to 1961 population increased by 27 %, and from 1961 to 1972 by 51%.[4] In 1980, Pakistan had a population of 77.3 million.

Regional distribution of population varies with the highest density in Lahore district, 1,698 people/square mile, while in Quetta division the average population density is 26 people/square mile.

2.1.7. Living Conditions

Although the standard of living has improved, poverty is still widespread. A large segment of the population is able to purchase only the basic necessities of life. Per capita income is around US $ 250. In recent years Pakistan has acquired self-sufficiency in food production.

There is an acute shortage of housing, totalling four million dwellings: one million in the urban areas and three million in the rural areas. Basic services such as water supply, sewage disposal, and electricity are generally inadequate in both urban and rural areas. health care is also inadequate, and generally falls into two categories: one along Western lines and the other a homeopathic approach which is indigenous, therefore, more popular and widespread.

2.1.8. Population Characteristics

The population is a complex mixture of many ethnic groups introduced by migrations from the northwest, and by internal migrations across the subcontinent.

The population can be grouped regionally into the following four categories:[5]

The Mediterranean type, found in Punjab.

The Oriental/Mediterranean type, found in both Punjab and Sind.

The Pashtuns of the Northwest Frontier province.

The Baluchis, who originate from Iran.

The country is linguistically heterogeneous. The distribution of languages as reported in the 1961 census was as follows: Punjabi 66%, Sindhi

13%, Pashtu 8%, Urdu 8%, Baluchi 2%, and Brahui 1%. Because of a lack of common language understood by all, English is used in addition to Urdu for official purposes, except in local administration, where local dialects dominate.

About 97% of the population is Moslem. There are both Sunnis and Shiites, including Ismailis, Bohras, and Ahmadis. In addition, the Christians constitute 1.4% of the population and the Hindus 0.5%.

2.1.9. Literacy

The literacy rate is about 16%. About 10% of the literate population has had no formal education. Urdu is the medium of instruction at the elementary and secondary levels, and English is the medium of instruction at the university level. There are five multi-faculty universities as well as several engineering and medical schools.

2.1.10. Settlement Patterns

The vast majority of the rural population lives in nucleated villages or hamlets. Dispersed habitation patterns in the form of isolated single homesteads are rare, occurring only in a few mountainous areas. Patterns of habitation in villages are varied and complex. Clusters have a dozen or so buildings, and there are usually a few hundred dwellings in each village with populations rarely exceeding 2,500 persons.[6]

There are two basic types of village layouts. Most of the older villages have a spider web form, having at least one focal point such as the village mosque, some shops, or a well, from which the lanes radiate outward. In the canal colonies, villages are of a regular rectangular pattern, with a well, a mosque, and a school or other communal facilities. The houses are generally arranged in a series of concentric rectangles.

Houses are built from locally available

material, and the majority are of mud. They generally have a courtyard where animals are tethered, and the open space is used for sleeping at night in summer. There is another type of layout which is found only in certain areas of the frontier provinces and tribal areas. It consists of isolated housing, each having a roofed structure and a walled enclosure so that each unit is like a fortress.

2.1.11. Urbanization

The country experienced rapid urbanization after independence. Initially this was a spontaneous process triggered by migration of millions from the Indian side of the sub-continent. Most of these migrants moved to large urban centers, i.e., Karachi, Daccan, Lahore, as well as to smaller centers like Chitagong, Khulna, Multan, Hyderabad, Quetta and Peshawar. The upper and the middle income groups were able to build pucca* and semi-pucca quarters while the poor had often no alternative but to squat on vacant land without any legal tenure.

The development of most cities has been unplanned and basic services and facilities are lagging behind the needs of the urban population. The urban growth rate is estimated at 6%, about twice the national population growth rate. Conservative estimates place growth of urban centers in Pakistan at a rate of a million per year, and it is estimated that by 1985, 35 - 40 million people[7] will be living in urban areas. The population growth is irrespective of any population control program. This will put an added strain on the country's resources to provide adequate jobs, housing and other social amenities.

2.2. Housing in Pakistan:

The shortage in urban housing has been linked to increased demand for housing by migrants attracted to job opportunities generated by industrial and commercial activities in cities. Government documents provide inadequate arguments for the shortfall.[8] These are

1. high cost of building material;
2. excessive and rapid increase in price of land ownership out of the reach of the lower middle and low income families,
3. the lag between housing construction and population growth;
4. the failure to achieve decentralization of industry and integration of industrial development and housing programmes;
5. low income of people - inability to pay rent for even cheapest form of housing;
6. lack of financial institutions for providing adequate credit for housing at reasonable cost;
7. lack of proper institutional arrangement to deal with the housing problems;
8. Implementation of immature policies converted to plans and programs which resulted in poor recovery of loans and mortgages.
9. shortage of materials, machinery and equipment;
10. lack of any process of evaluation and feedback; and
11. low priority accorded to housing at the time of preparation of annual development programme.

2.2.1. Conclusion:

In most Asian countries the uncontrolled migration can be attributed to "push" due to desperate necessity to move from conditions in rural areas.[9] In case of Karachi a large portion of the migrants have come from India and Bangledesh due to political factors. The skilled among these migrants have managed to obtain some form of regular subsistence but the majority live in hovels of poverty. The entire urban structure and the infrastructure was not designed to take in such a massive influx of population. The result is that they have been pushed to peripheral areas of the city and were initially treated as marginal population.[10] Government policies in recent years[11] have started to develop industries in these urban areas but they are more or less contained to cities which have ease of access or provide convenient distribution of manufactured goods.[12] These poles are Karachi, Lahore, Lyallpur, Hyderabad, Gujranwale, Multan, Rawalpindi, and Peshawar. More than 50% of the total labor is located in these cities. No serious effort has been undertaken by the Government to dispense industries to other poles. Hence, an industrialist prefers to invest in major urban areas where he has greater access to market, infrastructure, and credit facilities and will not be attracted to all kinds of subsidies that might be provided by the Government for developing in less populated areas.[13] Hence congested cities continue to grow with increasing levels of congestion.

2.2.2. Options for Solving Housing Crisis:

Given the situation as discussed above, the Government should seriously persue policies of mixed development. This will spread the resources more equitably over the entire country. The Government is aware of this and has been making attempts in this direction. The Government has come up with a proposal of agrovilles[14] which are a policy of implementing concentrated decentralized form of development. The agroville program, and several other programs, are part of a comprehensive long range planning policy. However these long range measures should be supplemented with short range curative measures, which address the more immediate priorities. Hence long range measures can be implemented through central government in Islamabad or could be policies of the provinces while short range policies would be in the domain of the city and towns. The Pakistan Planning Commission does acknowledge that there have been no comprehensive schemes which have looked at long term and short term goals as distint developmental programs.[15]

2.2.3. Investment in Housing:

In most developing countries including Pakistan, the housing sector receives a lower priority than other national economic sectors. The question that becomes most important for the Government is one of investment which has a higher and quicker return of capital.

However, research has shown that housing is a viable investment. In Colombia estimates suggest that income multiplier for housing construction is about 2,[16] and that seven additional jobs are created for every U.S. $10,000 spent on construction of dwelling units.[17] Similar results have been found for Pakistan, India and Mexico.[18] This does mean that self-housing should not be considered the only panacea to national housing shortage but should be one additional strategy for increasing the housing stock.

Karachi Development Authority, Master Plan Department. Master Plan for Karachi Metropolitan Region p.2

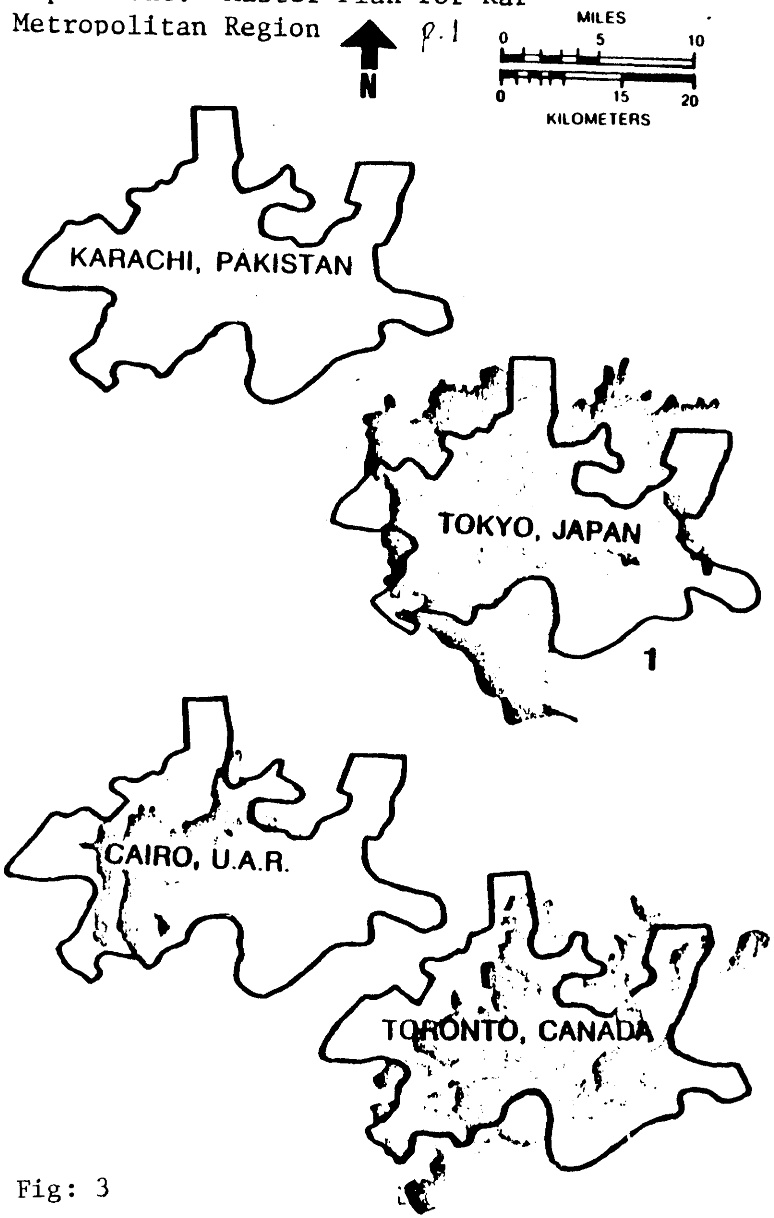


Fig: 3
Urban Area Comparisons

2.3 KARACHI: URBAN CONTEXT

2.3.1. Introduction.

Karachi is the principal seaport and the largest city in Pakistan. It is located on the coast of the Arabian Sea. It is the capital of the province as well as the headquarters of the district and division of Karachi. It is also a major commercial and industrial center. Karachi metropolitan area covers 560 square miles. About half of this area is highly developed, surrounded by a zone of agricultural land and government wasteland. The population is estimated 5,800,000.[19]

The city proper lies on the shores of the Karachi Harbor. Inland the ground rises from the shores to the north and the northeast to 120 feet above sea level. There are two main seasonal rivers passing through the city, the Malir and the Lyari.

Karachi enjoys pleasant weather during most

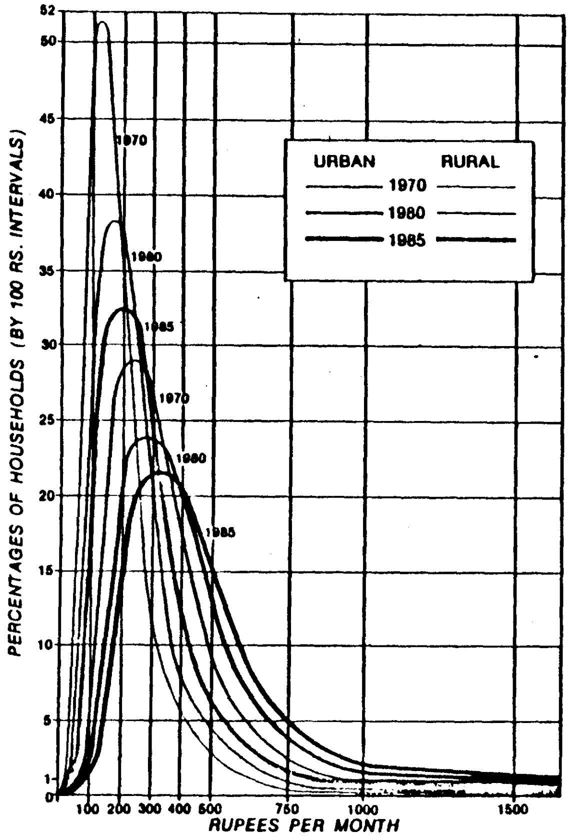


Fig. 4

Source:

Karachi Development Authority, Master Plan Department. Master Plan for Karachi Metropolitan Region p. 306

of the year. May and June, the hottest months, have a mean temperature of 93°F. The cooler months are January and February, when the minimum mean is 56°F. The relative humidity varies from 58% in October to 82% in August. Average rainfall is 8 inches.[20]

Natural vegetation is scanty. Mangroves lie along some of the shores; coarse grass, cactus, and castor plants occur on plains and hills, and dates and coconut palm groves in the river valleys.

2.3.2. Historical Background.

Karachi was a small fishing village in the early eighteenth century. It then started to expand rapidly as a port. The British formally annexed it in 1842 along with the province of Sind. It bacame the headquarters for the army and saw rapid urban expansion with the gradual development of its natural harbor into a major port. In 1924, an airport was built and it became the gateway to India by air. At the time of the creation of

Pakistan, Karachi was chosen as the capital of the new nation, and subsequently became the nerve center of the country's business, industry, and administration. It continues to play a very dynamic and dominant role in the country's economy.

2.3.3. Urban Population Growth: Karachi

During the period 1872 - 1921 there was approximately a 280% increase in the population. The other great increase occurred between 1951 and 1961 and the rate averaged 6.3 percent per annum. From 1961-1971 the growth rate has averaged 5.2% per annum. In 1981 the population was estimated at 6.0 million and by 2000 it is estimated at anywhere between 12-15 million.[21] These increases are attributable to high flexibility rates as well as continued migration of people from other regions as well as from India, Bangledesh, and most recently from Afghanistan.

In 1951 the high growth rate was attributable to immigration from India. In the period 1951-1961 immigration was still significant as it was between 1961-1971, the difference was that in this period it was from all over the country. There was significant migration after 1971 from Bangladesh of so called leih-aris who mostly settled in Aurangi, and in other squatter areas.

2.3.4. In-Migration of Future Urbanization

The forecast for employment in the country indicates that the major services, manufacturing, and construction will absorb the increasing labor force, while agricultural employment is expected to decrease by 33% by 1990. This assumes a considerable in-migration from rural to urban areas. In this connection, Karachi may expect to absorb a large portion of this in-migration.

2.3.5. Administration:

The city is administered by five institutions. The most important of these is the Karachi Municipal Corporation, which performs many civic functions affecting more than three-quarters of the population of greater Karachi. Other authorities address the needs of special residential quarters in the suburbs, the cantonment, and the port.

2.3.6. Socio-Economic Aspects:

Karachi is the largest city in Pakistan. The average population density is 300 persons to an acre, although some parts of the city reach from 500 to 700 persons per acre.[22] The city had a population of 1.9 million in 1961, which by 1972 had reached 3.4 million. The population is currently estimated at over 4.5 million.

Karachi is the largest city in Pakistan. Textiles and footwear are its primary manufactures.

Other industries include leather goods, chemicals, medicine, furniture, machinery, paper and printing material. It is also an important center for handicraft and cottage industries.

Karachi handles the entire sea-borne trade of Pakistan, as well as of landlocked Afghanistan. It is the country's banking center, and has a major stock exchange and other financial institutions. The twin bases of the city's prosperity are manufacturing and trade. Together they employ more than 44% of the total labor force. Services and professions employ 42%; transport, 9%; and agriculture, 1%.[23]

2.3.7. Housing

In 1969 when the population was estimated at 3.2 million, it was found that the city had 510,000 households in 490,000 dwelling units, an average of 1.04 households per dwelling unit. The number of persons per household was 5.75.

Over the decade between 1960 and 1970, there was a net increase of 168,000 dwelling units (an average of 16,800 per year), while the total population increased by 1.2 million. This meant an average of one new dwelling unit for 7.1 persons.

Over this period there was no change in the character of the housing stock: 45.7% was permanent; 36.8%, semi-permanent; and 17.5% temporary (shacks, etc.).

The city proper contains many old and decayed buildings occupied mostly by the middle and lower income groups. Further from the city core are new residential blocks and satellite towns for middle and lower income groups. The city is interspersed with squatter settlements which are being cleared by the municipal authorities; and the inhabitants are being relocated to other developed sites.

About 50% of the population own their houses; the remainder live in rented property.

Presently there are about 688,000 dewlling units in Karachi, of which 45% are permanent, 20% are semi-permanent, and 35% are temporary. A large population in the city lives under slum conditions. The average number of persons per habitable room is 3.9. For the lowest income groups the number is 4.7.[24]

30% of all dwellings have access to piped water supply and 20% are connected to the sewerage system. Only 16% of dwellings are fully served by sewerage and electricity connections.

In addition to the current housing deficit, population increase will generate a demand for 489,000 more housing units between 1980 and 1985. The Karachi Development Authority is able to provide only an average of 25,000 plot per year. This is highly inadequate considering that the city expects to grow to a population of 12 to 15 million by the year 2000.

Korangi. To understand the current housing policies in the city, one must go back to the first satellite town, Korangi, planned in 1958 for a population of 500,000. The site was located 10 miles outside Karachi. It was originally built to relieve the problem of refugees from India who were squatting in the city. The objective was not to create a township of low-income groups, but to provide various levels of housing so that its population would reflect the overall income distribution in the city. It was planned to be an independent community with employment, education, health, recreation, and utilities provided.

Korangi township was divided into several sectors intended to function as sub-communities. A typical sector would be as follows: (population density varies between sectors)

Sector 36A

Area:	107 acres
Gross residential density:	112 people/acre

Net residential density: 381 people/acre

Roads and unused land area: 36.5% of total area[25]

There were to be three housing prototypes: one-room, one-and-a-half-room, and two-room. Construction of these houses was heavily subsidized by the government, and the cost was to be recovered by having people pay in installments.

Most of the houses had water connection five years after the inception of the project. Sewerage was provided, but the system was plagued by malfunctions. Most houses were not connected to electric poles initially, although streets were lighted; however, connections were made later on an individual basis by the residents.

There were numerous problems with this project. First, sufficient employment was not provided in Karachi to allow Korangi to function as a satellite town. Other services (hospitals, health centers, recreation areas, schools, etc.) did not materialize due to insufficient funds. Many people did not pay their installments beyond the initial payments, and most of the defaulters were in the lower income group. Therefore, government lost considerable revenue. The cost of the project was too high - hence many of the services planned could not be provided.

Because of the exorbitant cost of the Korangi project, the Karachi Development Authority has been promoting other types of housing programs.

Open Plot Development. These schemes were attempted in North Karachi. The basic objectives were to provide the target group secure land tenure near a place of work, to prevent uncontrolled growth, and to regulate densities. A plot size of 80 square yards was decided on. Financing was to be achieved by enforced savings and taxation. It was assumed that with gradual improvement of utilities these areas will eventually become fully serviced. In spite of the fact that the authorities delayed by several years to bring the much publicized infrastructure- water, paved roads, and electricity- these areas have shown dynamic growth and continued determination of the population to upgrade their enviornment and economic status.

Utility Wall Development. These projects were conceived as both a medium and a long range program. In general, they address a higher income group than the Open Plot Developments. They provide house connections for water, sewerage, and electricity. The plots are either 60 or 80 square yards in size. Essentially, a 75 square foot concrete floor locates the kitchen, bath, and toilet core area, where the connections to utilities are provided.

The site and services project has been a complete disaster. Seven years after completion, it is still vacant. The Karachi development authority feels that this is due to the inability of the authority to provide water to this area.[26] However, interviews with several plot holders who preferred to live in unauthorized areas of Aurangi, had this to offer:

- Plots are too small:
  Hence a squatter considers 80 sq.ft. insufficient for the economic activity that he must partake in, in his house (see illustration on page
- Standard of housing:
  The standard of housing, implicit in certain model houses made by the authority, involve investments beyond the reach of even a middle income group.[28]

- Speculation in obtaining mortgages:

  They complained that mortgages were not available, accept to those who had connections with the local public mortgage bank the House Building and Finance Corporation.[29]

- Job opportunities and services:

  They felt that the area was undeveloped and the level of social services and the economic opportunities inadequate;[30] informal economic activities,[31] were absent.

Improvement and Regularization Programme

Government land leases are typically for a period of 99 years, and shorter leases provide for automatic renewals.

There is great disparity in land tenure between income groups. Extensive squatter settlements are the result of this inability of lower income groups to secure legal ownership. The Improvement and Regularization Programme for the informal sector has been developed as a short term solution to regularize land tenure in the city.

TABLE 2

Employment and Output in Economic

Sectors. Karachi District. 71-72.

Economic sector	Employment	Product (Rs. crores)[a]
Agrigulture and fishing	37,000	15.6
Manufacturing and mining large scale	173,000	182.2
Manufacturing and mining small scale	130,000	22.8
Construction	57,000	64.7
Public utilities and transportation	113,000	80.5
Trade	178,000	87.5
Banking and insurance	15,000	34.9
Ownership of dwellings	-	19.4
Services	353,000	46.1
Total	1,056,000	553.7

[a]One crore = 10 million

Source: K.D.A. Master Plan, p. 41

Table: 3

Cost of Utilities Development and Land*

Net Residential Land

Programme Type	Utility Standard	Utilities Rs/acre	Acres	Cost Utilities	Land Rs/sq.yd.	Cost of Land	Total
OPD	IV	14,800	113	1,672,000	5.00	2,820,000	
UWD	IIIa	30,070	104	3,127,000	8.00	4,160,000	
HSD	VI	43,300	27	1,169,000	50.00	6,750,000	
HSD	VIa	32,800	38	1,246,000	35.00	6,650,000	
			282	7,214,000		20,380,000	27,594,000
Community Facilities							
Education		20,000	51.0	1,020,000	10.00	2,550,000	
Health		25,000	12.5	312,000	10.00	625,000	
Com. organization		20,000	9.9	198,000	10.00	495,000	
Mosque	IV	14,800	2.2	33,000	Free		
Parks, playgrounds		50,000			Free		
Commercial	VI	43,300	19.7	853,000	150.00	7,500,000	
				2,416,000		11,170,000	13,586,000
							41,180,000

*Excludes cost of roads and off-site development for utilities.

Habitable Rooms and Construction Cost

	P/HR for 1985	HR	Housing Type	Cost Rs/sq.ft.	Average sq.ft. per HR	Construction Cost Rs
0-199	4.0	2,700	4 - 8	3.00	168	1,360,000
200-200	4.0	6,675	4 - 8	3.00	168	3,364,000
300-499	3.5	14,000	2 - 7	10.00	168	23,520,000
500-749	3.0	9,833	1 - 2	25.00	220	54,082,000
750-999	3.0	2,733	1 - 2	25.00	220	15,032,000
1000-1999	3.0	2,334	1 - 2	25.00	220	12,837,000
2000+	2.8	1,000	1 - 2	25.00	220	5,500,000
		39,275				115,695,000

Source: Karachi Development Authority, Final Report, 1974, op. cit., p. 28.

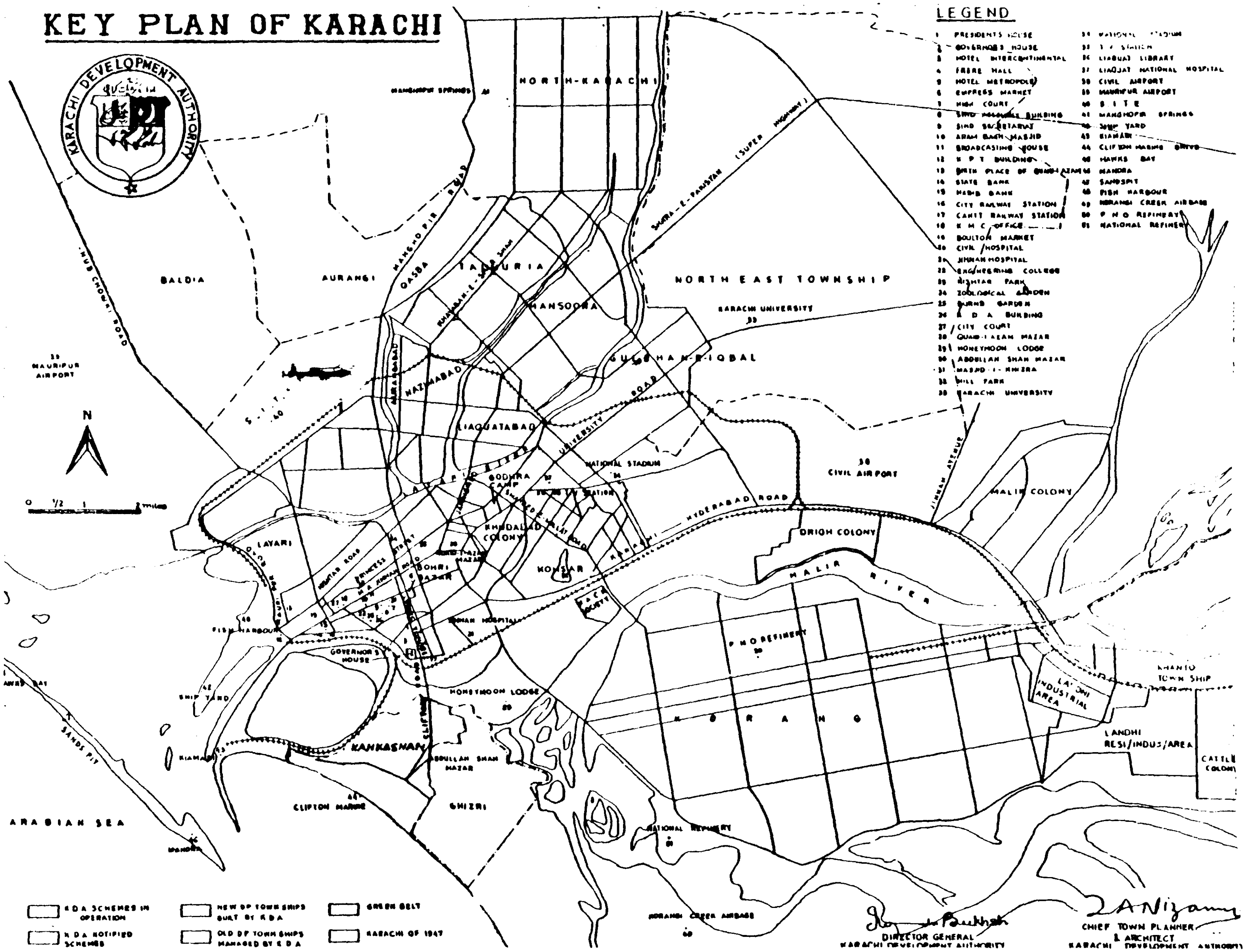

KEY PLAN OF KARACHI
KARACHI DEVELOPMENT AUTHORITY
LEGEND
NORTH-KARACHI
NORTH EAST TOWNSHIP
KARACHI UNIVERSITY
BALDIA
AURANGI
MANSOORA
GULSHAN-E-IQBAL
NAZIMABAD
LIAQUATABAD
NATIONAL STADIUM
CIVIL AIRPORT
MALIR COLONY
HYDERABAD ROAD
DRIGH COLONY
MALIR RIVER
LAYARI
GOVERNOR'S HOUSE
FISH HARBOUR
SHIP YARD
HONEYMOON LODGE
KAHKASHAN
CLIFTON
KORANGI CREEK AIRBASE
LANDHI INDUSTRIAL AREA
LANDHI
ARABIAN SEA
N
DIRECTOR GENERAL
CHIEF TOWN PLANNER
& ARCHITECT

Fig. 5

Footnotes:

1. Karachi Development Authority, Master Plan for Karachi Metropolitan Region, (Final Report, August, 1974) p. 1.

2. The New Encyclopedia Britanica, Encyclopedia Britanica, Inc., U.S.A., 1974, p. 892.

3. Ibid., p. 901.

4. Ibid., p. 898.

5. Ibid., p. 896.

6. Ibid., p. 896.

7. Ibid., p. 904.

8. Rudduck, Grenfell. "Towns & Villages of Pakistan, A Study," (Planning Commission, Government Printing Press, Karachi, 1964) p. i.

9. Robinson M. Ira. "Comprehensive Regional Physical Planning: A Second Pattern of Future Urban Growth in Pakistan," (Paper in problems of urbanization in Pakistan, Proceeding of N.I.P.A. Conference, Karachi, October 31, 1966), p. 29.

10. Lloyd, Peter, "Slums of Hope? Shanty Towns of the Third World, (N.Y.: St. Martin's Press, 1979), p. 60.

11. Pakistan Planning Commission, "Physical Planning and Housing in Pakistan," (Plan Publicity cell Planning Series, Islamabad, 1973) p. 18.

12. Ibid., p. 18.

13. Most of the country's industries are located in the few major urban centers like Karachi, Lahore, Lyallpur, Multan, Sialkot, etc. Government efforts to coerce industrialists to move to non-urban areas have not been very successful.

14. Pakistan Planning Commission, op. cit.

15. Pakistan Planning Commission. "Forths Five-Year Plan," 1970-1975 (Islamabad, July, 1970), p. 65.

16. Columbia, National Planning Office (Bogota, 1972).

17. Sarin, Madhu. "Policies Towards Urban Slums: Slums and Squatter Settlements in the ESCAP Region," United Nations, 1980.

18. Karachi Development Authority, op. cit., p. 45.

19. Current unofficial estimates. This range is felt to be within 5.5 to 6.5 million, as correct records are difficult to maintain due to irregular influx of refugees and rural migrants, etc.

20. Karachi Development Authority, Master Plan Department, Karachi, p.

21. Karachi Development Authority, op. cit. p. 18.

22. Ibid., p. 21

23. Karachi Development Authority, Master Plan Department. Master Plan for Karachi Metropolitan Region (First Cycle Report, Vol. I) September 1972, p. 23.

24. Karachi Development Authority, Karachi

Master Plan, Final Report, op. cit., p.21.

25. United Nations, Master Plan for the Karachi Metropolitan Region," Case Study: Karangi 36A," Report No. MP/RR/70, Karachi, 1973. p. 9.

26. Karachi Development Authority, Final Report, 1974, op. cit., p. 28.

27. Conversations with some residents of Aurangi revealed that they had bought plots in the site and services, Metroville I project, but due to delay in its scheduled delivery date, they had decided to settle in a non-regularized area of Aurangi. They were not sure if they would ever live in the sites and services project, instead were contemplating selling their plot at a premium price. Currently they did not pay any rent on their land but felt pretty confident that that they would not be evicted from the area they were squattting in. Their confidence stemmed from the fact that they were on the periphery of the city where nobody wanted to live.

CHAPTER 3.

3.1 The Squatter Settlements of Karachi.

The squatters in Pakistan are called "bustees" or "juggis." The term "juggi" is also used to refer to a dwelling unit in which a squatter lives. The houses initially are mere shacks made of chatai (bamboo or reed mats) or sarkanda (long reeds) or simply a bed (charpoi) spread under a tree or under a rudimentary canvas shelter. Once a plot is staked out the shelter is made more permanent using material as available in the local market (rags, tin sheets, etc.) Initially they build with bamboo for support and tarpaillin or reed for roof and wall. As liquid assets increase, employment, informal economic activities - they build with more permanent materials.

3.1.1. Origins of Squatter Settlements.

The first squatter population moved to the city immediately after partition of the subcontinent in 1947, and creation of Pakistan. The population influx into Karachi, after independence brought in about half-a-million refugees who initially squatted on open spaces, roads, footpaths, and on any space that they could find. From 1947 to 1952 the population of the city had increased from 436,000 to 1,150,000. Currently about 250,000 persons or 40,000 families are added each year to the city.[2] Out of the 60,000 dwelling units that are required annually, only 15,000 are being constructed by both the public and private sectors, bearely 25% of the actual need.[3] The total area on which squatters "Katchi Abadis" are located are estimated at 10,000 acres and are spreading at an annual rate of 300 acres. In 1957 the backlog in housing was estimated at 380,000 today it is estimated at 1,000,000.[4]

3.1.2. Reasons for Squatting:

The Karachi Development Authority has done considerable work on identifying these reasons. Some of the reasons KDA lists for creation of slums are:[6]

1. Initial influx of refugees after independence.
2. Unbalance between supply and demand for housing
3. Continuous in-migration from other parts of the country.
4. Rapid industrialization and consequent increase in employment opportunities within the city.
5. Lack of incentive, lesser yeild or division of land holdings in the rural areas and the hinterland.
6. Better employment and income opportunities in Karachi.
7. Better recreation facilities in Karachi.
8. Ethnic affiliation in the city.
9. Housing in squatter areas - for the original squatter - are usually free of lease.
10. Easy access to places of work. (Employment insures existence of slum).
11. Availability of vacant lands.
12. Planning deficency with regard to leaving unspecified lands.
13. Land speculation by unethical professionals in the field.
14. Ineffective measure for controlling squatting.

The above list however omits the most important factor - lack of coordination in the economic and physical planning programs of the Government, at the National, regional and local levels.

3.1.3. "Katchi Abadis"

The current KDA estimates put the squatter numbers of "Katchi Abadis" at 312[7] housing approximately 1.7 million people. However, informed figures place it above 2.4 million. The density in these areas are estimated at 150 dwellings per acre as compared to 11 dwelling units per acre for the whole of metropolitan Karachi.[8]

Most of the squatter areas lie close to employment generating areas. The main body of the "bustees" lie in the north of the city along the channel of the Lyari River, and in areas with easy access to S.I.T.E. (Sind Industrial and Trading Estates). This pattern is repeated at other industrial zones of the city like in Lyari and Karangi. In this category another set of squatters have been included called "goths" or old sindhi villages that have gradually been enveloped by the city. They can be categorized as old settlements rather than squatters.

3.1.4. Conditions in the Squatters.

Most of the squatters have a low level of municipal services. The rationale is that since they occupy land illegally - additionally pay no taxes - they are not entitled to any municipal service. The presence of any service in this area is incidental and not planned. The services that are mostly missing in these areas are all the services normally provided by KMC to other areas. These services are (1) water, (2) Karachi Municipal Corporation (K.M.C.) Sweepers, (3) sanitation and garbage collection facilities, (4) roads and streets, (5) central sewerage, drainage, (6) electricity, gas, and (7) transportation services. However, some of the slums have undertaken to provide these services through communal activity. This is discussed fully in the case of Aurangi.

3.1.5. Squatter ("Katchi Abadi") Improvement Program.

The directorate of Katchi Abodi Corporation has set out certain policy decisions concerning regularization and up-grading of Katchi Abadis. It is interesting to quote from an official report about squatters.

> "Most of them earn a decent living as labourers, petty traders or servants, but because of their low and often irregular income, they cannot afford to buy or rent a house and therefore resort to construction of unauthorized

dwelling on a self-help basis... That the problem of housing shortage for low-income groups cannot be solved by demolition of houses which, although illegally constructed, are sometimes of good quality and/or value to the residents. Government has come to understand that is should, on the contrary, preserve this housing stock and concentrate its efforts on improvement of these settlements."[9]

The salient features of the Regularization and Improvement policy on the KDA[10] are as follows:

1. Action to improve living conditions of squatters will consist of provision of security of tenure to the residents through regularization of their occupancy.
2. Upgrading of overall conditions through provision of basic urban infrastructure.

For the financing of Katchi Abadi improvement programme the directorate expects the squatters to pay at least the cost of the land lease and cost of improvement will be achieved through lease charges for serviced land.[11] In this way they hope the regularization program will be self-financing.

Before legalizing a settlement they hope to go through a regulatization procedure. The first question they ask is whether the settlement can be regularized. This will depend on location of the land and its urban functions according to the city master plan. Secondary factors would be size and density. Thus they hope to provide considerable leverage to deny regularization if they feel that the settlement is a disruptive element in terms of the overall Karachi Metropolitan plan. The steps to regularization would involve:

(i) Checking of the land if the land does not belong to any other lease issuing authority.

(ii) If the land does not belong to any other authority, resumption of transfer procedures.

(iii) Land transfered to lease-issuing authority free of charge or a nominal amount.

Market value can only be charged in exceptional cases, since excessive acquisition costs of land are likely to burden the project to such an extent that the self-financing of the project and the project as a whole could be jeopardized.

Anticipated physical planning procedure that the directorate intends to follow is seen as :

> "Security of tenure requires long term leases, but long term leases freeze the layout of the settlement for a long period. Adaptive planning before regularization is therefore necessary. The physical layout of the settlement is adapted to facilitate implementation of planned infrastructural improvements. At the same time, possible future demands for additional upgraded infrastructure (as a result of raised standards, increased population density, etc.) are taken into account. So, apart from demarcation of plots on a regularization plan, physical planners see to it that, when necessary, streets are widened and straightened, space for civic amenities is adequately distributed over the area and requirements for present and future infrastructural improvements are met." 12

The way the directorate proceeds with the physical planning is in two steps:

(i) The first step is preparation of a conceptual plan which relates "Katchi Abadi" as an integrated unit.

(ii) Detailed planning divides the area into planning units, which attempt to coincide with the socio-ethnic communities (in mohallas, colonies) in the settlement. The detailed regularization plan serves as a legal basis for leasing and to show location dimension and land use of individual plots, as well as details of proposed infrastructural improvements.

Their attitude toward preservation of existing housing stock is quite circumspect:

> In view of the aim of the policy to preserve the housing stock of Katchi Abadis

TABLE 4

Future Plans of Squatters if Allotment Takes Place, Karachi--1973

Plans	Number Responsible	Percentage of total
No plan	140	53
Make a better house	36	14
Rebuilding the house	30	12
R.C.C. and/or 2 story	45	17
Let out or sell	10	4

Note: 26 no answers or don't knows.
Total sample: 287

Source: Adapted from Harst, "Low Income Housing," IBA, Karachi University, 1973, p. 82.

> and improve the living conditions of the population, planners see to it that demolition of houses or parts thereof is kept to a minimum and that the planned physical layout meets the particular requirements of the low income groups. Since area upgrading will generally be reflected in enhanced property prices, Katchi Abadis should as a principle, be planned in such a way that prices of houses and plots in the area remain within the paying capacity of low-income residents. So, physical planners have to find a balance between present urban standards and future requirements on the one hand, and the necessity to keep property prices in the area within the paying capacity of low-income groups on the other hand."[13]

This shows a considerably enlightened attitude compared to past practice of indiscriminate eviction of squatters.

(a) On the subject of infrastructural works. The directorate finds it more difficult to affect a comprehensive program now. They admit that in almost all "Katchi Abadis" residents express urgent needs for water supply, construction of sewerage system and metalling of roads. But the directorate feels that this can be affected only gradually. Initially they will provide a system of public water standpoints, each serving about 50 households. Regarding roads and streets they feel the Government should metal the thoroughfares, while dead end streets and back alleys should be left to the initiative of the people themselves.

(b) Sewerage Disposal.

The directorate feels that closed water borne sewerage system in "Katchi Abadis" would be ideal for refuse and waste water disposal but feel there are major impediments to achieving them. These have been identified as:[14]

(i) the paying capacity of the residents of the Katchi Abadis is too low for such a system

(ii) the city of Karachi and Katchi Abadis feel a permanent water shortage, which is particularly acute just before the summer monsoon rains

(iii) purity is highly valued amongst the

TABLE 5

Number of Rooms by Type of Settlement in Thirteen Squatter Areas--Karachi-1973

Number of Rooms	Type of Settlement		
	No Hope	Some Hope	Hope
No room	2	--	--
1 room	69	54	38
2 rooms	24	46	40
3 or more rooms	10	13	28
Total	105	113	106

Source: Adapted from Harst, "Low Income Housing," IBA, Karachi University, 1974, p. 20.

TABLE 6

Incidence of Private Facilities by Type of Settlement As Percentage of Total Number of Dwelling Units in Thirteen Squatter Areas--Karachi--1974

Private Facilities	Type of Settlement		
	No Hope	Some Hope	Hope
Kitchen	37%	57%	66%
Bathroom	60%	75%	86%
Latrine	80%	99%	100%

Source: Adapted from Harst, "Low Income Housing, IBA, Karachi University, 1971, p. 21.

population and cleaning of latrines and drains is usually left to a specialized group of persons

(iv) residents of Katchi Abadis, who mainly come from rural areas, are usually unaware of modern requirements of hygiene. Consequently they feel that the sewerage system should be cheap. They favor pit latrines and have offered some designs for such schemes.[15]

(c) Budgeting.

Budgeting a regularization and improvement project is an activity that they feel deserves close attention. Once the design for the infrastructure is completed, they draw up a budget for the regularization and improvement scheme. The cost of land and intrastructure to be provided is offset by the lease rates. These lease rates vary depending on the paying capacity of the squatters.

(d) Community Participation.

The directrate feels that any decision effecting "Karachi Abadis" should be taken with colaboration with the residents of this area. Hence public participation is formalized through "periods of public objections."[16] During this period of 2-4 weeks (announced in local dailies) concept plan, lease rates and detailed plans are displayed and explained to residents. Objections are discussed by a committee consisting of representatives of the directorate and squatters. The committee decides on the objections and as soon as final approval is obtained, plan implementation begins.

(e) "Katchi Abadis" Regulatization and Improvement Fund.

This has been established in order to develope funds through development of a seed capital and a revolving fund. This is done as the directorate feels that most squatters lack confidence in the intentions of the Government, and are reluctant to pay regularization plus improvement charges until some improvement works have been carried out. Moreover, residents may be allowed to pay thier lease charges in installments and consequently funds are expected to be collected over an extended period of time.[17]

From the previous discussion of policies the directorate intends to take it is clear that a lot of the upgrading especially of the neighborhoods has to be performed through communal self-help or mutual help. Before the spirit of self-help can be generated, specific steps have to be taken to organize the communities and the residents have to understand the specific tasks they must perform to achieve these goals. This is discussed more fully in Chapter 4.

TABLE 7

Priorities Expressed by Respondents of Chanesar Goth Karachi to Two Questions by Income Level, 1973[a]

Suggested Provision of Service	Question No. 1 In your opinion what should the Government do to improve the conditions of people living in Chanesar Goth?	Question No. 2 What suggestions would you make for the improvement of Chanesar Goth?
	Number of income groups making suggestions	Number of Income groups making suggestions
Sewerage	All six groups	All six groups
Electricity	All six groups	All six groups
Better water supply	All six groups	Five groups
Pucca roads and streets	Five groups	Five groups
Improved garbage disposal arrangement	five groups	Five groups
Better educational facilities	Three groups	Four groups
Allotment of land	Three groups	One group

[a]For each question, it seems to this author, the sample was divided into six income groups ranging from Rs. 0-100 to Rs. 501 and above and the majority in a group was in favor of a particular service, the entire group has been listed as giving top priority to that particular service.

Source: Compiled from JRP-IV Research Reports, IBA, Karachi University.

3.2 Aurangi, Karachi

3.2.1. Background.

Aurangi is a settlement in Karachi consisting of regularized and officially developed sectors, as well as sectors which shelter unauthorized settlements. It was officially planned by the Karachi Development Authority in 1965 and about 5000 hut dwellers from Mauripur were first shifted in October, 1965.[18] After this period refugees from various other squatters were moved to this area and resettled in 15 sectors of almost 2000 acres.

After this period there was a significantly large expansion of almost 200,000-300,000 displaced people from Bangladesh in 1971 of the so called Biharies.[19] These people moved into adjacent areas of already developed sectors.

Population Characteristics:

Aurangi, like other slums in Karachi, consists mostly of low income people who are at the bottom rung of the economic sector.[20] The people who are settled in the township belong to different income groups.

Aurangi is a microcosm of the ethnic heterogenity of Pakistan. There are Punjabis, Baluchis, Sindhi, Pathans, and immigrants from different parts of India.[21] Most of the local population has either been relocated - from other parts of the city - or has been rehabilitated - like in the case of immigrating Biharies. The interesting aspect of this settlement is that people live in relative harmony and no instances of ethnic strife have been reported. In fact the cohesiveness in the community is remarkable. Numerous neighborhoods have taken upon themselves to improve their environment having given up all hope of public intervention to solve their needs for such basic amenities as sewerage disposal, drainage, water-supply, electricity, transportation, metaled road, education, and recreational facilities.

3.2.2. Settlement Pattern.

The unauthorized settlements are adjacent to the 15 sectors that have been developed. The initial development was only partial with a paved access road to the area and demarcated plots. Water supply was provided over the years with single tap for each group of dwellings. Water supply was provided additionally by the municipality trucks. Due to insufficient supply by trucks people had to resort to other means of supplying water to themselves through private water carriers or through tapping of the underground wells.[22]

TABLE 8

ETHNIC COMPOSITION

1.	Migrants (from India & Bangladesh)	90%
2.	Pattans (from NWFP)	4
3.	Baluchis	3
4	Punjabis	3
	Total	100%

TABLE 9

TYPE OF HOUSING IN THIS AREA

1.	Pucca (semi) low category	80%
2.	"Kutcha" (non-permanent)	15%
3.	Pucca (R.C.C.)	5%

Source: Quaratul Ain, "An Action Research Project on Improvement of Educational Facilities in Mominabad (Sub-Standard Slum) Sector 4/F Orangi Township. Unpublished paper for Department of Social Work, University of Karachi, Karachi 1981,

3.2.3. Physical Conditions: Authorized Areas.

There are 15 sectors housing almost 500,000 people that are living in approved plots. All approved sectors have their main approach roads paved. Basic amenities like water, electricity, sewerage, etc., have over the years been laid out. However, the infrastructure is not maintained so people have supplemented these services. Water is supplied with community taps. One tap serves 20 houses.[23]

3.2.4. Unauthorized Areas.

The basic amenities have not been provided by the government. Hence, there are no paved roads, no central sewerage, no tapped water supply - a municipal tanker supplies water every day but this supply is grossly inadequate - and there is no electricity in this area.

This thesis advances the notion that squatters have the potential to improve their environment and their economic status given the right incentives and given the necessary skills.

3.2.5. Current Self-Help/Mutual Help Activities

In Aurangi in both the authorized and unauthorized sectors, it is being observed that people are forming community organizations. These community organizations are of varying sizes. In all, Aurangi Federation is reported to have thirty-three units[24] in different sectors of Orangi. Another is the Benarasi cloth weavers and traders. The Federations have representative councillors or Federation organizers, usually people who are respected in the community or are relatively more educated, and are

TABLE 10

Income and Type of Settlement by Four Levels in Low Income Communities in Karachi, 1973

Monthly Income in Rs.	Settlement with		
	No hope total (head)	Some hope total (head)	Hope total (head)
1-150	20% (38%)	7% (14%)	7% (12%)
151-250	31% (37%)	30% (35%)	24% (41%)
251-500	31% (19%)	36% (37%)	31% (28%)
401 or more	18% (6%)	27% (14%)	38% (19%)
Total	100%	100%	100%

(2 no answers)

Source: Adapted from Harst, "Factors Affecting Housing Improvement in Low-Income Communities, Karachi, Pakistan." Ekistics, Vol. 39, No. 235, June 1975.

active in the area for political lobbying for greater service from the Karachi municipality or respond to emergencies like epidemics by soliciting voluntary help from doctors in the area; or have built mosques and other social institutions. The issues that the federation is concerned is with comprehensive upgrading of thier environment. They have started to publish small brochures which explain how to build water wells; how to build latrine pits; how to remove garbage; and other issues of communal interest are addressed through newsletters.[25] They are being partly financed by philanthropic groups, but most of their work is done by volunteers who are keen to upgrade their community. Recent activities: meeting with neighboring sectors - those who are as yet not conscious of improving their environment - and attempts to explain to them the importance of

TABLE 11

Average Total Investment, by Type of Settlement, by Income Group in Thirteen Squatter Areas of Karachi--1973

Monthly household income in Rs.	Average of the total investment in settlements with:		
	No Hope	Some Hope	Hope
1-150	Rs. 807	Rs. 1448	Rs. 1700
151-200	1127	1775	1911
201-300	1483	2488	2540
301-500	1717	3583	4143
500 or more	1903	3532	5655

Source: Adapted from Harst, "Low Income Housing," IBA, Karachi University, 1974, p. 10.

self-help and mutual help to improve their respective environments. Often those works require pooling of resources and this can be a strain on their savings but loans are arranged both to community activities and home improvement activities. This remains a crucial impediment to the development of the area.

3.2.6. Financing in Squatter Areas.

In Aurangi as in other squatter areas of Karachi, investment is possible only if one of the following is available: savings, incurring loans, membership in bisi community, and sale of property.[26]

Studies by JRP-IV by Dr. J. van der Harst indicate that one out of every two household heads borrowed money to finance there highest investment of the house.[27] It was also found that 69% take loans from friends and relatives.

Semi-skilled laborers, carpenters, masons,

TABLE 12

Number of Rooms by Type of Settlement in Thirteen Squatter Areas--Karachi-1973

Number of Rooms	Type of Settlement		
	No Hope	Some Hope	Hope
No room	2	--	--
1 room	69	54	38
2 rooms	24	46	40
3 or more rooms	10	13	28
Total	105	113	106

Source: Adapted from Harst, "Low Income Housing," IBA, Karachi University, 1974, p. 20.

and small contractors do give credit to their clients. In some squatter areas it was found that 18% of the borrowers built their house by supplier credit.[28]

3.2.7. Bisi Committee.

One of the most popular forms of loan borrowing is done through bisi committee. This committee consists of small groups of people related to each other by blood, or background - ethnic, regional - and they pay equal amounts of money periodically and at the end of each period one individual collects all the money.

People usually invest in their house when their turn comes on a bisi. The duration of the bisi is the number of the people in the group. In the survey of JP-IV it was found that 1 out of 3 respondents used this financing method for investing in the house.[29]

3.2.8. Conclusion.

From the foregoing observation about communal activities to upgrade their environment we can draw some very important conclusions about felt needs of the community and the present constraints.

One thing that came out clearly is especially in the unauthorized settlements is that they have accorded the biggest priorities to:[30]

1. improved water supply,
2. security of tenure,
3. provision of roads and streets,
4. sewerage disposal facilities,
5. electricity supply, and
6. improved garbage collection facilities.

These priorities are similar to those elsewhere in Chaneshar Goth.

Security of Tenure.

The most fundamental impediment to rapid growth in unauthorized areas is lack of security of tenure. We observe similar response from studies done in other Asian cities[31] and in Colombia. Thus as the KDA water supply tanker supplies water to Mominabad people are hopeful that ultimately their squatting will be legitamized. If one compares this area to central city squatters one observes that central city squatters[32] under threat of eviction, have not built durable housing, while people in "mominabad" have. In another study by Harst it was observed that the relationship between number of services present and the hope for allotment was very strong.[33]

Water Supply.

The next most felt need was of water-supply. The Karachi Municipal Corporation trucks are irregular in their supply of water and people have to resort to either private delivery of water, water-carriers, or have resorted to digging water wells. The only issue is that their expertise in making water wells is inadequate and often takes accumulation of savings before a family can resort to well making through subcontracting or mutual self-help.

Sewerage.

One of the more critical problems the communities are trying to resolve, in both authorized and unauthorized settlements, is the issue of sewerage disposal. There is no covered sewerage disposal system for these communities. However, we have seen that in areas where people have organized themselves, neighbors of 20 odd families or so have pooled their resources and built covered drains to latrine pits. These pits continue to pose a health hazard as they are exposed and raw sewerage ought to be treated with chemicals or removed by the municipal trucks. Other possibilities are design of pit latrines which can be cleaned periodically - monthly or semi-annually.

Garbage.

Garbage removal is a severe problem. People usually resort to dumping their garbage outside their house. However, we have seen in several areas[34] that people have erected garbage incinerators. These are as yet not very popular although once an awareness and social pressure to burn the garbage materializes, this promises to take care of potentially hazardous environmental problem of squatters.

Economic Activities.

Squatters lacking regular employment[35] resort to some form of economic activity at home. When no economic activity occurs at least one member of the family seems to have regular employment to allow a constant income. The type of economic activities range from owning small shops, manufacturing activities, sub-letting of rooms, poultry farming. Hence, their need for space is much greater than what is provided on site and service minimum plot, 80 sq. yds. Their space need would be closer to 120-160 sq. yds.[6] In fact this brings us to the question whether a house to a low-income dweller is mere shelter or an economic investment. The site and service project anticipates an initial down-payment which reduces the liquid assets of most potential tenants to nil or negative (borrowing). This leaves them with very little to put up a house. In fact, an owner of a site and service plot ends up paying a double rent, in the situation when he does not occupy his plot but instead lives in a squatter area.

House.

When security of tenure is present there is a rapid rate of development. A major part of the family's income is invested into the extension of the house. It was found that, as Aurangi is an area of hope and some hope, 80% of the houses are "semi-pucca". If the unauthorized settlements are regularized there will be a much greater investment in the area.

Another observation is that people do not prefer communal latrines. They have mostly provided themselves with at least a crude latrine, bathroom and kitchen.

Community Spirit.

Communal cohesiveness is very strong. People are keen to improve their environment. However, some sort of economic incentive seems to be a strong stimulant to collective action.

In some areas people are not convinced or are apathetic to communal activity and this ought to be understood better.

Marketing Facilities.

A reasonable proportion of the population is semi-skilled.[38] There are masons, carpenters, plumbers, electricians, tailors, etc. who not only serve their immediate market but occasionally are hired for temporary periods - seasonally.[39] Hence, if there is a better marketing structure of their goods this will be a boon to their informal manufacturing activities.

3.3. Evaluation of the Current Public Housing Schemes.

The various current programs being executed in Karachi will undoubtedly improve the housing situation, however, they overlook certain issues:

1. They are concerned with the house as a physical shelter and neglect all other concommitant socio-economic, phsychological, political and cultural issues which are very critical while considering a housing strategy for the low-income groups.
2. The total estimated cost for the distributed investment plan for housing between 1975-1985 is approximately Rs. 4000 million will be spent, out of which Rs. 600 million will be for site development and Rs. 3200[27] will be for minimum and essential construction. This is a phenomenal amount considering that its success depends on mobilization of large amounts of capital raised from the public sector. The program initially depends on public trust and the public's ability to save. We have already seen from the default in payment of House Building Finance Loans that people's savings are not regular and enforcement of payment once a lot is allocated is difficult. The fate of Metroville I project, where owners have not built on this plot for over 6 years, indicates some serious shortcomings of such capital intensive projects which do not recognize the liquidity[30] status of their assets and the double rent issues.[31]
3. The program overlooks the fact that squatters once settled in an area develop socio-economic ties with the rest of the community and are reluctant to leave thier present

area of residence. Similar observations have been made in Columbia and in Sites and Services project in Pakistan and elsewhere. Any relocation which does not respect economic or income generating activity of the dwellers within their residential zones will have dubious success.

4. The programs also segregate the various socio-economic groups on their income levels. However, studies in squatter settlements show that there is a mix of various income groups. Isolating income categories prevents an active exchange with people in the lower income group. They would be a far cry from the classless squatter settlements which show a remarkable degree of community consciousness.

5. The program which offers most hope is the improvement and regularization program. It is not as capital intensive as other schemes and relies mostly on people's willingness to improve their environment through self-help and mutual help activities. The socio-economic benefits of self-help have not been adequately studied but let it suffice that given the current policies on public housing, self-reliance is the only viable option for the populace of most developing countries.

MAJOR SQUATTER AREAS OF KARACHI:

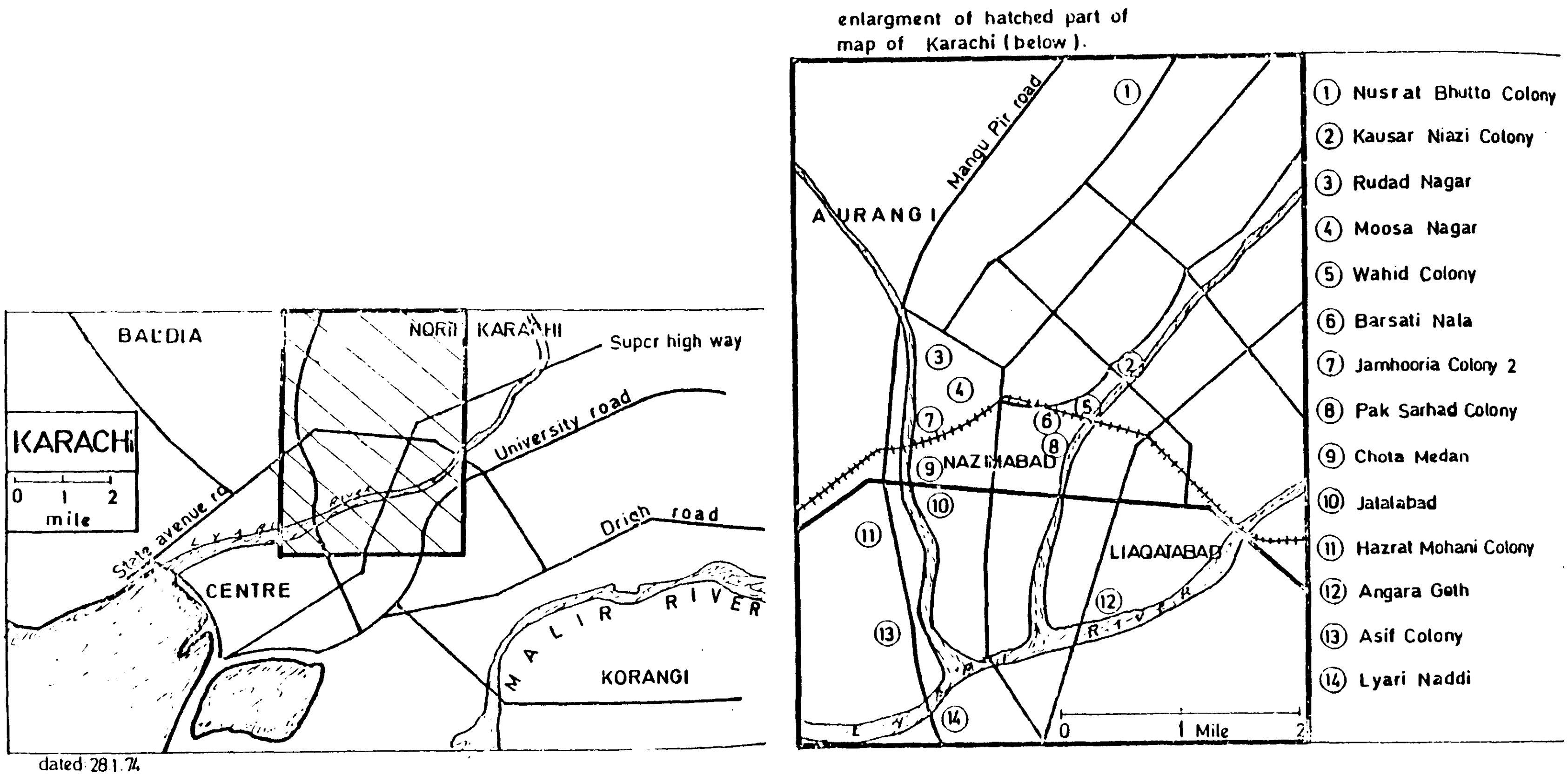


Fig: 6

Source: Harst, DJ. van der. "Low Income Housing." JRP Project Iv, Institute of Business Administration, University of Karachi, 1974. p.2

TABLE 13

Number of Dwelling Units, by Type of Housing and Type of Settlement, for Housholds with Income of Rs. 301-501/Month--Karachi--1973

Type of Settlement	Type of Houses					
	Juggi	Kutcha	Semi-pucca unplastered	Semi-pucca plastered	(double storied) pucca	Total
no hope	0	3	18	1	0	22
some hope	0	0	21	9	0	30
hope	0	0	19	15	4	

Source: Adapted from Harst, "Low Income Housing," IBA, Karachi University, 1974, p. 8.

Footnotes:

1. Abrams, Charles. Man's Struggle for Shelter in an Urbanizing World. M.I.T. Press, Cambridge, Mass., 1964. p. 72

2. Directorate of Katchi Abadis, "A Place to Live: Katchi Abadi Improvement in Karachi, Pakistan", Karachi Metropolitan Corporation, Karachi, 1979. p. 3.

3. Ibid., p. 3.

4. Planning Commission, "Physical Planning and Housing: The Fifth Plan 1978-83", Government of Pakistan, Karachi, 1978. p. 3.

5. Ibid., p. 3.

6. Shah, A.H. and Nizami Z.A. "Problems of Urban Slums, Slum Clearance and Slum Improvement in Karachi, (Karachi Development Authority, 1973) p. 1.

7. Directorate of Katchi Abadis, op. cit., p. 4.

8. Meier, R.L. "Development Features of Great Cities of Asia IV: Physical Expansion, Institution Building, and Political Crises in Karachi and Bangkok" (University of California, Berkeley, October 1971), p.1-19.

9. Directorate of Katchi Abadis, op. cit. p. 5.

10. Ibid., p. 7.

11. Ibid., p. 7.

12. Ibid., p. 8.

13. Ibid., p. 11.

14. Ibid., p. 13.

15. Ibid., p. 14.

16. Ibid., p. 15.

17. Ibid., p. 15.

18. Azam, O.L., "Multi-purpose Community Development Project for Oranrgi Town", unpublished paper social works department, University of Karachi, Karchi 1981. p. 1.

19. Biharies: People who came from Bibar in India and migrated to Pakistan in 1947. Loosley applied to all immigrants from the Indian sub-continent.

20. Quaratul Ain, "An Action Research Project on Improvement of Educational Facilities in Momirabad (Sub-Standard Slum) Sector 4/F Orangi Township. Unpublished paper for Department of Social Work, University of Karachi, Karachi 1981, p. 2.

21. Ibid., p. 3.

22. Discussion with residents in Aurangi revealed that water supply by municipality is irregular and a family has to resort to building water-wells or purchasing water from water carriers.

23. Quratul Ain. op. cit., p. 5.

24. Khan, Akhtar Hameed. "Orangi Pilot Project". Karachi 1981. p.

25. On a visit to Orangi federation, I was handed the newsletters. However these publications are being financially assisted by a philanthropic organization which is concerned with community development in squatter areas of Karchi.

26. Discussion with residents in Aurangi revealed that bank loans or mortgages cannot be obtained easily when on has connections with people working in mortgage banks (House Building and Finance Corporation). People therefore borrow from each other or develop other forms of financing like revolving funds etc. Nobody mentioned borrowing from money lenders.

27. Harst, J. Van der "Factors affecting Housing Improvements in Low Income Communities, Karachi, Pakistan", Ekistics (Vol. 39, No. 235, June 1975) p. 396.

28. Ibid., p. 395.

29. JRP-IV, IBA/Lyari

30. Ibid., p. 397.

31. Observations made on items considered as priorities by residents of unauthorized settlements in Aurangi (e.g. in Mominabad and others).

32. Sarin, Madhu, "Focus towards Urban Slums: Slum and Squatter Settlements in the ESCAP Region, United Nations, 1980. p. 12.

33. Turner, John C., AIP Journal 1968, p. 358 and 359.

34. Harst, J. Van der, Low Income Housing. Institute of Business Adminstration, University of Karachi, Pakistan, 1974. p. 39.

Chapter 4

4.1 Existing Buildings in Squatter Areas.

This chapter examines the various types of indigenous housing that are built by the squatters in the slums of Karachi. This will establish a guideline for proposed housing building systems.

Any proposed building system must recognize the need of the squatters to build over an extended time frame. Another issue that is extremely important to the Squatter is that house is not merely a shelter but is also an economic investment. So architectural design which permits expansion of his dwelling both vertically and horizontally will be preferable.

Studies indicate that there are several categories and types of slum dwellings and that the rate of development and improvement is closely dependent on legal status of tenure and the hope-inducing incentive it has on the squatter. The ultimate aim of the squatters is to have a "pucca home" that is a permanent house closely akin to that which shelters the higher income groups.

The JRP-IV[1] team for Urban Development has carried out extensive research in determining typology of houses in various settlements and has come up with six categories based on quality of material used in construction. However this category only lists techniques of construction that are known in this area and certainly any techniques which could provide squatters with more permanent dwelling at the same cost, it is hoped, would be welcomed by squatters. Some definitions concerning the categories follow:

1. Very Temporary: All elements - except the door - are made of matting, reeds, and jute.
2. Temporary: At least one wall (either compound or housewall) is made of tin, wood, mud, or stones (except complete nudhouse). No use of cement made.

3. Prolonged Temporary:
   a. Like temporary, but durable over a period.
   b. All walls and roof made of mud.
   c. One wall made of cement blocks.
   d. Both walls of cement blocks, but inferior roof and door.
4. Semi-Permanent: Both walls of unplastered cement blocks, sheet roof (either asbestos of corrugated).
5. Provisional Permanent: At least one wall plastered; or all walls unplastered, but the buildings has a story.
6. R.C.C.: Walls of plaster and cement blocks and roof made of reinforced concrete.

4.2 Current Housing:

The following figures show various types of indigenous houses[2] starting from a very temporary "juggi" house to a "pucca" house. The following are the three major categories of houses in a squatter settlement in Aurangi and other squatter areas of Karachi.

"Juggi"

The juggi primarily consists of bamboo and reed mats. There is no specific method of build- a juggi - each builder more or less builds it through his knowledge or understanding of construction and usually within a few days. The frame of a juggi consists of bamboos. The bamboos supporting the main frame are placed in holes 1 to 2 feet under the ground and later packed with mud and gravel composite. Horizontal bamboo pieces placed horizontally and tied to the vertical poles provide rigidity to the frame. The distance between poles is usually 4 feet center to center.

Sarkanda: A reed-mat consisting of parallel stalks knotted together with rope. It is used for thatching both the walls and the roofs.

Chatai: A woven mat is the external most mat used for thatching the outside walls.

Panka: Panka is similar to Sarkanda. It consists of parallel reed-stems, knotted together with a rope. The panka is water-repellent which makes it ideal for thatching roofs.

Construction of a Juggi:

Investigation by JRP-IV group indicated that as a rule Juggis are built in 1 to 4 days. The first step in the building process is placing of the vertical poles, followed by the rest of the frame. Once the frame is up, the mats are placed as coverings. The final step in completion of the Juggi is leveling and smoothing of the floor. Juggis do not require any special skills and are built by the dwellers themselves.

Mud-House:

Different construction methods can be employed for making mud houses. Essentially each dweller builds more or less as he wants depending on his knowledge and skill. Van der Harst lists 3 types of mud-houses[3] using his categories on an earlier work done by Iqbal Kalim Chanesar Goth.

Walls:

1. In one type, frequently found in Karachi the wet mud is piled up to a height of 2 to 3 feet. This low wall is left to dry to harden. In summer the wall dries within 3 days; in winter this may take as much as 10 to 12 days. After the wall is dry another layer of mud is packed to a height of 5 to 6 ft. When the second layer is finished a final layer of mud is piled to a height of approximately 8 ft.

2. In the second method of constructing walls, sun-baked mud-bricks are used. The dwellers, if they can use this method, find this more time consuming than the first method but prefer this method as it makes the wall stronger and vertical and horizontal alignments are more accurate.

3. The third method of constructing a mud wall consists of plastering the wall made of Sarkandas and bamboos. This bamboo frame is very similar to normal Juggi-wall. This method has considerable advantages. The reed-mats and bamboos will last longer which keeps the costs down as compared to the cost of their application in a Juggi. The Sarkandas offer protection against rain, unless it is a very heavy rainfall. This type of wall is stronger as most of the load is subsequently carried by the mud wall rather than the bamboo frame.

Roofs:

There are three different major types of roofs identified by the JRP-IV group.[4]

1. The heavy mud-roof.

In this type of roof a heavy beam spans the opposite walls of a room. If the room is larger, several beams may be used. There may be a set of smaller cross-beams resting on the edges of the other two walls and on the main beam. One pair of Sarkanda is subsequently placed on top of the smaller beams which is itself covered by a Chatai (mat). A 1/2 inch thick, wet mud is applied to the top of the Chatai (mat). Once this layer has dried another 4-5" thick layer of mud is applied on top. A final mud coat of 2 inches then completes the roof.

2. The light mud-roof.

A heavy beam is not necessary, as the layer of mud is not thicker than 2 inches. In this case thick bamboos or strong, small beams, placed 1-1/2 feet to 4 feet apart, provide the needed rigidity to the roof. Either a "Sarkanda" or a plastic water-proof membrane is placed on top of the beams. This is topped with a "Chatai" (mat) and this is finally given a coat of a thin layer of mud-plaster.

3. The Juggi-mud adapted house.

In this type where the Juggi walls were plastered with a layer of mud wall, retain their original Juggi roof - discussed earlier in Juggi type.

Mud:

In the case where the mud-house is built by packing the mud, the mud is usually dug up close to the site of the dwelling. When sun-baked bricks are used, they can either be made on site or bought in sizes of 12"x8"x6" for a nominal price of 100 bricks for Rs. 36.00. The walls are built by the dweller himself and rarely sub-contracted.

Plaster:

The walls are occasionally plastered. In the first kind a rough mixture of busa (Chaff) mud, water and in some cases cow or donkey dung is used. This plaster is kept thoroughly wet for 1 to 3 days, mixed and then plastered onto the wall. After the first plaster has dried some cracks will normally appear, which is usually repaired by a similar plaster mix as in the initial plastering

This plaster is given a final coating (optional) of white mud and water. First a paste of white mud and water is prepared. In 5 days or so the white mud completely dissolves in water, and this solution is used as a wall-paint. This white mud is not found everywhere and has to be bought in the market or dug up from locations where it is available. It is relatively cheap. It essentially covers the crack and provides a hard cover to the wall and protects the wall from insects.

Labor:

Building a mud-house is labor consuming. All the dwellers interviewed by JRP-IV group claimed to have built the houses themselves. They spent one or two hours on building their house after finishing their daily work. It takes them occasionally months before the house is finished. The following table gives an idea of the labor consumed.

TABLE 14

COST OF LABOR FOR A MUD-HOUSE

Size of the Plot: 40 to 50 sqy (One room and a courtyard).

1.	digging the foundation	1 day	2 men	2 mandays
2.	making of blocks	4 days	4 men	16 mandays
3.	putting up walls	3 days	2 men	6 mandays
4.	putting up roof without mud	1 day	4 men	4 mandays
5.	application of thin, wet layer of mud	1/2 day	2 men	1 manday
6.	application of thick layer of mud	1/2 day	2 men	1 manday
7.	mixing and keeping wet plaster 1	1 day	1 man	1 manday
8.	plastering (including roof and floor)	3 days	2 men	6 mandays
9.	mixing and keeping wet plaster 2	1 day	1 man	1 manday
10.	application of plaster 2	2 days	2 men	4 mandays
11.	total			42 mandays

Source:

Semi-Pucca and Pucca Houses:

(Partially Completed and Completed Houses)

The construction process of a semi-pucca house is different from that of a juggi or a mud-house. It is rarely completed by the dweller himself unless the dweller is a mason ("mistri"). The dweller will usually hire a mason and serve as extra labor and supervisor. He sub-contracts the masonry work essentially because he considers it difficult and requiring skills he does not possess.

The construction of a pucca house with a reinforced concrete slab as roof) is considered too complicated and the dweller prefers to leave the work and the site organization to a contractor. This makes a substantial difference in the investment required for the two types of buildings. They require greater cash outlays and unless the dweller is able to accumulate savings over time, or borrow money from friends, etc., he is deterred from investing in a permanent type.

Building Materials:

Walls:

In both pucca and semi-pucca houses both the load-bearing and partition walls are made of cement blocks of varying dimensions (see page for a list of sizes available). These walls usually rest on a foundation, one to two feet deep - depending on soil conditions - made of cement blocks. In semi-pucca type the walls are often left unplastered while in the pucca type this is plastered.

Roof:

In the semi-pucca types the roof consists of either iron corrugated sheets or asbestos. These sheets come in varrying sizes. These are usually placed on wooden beams to support the roofing sheets. For pucca houses the roof usually consists of a reinforced concrete slab, the casting of which is sub-contracted and involves substantial initial investment.

Doors and Windows:

The choice of doors and windows usually depends on the individual dweller. Usually a wooden framed door is used of dimensions ranging from 2 1/2' to 6' for toilets, etc.

Windows come in various sizes ranging from 2'x3' or 1'x2' and other sizes. Occasionally metal framed doors are also used but these are more expensive.

Floors and Finishing of Floors:

The floors in both semi-pucca and pucca types usually consist of a concrete slab. This is generally sub-contracted. A mason (+ one helper) usually takes one day to finish a slab of 140 sq.ft.

Plastering of Walls:

Both the semi-pucca and pucca houses can be plastered, but this operation is usually a final investment. This is sub-contracted to the mason. The plaster mortar is usually 1/2" thick on both interior and exterior walls and the work is executed per surface area. The mortar composition is usually 1 part of cement to 6 parts of sand.

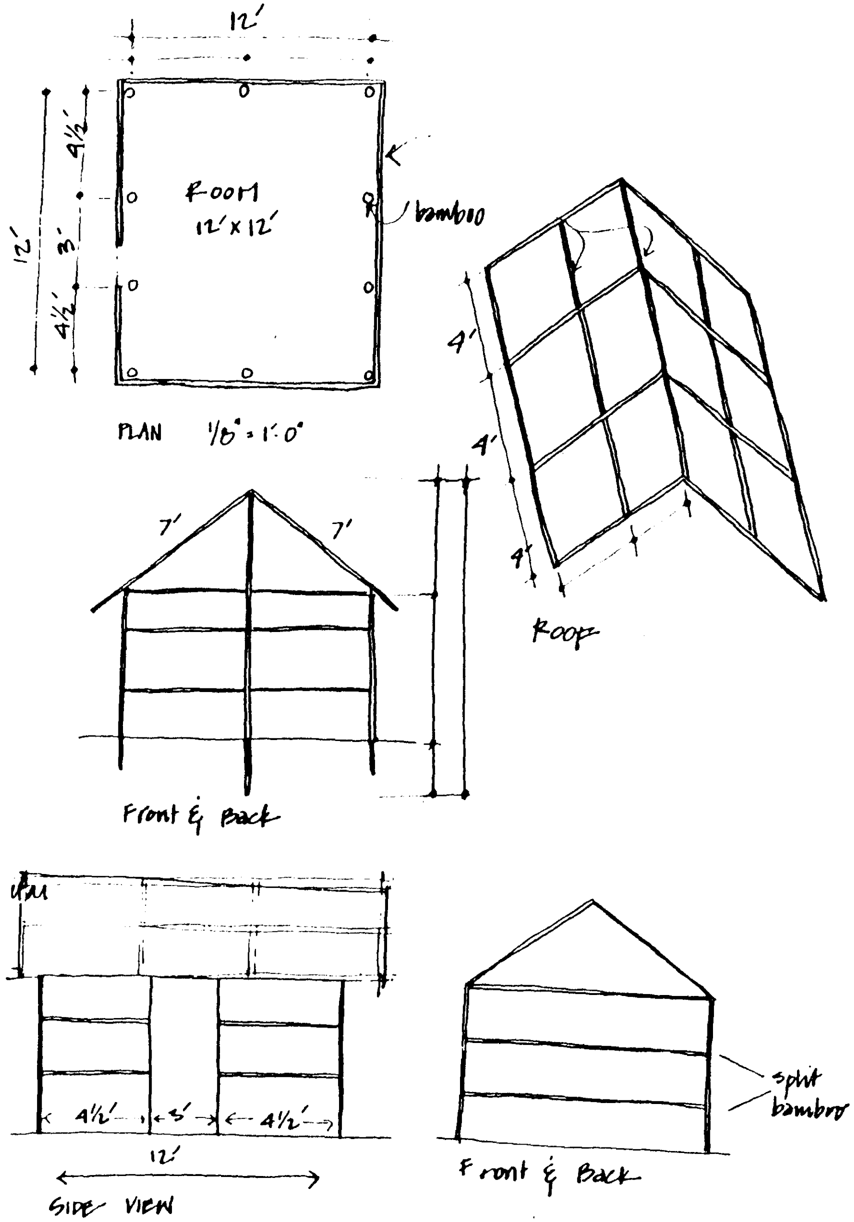
Contractors Profit:

In both the semi-pucca and pucca type of houses, it is estimated that the sub-contractor's profit is 15% - 20% of the investment in parts sub-contracted, not counting the profit on materials to the manufacturers.

4.2. Current Housing Types in Squatter Areas:

On the following pages 11 major types of housing in squatter settlements are recorded.[5] This category doesnot cover all the housing types found in the unauthorized settlements of Karachi it is merely representative of the more frequently observed types.

The study of the existing housing types in squatter areas of Karachi is important in the sense that it provides us certain guidelines for our designs. It becomes the basis for comparison for any proposal that one might make.



PLAN TYPE: JUGGI TYPE I

MATERIALS USED

1. ROOF: SARKANDA, PANKA, PLASTIC
2. WALLS: CHATAI, SARKANDA
3. FENESTRATION: CHATAI, SARKANDA
4. FOUNDATION: NIL

VOLUME

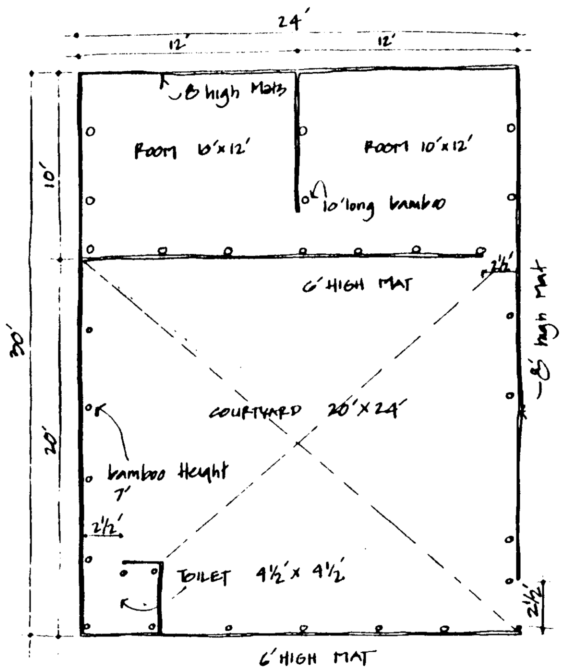
NO. OF ROOMS: 1
ROOM SIZE: 12' x 12'
HEIGHT: 6' x 10'
COURTYARD SIZE: None
TOTAL AREA: 124 sq. ft.

COST in 1974 prices

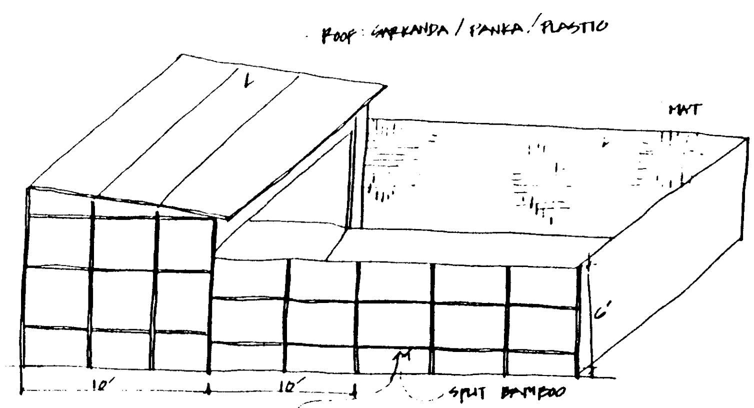
1.	MATERIALS:	Rs. 201.04
2.	LABOR: (mandays ± 2 days)	Rs. 20.00
3.	TOTAL:	Rs. 221.04
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 7.57
5.	INTEREST PER MONTH: (indlucing #4)	Rs. 9.03

Source:

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1'0"



SIDE VIEW

PLAN TYPE: JUGGI II

MATERIALS USED

1. ROOF: SARKANDA, PANKA, PLASTIC
2. WALLS: SARKANDA, CHATAI
3. FENESTRATION: SARKANDA, CHATAI
4. FOUNDATION: NIL

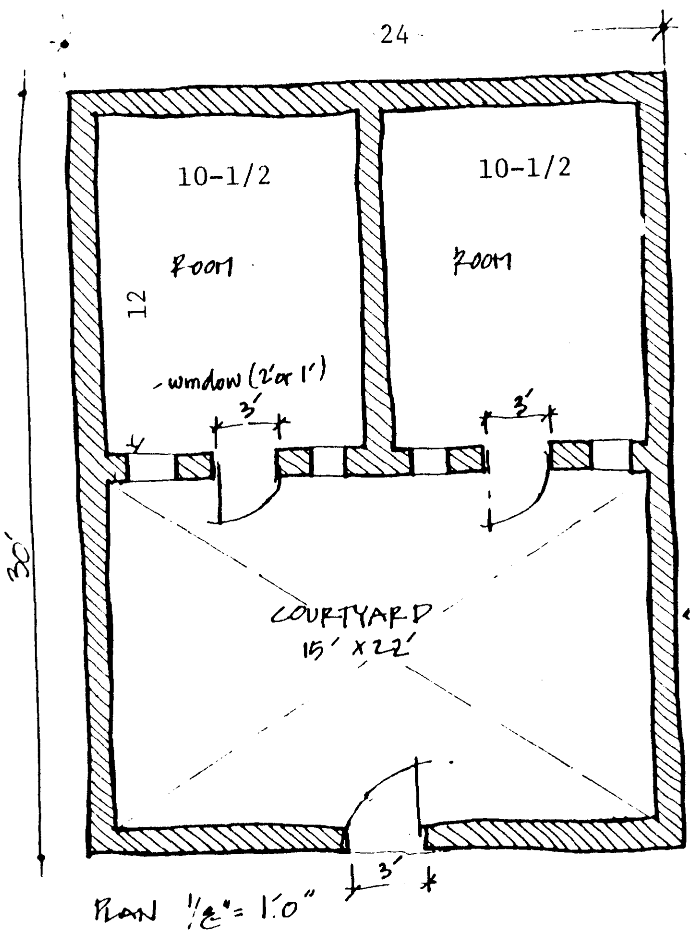
VOLUME

NO. OF ROOMS:	2
ROOM SIZE:	10' x 12'
HEIGHT:	8' - 9'
COURTYARD SIZE:	20' x 24'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 501.65
2.	LABOR: (mandays: ± 4 days, 2 or 3 men)	Rs. 40.00
3.	TOTAL:	Rs. 541.65
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 21.00
5.	INTEREST PER MONTH: (including #4)	Rs. 24.80

Source: Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN TYPE: MUDHOUSE II

MATERIALS USED

1. ROOF: MUD, CHATAI, BAMBOO
2. WALLS: MUDBRICKS
3. FENESTRATION: MUDBRICKS
4. FOUNDATION: NIL

VOLUME

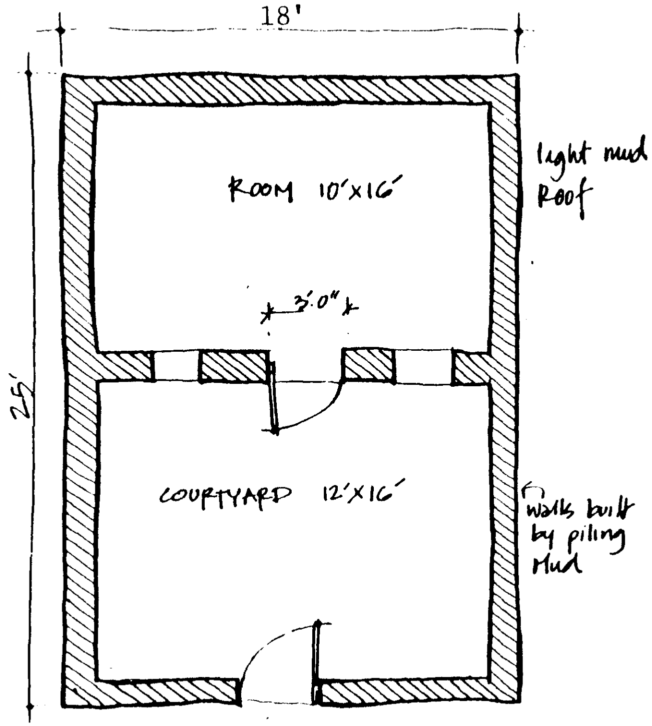
NO. OF ROOMS:	2
ROOM SIZE:	10-1/2' x 12'
HEIGHT:	8' - 8-1/2'
COURTYARD SIZE:	15' x 22'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 695.34
2.	LABOR: (Rs. 6.00/manday ± 60 mandays)	Rs. 360.00
3.	TOTAL	Rs. 1055.34
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 8.89
5.	INTEREST PER MONTH: (including #4)	Rs. 23.62

Source:

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN TYPE: MUDHOUSE III

MATERIALS USED

1. ROOF: MUD, CHATAI, BAMBOO
2. WALLS: MUD
3. FENESTRATION: MUD
4. FOUNDATION: NIL

VOLUME

NO. OF ROOMS:	1
ROOM SIZE:	10' x 16'
HEIGHT:	8' - 8-1/2'
COURTYARD SIZE:	12' x 16'
TOTAL AREA:	450 SQ. FT.

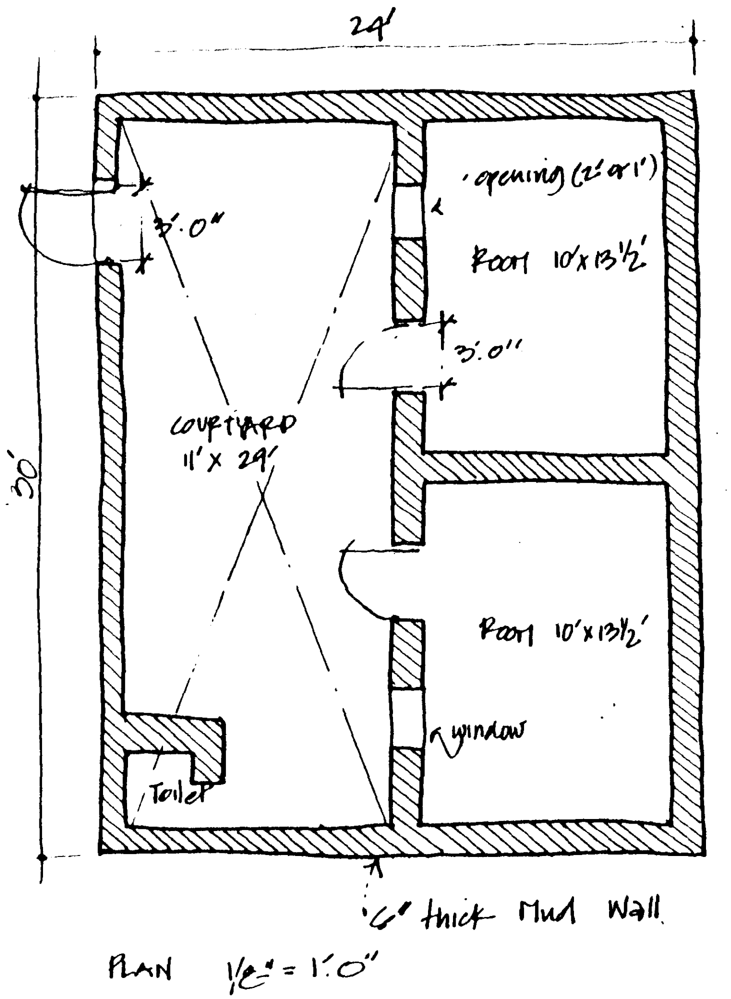
COST

1.	MATERIALS:	Rs. 209.74
2.	LABOR: (Rs. 6.00/manday ± 30 mandays)	Rs. 180.00
3.	TOTAL:	Rs. 389.74
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 4.81
5.	INTEREST PER MONTH: (including #4)	Rs. 9.18

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.

PLAN TYPE: MUD-HOUSE IV



MATERIALS USED

1. ROOF: MUD, CHATAI, BAMBOO
2. WALLS: MUD
3. FENESTRATION: MUD
4. FOUNDATION: NIL

VOLUME

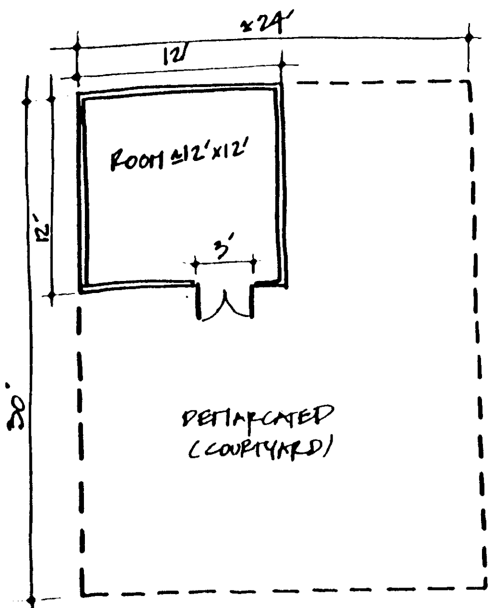
NO. OF ROOMS:	2
ROOM SIZE:	10' x 13-1/2'
HEIGHT:	8' - 8-1/2'
COURTYARD SIZE:	11' x 24'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 332.90
2.	LABOR: (Rs. 6.00/manday ± 45 mandays)	Rs. 270.00
3.	TOTAL	Rs. 602.90
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 7.34
5.	INTEREST PER MONTH: (including #4)	Rs. 15.11

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1' 0"

PLAN TYPE: SEMI-PUCCA I

MATERIALS USED

1. ROOF: IRON CORR. BLOCKS
2. WALLS: UNPLASTERED BLOCKS
3. FENESTRATION: JALLI
4. FOUNDATION: BLOCKS (LIGHT)

VOLUME

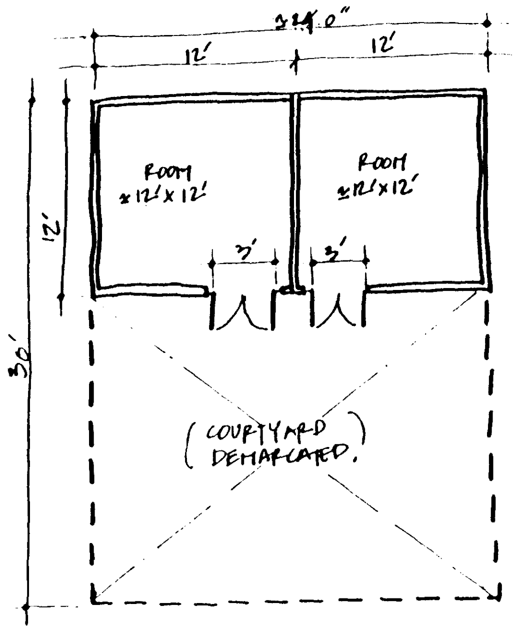
NO. OF ROOMS:	1
ROOM SIZE:	12' x 12'
HEIGHT:	9' - 9-1/2'
COURTYARD SIZE:	None
TOTAL AREA:	144 SQ. FT.

COST in 1974 prices

1.	MATERIALS:	Rs. 778.29
2.	LABOR:	
3.	TOTAL:	Rs. 778.29
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 5.23
5.	INTEREST PER MONTH: (including #4)	Rs. 11.31

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN: 1/8" = 1'0"

PLAN TYPE: SEMI-PUCCA II

MATERIALS USED

1. ROOF: IRON CORR. SHEETS
2. WALLS: UNPLASTERED BLOCKS
3. FENESTRATION: JALLI
4. FOUNDATION: BLOCKS (LIGHT)

VOLUME

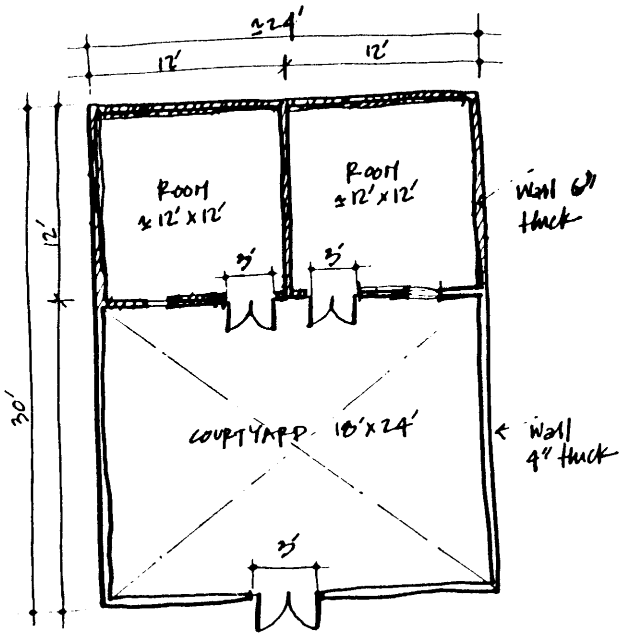
NO. OF ROOMS:	2
ROOM SIZE:	12' x 12'
HEIGHT:	9-1/2'
COURTYARD SIZE:	NONE
TOTAL AREA:	288 SQ. FT.

COST in 1974 prices

1.	MATERIALS:	Rs. 1572.04
2.	LABOR	
3.	TOTAL:	Rs. 1572.04
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 10.56
5.	INTEREST PER MONTH: (including #4)	Rs. 22.87

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1'

PLAN TYPE: SEMI-PUCCA III

MATERIALS USED

1. ROOF: ASBESTOS CORR. SHEETS
2. WALLS: UNPLASTERED BLOCKS
3. FENESTRATION: NEW WINDOWS
4. FOUNDATION: BLOCKS (LIGHT)

VOLUME

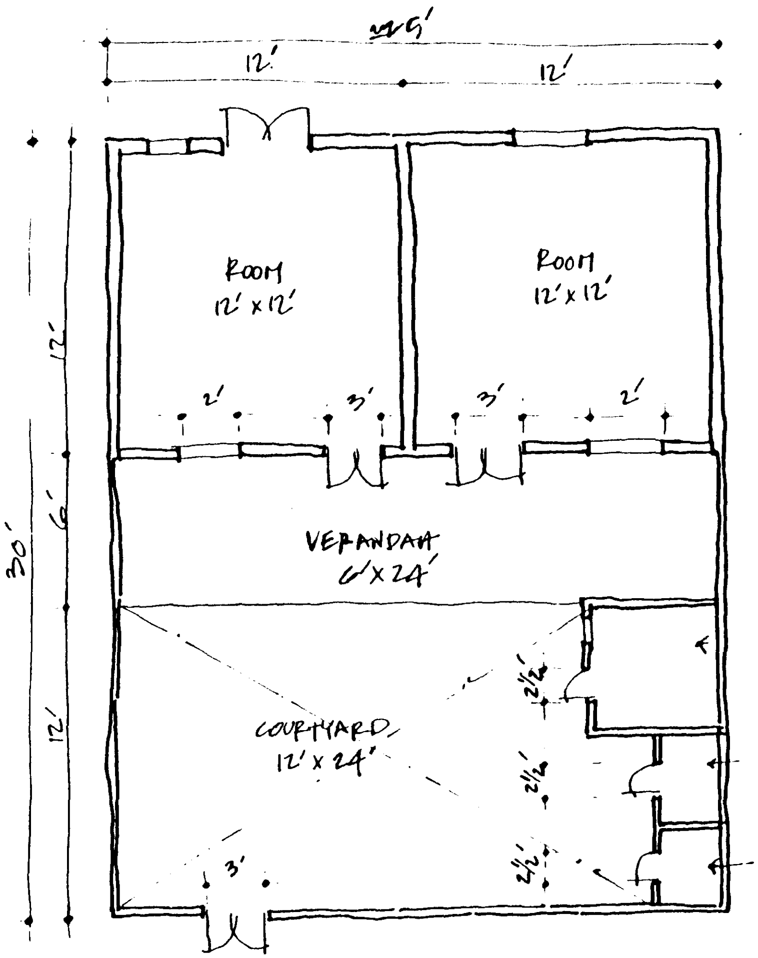
NO. OF ROOMS:	2
ROOM SIZE:	12' x 12'
HEIGHT:	9-1/2'
COURTYARD SIZE:	18' x 24'
TOTAL AREA:	720 SQ. FT.

COST in 1974 prices

1.	MATERIALS:	Rs. 2264.94
2.	LABOR:	
3.	TOTAL:	Rs. 2264.94
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 14.47
5.	INTEREST PER MONTH: (including #4)	Rs. 36.61

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1'-0"

PLAN TYPE: SEMI PUCCA IV

MATERIALS USED

1. ROOF: ASBESTOS CORR. SHEETS
2. WALLS: UNPLASTERED BLOCKS
3. FENESTRATION: NEW WINDOWS
4. FOUNDATION: BLOCK (LIGHT)

VOLUME

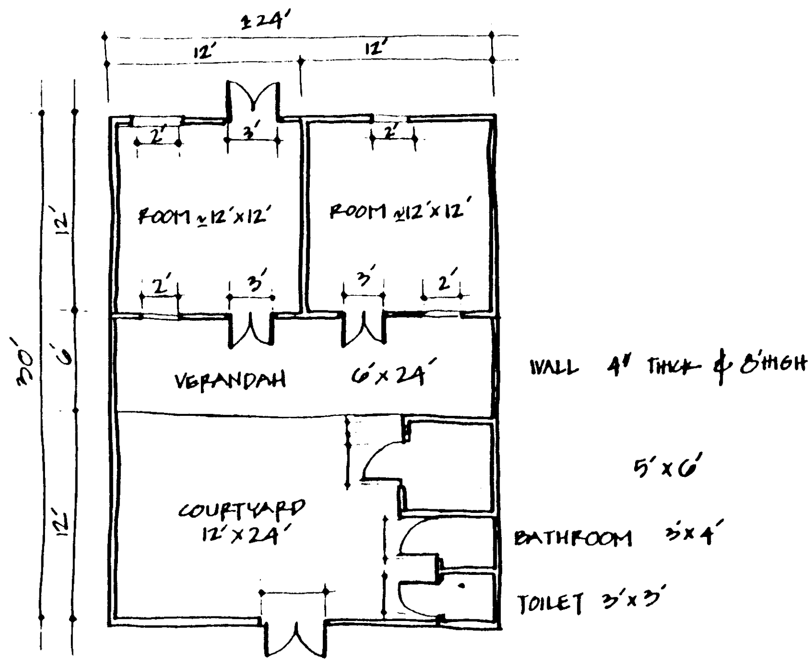
NO. OF ROOMS:	5
ROOM SIZE:	12' x 12'
HEIGHT:	9-1/2'
COURTYARD SIZE:	12' x 24'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 3276.16
2.	LABOR:	
3.	TOTAL:	Rs. 3276.16
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 20.93
5.	INTEREST/MONTH: (including #4)	Rs. 52.96

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1'.0"

PLAN TYPE: SEMI-PUCCA V

MATERIALS USED

1. ROOF: ASBESTOS CORR. SHEETS
2. WALLS: PLASTERED BLOCKS
3. FENESTRATION: NEW WINDOWS
4. FOUNDATION: BLOCK (LIGHT)

VOLUME

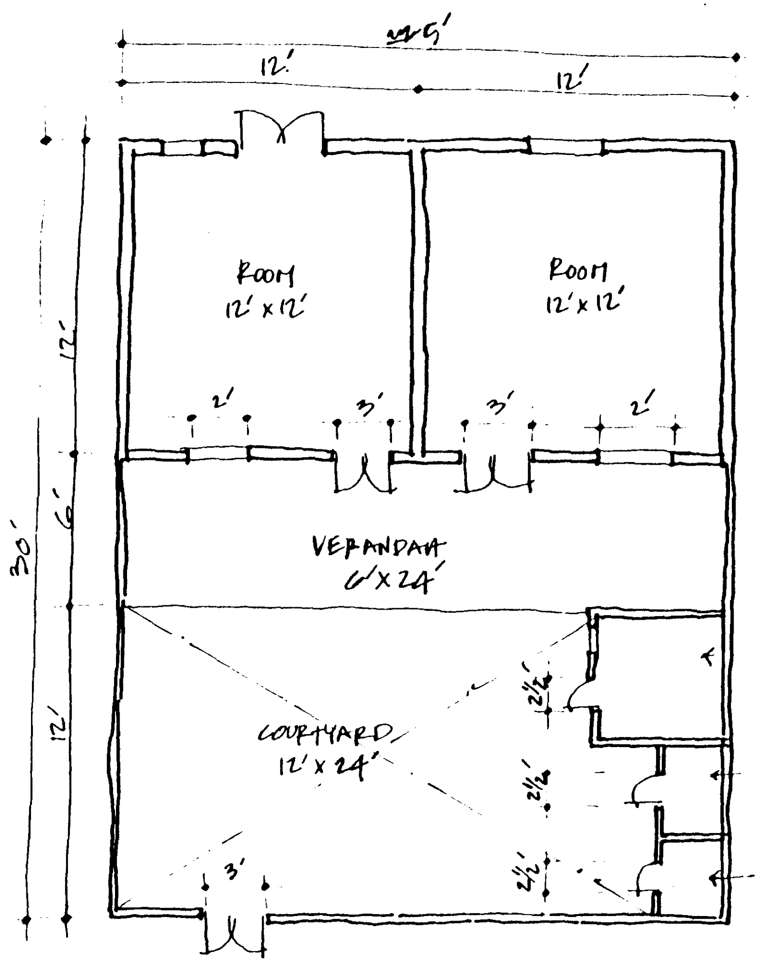
NO. OF ROOMS:	5
ROOM SIZE:	12' x 12'
HEIGHT:	9-1/2'
COURTYARD SIZE:	12' x 24'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 4361.56
2.	LABOR:	
3.	TOTAL:	Rs. 4361.56
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 18.20
5.	INTEREST/MONTH: (including #4)	Rs. 82.60

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.



PLAN 1/8" = 1'. 0"

PLAN TYPE: PUCCA

MATERIALS USED

1. ROOF: R.C.C. (rooms) ASBESTOS (other)
2. WALLS: PLASTERED BLOCKS/PILLARS
3. FENESTRATION: NEW, IRON DOOR
4. FOUNDATION: BLOCK, CONCRETE

VOLUME

NO. OF ROOMS:	5
ROOM SIZE:	12' x 12'
HEIGHT:	9-1/2'
COURTYARD SIZE:	12' x 24'
TOTAL AREA:	720 SQ. FT.

COST

1.	MATERIALS:	Rs. 6804.90
2.	LABOR:	
3.	TOTAL	Rs. 6804.90
4.	ESTIMATED DEPRECIATION: (cost/month)	Rs. 17.01
5.	INTEREST/MONTH: (including #4)	Rs. 340.24

Source: see Appendix A.

Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.

Comparison of Cost (in Rupeea) of Various House Types in Slum Areas of Karachi

Type	Cost Including Labour	Interest Costs
Juggi I	221.04	9.03
Juggi II	541.65	23.18
Mudhouse I	607.67	13.37
Mudhouse II	1,055.34	23.62
Mudhouse III	389,74	9.18
Mudhouse IV	602.90	15.11
Semi pucca I	778.29	11.31
Semi pucca II	1,572.04	22.87
Semi pucca III	2,264.94	36.61
Semi pucca IV	3,267.16	52.96
Semi pucca V	6,804.90	340.24

Data Survey: 1974.

Source: Harst, D.J. van der. "Cost of Residing of Low Income Groups." JRP Project IV, Institute of Business Administration, University of Karachi, 1974.

4.3. Analysis of Current Housing in Squatter Areas:

1. We find that the investment cost of a juggi or a mud-house is comparatively lower than that of a semi-pucca house. However, the semi-pucca requires an investment far larger than the squatter can afford at one time. When he finally does make a transition from the juggi I or mud-house to a semi-pucca type, his return on investment on the existing building is very low.

2. Although the investment cost of a juggi is relatively low, its monthly cost is almost as high as that of a semi-pucca house which provides a better accommodation. The depreciation charge of reed and cane are the main reason for the high monthly cost. Eventually the dweller finds it more convenient to substitute reed and cane by tin, plastic, wooden planks or mud in order to keep the depreciation charges down.

3. Although suitable for a short time, the juggi is ultimately replaced by more durable materials. The juggi dweller must finance the large maintenance cost

4. The juggi offers little protection from inclement weather, i.e., wind, cold, dust, rain, and from fire.

5. The investment cost as well as monthly cost of a mud-house are relatively low. In spite of its relatively low costs, the long period required for construction makes it less popular. Maintenance has to be regular and especially after rain, considerable time may be spent in repairs.

6. Large investments at a time are beyond the capacity of a low-income household.

Savings have to be accumulated over a long time before a mud-house or juggi dweller is able to contemplate building a more permanent dwelling of semi-pucca or pucca type.

7. The juggi or mud dweller when he does invest in a semi-pucca or pucca house, sub-contracts all the masonry work and the work on fabrication of roof slab. He does this essentially as he feels masonry requires specialized skills which he does not possess.

4.4. Conclusion and Summary:

When a squatter builds using bamboo and thatch, he is keeping his investments low for he knows that if he is evicted - which he believes he will be - he wants to loose a minimum investment. As discussed earlier in this paper, squatters who do not have a feeling of security or tenure do not build permanent structures where they squat. However, given current government policies toward regularization of unauthorized settlements more and more squatters find that they can erect permanent structures. Transition from bamboo housing to cement block - the ideal aspiration of most squatters - is not one quick jump but a slow process of accumulating savings, borrowing from friends, and obtaining loans as discussed earlier. In fact, with low liquid assets the squatter is deterred from the thought of attempting the herculean task of building himself let alone through sub-contractors.

Apart from this, when he does initiate a building activity involving incremental growth of his dwelling, he must discard the bamboo or use it for other purposes - especially if he is building in cement blocks. He therefore seeks options for incremental growth of dwelling. Before we discuss the actual implementation of incremental growth it is worthwhile to note the reasons why the squatter would like to build a permanent structure.

1. The rent accrued from any permanent or semi-permanent dwelling is much higher in squatter areas than temporary "kutcha" buildings as studies by JP-IV group have shown.

2. The maintenance cost of temporary structures like Juggi I and Juggi II are extremely high as shown by studies done by Harst with JP-IV.

3. Depreciation of thatch material occurs at a faster rate than more permanent building materials.

4. The squatter aspires for some feeling of permanence, but he wants to keep his investment low in case anything goes wrong.

Given all these arguments we can assume that a squatter would welcome the opportunity to build a more permanent structure, which would require low investment and save him maintenance and depreciation costs which are a significant part of his annual costs, as well as his savings.

The annual costs incurred from using different building materials are discussed later in pages . It is shown that although the Juggi (thatch hut) has a low initial investment its annual costs - which include foregone interest costs, depreciation, and periodically recurrent maintenance costs - are close to semi-permanent types of dwellings. Hence, any proposal for housing that hopes to minimize only the investment cost and overlooks annual maintenance and depreciation costs, will be inadequate. However, reduction of costs usually involves a trade-off with some other utility. A decision to reduce a 6 inch wall to a 4 inch wall will impose a constraint on the dweller's ability to grow vertically. Any new proposal would not be accepted easily as the low-income dweller will not risk his investment in an untried system whose merits have not been totally explored. However, it is clear that the present semi-permanent types involve major investments and such investments are not possible for the low-income population, unless the government provides subsidies for purchase of material, which most governments of developing countries cannot afford.

So a search for alternatives must continue. In the next chapter one such alternative proposal for construction is described. This proposal offers a new way of construction, as well as permits incremental growth of existing temporary housing in squatter areas.

Footnotes:

1. Harst, D.J. van der. "Cost of Residing of low Income Groups." JRP Project lV, Institute of Business Administration, University of Karachi, Karachi, 1974.p.7-p.100.
2. ibid. p.16 - p.93.
3. ibid. p.31.
4. ibid. p.35.
5. ibid. p.16 - p.93.

CHAPTER 5: An Alternative Proposal for Low-Cost Housing.

5.1. Introduction:

In this chapter an alternative proposal for low-cost housing is made. The essential element of this proposal is use of fabric as formwork in construction. The proposal of using fabric as an alternative construction strategy is based on the following premise.

Fabrics of organic material (jute, cotton, flax) are abundantly available at low prices - compared to other construction material - in most developing countries, especially Pakistan, India, Bangladesh and toher S.E. Asian countries. There are, however, some disadvantages of using fabrics made of organic materials. Organic fabrics tend to deteriorate over time. This proposal hopes to exploit the large tensile strength fabrics have in the initial stages of their life-cycle. The roots of this research is based on that observation. From this modest and vague beginning a strategy for fabricating various components of a house, i.e., walls, beams, and domes was developed. This research is still in its infancy so it is difficult to predict the potentiality of the proposed system.

This chapter is divided into two parts. The first part explains the results of initial investigation in the laboratory highlighting especially the difficulties, as well as pointing out some of the more successful results, in using fabric as a construction material.

The second part hypothesizes an actual application of building using fabrics as formwork. The second part is an untested proposal and is still in the process of development.

5.2 Laboratory Experiments on Fabric-Form:

The experiments in the laboratory were concerned with techniques of using fabric as a formwork, to fabricate;

(i) walls (with or without openings)

(ii) floor slab* (includes beams, domes, vaults)

In the earlier stages of the experiment many false starts were made, but finally the use of burlap was narrowed down to either a funicular or catenary form. This investigation is considered preliminary and further investigation has to be done before the results are conclusive. The set of experiments described are arranged as:

1. Walls
   .1. Wall
   .2. Void
2. Floor Slab
   .1. Beams
   .2. Vaults
   .3. Domes

*floor slab: Since the design was to incorporate incremental growth, the domes and vaults were considered as not mere roof components but as an integrated part of a potential future floor slab.

5.2.1 Constructing Walls Using Fabric as Formwork:

The objective in construction of walls was to develope a system by which the fabric could be simply used in such a way that the fabric could form the exterior of the wall; that under load it would not deform extensively; and that in order to control this deformation a minimum of accessory formwork would be used. The solution that seemed to offer best application was to hang the fabric from horizontal poles and allow a funicular deformation which would stretch the fabric in the vertical axis. Once the fabric was stretched any extra side thrust would be absorbed by the tension in the fabric. In terms of the aggregate in-fill within the void, two opetions are available.

i - To have a thick wall of approximately one foot wide which could be in-filled with very poor mass concrete or even soil stabilized with organic waste like cow or donkey dung. It has to be understood that the poor in most developing countries cannot afford to purchase cement or cement blocks unless they have accumulated savings over a long period of time. If they use soil they can stabilize it with small amounts of cement. This will not provide the dweller with a very strong wall but will suffice in the initial stages to build a shelter.

ii - The other choice in building the wall system would be to have an in-fill for the core of the wall and to fill the outer sides with normal concrete. This system would reduce the quantities of in-fill used in the walls. In the case of developing countries this core could consist of organic materials - like fibrous stalks, etc.

The decision that seems most sound at this stage is to have a thick wall of at least one feet width and to in-fill it with poor concrete or stabilized soil. The increased width of wall will provide greater lateral stability. The room with thick walls of soil composite will be cooler and more comfortable to live in than a 6" cinder block wall currently used in Semi-Pucca I or Pucca types.

Fabric as Formwork for Walls:

The following set of experiments were done to develop a system of building walls with fabric;* in our case the fabric chosen was jute burlap.

Certain goals were identified before beginning the experiments. It was hoped that by the end of the experiments these goals will be acheived. The other aspect of the experiment was that certain methods of setting up the formwork were common to all experiments and this is mentioned before describing the experiment. Any deviation from the specified method is indicated in the description of methods for the specific experiment.

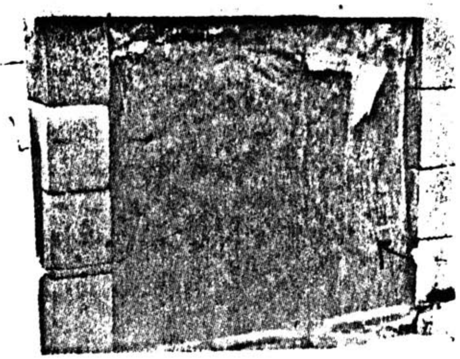
Goals: (experiments on walls)

(i) To suspend a continuous length of jute burlap from two horizontal bars - with a void of 12 inches between the two fabric surfaces, so that it may form the external shell of the proposed wall system.

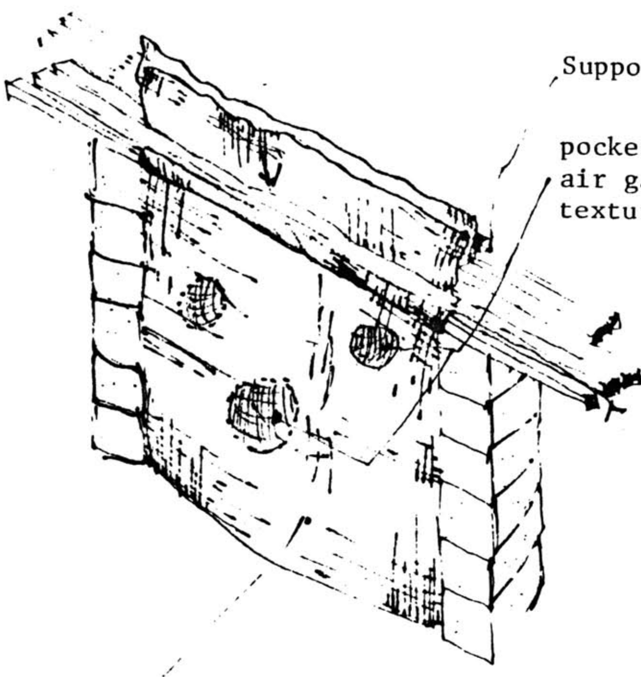
(ii) Develope a simple method - few operations not involving a great deal of time - this was more of a comparative evaluation between different ways of setting up the initial formwork. The constraint in our set of experiments was that it should not take more than 10-15 minutes to hang the jute burlap, for a wall 3 feet high and 3 feet long, assuming that the wall will be built vertically in stages of 3 feet each, or walls can be built in dimensions of 12'x9'x1' as a continous unit, or in any dimension - as required.

(iii) Minimize accessory support elements including those that must be used to reduce surface deformation of wall.

*Any reference to fabric in these set of experiments refers to jute burlap. It is, however, expected that other coarse organic fabrics would exhibit similar properties as jute burlap.



Experiment: 1 (Surface deformation large*)



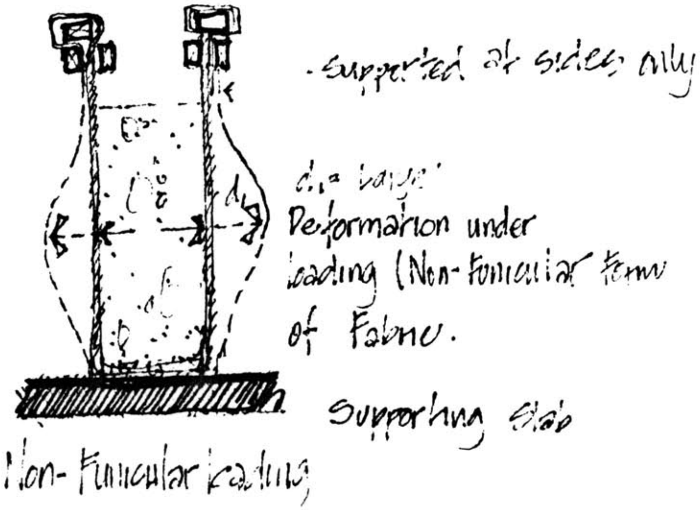
(iv) Have a process - which does not need mechanical equipment to pour the in-fill material inside the burlap formwork.

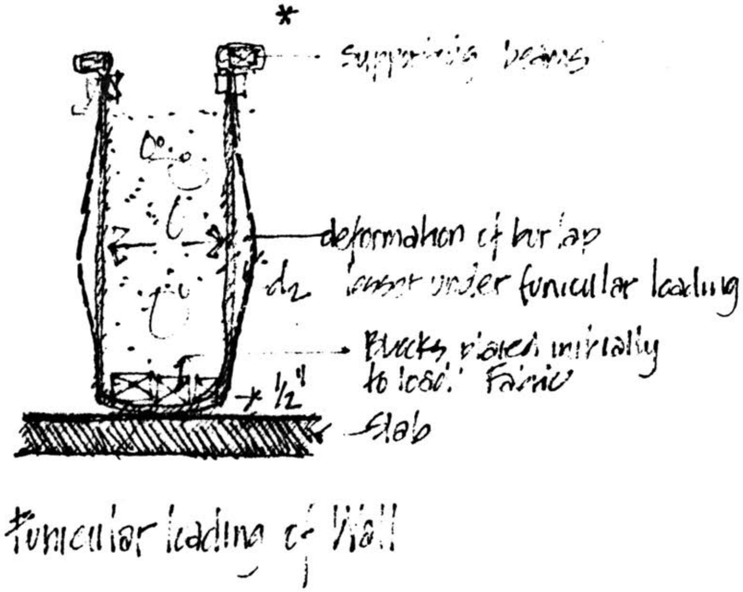
Method: (common to all the experiments on wall)

Jute burlap is suspended on two horizontal wooden beams of cross-section (1-1/2" x 3-1/2") spanning a distance of three feet (3') between supporting concrete cinder blocks. The top edge of the burlap is kept 3 feet (3') above the floor surface. The distance between the two fabric surfaces was kept at 1 feet (1'). (All deformation of fabric was measured from these two planes of fabric surface.) The width of jute burlap used in all the experiments was three feet and three inches (3'3") and the length of suspended burlap wall surface (wall + base) was seven feet (7'). The burlap was attached to the beam by looping it around one

* see experiment 1.

A Comparison of Funicular and Non-Funicular Loading:





beam and sandwiching it between two others (see diagram). Two clamps for each beam assembly held the sandwiching beams together (see diagram).

<u>Experiment 1:</u> There were two sets of experiments done in Experiment 1.

(i) Using dry fabric.

(ii) Wet fabric (subsequent to Experiment 1 all other experiments used wet fabric).

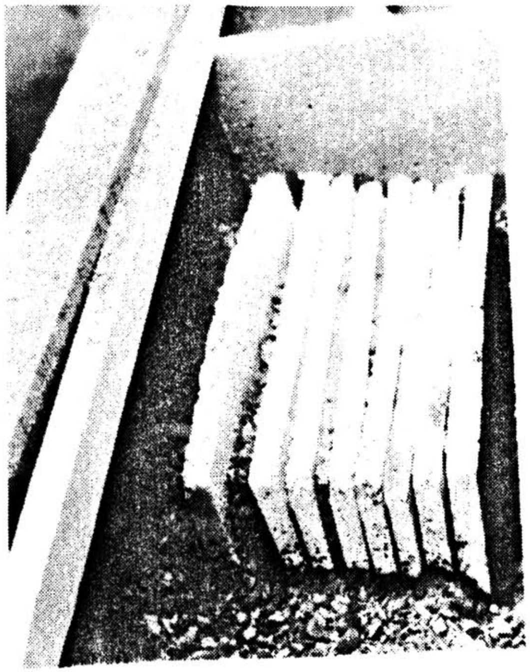
<u>Experiment 1.1:</u>

Objective: Construction of wall with fabric as external formwork.

(i) Dry burlap was suspended as explained earlier in section on methods. It was made to hang 1/2 inch above the ground floor level. The next step was to put weight on the base of the burlap surface just above the floor with bricks to stretch the burlap* to a width of 1 feet at base and length of 3 feet between the span of the

*funicular form development.

Experiment 1.1



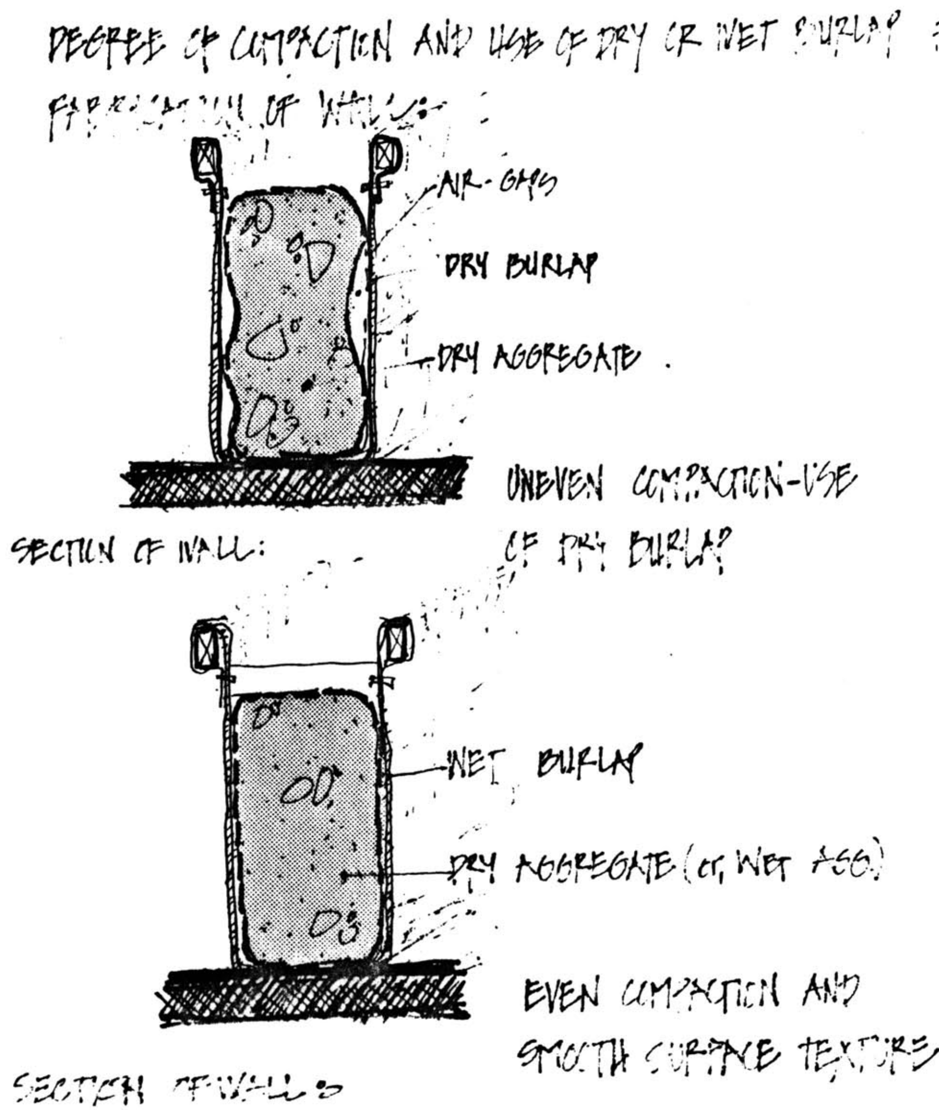
Core partly filled
with insulation, and the
rest with ggregate

Supporting beams

supporting blocks. This resulted in the stretching the burlap so that it rested on the floor and the wall surface became flat and taut. The next step was to tie the open ends of the burlap (sides adjacent to supporting blocks) with wire ties at heights of approximately 3 inches. This done, the void was filled with a mix of 3 parts fine sand and 6 parts coarse gravel (1/2" to 3/4" diameters) in stages of every one feet height. After each stage (3 stages in total) water was sprayed to thoroughly soak the mix. Once the top of wall (3') was reached, this mix was pounded from the top to compact the in-fill.

Observations and Results:

Once the wall had been filled and compacted it was noted that the deformation of the surface at a height between 1' to 2' was large, approximately 2" to 3" from the initial plane of fabric surface. Also the bulge was uneven



and there were pockets of voids (gaps) between surface of burlap and the in-fill mix. Even further compaction did not eliminate these gaps. Also the observed surface deformation was only due to stretching of the burlap within the 7' suspended length. No tearing of fabric was observed.

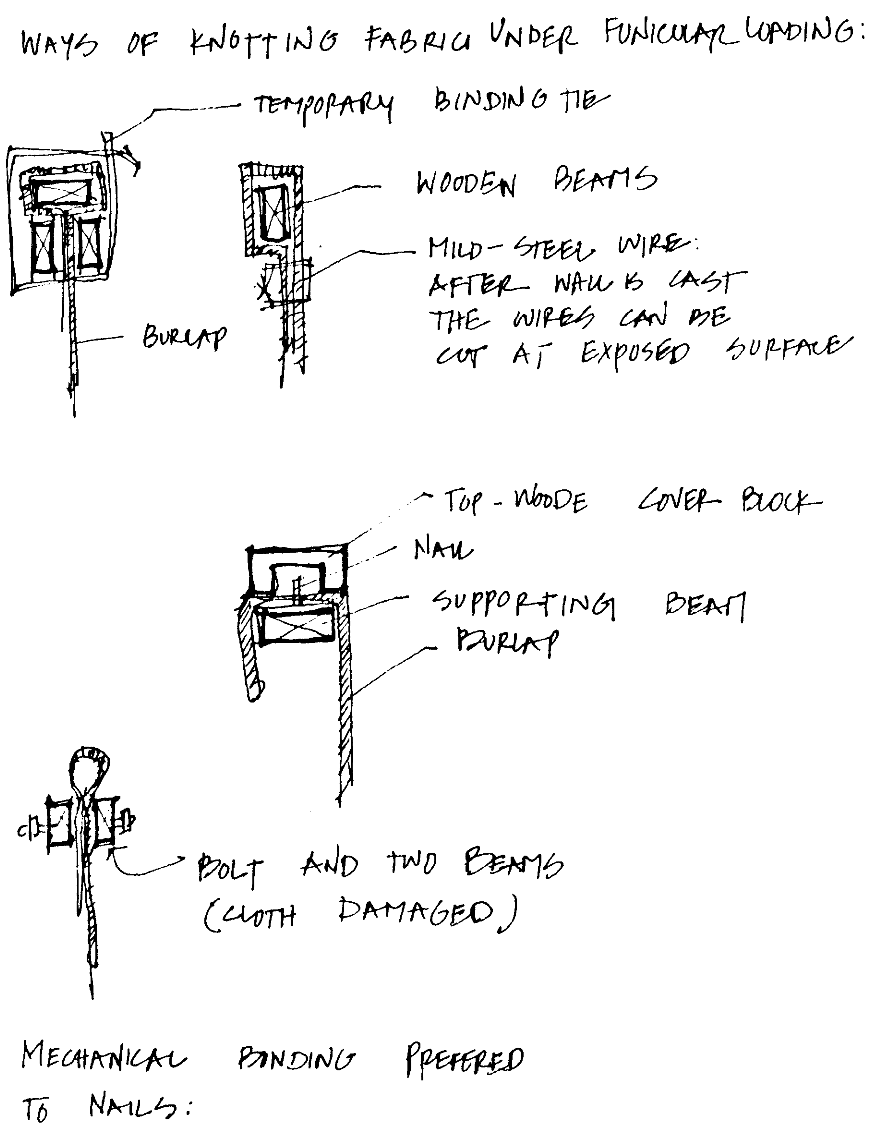
.2. <u>Wet burlap</u>:

<u>Experiment 1.2.</u>

This experiment was repeated as in Experiment 1.1 the only difference was that wet rather than dry burlap was used.

<u>Observation and Results</u>:

With the use of wet burlap there was a slight reduction in the surface deformation (a reduction to 2"-2 1/2"), however, the surface of fabric was smoother and there were no voids (air-gaps) between the surface of burlap and the sand-gravel in-fill. (Subsequently all



experiments on wall was done with burlap initially soaked in water or concrete slurry and then hung on the supports.) Observations were made on the fabric surface after 3 or 4 days after the aggregate had dried. The fabric surface had the same deformation and the wall exhibited the same smoothness of surface - not observed with the dry fabric experiment. No tearing of fabric at any point was observed.

Experiment 2.1. (wet burlap)

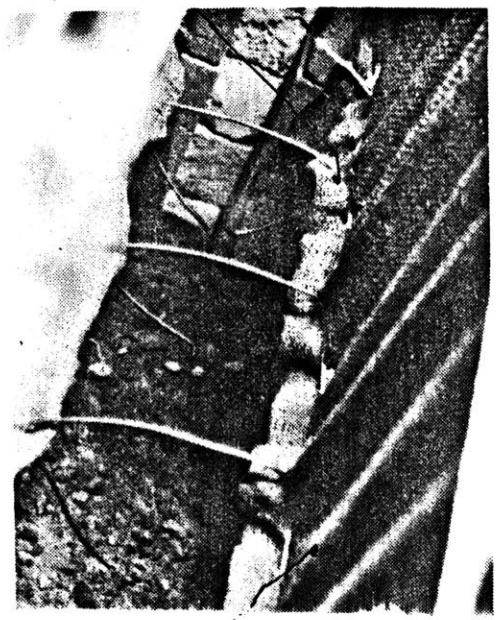
Objective:

The second experiment was concerned with the reduction of surface deformation.

Method:

The same steps were followed as in Experiment 1.2 excepting that once the wet fabric had been suspended, metal ties were attached at heights of every one feet (1') and at distances (horizontal) of every six inches (6"). The

Experiment: 2.2



process of in-filling the wall void was repeated as in Experiment 1.1 and 1.2.

Observations and Results:

In this case it was observed that there was bulging of fabric so that the surface resembled a set of cylindrical tubes placed horizontally in rows. The maximum deformation was less than in Experiments 1.1 and 1.2 (the deformation was about 1"-2" from initial plane). The surface was smooth. However, there was tearing of fabric where the metal ties had been attached. This wall was pounded all around to see if the tearing increases at points where the ties were attached, and this tearing was observed to increase.

Experiment 2.2

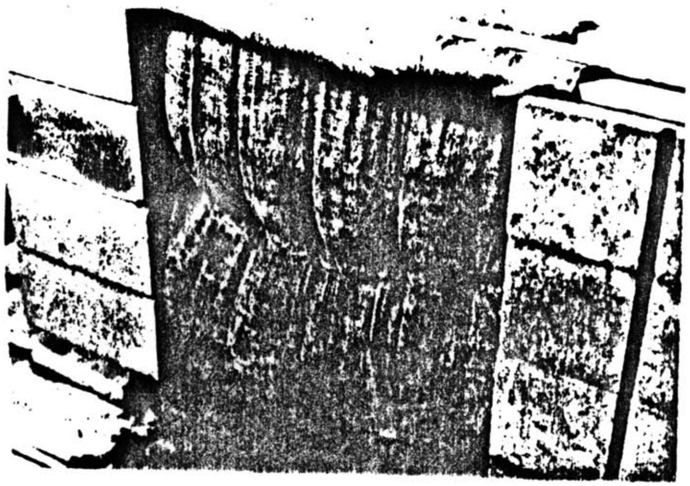
Objective:

Reduction of tearing of burlap at points of connection with metal ties.

Experiment: 2.2

flaps put in horizontal bands

surface undulation larger when distance between ties large



Method:

Before hanging the fabric as in other experiments, 1" flaps were sewn along the length of the wall (3') at distances of 8". The opposite faces of the wall were then connected at the flaps by mild steel ties.

Observations and Results:

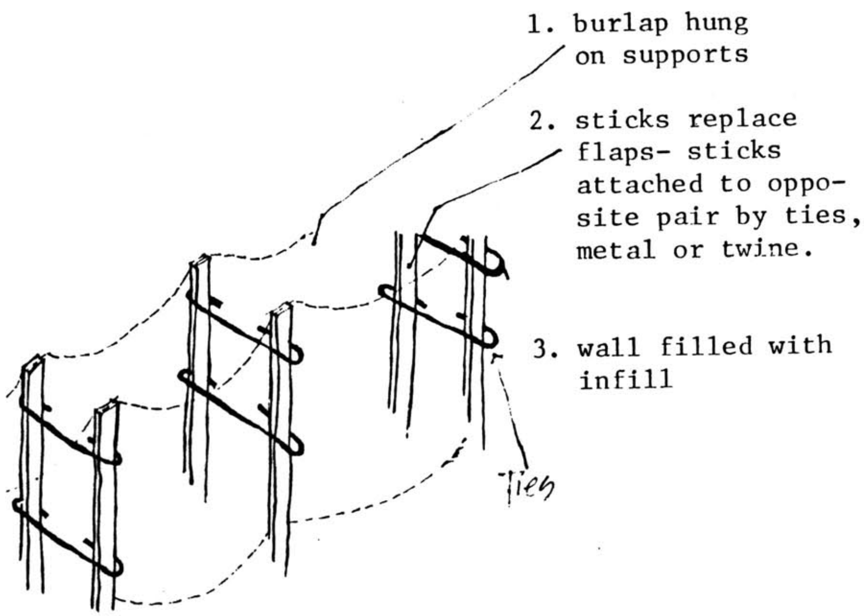
It took about 10 minutes to sew 4 sets of 1" flaps on a sewing machine. It was observed that there was no tearing of fabric and the surface was smooth but deformation was still large 2"-3" from initial fabric plane. The soil was subsequently compacted (pounding with bricks). The fabric showed no increased deformation or tearing at any point.

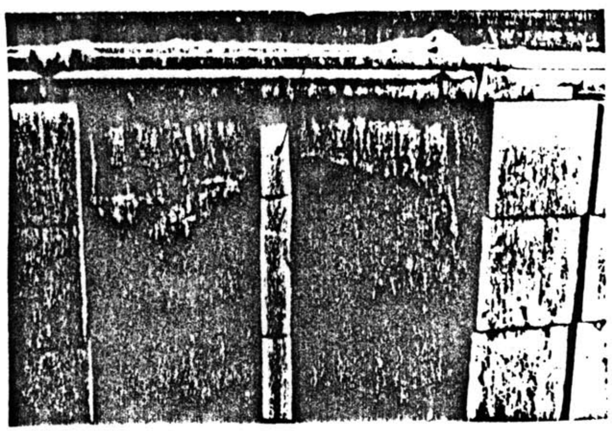
Experiment 3: (wet burlap)

Objective:

Use of sticks to reduce surface deformation.

Experiment 3:





Method:

The method of hanging the fabric was repeated as in Experiments 1 and 2, however, metal ties were not attached directly to the fabric. A set of sticks (3 on each face) of lenght 2' 6" were placed on the external face and the pairs on opposite wall faces were connected with metal ties.

Observations:

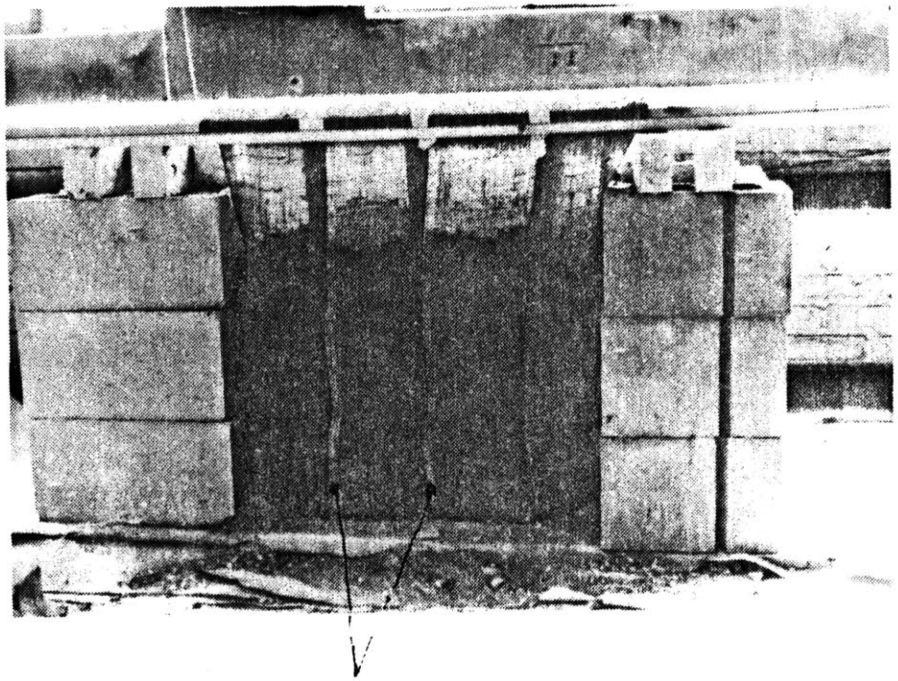
It was observed that the surface resembled vertical tubes stacked side by side. The surface was smooth and there was no tearing of fabric. When the in-fill was compacted the surface gave a smooth appearance. The deformation was also minimal 1"-1-1/2" from initial plane of burlap surface.

Experiment 4:

Objective:

To have vertical cylindrical wall surface.

Experiment 4:



Flaps sewed on fabric lengthwise at distances of 8" between them. There was no tearing of burlap

Method:

This time the burlap was sewn in folds - 3 folds of 1" width and at distances of 8" between them all along the 7' length of the burlap and the burlap hung as in all other experiments. It took about 20 minutes to make the three sets of folds on a sewing machine. The wet burlap was hung as in Experiment 1.2 and opposite faces of burlap were connected at the flaps with mild steel ties at heights of 1 feet. This was subsequently filled with sand-gravel in-fill as in 1.1 and all other experiments.

Observation:

The fabric surface was very smooth and there was no tearing of the fabric. Additionally the maximum deformation of surface was only a 1" to an 1-1/2". The surface of the wall appeared like vertical tubes stacked side by side with a grove of 1/2" at points of attachments of metal ties to the flap.

Experiment 5:

Objective:

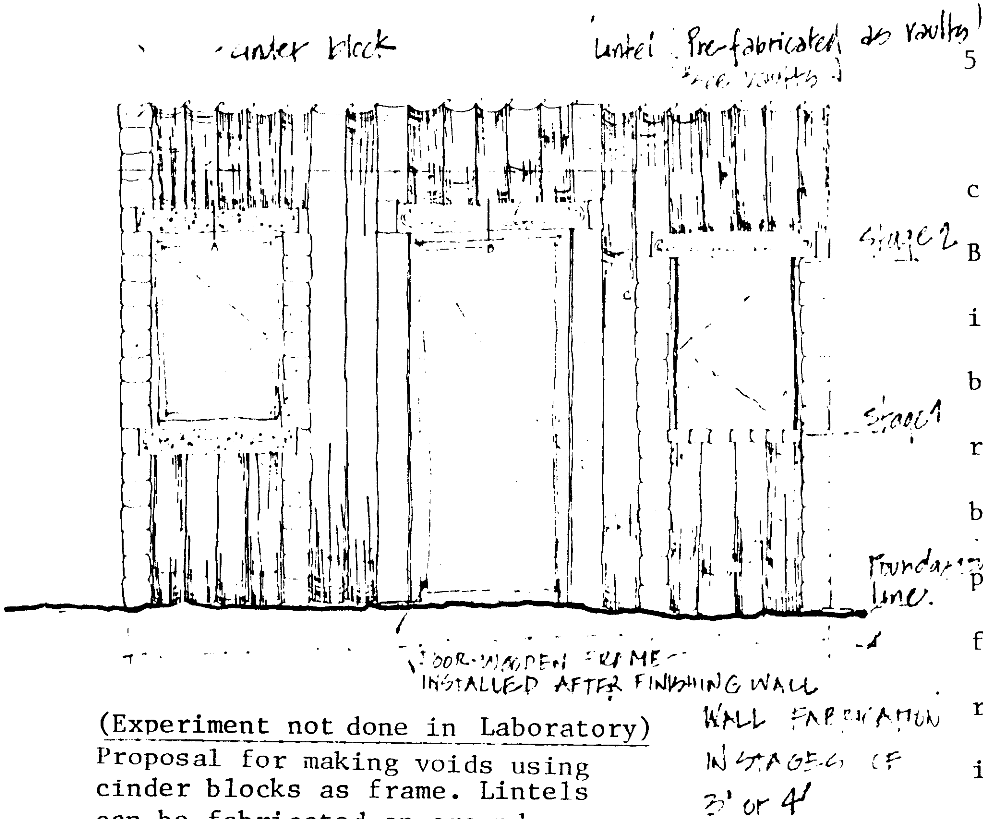
To determine assembly time of a 3 feet high and 10 feet long wall.

Method:

The same method of hanging fabric was used as in other experiments, only the cinder blocks were placed 10' apart.

Observation:

It took 20 minutes for one person to hang the fabric on the supports and another 30 minutes to complete putting the mild steel ties at distances of 16", lengthwise, and at heights of 1 feet (1') along the burlap wall unit.

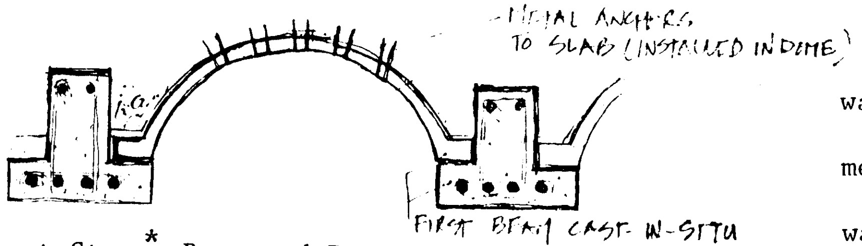


(Experiment not done in Laboratory)
Proposal for making voids using cinder blocks as frame. Lintels can be fabricated on ground by either using fabric-form, as discussed in making of vaults.

5.2.2 Making Openings in Wall:

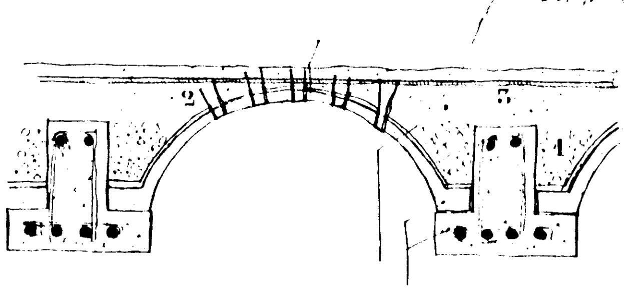
There were no specific experiments done to create voids, doors or windows, or openings. But it was seen as possible considering that in the process of fabricating walls, certain blocks could be placed where the openings are required and the fabric folded inwards just before the blocks (see sketches). Another possibility considered was putting a wooden frame inside the fabric and nailing the fabric onto the surface. Subsequently the wall is poured and cast and the fabric is simply cut from the opening. Doors or windows can be attached to this frame before or after casting has taken place. If a cinder block frame was being considered, lintels would be required. Lintels could be fabricated as vaults, shown in the section on roof, and spanned over the two end blocks framing the opening.

(Proposed, Not experimented in the Laboratory)



First Stage*: Beam and Dome

Beam, cast-in-situ and made in fabric -form as a T·· beam, and dome fabricated on ground as a catenary



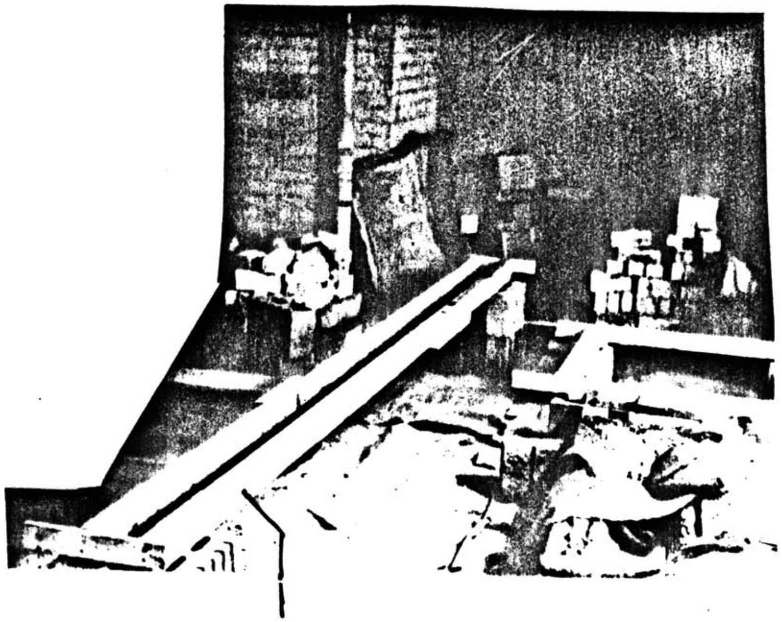
Second Stage*:Protruding metal ties from dome linked to reinforcements from slab and integerated slab-dome fabricated.

* see following sections on fabrication of domes and beams.

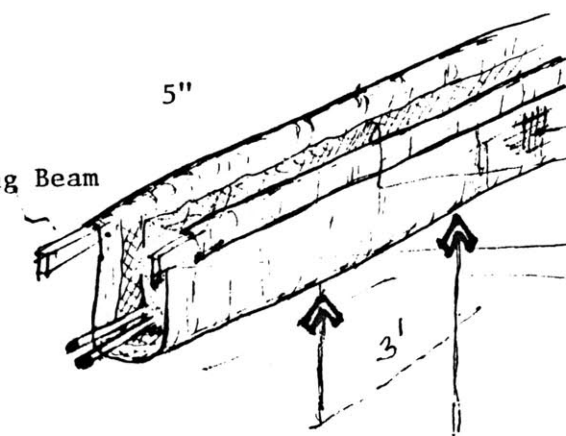
5.2.3 Floors: Beams + Roof Slab (Domes, Vaults)

Introduction:

The objective in these sets of experiments was to develope a simple and more economical method of casting floor slabs. The problem was seen as fabricating of floors rather than roof systems as one of the most important issues in self-help building systems was to devise a cheaper roof system which can be developed to serve as a floor slab if the dwelling needed to expand vertically. In order to do this it was necessary to identify the different components that make the floor or roof system. It was decided that the components which ought to be developed at this stage of investigation should be beams, to span the length of the wall, and roof slabs (domes in our case) to span the shorter distances between the beams. The criteria for design of the beam was that it ought to be cast-in-situ on top of the wall as fabrication on ground would involve transferring heavy beams to the top of the wall. The criteria for weight of roof slab was that it should be light enough to be lifted by 2 or 3 people - approximately 120 to 140 lbs - and its span should be as large as possible within the weight constraint. The next set of experiments show the experiments that were done to fabricate beams and roof slabs (in our case domes and vaults). These only form part of the roof system. Fabrication of a floor slab was not done in the laboratory but has been assumed as possible once the proposed roof has been made.



Form_Work for Fabrication of Beam (10' Span)



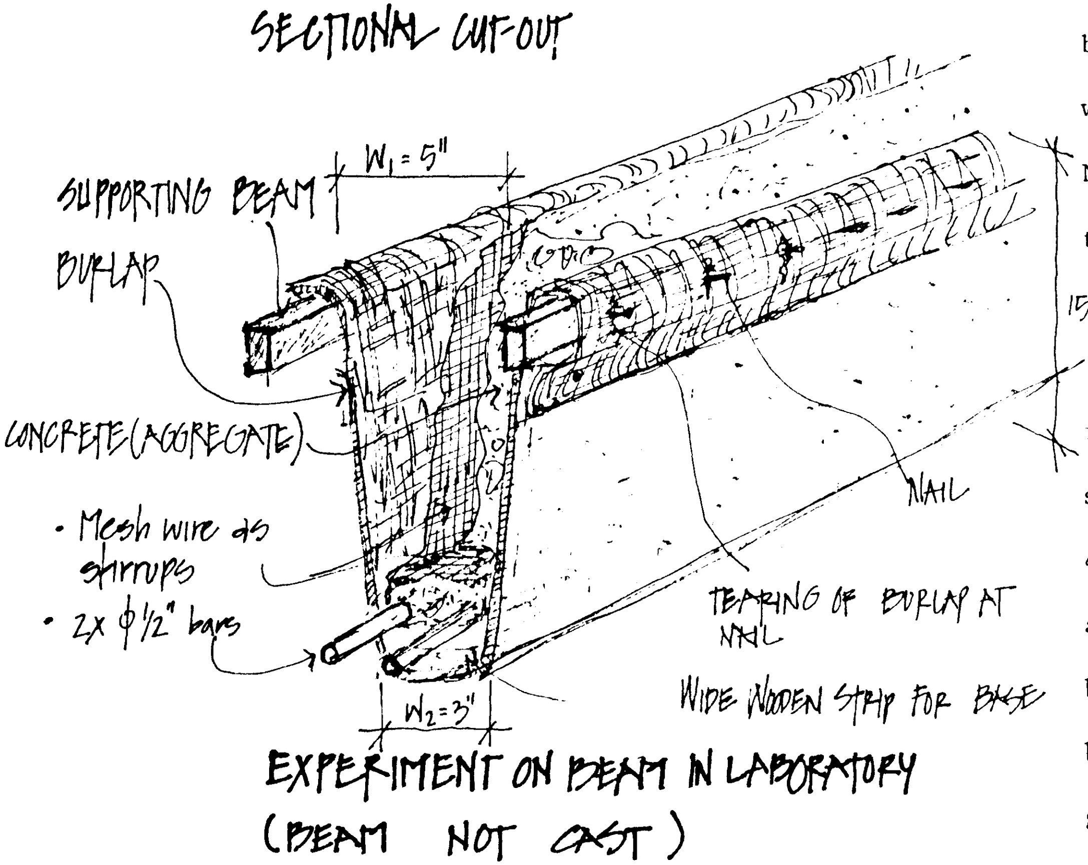
5.2.4 Beams

Objective:

To simulate fabrication of a beam of clear span 10' and cross-section 5" x 3".

Method:

A wooden frame of cross-section 1-1/2" x 3-1/2" and internal dimensions of four inches by eleven feet (4" x 11') was fabricated. This was supported on cinder blocks placed at ends so that it was supported for a length of six inches on the blocks. Dry burlap of dimension 11 feet by 8 feet overlapped into two 1' x 4' pieces, was nailed to the frame. (The frame had nails at every 10 cm distance on each side.) A 1/2" x 3" x 10' wooden strip was placed at the bottom of the burlap catenary. Subsequently 2 cm 1/4" bars of 9 feet length with six inches at ends turned inwards (total length of bar = 10") were placed inside. The



beams did not have the conventional stirrups but were rolled inside mesh-wire with mesh wire sticking out of the top of the beam. Next, dry sand and gravel mix was poured into the catenary.

Observations and Results:

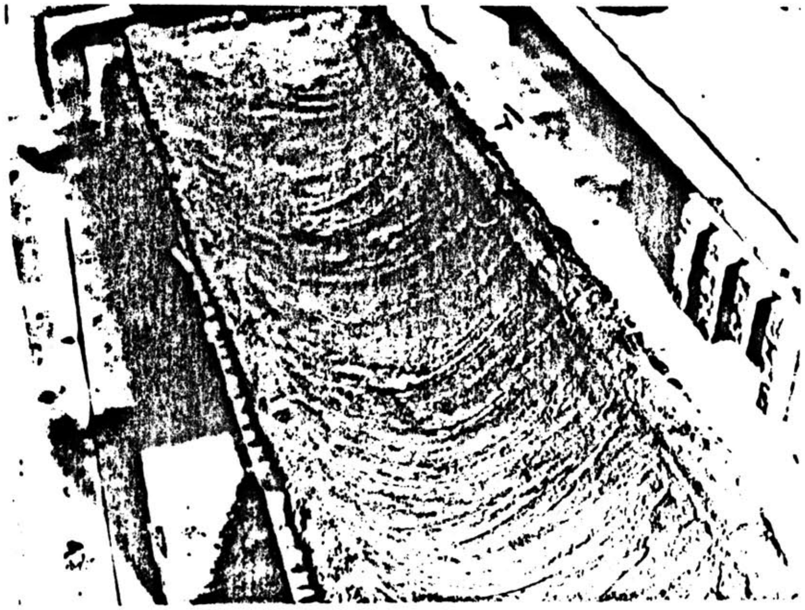
With about 4" of sand inside the funicular form the beam started to deflect. At this stage additional supports were placed at every 4 feet (cinder blocks) under the wooden beam and burlap surface, and the top of the pair of beams was connected with strips of wood. This beam was subsequently filled with sand and gravel to a height of 10" and water was poured to soak the aggregate. The beam did not deflect or fail, although the burlap tended to stretch at points where it was connected to the nail. It was not determined if a single fold of burlap

1' x 4' would be enough to support the load of beam.

Conclusion:

In the above case the beam was actually not cast. However, the experiment indicates that burlap can be used to fabricate beams but intermediary supports may be necessary at say every 3 feet (3') length supporting both the burlap and the wooden beams. Also, the method of anchoring the burlap to the beam should be changed. Nails tend to tear the burlap. If the burlap had been rolled over a beam and sandwiched between two others (see sketch) beams this tearing can be avoided.

The next set of experiments were concerned with fabrication of vaults and domes.



Experiment 1:
(Using dry burlap)
Very difficult to trowel. Rough finish and the fabric could be peeled off after casting of slab.

5.2.5 Vaults:

Objective:

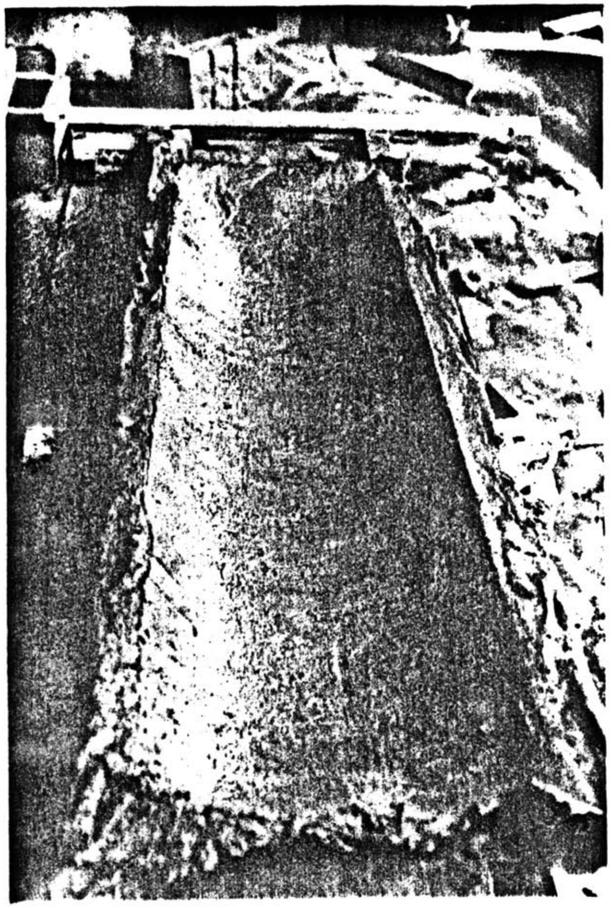
Fabrication of vaults of maximum weight 60 - 80 lbs, and dimensions 1 feet (1') wide and six feet (6') long.

Method:

A wooden frame for the vault was made with wood of cross-section 3/4" x 2-1/2" and internal dimensions of 1 feet by 6 feet. A base frame of wood, dimensions 3/4" x 2-1/2" was nailed to the frame so that the pointed ends stuck out upwards. Next burlap* of dimensions 2' x 9' was suspended on frame so as to form a single curvature catenary vault spanning 6', i.e. that is the full distance of the frame. (Catenary depth = 6".)

Experiment 1: (using dry burlap)

*coarse jute burlap.



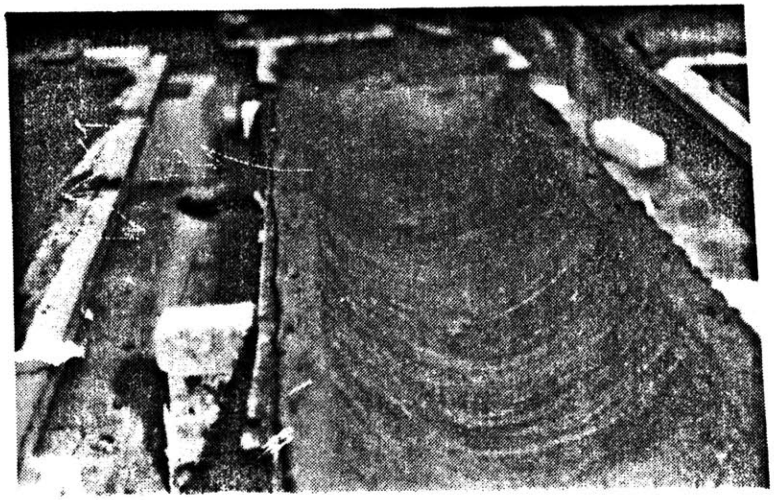
Experiment 1
(After addition of Water to
to initial aggregate mix.
Easier to mortar but slurier
mix- not desirable in terms of
concrete strength)

The first experiment was done using a dry burlap. Mortar consisting of 1 part of cement and 4 parts of sand and 1 part water** was prepared. Attempts were then made to trowell a 1/2" concrete onto the catenary vault. This was found very difficult to do as mortar would not adhere to the burlap. The concrete mix was added another 1 part by volume of water to make a more slurry mix. This slurry mix was then trowelled on the burlap.

Observations and Results:

The weight of the shell was approximatley 40 lbs. The trowelling of mortar on dry burlap was found impossible to do. The mortar would not adhere to the burlap and peeled off with every application. When a slurrier mix

**All proportions were by volume
+ Catenary depth = maximum depth from apex of catenary to plane of edge of catenary.



Experiment 1.2:
(Using Wet Burlap)
Application of concrete on burlap was easy and the bond between fabric and concrete was well integerated.

was made - trowelling was easier but still the mortar did not adhere to the burlap at several points on the surface and it was difficult to obtain a consistent thickness.

After three days of curing, the catenary form-dome- was removed from the frame and over-turned. The vault was tested with a load of 50 lbs - (edges restrained) - the vault did not fail. It was not tested to failure. (Catenary depth = 7" after concrete shell is cast.)

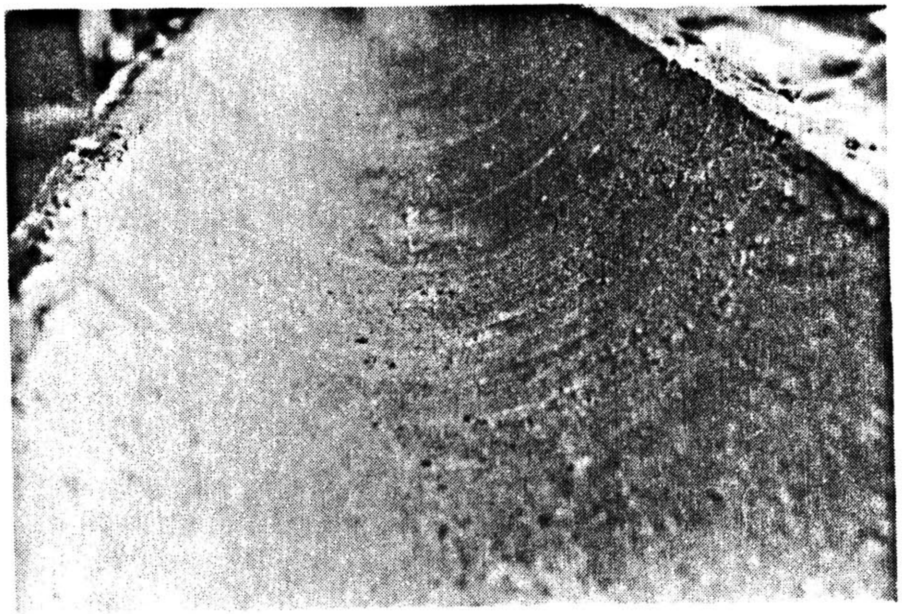
Experiment 1.2:

Objective:

To increase the bond between burlap and concrete mortar.

Method:

In this experiment the process of fabrication was as in Experiment 1.1 except for the fact that the burlap was soaked in water for a few minutes - the water squeezed out - and subsequently burlap hung on the frame. Mortar



Experiment 1.2:
Very smooth surface can be obtained when using wet burlap.

(same ratio as in Experiment, i.e., 1:4) was troweled onto the surface of the catenary. (Catenary depth = 6" before trowelling of concrete.)

Observations and Results:

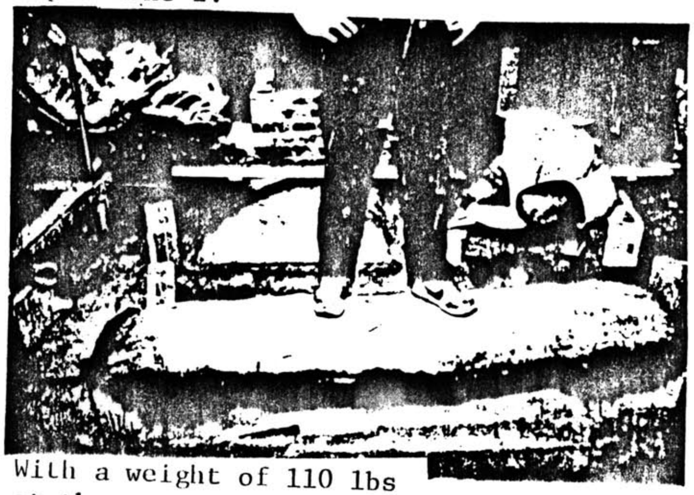
The weight of this shell was approximately 40 lbs. It was found that with wet burlap it was easier to trowel the surface with concrete. The process of trowelling was from the center (apex) to the outer edges. It was possible to obtain approximatley a 1/2" shell. Both these vaults were loaded with a weight of 50 lbs/sq. ft. at the apex (restrained edges). The vault did not fail. They were not tested to failure. (Catenary depth = 7" after casting of shell.)

Experiment 2:

Objective:

To measure strength of reinforced concrete vault with coarse aggregate mix.

Experiment 2:



With a weight of 110 lbs at the apex - center of six foot span- the vault did not fail

With a weight of 225 lbs - loaded at mid-section- the vault failed (This vault was weaker than others as coarse aggregate (1/2" to3/4" iches was used in a shell of thickness 1/2 inches).

Method:

The same method as in Experiments 1 and 2 was repeated. The exception was that a wire mesh 1" gauge was laid on top of the burlap before trowelling. Also the concrete mix was of the proportion one part of cement : two parts sand : and two parts gravel (1/2" to 3/4") (1:2:2). Concrete shell was approximatley 1/2" thick. (Catenary depth = 6" before trowelling of concrete.)

Observations and Results:

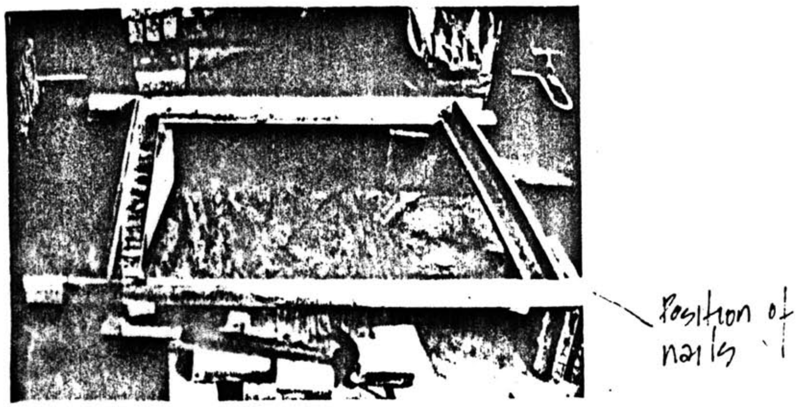
The weight of this vault was about 40 lbs. The inner surface of catenary was very rough because of the coarse aggregate. This vault was loaded at the apex with a load of 225 lbs (unrestrained edges, and spanning 6 feet length). The vault failed and the wires were sheared completely. The failure was at the center of the vault (3' distance) and it was found that at points of failure there was less mortar thickness. (Catenary depth = 7" after casting of shell.)

Conclusion:

The set of experiments on vaults indicated that it was possible to fabricate them, however, with shorter widths of vault - trowelling was more difficult and consistent thickness of shell was difficult to obtain. The reinforced vault that failed appeared to have failed due to a poorer strength of concrete due to the coarse gravel in the mix. If the mix was of 1:4 proportion of sand and cement, and the vault was reinforced, it was felt that it would not have failed under that load of 100 lbs/sq. ft.

These sets of experiments were suspended at this stage and it was decided to fabricate larger domes - having double curvature. This is explained in the next set of experiments.

3/4"-2 1/2 " wooden frame
117



First Stage:
Fabrication of frame for catenary.Nails were stuck on the base plate.

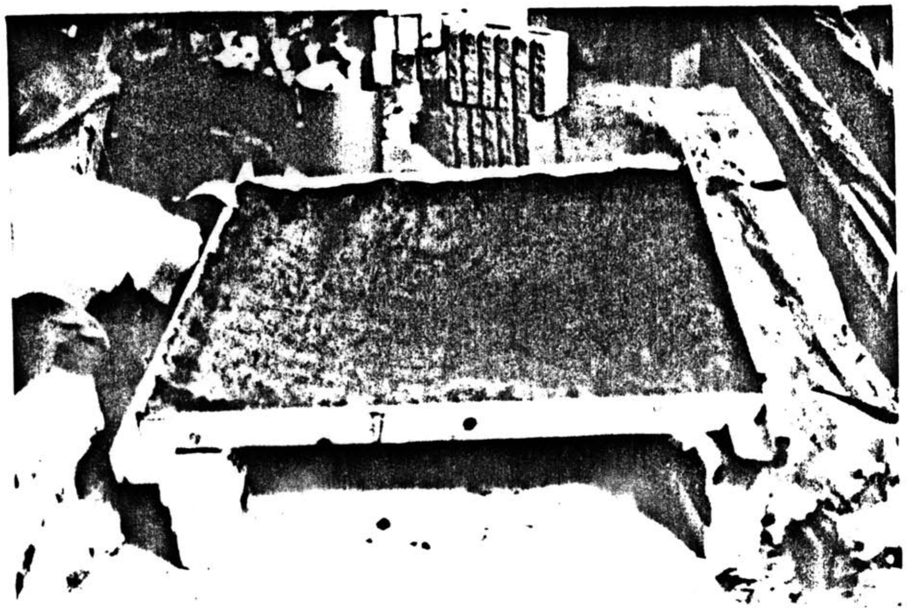
5.2.6 Roof

Objective:

To fabricate a dome by using burlap as the catenary framework.

Method:

A square frame, 3 feet x 3 feet made of timber of cross-section 3/4" x 2-1/2" was fabricated. This frame had a base strip. The base strip (cross-section 3/4" x 2-1/2" had nails - ends protruding upwards from the base at distances of 6" all around the perimeter of the frame. The frame edge was lined with building paper. Wet burlap of dimensions 3'4" x 3'4" (100 cm x 100 cm) was attached to the nails and suspended from the frame to form a double curvature catenary (catenary depth = 6" before trowelling concrete).



Paper lining. to facilitate
removal of dome.

wet burlap hung on frame

Experiment 1:

Objective:

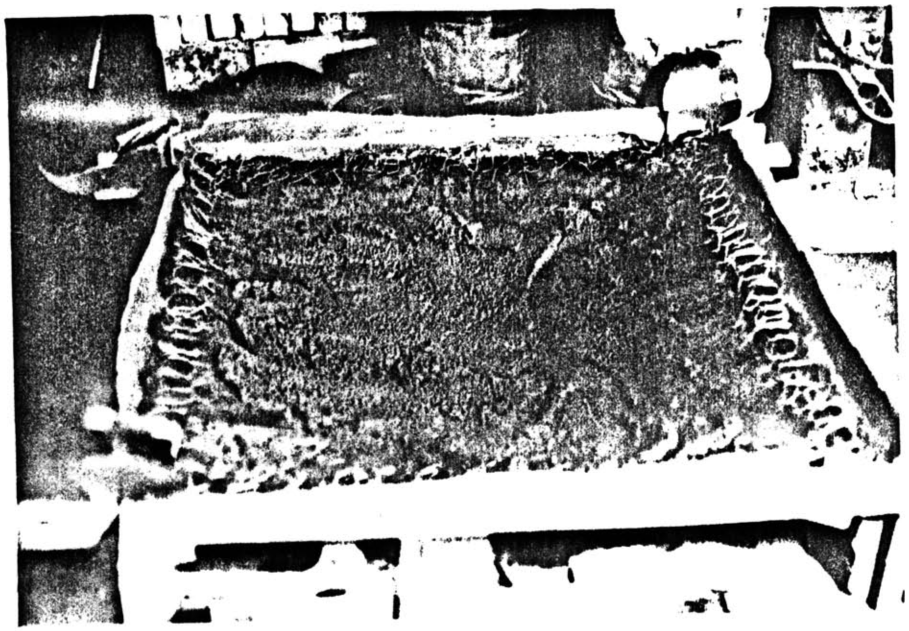
Make a 3' x 3' dome. Shell thickness 3/4".

Method:

Formwork was made as explained above. Concrete of proportion - one part cement to two (2) parts sand, and 1 part water (by volume) - was prepared and trowelled onto the fabric. The trowelling began at the center of the fabric and proceeded outwards to the edges. This resulted in a catenary of an average shell thickness of 3/4".

Observations and Results:

The trowelling on wet fabric went smoothly, however, there were some problems of getting a consistent thickness over the surface of the catenary. It was also difficult to trowell concrete near the corners. After 3 days the shell was removed from the



Experiment 3:
Mesh wire placed on top of burlap and concrete (1:2) applied. Shell thickness 1/2"

**Catenary depth (for all experiments) = maximum depth measured from apex to plane of edge of catenary.

frame and over-turned. It was found to weigh approximately 80 lbs. A load of 50 lbs/sq. ft (by placing bricks on top) was applied at the apex of the dome (dome restrained at the perimeter). The dome showed no signs of failure. The dome was not tested to failure. (Catenary depth 7-1/2-8" after trowelling.)

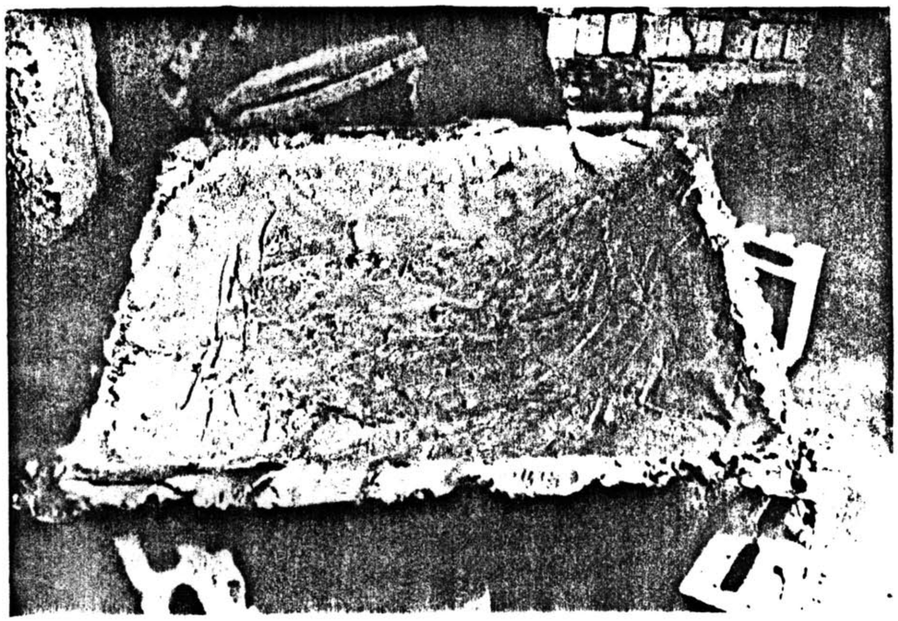
Experiment 1.2.2:

Objective:

Dome (3' x 3') with better bond between burlap and concrete.

Method:

A similar wooden form work as in Experiment 1 was used. Only this time the burlap was dipped in a concrete slurry of mix 2 parts cement and 1 part sand, and 2 parts water (by volume). This burlap was then squeezed to remove any thick layer of concrete on the burlap. The burlap was then hung on the frame as in Experiment 1.



Experiment 3:
Careful mortaring is required especially while applying a final coat to get a smoother finish. A slurrier final coat produces a smoothe finish.

As in Experiment 1, the catenary burlap form was trowelled with a layer of 1/2" concrete of one (1) part cement to two (2) parts sand and one (1) part water (by volume). (Catenary depth 6" before trowelling cement.)

Observations and Results:

It was found that trowelling was easier and it was possible to get better bond between the burlap and the concrete - obtained a more consistent thickness - and working on the corners was less difficult. This dome was found to weigh around 85 pounds. It was tested with a 50 lb/sq/ft load (perimeter restrained). It did not fail under loading, however, this dome was not tested to failure. (Catenary depth 7-1/2-8" after trowelling.)

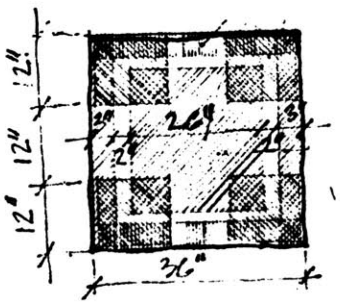
Experiment 3:

Objective:

To fabricate a nominally reinforced dome (3' x 3') in dimension.

Experiment:3

Reinforcement: Mesh-Wire (gauge 1")
at apex, corners, and
perimeter.



PLAN

Dimension 3'x3'
Shell : 1/2"

Load of 300 lbs/ sq.ft. was applied (clear span= $2^1/2$ feet). Dome did not fail.

Method:

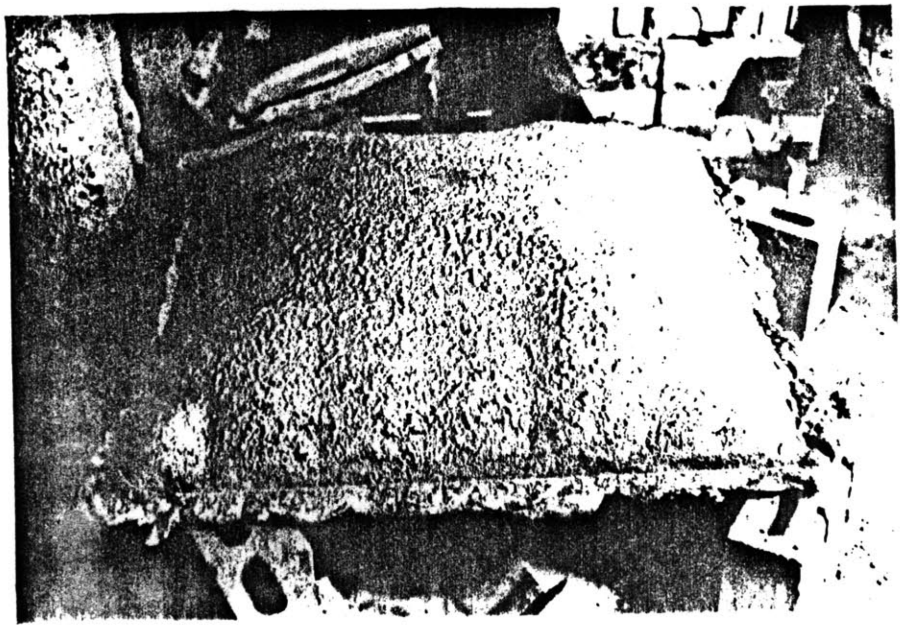
The burlap was suspended in a similar manner as in Experiment 2. However, in this experiment mesh-wire of gauge 1" was laid on top of the burlap. The mesh was placed, one at the apex, dimensions 26"x26" ; and at each of the corners - mesh dimension 12"x12". Additionally, a double folded layer of 3" width mesh was placed all around the perimeter of the catenary. (Catenary depth = 6" before trowelling.)

Observations and Results:

A concrete mix 1 part cement : 2 parts sand same as Experiments (1) and (2) was trowelled on this burlap mesh wire surface. The thickness of shell was approximately 1/2".

Observations and Results:

Trowelling was not difficult, however, the mesh tended to pop out of the concrete mix, and it became necessary to apply a thicker layer



The Completed Dome 3'x3' (Cost: Rs.
Shell thickness: 1/2" ; Shell depth= 6"

where the mesh protruded out of the surface. After 3 days of curing this catenary was removed from the form and over-turned. This dome weighed about 85 lbs. A load of 300 lbs/sq.ft was applied on the top of the dome (unconstrained edges). The dome showed no sign of failure. The dome was not tested to failure. (Catenary depth = 7-1/2" - 8" after trowelling.)

Experiment: .4.

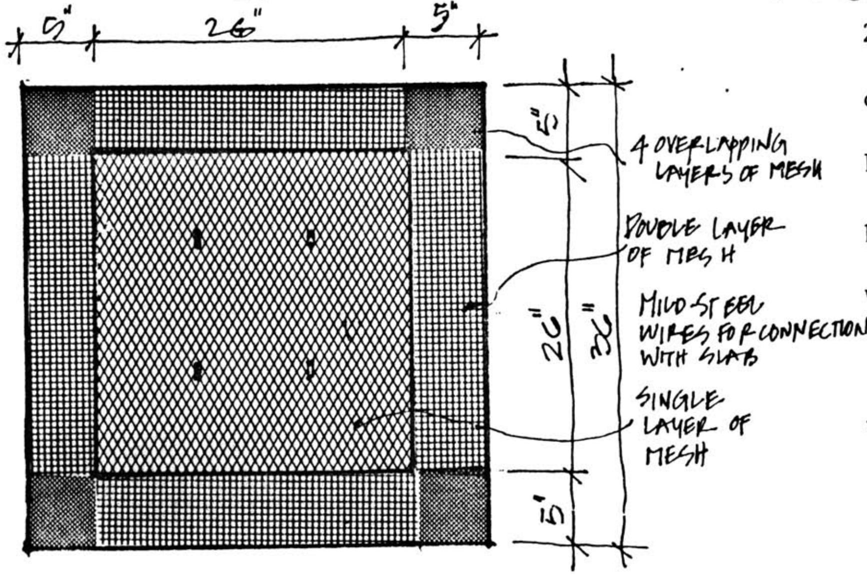
Objective:

Reinforced dome with edge lining.

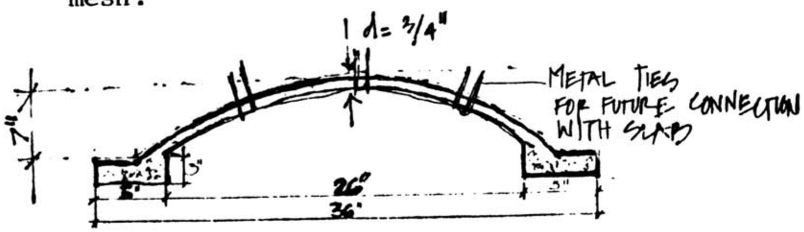
Method:

The same formwork as in Experiment 3 was used. However, this time the mesh wire was separated from the burlap surface by gravel of thickness 1/4" - this was done to provide a concrete cover for the wire mesh - and the wire was subsequently attached to the burlap by short pieces of metal wire at distances of approximately

Experiment 4: Dome with lining 5" wide.
Reinforcement: Mesh-Wire (Gauge= 1/2")



Two layers overlap at perimeter and four layers at corners. Apex with connecting mild -steel ties and one layer of mesh.



Section:

Shell thickness: 3/4"
Weight: 110 lbs.
Loaded(without failure): 400 lbs/sq. ft.
Lining(2-1/2" x 5")

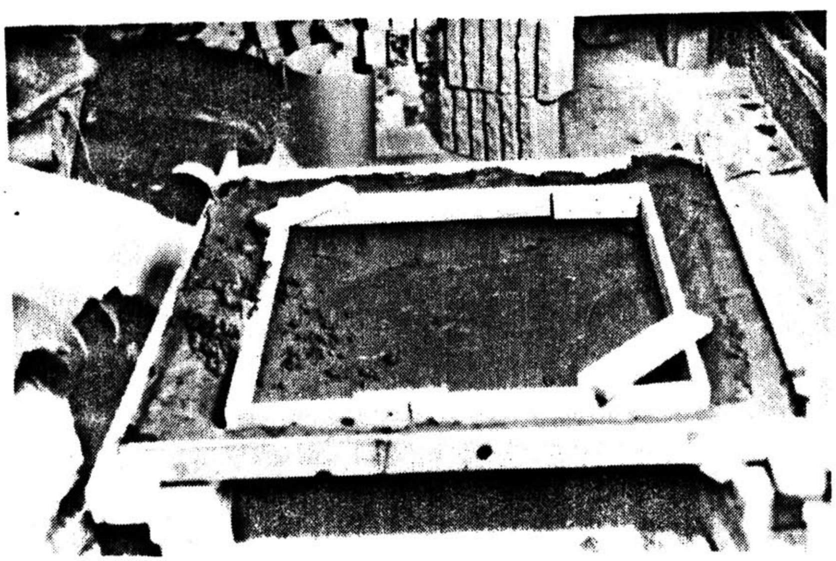
20 cm. Mortar of mix 1 part cement and 2 parts cement was trowelled onto the surface, as in Experiment 3. The thickness of shell was approximately 3/4". A set of 1/8" mild steel wires were pierced through the surface around the apex of the dome over an area of approximately 16" x 16" dimension. Additionally, a square timber frame of 3/4" x 2-1/2" cross-section and external dimensions of 26" x 26" was placed on top of the mesh wire. This created a lip of 5" width and 2-1/2" depth all along the perimeter of the dome. Inside the lip was placed a double layer of 1" gauge mesh-wire all along the perimeter. This lip was subsequently filled with concrete of mix 1 part cement : 2 parts sand : and two parts gravel. (Catenary depth = 6".)

Observations and Results:

After 3 days the catenary was removed and

Experiment 4:

Placement of Mild-Steel ties



Casting of lining

over-turned. The dome weighed approximately 110 lbs. A load of 400 lbs/sq. ft was applied at the apex. There was no sign of failure. The dome was not tested to failure. (Catenary depth = 7" after trowelling.)

Experiment 5:

Objective:

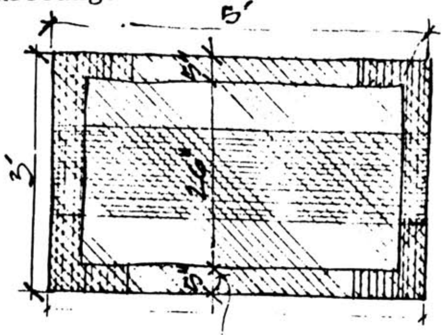
To develope rectangular (3' x 5') double curvature dome - with reinforcements on dome surface for construction of integrated floor slab (not done). To determine weight, and effect of surface loading.

Method:

The frame was similar to the one used for the previous four experiments but dimensions of the frame were larger in that its internal dimensions were 3 feet by 5 feet (3' x 5'). The method of hanging burlap, providing mesh wire reinforcement, and lip at the perimeter

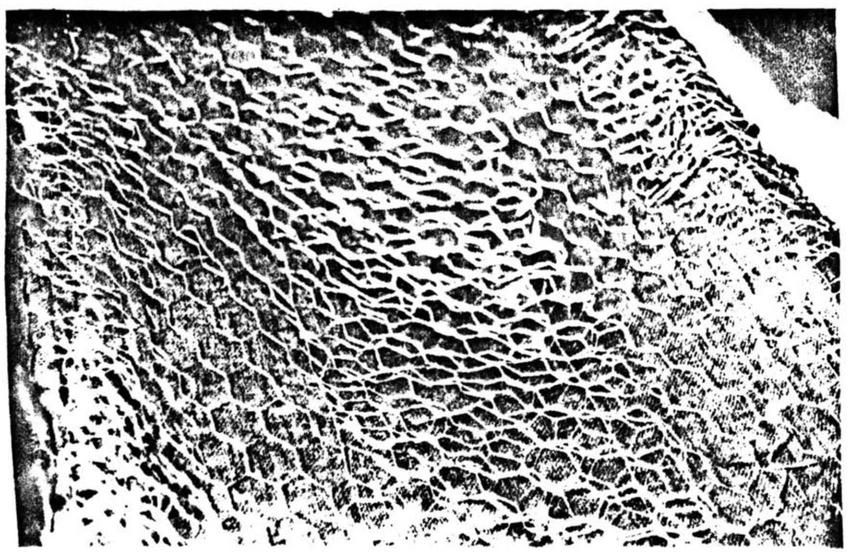
Experiment 5:

Rectangular dome:



Weight: 140 lbs
Loadeded (without failure) :

400 lbs/ sq. ft.



Reinforcement: Mesh wire, double overlap at apex.

was the same as in Experiment 4 (the edge lip had the same dimensions as #4, 3" x 5"). (Catenary depth = 6".)

Observations and Results:

After 3 days of curing time, the dome was removed from the frame and over-turned. The dome weighed around 140 lbs. A load of 400 lbs/sq. ft was applied at the top of the dome. The dome showed no sign of failure. Also the reinforcements (mild-steel wires of ϕ 1/16") seemed firmly set in the concrete dome. No experiments were done to form a concrete slab over the dome (it is anticipated that a slab can be poured and an integrated floor + dome can be developed). (Catenary maximum depth = 7" after trowelling.)

Conclusion:

From the foregoing experiments certain conclusions can be drawn.

Fabric-Form for Walls:

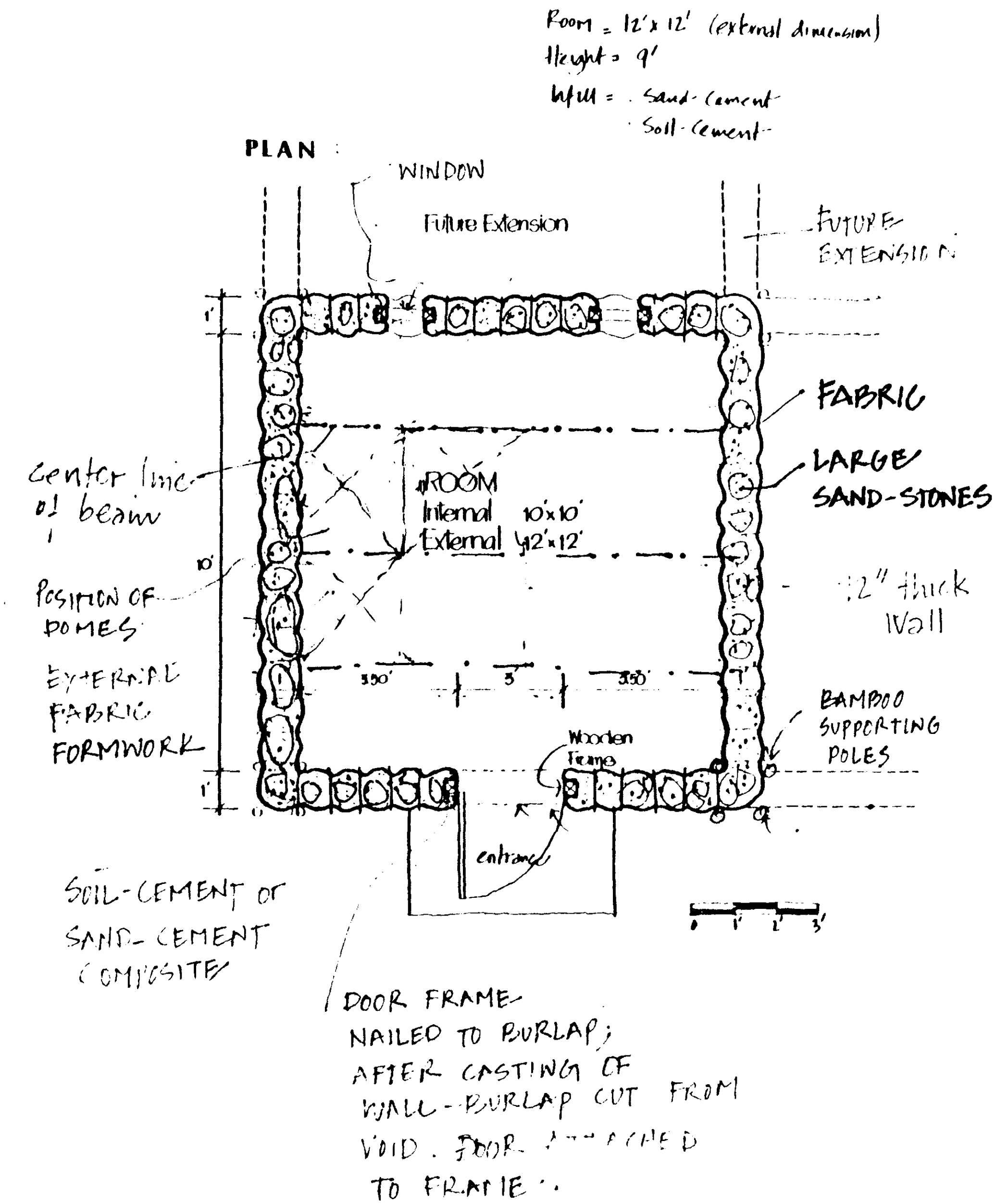
Experiment #4 indicates that the surface deformation is nominal when mild steel ties are used to connect the flaps. The use of flaps - can be made in many different ways and quite quickly- essential in order to avoid tearing of burlap - which would occur if the ties were directly attached to the burlap. It is also clear that once the aggregate within the void has been compacted and the surface deformation has occurred, further compaction does not deform the surface noticeably. In the laboratory experiments were done with a wall one feet wide. This provides a certain lateral stability. However it is not certain how stable the wall will be if it were to be slenderer (6" wide). It is clear that it will be difficult to in-fill a slenderer wall and this wall would use a higher proportion of cement - to increase its rigidity - and this increase may be substantial to make it economically untenable. Another point that is not clear is the effect of cement and humidity on the organic fibre in time. The question of how the wall will behave once burlap starts to disintegrate has not been answered. Will the wall have enough cohesion or bond to stand up by itslef? Another issue that has not been resolved is in the curing of the concrete once it is inside the fabric-form. Burlap tends to absorb water and this may effect water of hydration required by the concrete to cure.

Fabric-Form for Beams:

The experiments indicate possibilities of using burlap for fabrication of beams. However, the beam would have to be supported intermittently to avoid tearing of burlap and the method of anchoring the burlap to the beam should not be with the use of nails but instead some mechanical tie as suggested in the experiment should be used.

Fabric-Form for Domes, Vaults:

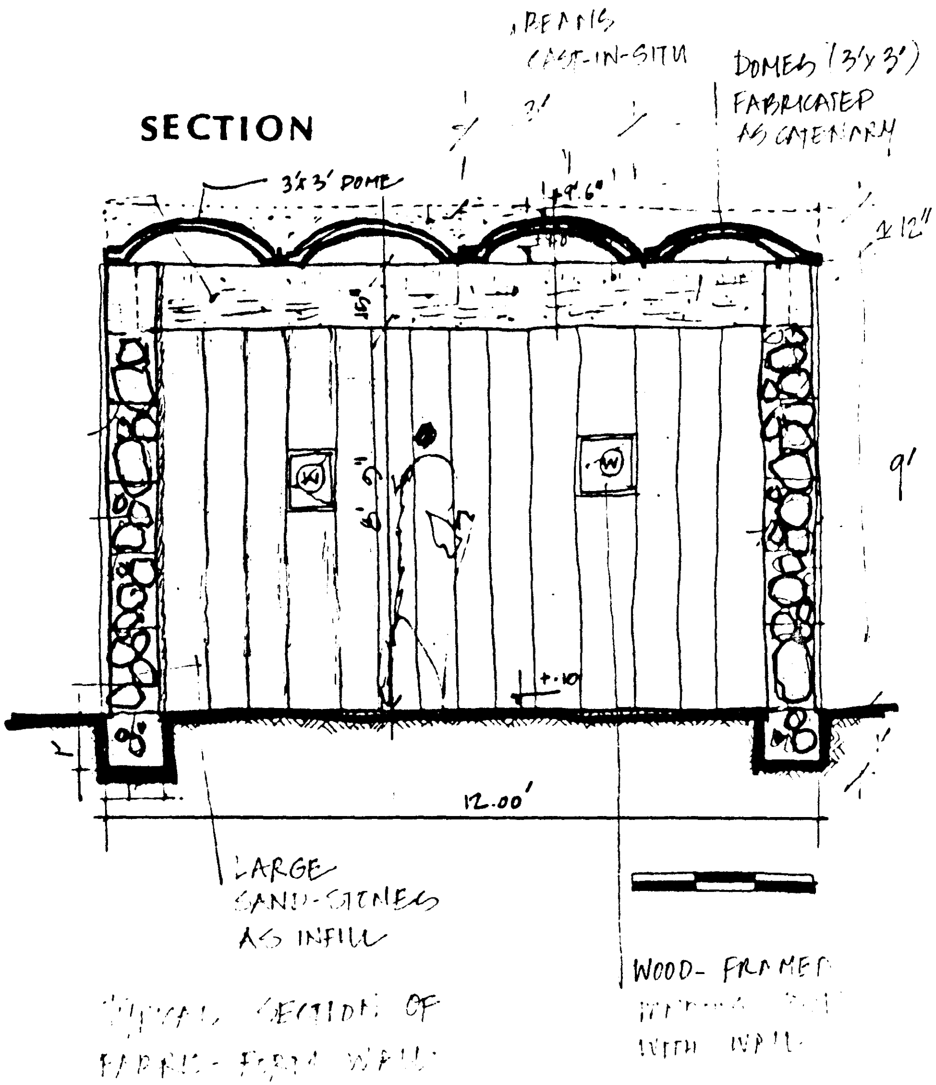
The experiments indicate that burlap can be used for making various catenary forms of any desired depth. This provides a very cheap method of making domes. Those domes that were combined with coarse aggregate were not as strong as ones made with sand-cement aggregate. The method of applying concrete into wet burlap provided a good bond with the burlap even after curing. Burlap attached itself to the concrete shell and could not be peeled off. Some problems that remain are getting a constant thickness over the shell, as it is difficult to measure the exact shell thickness at each point. Mesh wire reinforcements are easy to place and add to the strength of the concrete substantially. It was not found difficult to attach the mesh wire to the burlap. The domes also indicated great strenth if the perimeter was constrained or if, at least, a mesh wire was used to line the perimeter. The lip is not absolutely necessary and tends to make the dome considerably heavier. However, this would provide greater strength to the dome when these domes are placed in situations where their perimeters are not constrained. Forms having double curvature were found to be stronger than vaults. Square forms were relatively easy to fabricate; but trowelling corners was more difficult. The topping of domes with a poured in-situ slab although not cast in the laboratory should not pose any difficulties.



5.3. Proposed Building System for Housing in Pakistan: Fabric as a Funicular Formwork For Walls, Beams, and Floor Slab :

The proposed design "Borion Se Makan" or literally houses made out of fabric is a proposal of the author. The use of fabric in construction is nothing new. Use of fabric membrane for roofing is known since antiquity. However, use of fabric as a formwork has seen limited application. Recent experiments with stack sack* for building and use of nylon fabric for use in underwater abutments has had mixed results. The use of fabric here is radically different. It is essentially used as a formwork for making walls, lintels, roof-tiles, and beams. No instance of a similar proposal has been observed in documented form - one resulting in a practical application in construction.

*Funicular: Form of fabric under load.



Applications of Fabric Form to Housing in Pakistan:

Before we discuss the actual construction process it is useful to identify one assumption that is being made:

It is being assumed that the dweller is familiar with the rudimentaries of construction, i.e. knowledge and skills that are required for fabricating a "juggi" or a "mud-house." This assumption is not far fetched as most squatters build their first dwelling with bamboo or mud.

We are assuming the site of construction to be flat (the process can also be applied to slopes).

Application of Fabric Form in Construction: This proposal is for a single room dwelling.

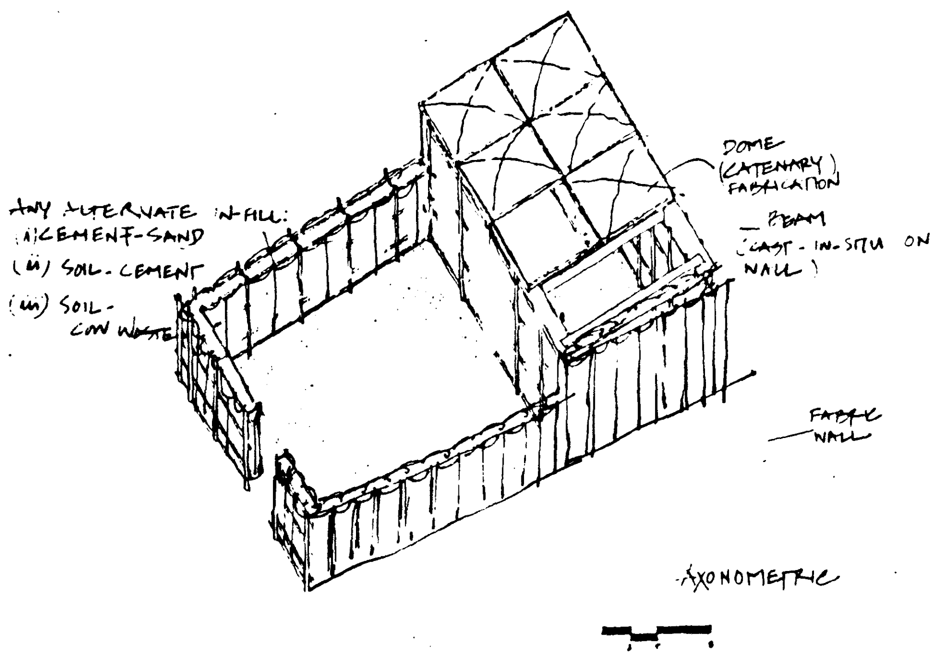
Foundations:

The first step in the construction process is the foundation. The dweller marks out the dimensions of the room; in our case these external wall to wall dimensions are 12 feet x 12 feet, and the internal room dimensions are 10 feet by 10 feet. He clears the site of the room or organic material, levels the site of the room (not necessarily to precision, and excavates a trench approximately 1 foot deep and 1 foot wide all along the perimeter of the room. He can then compact the soil by a simple hand held compactor or a small roller. At this point the fabric form deviates from the conventional construction method. The foundation is not made separately but is conceived as a continuous wall section going down to the surface of the trench. This method provides for a more integrated and stronger wall system as there are no mortar joints or other points of interface in the wall system. This is especially important as the strength of mortar normally used is not consistent, due to lack of care in either preparing the appropriate mix or lack of care about impurities that often get mixed with the mortar.

Walls:

Once the 1 foot deep trench is excavated the dweller is ready to fabricate the wall. Here he has a choice of two approaches depending on his income.

(i) He can decide to build in 3 or 4 stages - walls of 3'-4' height all along the perimeter of the room. This will require more bamboo poles, but would involve less work in removing and placing bamboo poles. As these poles are being used as shuttering, and are not being seriously damaged during the fabrication process, as they ought not to be, he could recover part of his initial investment



ALTERNATE PROPOSAL
USING BAMBOO OR EITHER ORGANIC STALK OR BRANCHES OF TREE AS SIDE SUPPORTS.

by selling back these support bamboos. This will also enable him to fabricate his wall at a faster pace.

(ii) He can decide to fabricate one wall first to a height of 9' above grade and then proceed with the next wall. If he chooses this process, he has to insure that the wall junctions are well integrated and will perhaps have to do some extra work in aligning the various walls.

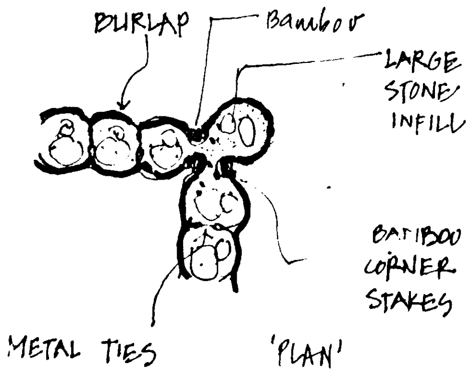
Whichever process is selected he will have to proceed as follows:

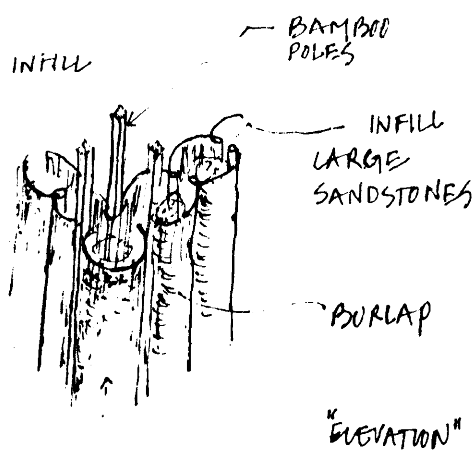
(i) Once the 12' bamboo poles are secured within the ground, the horizontal bamboo short pieces are tied to vertical poles to function as support poles for fabric. Once the bamboo ties are secured, the frame is ready for draping the fabric.

(ii) The fabric selected should be coarse, and preferably cheap, like gunny sack. (These are extremely cheap in Pakistan, India and Bangladesh and most of S.E. Asia). The length of fabric should be twice the height of the wall plus the width of the trench plus extra length for adjustment. In our case of 10' high sides (including foundation) the fabric should have at least a length of 10 + 10 + 1 + (2) = 23 feet. The center of this length that is the 11-1/2 feet point of fabric should rest at the center of the trench since fabric comes in lengths of 3 feet widths. The separate fabrics can be sewed together or overlapped locally - joined with some mild-steel ties. In the first section of the wall the fabric is draped over the horizontal pole placed 3' above grade, the extra length allowed to fall outside the void. The void between the fabric is lightly packed with small stones to stretch the fabric in a funicular form. Once this is done the fabric

SOME SOLUTIONS FOR MAKING WALLS AT CORNERS

TURNING CORNERS



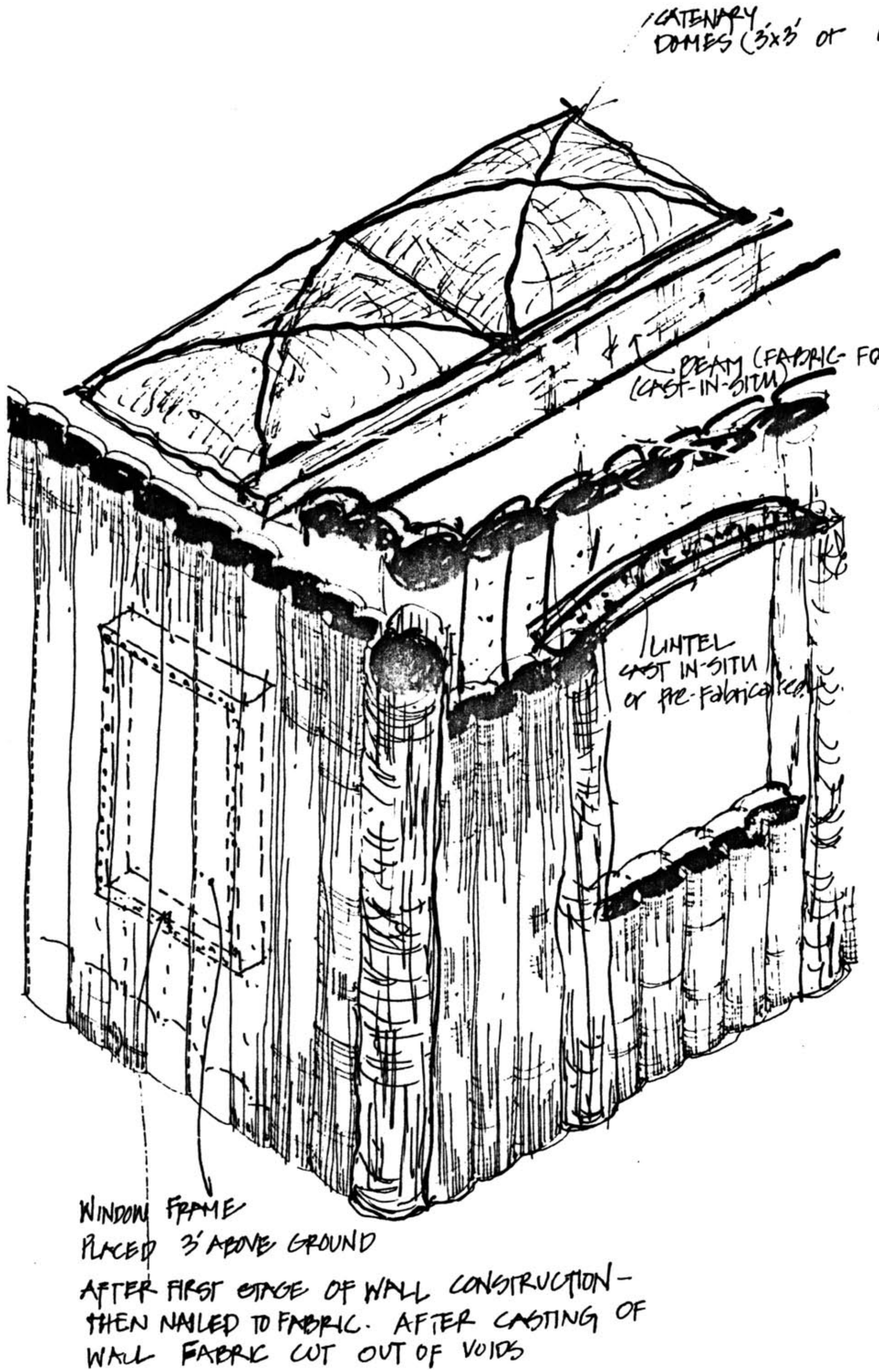


ALTERNATE METHOD OF TURNING CORNERS

is secured at the horizontal bamboo poles 3' above grade.

(iii) The next step is to place metal ties at every one feet height and 2 feet width all along the length of the wall. The ties should pass through the opposite fabric falls but should leave a void of approximatley 11 inches. These ties prevent excessive deformation of the surface. (The use of ties is optional and in other processes is not strictly required). Once the fabric has been prepared, as above, it is ready for infill material.

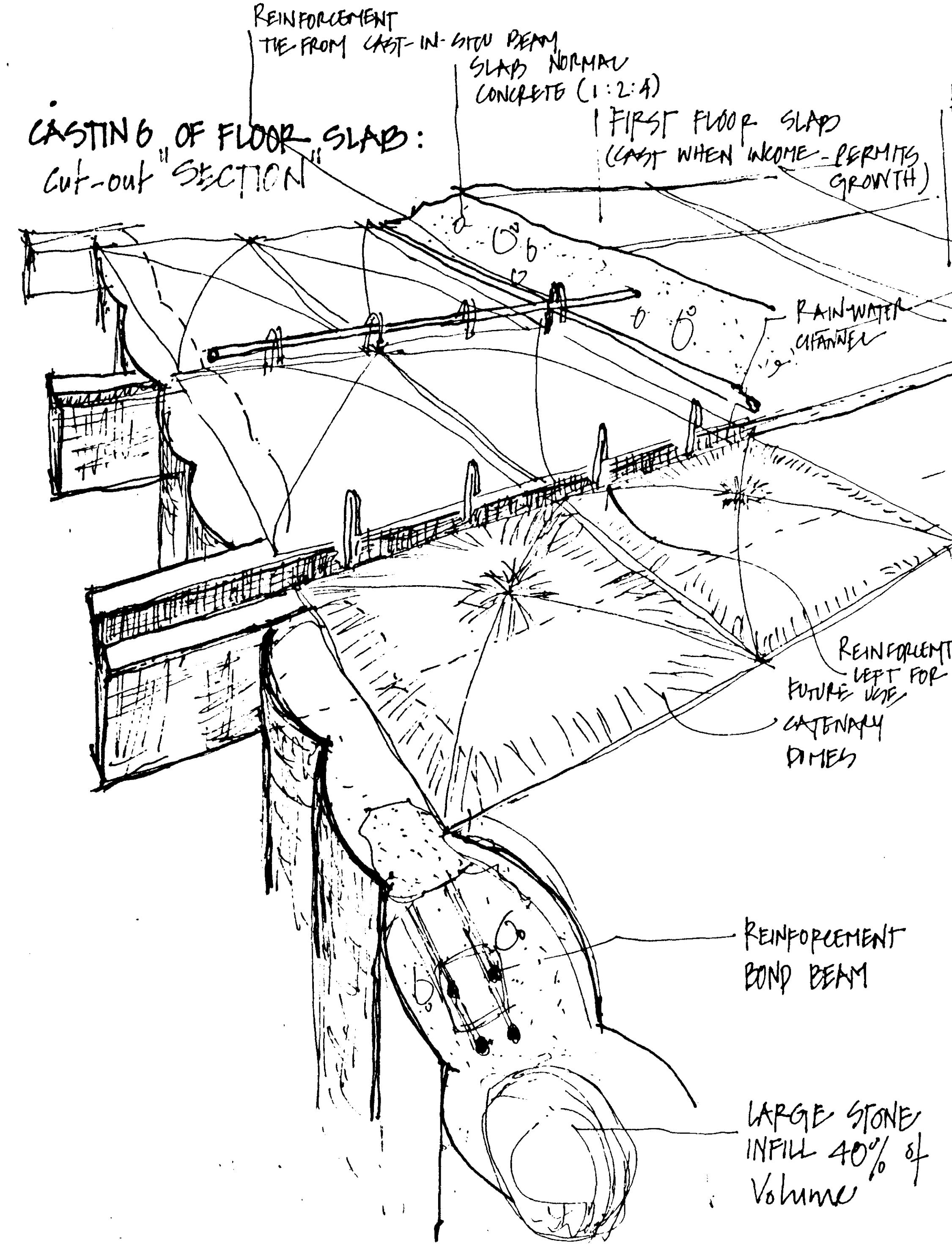
(iv) The next step is to prepare either a poor concrete mix, i.e., a soil-cement or sand-cement mix or merely mud infills (cost estimates of various methods are given in Appendices A and B). A 4" to 6" layer of aggregate mix is poured. On top of this is placed large stones packed with smaller stones of



various sizes. This is followed by pouring another layer of poor concrete. This process is repeated until a height of 3 feet is reached. This is either left to harden, i.e., for 2 or 3 days, or another set of horizontal bamboos are placed at a height of 3' above the last one, and the process repeated. This is done in 3 or 4 stages until the height of the room is reached. As explained earlier, all the walls can be fabricated together or sequentially.

Voids (Doors, Windows, etc.):

Fabric form allows a very simple method of fabricating windows and doors. This is done very simply with wooden framed openings. The wooden frame is placed inside the void - placing at correct height to get the openings at desired heights - the fabric is nailed to the side of the wooden frame. Concrete is next poured in the void to fabricate the wall around the frame.



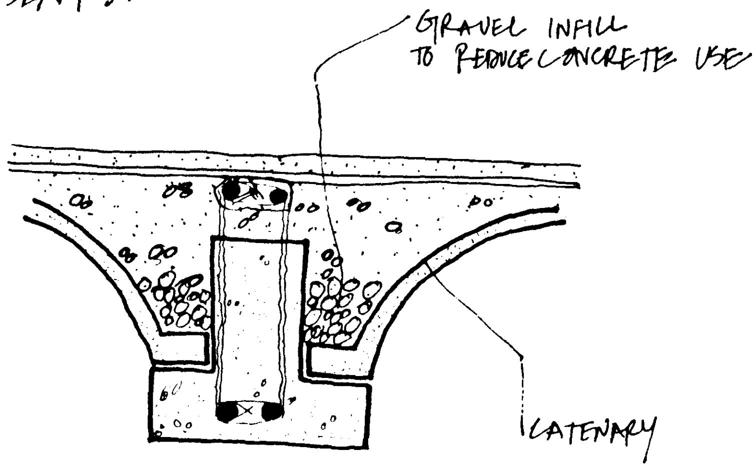
Once the wall is completed the fabric is simply cut with scissors around the frame. To provide extra rigidity for concrete around the edges of the frame, the frame itself can be initially lightly framed with chicken-mesh wire.

Roof:

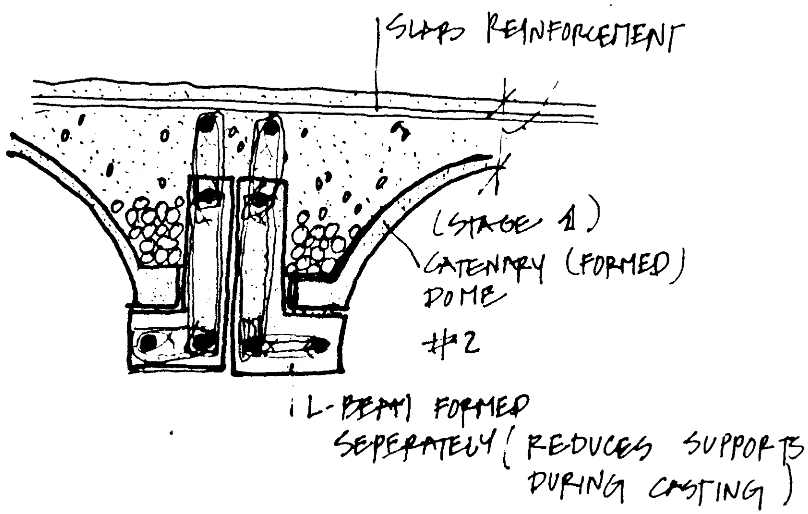
Once the wall has reached about 15" below the desired height, blocks of wood of dimensions 5" x 15" x5 " at 3 feet centers are placed on the wall, on the side facing the room, as blocks for placement of beam. Once the wall has been formed to the room-height and the wall has hardened, then dummy blocks are removed (these are not placed on adjacent walls - in our case only 3 sets of two blocks for three beams).

The first step in fabricating the roof is pouring of the beam. Two bamboo poles of 12' length set 5" apart are made to span between

ALTERNATIVES IN BEAMS:



A T-BEAM SOLUTION



A L BEAM SOLUTION

opposite wall faces. These are secured at ends to provide the even void throughout the length of the bamboo. Fabric is draped over the bamboo to provide a catenary of ≈19" depth, a small bamboo strip 3" wide is placed inside the void to give a 3" wide bottom face of the beam. A 1" layer of concrete (1:2:4)* mix is poured. Subsequently 2 bars of ϕ1/2" diameter+ are placed and concrete poured to height of beam. A wooden block may be left at the top surface of the beam, removed later to form the drainage channel for the roof. If the bamboo deflects, additional intermediary supports can be provided. Once the beam has cured, 3-4 days, the bamboo is removed from the fabric and the next set of beams are cast at distances of every 3 feet center to center.

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*1:2:4 (cement : sand : gravel proportion by volume)

+see opposite page.

Domes:

The domes are fabricated on the ground. The process of fabricating double curvature domes of 3' x 3' dimension has been discussed earlier in the section on experiments with domes (page). However one thing needs repetition. If the dweller anticipates building vertically, he should place metal ties on the surface of the domes to tie the reinforcement of slabs that will be cast later on top of these domes. This will allow the dome to work as an integrated slab.

Once all the domes have been placed, the dweller finishes the gaps in the roof with a 1/4" to 1/2" layer of mortar and paints a layer of water-proofing such as asphalt on top surface. He should make sure that channels for drainage of water slope towards the exterior of the house.

Floor:

Once the roof has been put up the dweller is ready to live in the house. He can then either finish the floor with a 1" - 2" to level the surface and then pour his floor slab (optional), depending on his investment capabilities.

Future:

Once this room is completed, he can proceed to grow either horizontally or vertically whenever time and money allow him to do so.

6.0 Cost Estimating and Economic Evaluation of Alternative Construction Methods:

6.1 Introduction :

In order to determine costs associated with various building systems (methods and materials of construction) is is useful to initially develope a cost estimating model. The current estimating models do not effectively incorporate a self-help type of construction - where part of the construction is done through hired labor and the rest by the dweller himself. Additionally the work is staged over an extended period of time and the schedule of work is often randomly established depending on the individual's time and economic preference. To clarify this point, an individual dweller might leave finishing of the windows until he has completed the roof. So a model which identifies cost by components and tasks, not constrained by time schedules associated with it, in a simple hierarchial manner, will facilitate cost comparison between various self-help building methods. The cost estimating model used aggregates cost hierarchically.

Such a model will break the costs into several large discrete sets of detailed components. These detailed components can be broken into physical and functional components, as well as on levels of implementation, i.e., those tasks that have to be performed by the dweller himself and those that will be subcontracted. The hierarchial structure would look like a tree structure where the terminal branches at the nodes of the tree represent a of more detailed components and near the trunk of the tree we find more generalized components representing major cost items or/and milestones. Each generalized component will represent a unique or similar set of activities and skills. This set of relationships between larger generalized components and specific set of components can be termed as a parent-child set relationship.

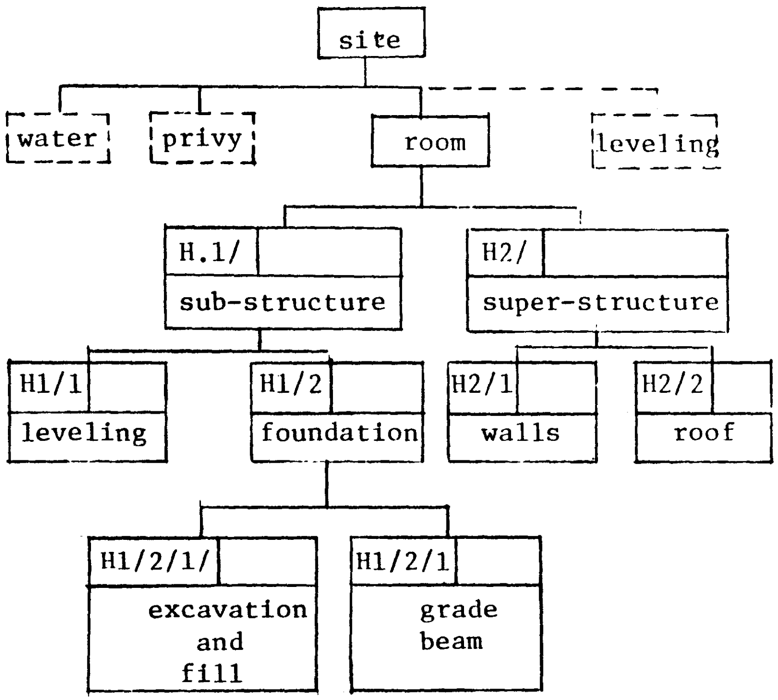
This structure can identify specific tasks and components used. Each task has an associated cost. This cost can be shown directly on the tree, so that tasks and cost of performing them is available at once from just looking at that particular node(this is shown more clearly on page

Comparison of various construction techniques can be done by identifying specific tasks that need to be compared. This model will then indicate trade-offs between the techniques. To give an example, one could build a wall by a conventional method but choose to build the roof by a cheaper method (non-conventional) and measure his cost for switching techniques by simply changing the cost of the component in the tree structure and subtract from the total sum the savings from the switch.

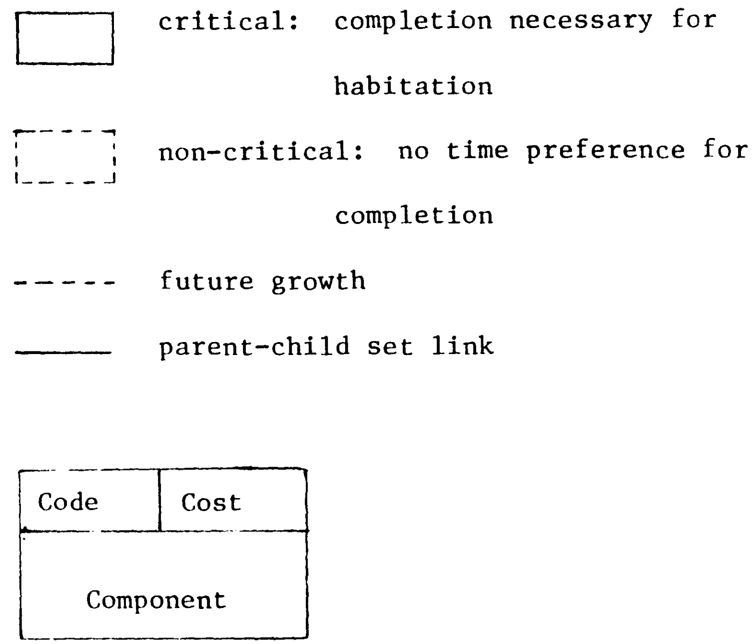
In the following pages the hierarchial cost model is shown and is developed for comparison of costs associated with using various construction techniques.

The Hierarchial Cost Model:

For Semi-Pucca Type



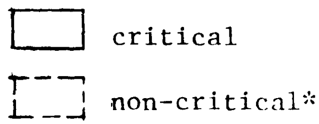
Legend:

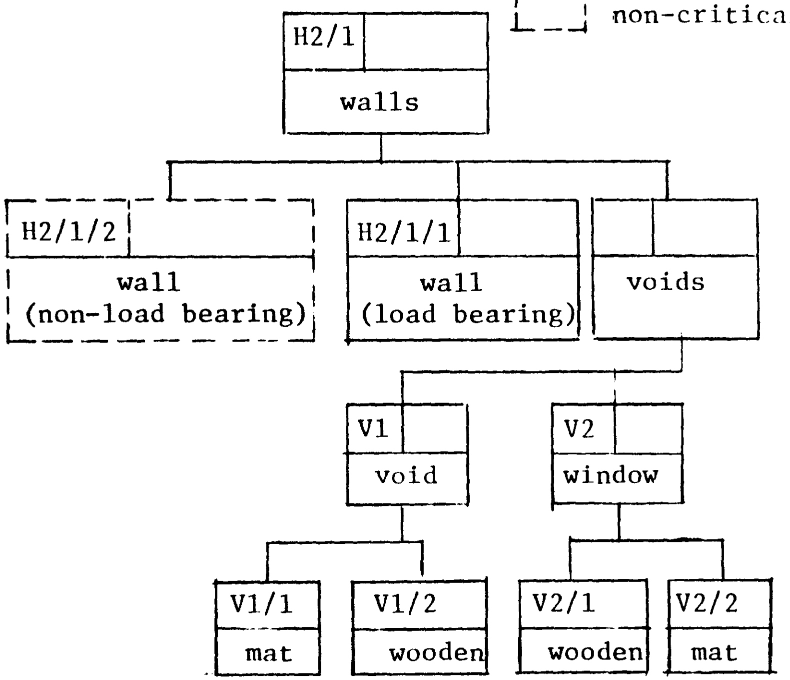


A typical hierarchial cost model would indicate the hierarchial parent-child relationship; identify the duration for each component; and provide an estimate for cost.

Having made such a broad structure which represents the major components, this can be further disaggregated.

STEP 2: Walls





Cost Breakdown:

Estimated cost of building

Semi-Pucca : (cost figures: May 1982 from survey in Aurangi; and Karachi; Development Authority circular, 1st quarter, 1982)

Cost Breakdown:

1. Disaggregating the costs into those done through self-help and those to be sub-contracted. Subsequent aggregation of cost will give the total project estimate.
2. By aggregating costs referring to constituent components and task units which when accumulated will give cost of milestone, major component, and overall project cost.

The costs could be broken down at increasing levels of detail. The actual cost estimation must start from lowest level of detail - showing cost of task units. So at highest level of detail we will have cost showing:

* Not critical to completion of project (indicates no time-preference for completion)

Major Cost Categorization:

This would be grouped at various levels of hierarchy.

Cost figures: Karachi Development Authority, 1st quarter 1982.

Level I:			Material		Labor (hired only)			
Cost of House:	Qty	Unit	Cost/Unit (Rs.)	Total (Rs.)	Man/Hrs.	Unit	Cost/Hr. (Rs.)	Total (Rs.)
I. Sub-Structure								
1.1. Excavation	48	c/ft			2	hr.	8.25*	17.50
1.2. Foundation	144	each	2	288				
II. Super-Structure (detailed cost see Appendix A)				3763				
				Rs. 4051.75				17.50

Total Investment Cost = Material + Labor

= Rs. 4069.25

Source: Assumed plan type.

H/2 Super-Structure:

H2/1 Wall (load-bearing) Assumed: sub contracted

Item	Material				Labor			
	Qty	Unit	Cost/Unit (Rs.)	Total (Rs.)	Man/Hour	Unit	Cost/Unit (Rs.)	Total (Rs.)
concrete blocks (12" x 8" x 6")	660	each	2	1320				
Labor					2.7	days	100	270
			TOTAL =	1320				270

Total cost for H 2/1 = 1320 + 270 = Rs. 1590.

This model can be developed into a comprehensive table which disaggregates costs based on various expenses, i.e., material, transportation, labor. It can give us an idea of the total man hours needed to complete the tasks. These costs can then be transferred to a hierarchical cost model which would immediately identify significant costs. These cost models - cost brakdown structure- follow the set of specific cost itemization. A typical cost-model is shown on page 154).

Cost Comparison of Various Building Types and Proposed System:

We can apply the hierarchial estimating model to determine the cost of construction of a one room (12' x 12') dwelling using different construction materials. The type of construction methods chosen are:

1 - Juggi Type as in Category Type I. (page 72)

2 - Semi-Pucca Type (estimates with both temporary and permanent roof, i.e., reinforced concrete slab.

3 - Fabric Form (proposal of author) with construction of walls in,

.1. sand-cement aggregate (concrete)

.2. soil-cement aggregate (concrete)

(Estimates for permanent concrete domed roof as well as concrete domed slab are given in the cost breakdown.)

It is hoped that this will make the selection process more objective. These comparisons make assumptions which michg not be representative of the actual situation:

1 - Labor cost in all the construction types have been assumed to be zero. It is being assumed that the dweller has irregular employment and has free time to build his own dwelling.

2 - Site conditions are considered similar. Essentially the site is assumed to be flat, with a uniform bearing capacity, and a capacity to support a dwelling, single story high with the simplest foundation.

3 - The schedule of rates used are current rates as published by Karachi Development Authority for 1st quarter 1982. These rates may be lower in the squatter areas. Fluctuations in

prices over construction period have not been taken into consideration.

4 - Cost of water has been excluded - this could be significant in squatter areas.

5 - Duration of Project: It is being assumed the dweller does not have a time constraint - a target date to complete construction - instead it is assumed that he has free time and more or less will build over an extended period of time.

6 - The cost of land is not included - in anycase it is common to all the types. The land cost is not included as these vary with government policy for land rates for specific areas and types of settlements.

7 - Semi-Pucca Type: It has been assumed that the dweller is capable of building this type of masonry building by himself. This is strictly not true, as discussed earlier, unless the dweller happens to be a mason. This enables us to make comparisons between various building systems strictly on the basis of cost of construction. In fact the semi-pucca type will cost 15% - 20% more if one were to include the sub-contractor's profit on all masonry work and other works requiring skilled labor.

8 - Fabric Form Type:

.1. It is being assumed that the dweller will accept the idea of building with fabric, and would understnad the process of construction with the aid of simple oral and visual instructions (graphics or even models of the process).

.2. It is being assumed that he will be able to mix the batch of cement as per specifications - different for walls, beams, and catenary dome - and will be able to quarry the sandstone from nearby hills - a common practice especially among pathan dwellers of Aurangi.

9 - It is being assumed that the building authorities will permit construction using fabric systems without need for modifications.

6.2.1. PLAN TYPE: JUGGI TYPE I

Floor Area = 12' x 12'

Height Above Ground Level = 9'

Foundation = None

Wall: Bamboo frame, with "chatai" (mat) cover.

Roof: Bamboo rafter, with sarkanda,* panka,* and pvc as water-proof) membrane.

Construction: Self-help. Labor price considered zero.

Life Expectancy = 12 years

---

*See Glossary of Terms.

Category type: Juggi - Type I (Staged expansion to Pucca)
(semi-Pucca Type I)

Cost breakdown:

Parent component: Foundation

Component Relationship
MAJOR-MINOR = Parent-Child
****Man = Assumes 9 man/hour/day**
***TOTAL(4) = 1+2+3**
Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST*/ UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
foundation		excavation		digging	48	c.ft	--	--	--	--	4	--	--	--	--
				fill	48	c.ft	--	--	--	--	1	--	--	--	--
				compaction	48	s.ft	--	--	--	--	2	--	--	--	--
											7				
								--		--					--

*All costs in Ruppees.

Sub-Total

Total carried over

Category type: Juggi-Type I (for details see drawings on page 68)

Cost breakdown:

Parent component: Wall

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
wall		column (bamboo)		7'	8	each	15	120	--	5	4	--	--	--	125
				12'	2	each	25	50	--	--	--	--	--	--	50
		horizontal ties (bamboo)		10'	4	each	21	84	--	5	1-1/2	--	--	--	89
				7'	2	each	15	30	--	--	--	--	--	--	30
				12'	1	each	25	25	--	--	--	--	--	--	25
		wall cover (chatai)		mat (6'x4')	11	each	5.00	55	--	--	3-1/2	--	--	--	55
											9				
*All costs in Ruppees.								364		10					374

Sub-Total =374

Total carried over =

Source:

Category type: Juggi Type I

Cost breakdown:

Parent component: Voids

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT*	TOTAL (1)*	COST/ UNIT*	TOTAL (2)*	Hrs. MAN**	UNIT	COST/ UNIT*	TOTAL (3)*	TOTAL (4)*
void		door		mat (6'x4')	1	each	5	5	--	--	1/2	--	--	--	5
											1/2				
								5							5

*All costs in Ruppees.

Sub-Total = 5

Total carried over

Category type: Juggi Type I (For details of components see page 66)

Cost breakdown:

Parent component: Roof

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/UNIT*	TOTAL (1)*	COST/UNIT*	TOTAL (2)*	Hrs. MAN**	UNIT	COST/UNIT*	TOTAL (3)*	TOTAL (4)*
roof		rafter (bamboo)		(i) (7')	8	each	15	120	--	5	43	--	--	--	125
				(ii) 12'	4	each	25	100	--	5	--	--	--	--	105
		sarkanda		reed mat (7'x12')	2	each	30	60	--	5	3	--	--	--	65
		panka		mat (7'x12') pair	1	each	40	40	--	--	2	--	--	--	40
		water-proof		plastic	216	s.ft.	.20	43.20	--	--	1	--	--	--	43.20
											9				
								363.20		15					378.20

*All costs in Ruppees.

Sub-Total = 378.20

Total carried over

Category Type: Juggi I

THE HIERARCHIAL COST MODEL:

FOR

Date of Estimate:

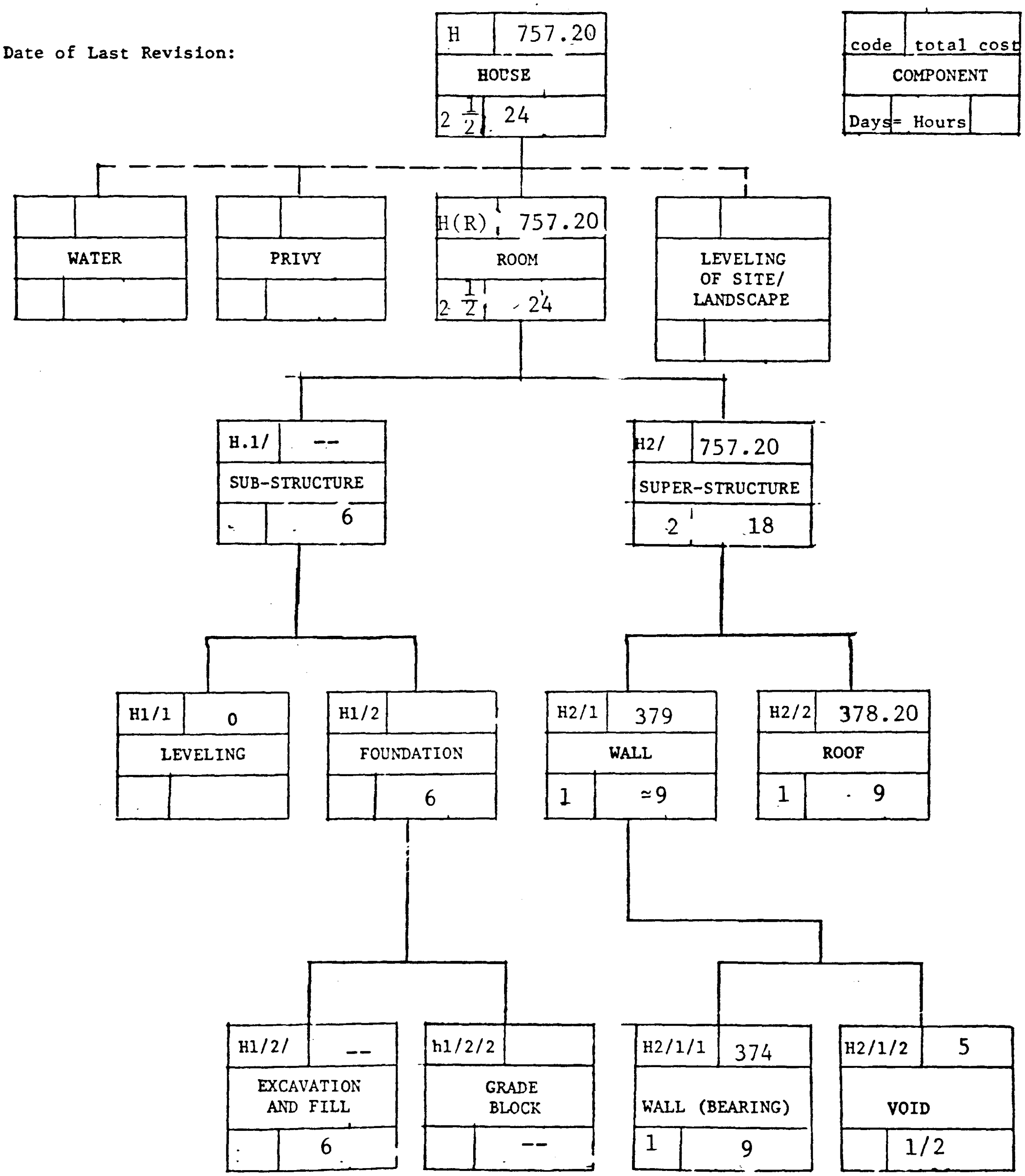
Date of Last Revision:

LEGEND

– – – non-critical

(no time preference)

——— critical



Source: Materials Cost: Karachi Development Authority, April, 1982.

Note: All costs in Ruppees.

6.2.2. PLAN TYPE: SEMI PUCCA TYPE 1

Floor Area = 12' x 12'

Height Above Ground Level = 9'

Foundation = light (12" x 8" x 6" blocks to a depth of 1 feet below grade)

Wall = 12" x 8" x 6" cement blocks

Roof = (i) Aluminum roofing sheets on wooden rafters

(ii) Reinforced concrete slab of 4" thickness

Construction = Self-help. Labor cost assumed nil.

Life Expectancy = 25 years

(Structure and Annual Costs: See Appendix 'A') For All Plan Types.

Sheet #1
Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. = Ruppees, 1 Rs. = 1 $ US

Category type: Semi-Pucca I

- Cost breakdown:

Parent component: Sub-Structure = Rs. 314.70

MAJOR		MINOR		MATERIALS					TRANSPORTAT...		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT	TOTAL (1)	COST/ UNIT	TOTAL (2)	Hrs. MAN**	UNIT	COST/ UNIT	TOTAL (3)	Rs. TOTAL (4)
	/1	Leveling	/1	Clearing	10	c.ft	-	-	-	-	-	-	-	-	-
				Leveling	-	-	-	-	-	-	2	-	-	-	-
Foundation	/1	Excavation	/1	Digging	48	c.ft	-	-	-	-	4 hrs	-	-	-	-
				Fill	48	c.ft	-	-	-	-	2	-	-	-	-
				Compaction	-	-	-	-	-	-	1/2	-	-	-	-
	/2	Grade	/2	Gravel	6	c.ft	2.75	16.5	.25	3	1	-	-	-	19.50
		Block		Block	144	each	2	288.	.05	7.2	7	-	-	-	295.20
											16-1/2				
								304.50		10.20					314.70

Sub-Total

Total carried over

Source: Current Rates in Karachi from Karachi Development Authority, April 1982.

Category type: SEMI-PUCCA I

Cost breakdown:

Parent component: Wall (load-bearing) = Rs. 1597.15

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. 1.00 = US $.10

MAJOR		MINOR		MAJOR					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
walls	H2/1	cement block (12"x8"x6")	2/1/1	wall I	162	each	2	324	.50/%	8.10	10.00	--	--	--	332.10
			2/1/2	wall II	132	each	2	264	100	6.60	8.00	--	--	--	270.60
			2/1/3	wall III	162	each	2	324	100	8.10	10.00	--	--	--	332.10
			2/1/4	wall IV	117	each	2	234	100	5.85	7.25	--	--	--	239.85
		mortar		cement	5	bag	55	275	5	5	3	--	--	--	280
				gravel (bajri)	1/2	cart	295	137.50	5	5	1	--	--	--	142.50
											39.25				
								1558.50		38.65					1597.15

*All costs in Ruppees.

Sub-Total = 1597.15

Total carried over

Sheet #3

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. = Ruppees, 1 Rs. = 1 $ US

Category type:

Cost breakdown:

Parent component: Voids = 148

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT	TOTAL (1)	COST/ UNIT	TOTAL (2)	Hrs. MAN**	UNIT	COST/ UNIT	TOTAL (3)	Rs. TOTAL (4)
Voids	H2/1/2	Window		Chiselling	-	-	-	-	-	-	6	-	-	-	-
				Window (jalli)	6	each	3.0	18	-	-	4	-	-	-	18
		Door		Frame (3'x6')	1	each	120	120	10	10	3	-	-	-	130
											13				
								138		10				0	148

Sub-Total = 48

Total carried over

Source: Current Rates in Karachi From Karachi Development Authority, April, 1982.

Sheet #4
Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. = Ruppees, 1 Rs. = 1 $ US

Category type: Semi-Pucca I

Cost breakdown:

Parent component: Roof = Rs. 571.40

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	Rs. QTY	UNIT	COST/ UNIT	TOTAL (1)	COST/ UNIT	TOTAL (2)	Hrs. MAN**	UNIT	COST/ UNIT	TOTAL (3)	Rs. TOTAL (4)
Roof	H2/2	Beam	2/2/1	Timber (2 1/2"x4") inches sq.	13	sq.ft	12	156	5	5	4	-	-	-	161
				Iron Sheets (2 1/2x6) sq. ft.	6	each	64	384	2	12	16	-	-	-	396
				Metal Anchors	144	100	.10	14.4	-	-	-	-	-	-	14.4
											20				
								554.4		17				0	571.4

Sub-Total = Rs. 571.40

Total carried over

Source: Current Rates in Karachi From Karachi Development Authority, April, 1982.

THE HIERARCHIAL COST MODEL:

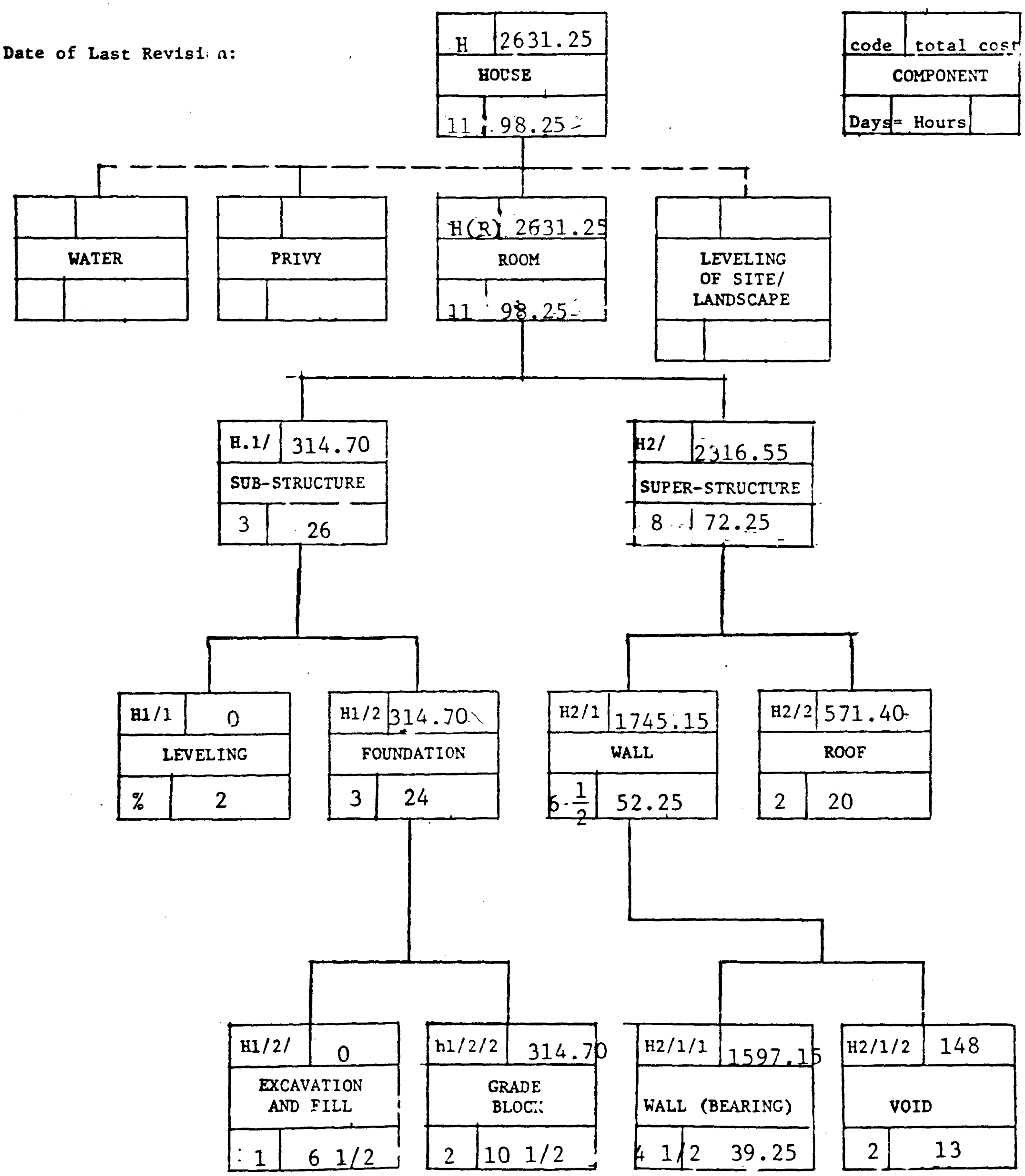
FOR Semi-Pucca Type 1

Date of Estimate:

Date of Last Revision:

LEGEND

- – – non-critical (no time preference)
- ——— critical



Source: Materials Cost: Karachi Development Authority, April, 1982.

Note: All costs in Ruppees.

6.2.3. PLAN TYPE: FABRIC FORM (SAND CEMENT) TYPE

Floor Area = 12'x12'

Height Above Ground Level = 9'

Foundation = Light. One feet below grade using mass concrete.

Wall = Furnicular fabric formwork and mass concrete (1:10:20) Cement-Sand-Gravel, aggregate, and Stone infill.

Roof = (i) Concrete domes (double curvature catenary shell thickness of 1") reinforced nominally with chicken-mesh wire. Weight of each dome = 110 lbs. Domes supported on reinforced concrete beams at 3 feet centers.

(ii) Composite dome + slab (average thickness assumed as 6") nominally reinforced.

Construction = Self-help. Labor price considered zero.

Life-Expectancy = 25 years

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component: Wall 1 + Wall 3 = Rs. 648.80 (324.40 + 324.40)
(for calculations, see page)

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. 10 = US $ .10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
wall(1+3) (including foundation)		wall (12'x10')	/1	sand-stone (.40 cu.ft. per cu.ft. of wall)	120	each	.50	60	.10	12.00	18	--	--	--	72x(2)
			2/	aggregate (1:10:20) see page	84	cu.ft	2.57	216	.05	4	9	--	--	--	220x(2)
			3/	gunny cloth (13'x23')	≈300'	sq.ft	01	30.00	--	--	4	--	--	--	30x(2)
			4/	mild-steel ties(2 per sq. ft.)	240	each	0.01	2.40	--	--	2	--	--	--	2.40(2)
			5/	bamboo support*	--	--	--	--	--	--	5	--	--	--	
											38				
*All costs in Ruppees.				(*cost separate)				308.40 x(2)		16.2 x(2)					324.40 x(2)

Sub-Total

Total carried over

Total = 648.80

Note: Walls 1 and 3
Σ Surface area = 120' x 10' = 120 sq. ft.
Σ Volume = 120' x 1' x 1' = 120 cu. ft.

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component: Wall 2 = 268.50

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
		wall 2	1/	stone (40 cu.ft.)	100	each	.50	50	.10	10.00	15	--	--	--	60
			2/	aggregate (calcula-tions, see page)	70	cuft	2.57	179.90	.05	3.5	7.5	--	--	--	183.40
			3/	gunny cloth (21x11)	231	sqft	.1	23.10	--	--	4	--	--	--	23.10
			4/	mild-steel ties (2 per sqft)	200	each	.01	2	--	--	2	--	--	--	2.00
			5/	bamboo sup-ports (cost separate)	--	--	--	--	--	--	5	--	--	--	--
											33.50				
								255		13.50					268.50

*All costs in Ruppees.

Sub-Total

Total carried over

Note: Wall 2
Surface area - 10' x 10' = 100' (void not excluded)
Volume = 100 cu. ft.

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component: Wall 4 = 224.32

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
			1/	stone (.40 cu.ft per cu.ft)	82	each	.50	41	.10	8.2	12.3	--	--	--	49.20
			2/	aggregate (calcula-tions see page)	57.40	cuft	2.57	147.51	.05	2.87	6.15	--	--	--	150.38
			3/	gunny cloth	231	sqft	.1	23.10	--	--	--	--	--	--	23.10
			4/	mild-steel ties	164	each	.01	1.64	--	--	2	--	--	--	1.64
			5/	support as-sembly											
				(bamboo cost computed separately)				--	--	--	5	--	--	--	--
											25.45				
								209.85		11.07					224.32

*All costs in Ruppees.

Sub-Total

Total carried over

Note: Σ Total Wall = wall - door = 100 - 18 = 82 sq. ft.
Volume = 82 cu. ft.

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component: Wall (load-bearing) = Rs. 1200.00

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
		Wall 1													324.40
		Wall 2													268.50
		Wall 3													324.48
		Wall 4													224.32
		Supports													65.00
*All costs in Ruppees.														≈	1206.00

Sub-Total

Total carried over

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component:

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
support for fabric formwork		vertical		bamboo (12')	4	each	30	120	--	--	(window in wall)			--	120
		horizontal		bamboo (12')	2	each	30	60	--	--	--	--	--	--	60
				bamboo	2	each	5	10	--	--	--	--	--	--	10
				rope	1	roll	5.00	5	--	--	--	--	--	--	5
*All costs in Ruppees.								195		--					195

Sub-Total = Rs. 195-130=Rs.65

Total carried over

Type: Support (walls 1 + 2 + 3 + 4)	=	195 Rs.
Resale	=	130 Rs.
Investment	=	65 Rs.

Category type: Fabric-Form
(Sand-Cement)
Cost breakdown:

Parent component: Voids = Rs. 138

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST*/ UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
voids		window		jalli (12"x5")	6	each	3.0	18	--	--	1	--	--	--	18
		door		frame + door (3'x6')	1	each	120	120	--	--	3	--	--	--	120
											4				
								138						nil	138

*All costs in Ruppees.

Sub-Total = Rs. 138

Total carried over

Category type: Fabric-Form (Pucca) Stage: 2

Cost breakdown: Domed Roof (Asphalt water-proofing)

Parent component: Roof= Rs. 1046

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT	TOTAL (1)	COST/ UNIT	TOTAL (2)	MAN**	UNIT	COST/ UNIT	TOTAL (3)	TOTAL (4)
Domes		Domes		Catenary domes (for calculations see page)	16	each	25	400		25	75	--	--	--	425
Beams		Beams		Beam (calc. see page	3	each	105	315		40	15	--	--	- -	355
Extras		Finish (screed)						100		-	10				100
		Asphalt (water-proof)						50		5	5	--	--	--	55
		Gutter						40		5	6				45
		Ground Drainage						60		6	10	—	—	-	66
											123				
								965		81					1046

Sub-Total = Rs. 1046

Total carried over

Category type: Fabric-Form

Cost breakdown:

Parent component: Sub-Structure (H1/)

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT*	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
H1/1 leveling		clearing			10	cft	--	--	--	--		--	--	--	--
		leveling			--	--	--	--	--	--		--	--	--	--
H1/2 excavation		digging			48	cft	--	--	--	--		--	--	--	--
		fill			48	cft	--	--	--	--		--	--	--	--
		compaction			48	s.ft	--	--	--	--		--	--	--	--
foundation (see wall)															
											4				
								nil		nil					nil

*All costs in Ruppees.

Sub-Total = 0 (nil)

Total carried over

Fabric-Form (Pucca)

(With concrete domed roof)

Date of Estimate:
April, 1982

Date of Last Revision:

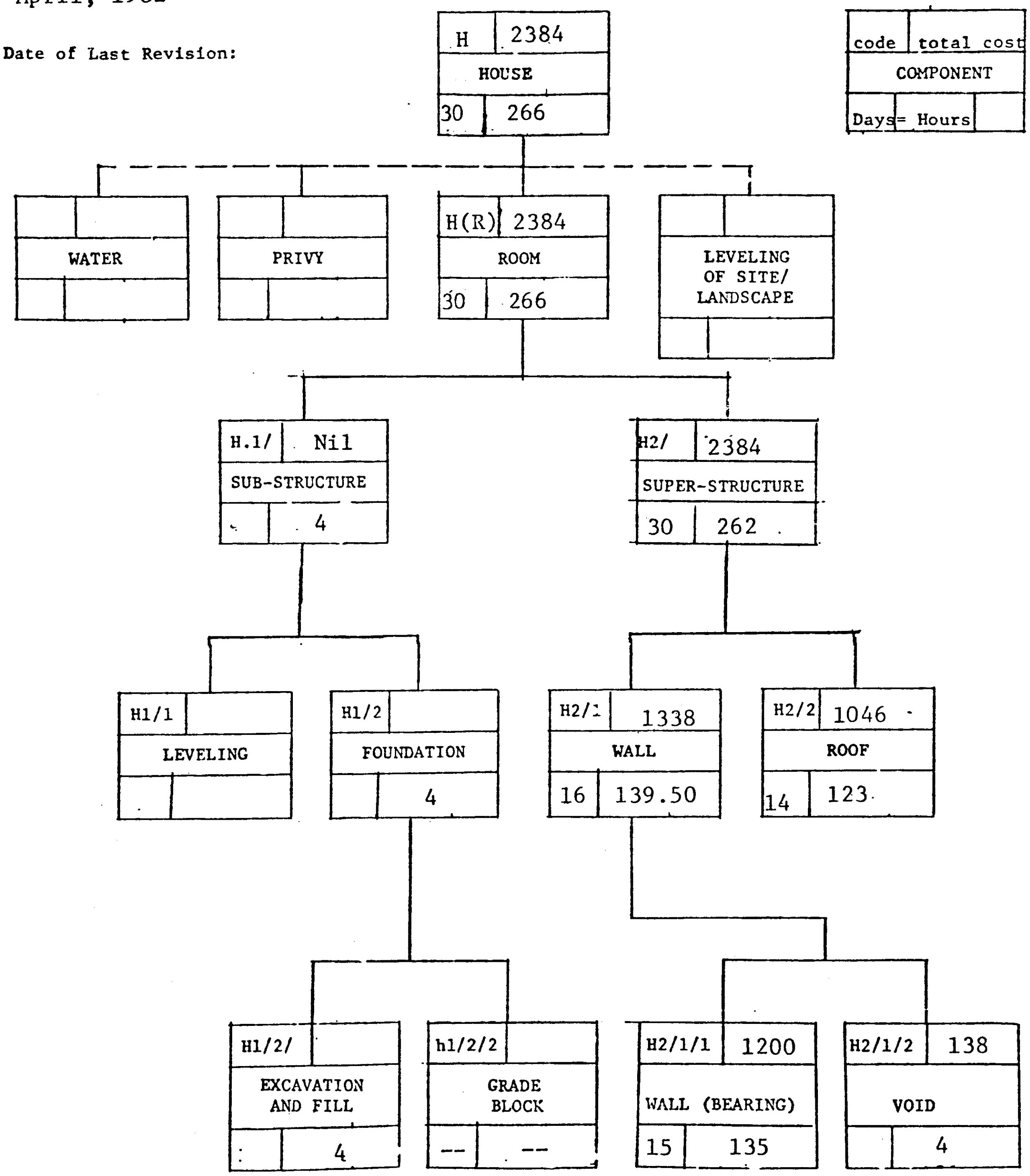
THE HIERARCHIAL COST MODEL:

FOR Fabric-Form
(sand-cement)

LEGEND

— — — non-critical
(no time preference)
——— critical

code	total cost
COMPONENT	
Days = Hours	



Source: Materials Cost: Karachi Development Authority, April, 1982.

Note: All costs in Ruppees.

6.2.3.1. Fabric-Form (Reinforced Concrete- Dome Slab)

Fabric-Form, Pucca (Stage: 3 only)

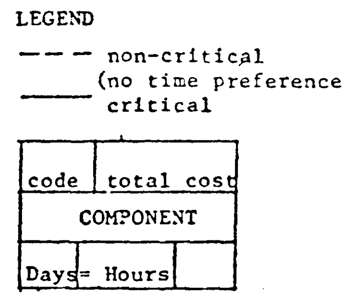
(with dome + R.C. roof slab) THE HIERARCHIAL COST MODEL:

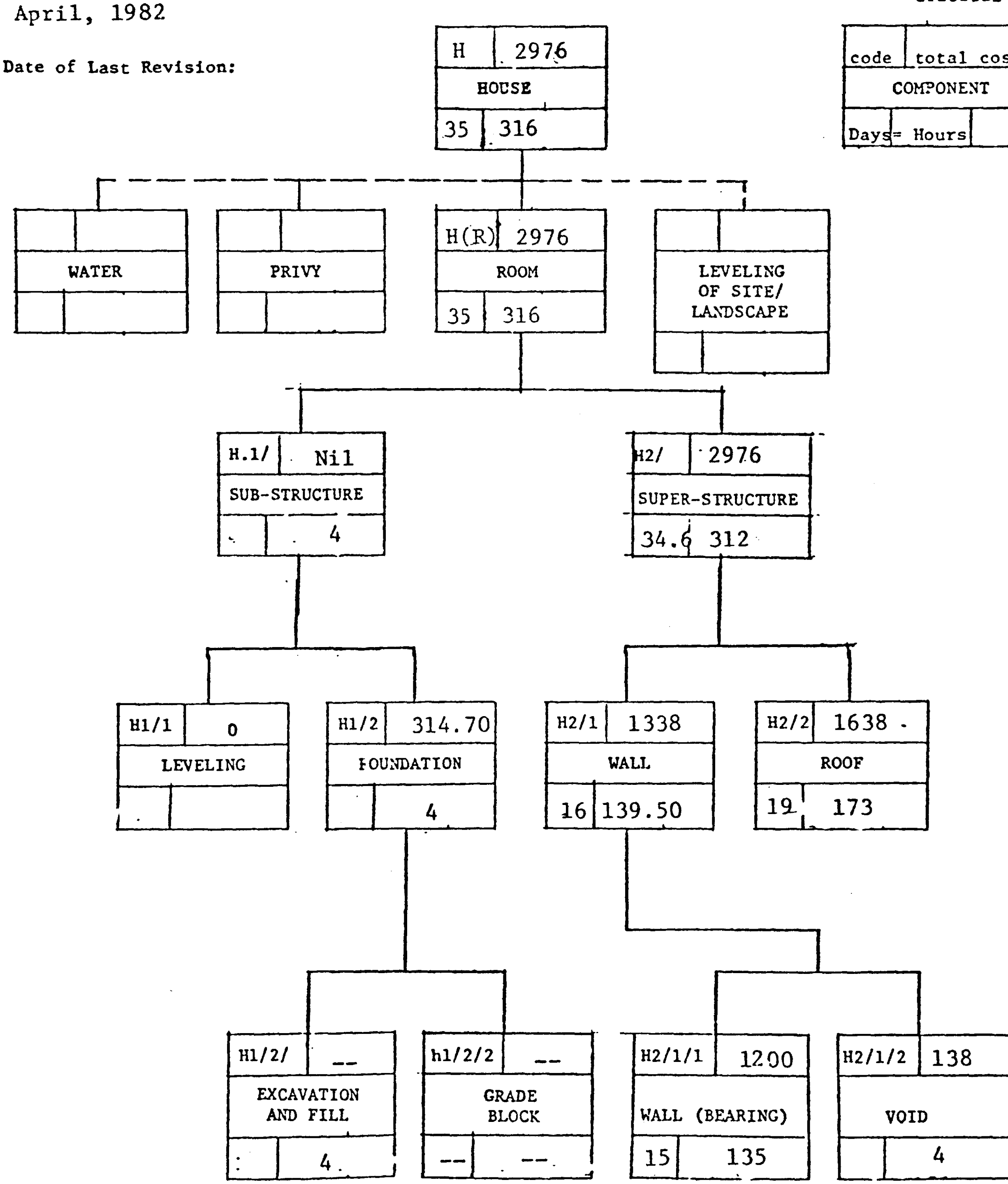
FOR .

Date of Estimate:

April, 1982

Date of Last Revision:





Source: Materials Cost: Karachi Development Authority, April, 1982.

Note: All costs in Ruppees.

6.2.4. PLAN TYPE: FABRIC-FORM (Soil-Cement) TYPE:

Floor Area= 12'x12'

Height Above Ground Level = 9'

Foundation = Light. One feet below grade using mass concrete.

Wall = Funicular fabric formwork and mass concrete (1:10:20, i.e., cement : soil : gravel) with sand stone infills

Roof = Concrete domes (double curvature catenary shell of 1" thickness) reinforced nominally with chicken mesh wire. Weight of each dome = 110 lbs. Domes supported on reinforced concrete beams at 3 feet centers

Construction = Self-help. Labor price considered zero

Life-Expectancy = 15 years

Category type: Fabric-Form
(Soil-Cement)
Cost breakdown:

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. 1.00 = US $.10

Parent component: Wall 1 + Wall 3: Rs. 384
(for caluclations see page)

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
wall(1+3) (including foundation)		wall (12'x10')	/1	sand-stone (.40 cu.ft. per cu.ft. of wall)	120	each	.50	60	.10	12.00	18	--	--	--	72x(2)
			2/	aggregate (1:10:20) see page	84	cuft	1	84	.05	4	9	--	--	--	88x(2)
			3/	gunny cloth ties (2 per sq. ft.)	300	sqft	.01	30.00	--	--	4	--	--	--	30x(2)
			4/	mild-steel ties (2 per sq. ft.)	240	each	0.01	2.40	--	--	2	--	--	--	2.40(2)
			5/	bamboo support (cost separate)	--	--	--	--	--	--	5	--	--	--	--
											38				
*All costs in Ruppees.								176.40 x(2)		16.0 x(2)					192.40

Sub-Total

Total carried over

Total = 384.80

Note: Walls 1 and 3
Surface area = 120' x 10' = 120 sq. ft.
Volume = 120' x 1' x 1' = 120 cu. ft.

Category type: Fabric-Form
(Soil-Cement)
Cost breakdown:

Parent component: Wall 2 = 158.60

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
		wall 2	1/	stone (40 cu.ft.)	100	each	.50	50	.10	10.00	15	--	--	--	60
			2/	aggregate (calcula- tions, see page)	70	cuft	1	70	.05	3.5	7.5	--	--	--	75.50
			3/	gunny cloth (21x11)	231	sqft	.1	23.10	--	--	4	--	--	--	23.10
			4/	mild-steel ties (2 per sqft)	200	each	.01	2	--	--	2	--	--	--	2.00
			5/	bamboo sup- ports (cost separate)	--	--	--	--	--	--	5	--	--	--	--
											33.50				
								145.10		13.50					158.60

*All costs in Ruppees.

Sub-Total

Total carried over

Note: Wall 2
Surface area = 10' x 10' = 100' (void not excluded)
Volume = 100 cu. ft.

Category type: Fabric-Form
(Soil-Cement)
Cost breakdown:

Parent component: Wall 4 = 134.21

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
			1/	stone (.40 cu.ft per cu.ft)	82	each	.50	41	.10	8.2	12.3	--	--	--	49.20
			2/	aggregate (calcula-tions see page)	57.40	cuft	1	57.40	.05	2.87	6.15	--	--	--	60.27
			3/	gunny cloth	231	sqft	.1	23.10	--	--	--	--	--	--	23.10
			4/	mild-steel ties	164	each	.01	1.64	--	--	2	--	--	--	1.64
			5/	support assembly	--	--	--	--	--	--	5	--	--	--	--
		(bamboo cost computed separately)						--							
											25.45				
								119.74		11.07					134.21

*All costs in Ruppees.

Sub-Total

Total carried over

Note: Σ Total Wall = wall - door = 100 - 18 = 82 sq. ft.
Volume = 82 cu. ft.

Category type: Fabric-Form
(Soil-Cement)
Cost breakdown:

Parent component:

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL* (4)
support for fabric formwork		vertical		bamboo (12')	3	each	30	90	--	--	(window in wall)			--	90
				bamboo (12')	2	each	30	60	--	--	--	--	--	--	60
				bamboo	2	each	5	10	--	--	--	--	--	--	10
				rope	1	roll	5.00	5	--	--	--	--	--	--	5
	water-proof: (optional) plastic (PUC)			poly-vinyl covering	1062	sqft	.20	212.40							212.40
*All costs in Ruppees.								377.40		--					377.40

Sub-Total

Total carried over

Walls (1+2+3+4)
PUC + (300 + 231 + 300 + 231) = 1062 sq. ft.

Category type: Fabric-Form
(Soil-Cement)
Cost breakdown:

Parent component: Wall (load-bearing) = 1300.00

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT*	TOTAL* (1)	COST/ UNIT*	TOTAL* (2)	Hrs. MAN**	UNIT	COST/ UNIT*	TOTAL* (3)	TOTAL* (4)
		Wall 1													192.40
		Wall 2													158.60
		Wall 3													192.40
		Wall 4													134.21
		Supports													65.00
		Plastic													377.40
															1120.01

*All costs in Ruppees.

Sub-Total

Total carried over

Category type: (Soil-Cement) Fabric-Form
Cost breakdown:

Parent component: Voids = Rs. 138

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3
Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/* UNIT	TOTAL* (1)	COST/* UNIT	TOTAL* (2)	Hrs. MAN**	UNIT	COST/* UNIT	TOTAL* (3)	TOTAL * (4)
voids		window		jalli	6	each	3.0	18	--	--	1	--	--	--	18
		door		frame & door (3'x6')	1	each	120	120	--	--	3	--	--	--	120
											4				
								138						nil	138

*All costs in Ruppees.

Sub-Total = Rs. 138

Total carried over

Category type: Fabric-Form

Cost breakdown:

Parent component: Sub-Structure (H1/)

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

Rs. 1.00 = US $.10

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT*	TOTAL (1)*	COST/ UNIT*	TOTAL (2)*	Hrs. MAN**	UNIT	COST/ UNIT*	TOTAL (3)*	TOTAL (4)*
H1/1		clearing			10	cft	--	--	--	--		--	--	--	--
leveling		leveling			--	--	--	--	--	--		--	--	--	--
H1/2															
excavation		digging			48	cft	--	--	--	--		--	--	--	--
		fill			48	cft	--	--	--	--		--	--	--	--
		compaction			48	s.ft	--	--	--	--		--	--	--	--
foundation (see wall)															
											4				
								nil		nil					nil

*All costs in Ruppees.

Sub-Total = 0 (nil)

Total carried over

Category type: Fabric-Form (Pucca) Stage: 2

Cost breakdown: Domed Roof (Asphalt water-proofing)

Parent component: Roof= Rs. 1046

Component Relationship
MAJOR-MINOR = Parent-Child
**Man = Assumes 9 man/hour/day
*TOTAL(4) = 1+2+3

MAJOR		MINOR		MATERIALS					TRANSPORTATION		LABOR				
COMPONENT	CODE	COMPONENT	CODE	COMPONENT	QTY	UNIT	COST/ UNIT	TOTAL (1)	COST/ UNIT	TOTAL (2)	MAN**	UNIT	COST/ UNIT	TOTAL (3)	TOTAL (4)
Domes		Domes		Catenary domes (for calculations see page)	16	each	25	400		25	75	--	--	--	425
Beams		Beams		Beam (calc. see page	3	each	105	315		40	15	--	--	- -	355
Extras		Finish (screed)						100		-	10				100
		Asphalt (water-proof)						50		5	5	--	--	--	55
		Gutter						40		5	6				45
		Ground Drainage						60		6	10	—	—	—	66
											123				
								965		81					1046

Sub-Total = Rs. 1046

Total carried over

Fabric-Form (Pucca) Stage:2
Second Stage (only)
(With concrete domed roof)

Date of Estimate:
April, 1982

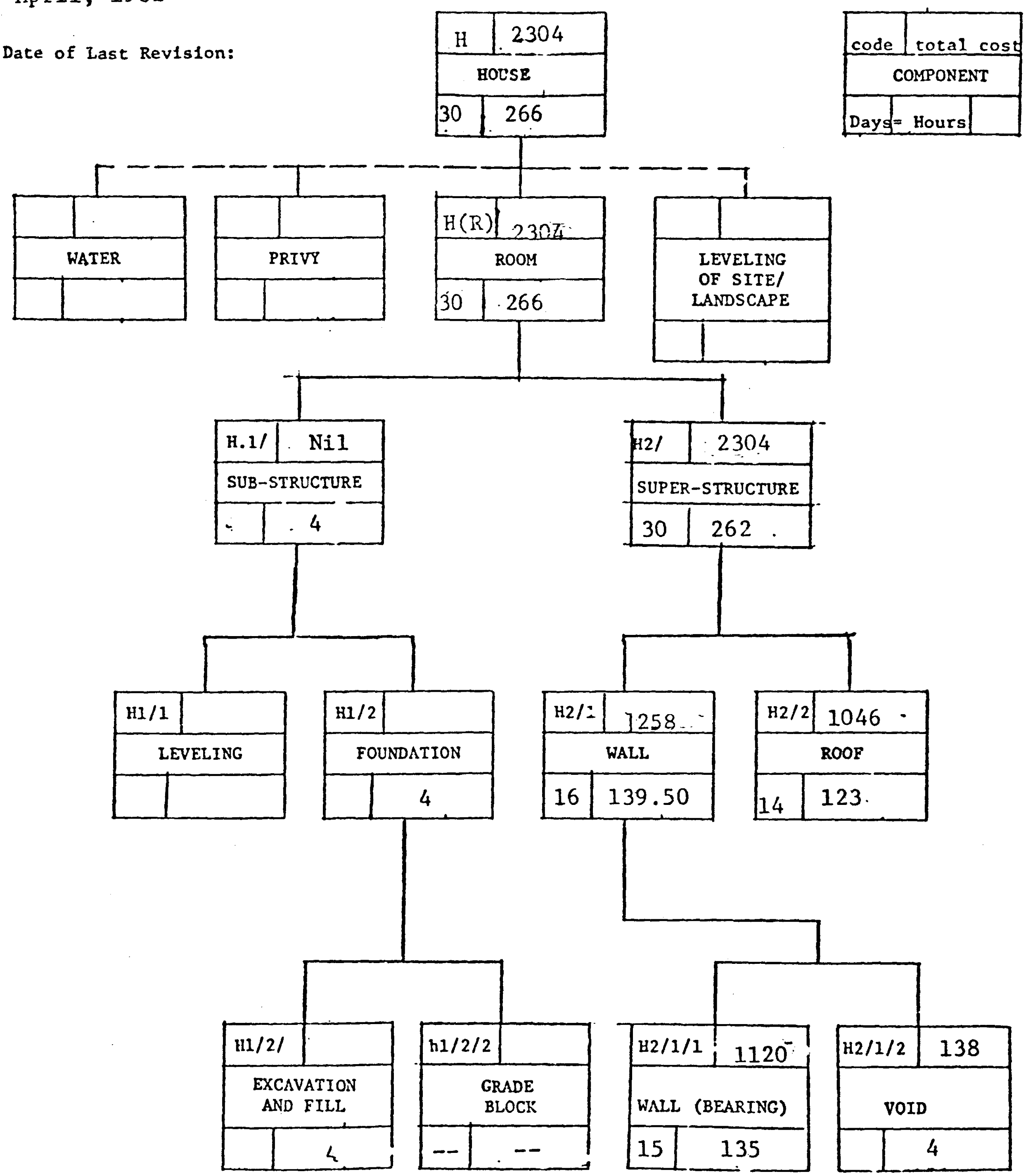
Date of Last Revision:

THE HIERARCHIAL COST MODEL:

FOR Fabric-Form (Soil-cement)

LEGEND

- - - non-critical (no time preference)
——— critical



Source: Materials Cost: Karachi Development Authority, April, 1982.

Note: All costs in Ruppees.

Table 15

Comparison of Cost of Construction and Life-Cycle Costs
Using Different Construction Methods

Cost of constructing 1 room = 12' x 12' = 144 sq. ft.

Costs in Ruppees = Rs. 1.00 = US $.1

	Foundation	Walls	Roof	Voids: Doors & Windows	Total Investment Cost	Life-Cycle Cost
1. Juggi I	nil	374	378.20	5	757.20	Rs. 25.18/ month
2. Semi-Pucca I (with corrugated aluminum roofing)	314.70	1597.15	571.40	148	2631.25	Rs. 30.85/ month
3. Semi-Pucca I (with roof slab)	314.70	1597.15	3744*	148	5803.85	Rs. 46.30/ month
4. Fabric Form (sand-cement) (domed roof)		1200 (includes	1046 foundation)	138	Rs. 2384.00	Rs. 19.03 / month
5. Fabric Form (soil-cement) (domed roof)		1120 (includes	1046 foundation)	138	Rs. 2304.00	Rs. 26.04/ month
6. Fabric Form (sand-cement) (domed + R.C. slab)		1200 (includes	1638 foundation)	138	Rs. 2976	Rs. 23.76/ month

Note: Labor cost considered nil for all above types.

For calculations on annual costs see Appendix 'A'

6.2.5. Conclusion:

The comparison of investment cost and life-cycle costs highlight important indicators in terms of economic costs of selecting various building systems.

(1) Firstly, both the investment cost and life-cycle costs of using fabric form for construction come out much lower than other systems. The building type made of fabric-form (using sand-cement) shows cost less than 50% of semi-pucca I (with roof slab, #3), both in terms of investment cost and life-cycle costs. The relative costs for fabric-form will be even lower if contractors' profits are calculated for semi-pucca type I - as the masonry work is invariably sub-contracted unless the builder is himself a mason .

(2) Although the investment cost of a juggi is low, the life-cycle cost is relatively high. This is mainly due to recurrent costs accrued from cost of regular maintenance. In fact the juggi dwellers' investments are considerably high as he continuously replaces the more temporary materials with permanent ones - like reed mat is replaced by tin sheets, etc. - but the economic value of his dwelling does not appreciate at the same rate. Juggis are considered the most undesirable shelters by the dwellers.

(3) Although the cost of investment in semi-pucca I is comparable to fabric-form, the semi-pucca I has a temporary roof. If the dweller wants to expand vertically, he must remove this roof and replace it with a reinforced concrete roof slab which costs Rs. 3744/= for a roof slab of area = 144 sq. ft.

In comparison the domed roof (using catenary fabrication on ground), for the same covered area; costs Rs. 1046 and if the dweller wants to expand vertically, he provides a topping of concrete - average thickness 6" - at additional cost of Rs. 592.00. This roof will cost him less than 50% of the conventional reinforced concrete slab.

(4) Although soil-cement-gravel construction reduces the cost of aggregate in wall, the cost of poly-vinyl covering as waterproof membrane is high and brings the cost close to cost of wall using sand-cement-gravel as aggregate. Also, maintenance costs are much higher due to humidity and damages that might necessitate repairs after heavy showers, especially during summer.

<u>Advantages of Using Fabric-Form</u>:

(1) Fabric-form speeds the process of construction. Although time is not a major constraint to the squatter or low-income dweller he does prefer to build with systems which are not overly time consuming. This has been discussed in disadvantages of constructing mud-house which is extremely time consuming (see Table 14).

(2) Fabric-form permits choice of infill depending on income of the dweller. In fact, the economic advantages of using the fabric-form would be to the poorest dwellers who will simply use mud and stones gathered from surrounding areas and use it as in-fill. They can use organic materials as binder (i.e., cow dung, etc.). Two men could build a wall 9' high in less than 2 or 3 days. They do not have to dry the mud-bricks and place it one on top of the other; or wait for it to dry before building it in successive stages as is

done currently.

(3) The fabric-form does not require precision in wall alignments - an important advantage for an unskilled and uneducated builder.

In fact, Harst has found that the biggest deterent for a dweller to build his own shelter of semi-pucca type-using masonry block - is in that he considers masonry work to be complicated and one that can only be performed by a skilled laborer (mason).

(4) The fabric-form wall uses a 12" thick wall which is quite stable for multi-story construction. This is a clear advantage over semi-pucca I which uses a 6" thick wall and would require extra columns if the building were to grow vertically - very expensive and difficult to do once the foundation and walls have been erected in 6" blocks.

(5) Voids: The fabric-form wall permits a very simple process of making voids. The wooden framed doors and windows are placed within the void of the fabric - such that the height of the windows or doors are at desired heights and the fabric is nailed to the frame. Subsequently concrete is poured into the wall. Once the wall has hardened, the fabric is cut off from the voids with scissors, and the door or window can be attached to the frame. (See sketches

(6) The major advantage of fabric-form is in fabrication of the beams and domes. The beams are fabricated at roof height on the wall, so it does not have to be carried from ground to roof. This represents a major advantage, if there is a constraint on manpower. The other advantage of using fabric as formwork is that it excludes the use of expensive wooden shuttering.

In fact, one fabric can be re-used several times to fabricate beams (see sketch

(7) The catenary domes can be fabricated in a very simple manner on the ground as they weigh a mere 90 - 120 lbs (3' x 3' catenary dome of shell thickness between 3/4" to 1"). These domes can later have a concrete topping - average thickness of 6" - and would subsequently permit vertical growth.

(8) Fabric-form adapts well to incremental growth - especially that of a juggi. The juggi bamboo frame is used as the inner support for fabric-formwork. This reduces his investment on bamboo supports. He can continue to live within the juggi while he builds his permanent walls on the external side. Fabrication of beams or domes do not hinder his existing shelter - as existing floor to ceiling heights are lower in current "juggi" plan types - but if he plans to use the fabric-form at a future date - he could, in the beginning, build his "juggi" with a greater floor to ceiling height.

Chapter 7. Guideline for Low-Income and Squatter Housing in Pakistan:

7.1 Guidelines for Design of Appropriate Building System.

From the previous discussion we can conclude that design of any housing system should try to achieve certain objectives. These systems will apply to unauthorized slums-with-hope and to regularized plots. We have convincing proof that in slums without hope building activity does not take place.

1. The building system must be simple enough to be comprehensible to even an uneducated person, who can get instruction on the system through an educated neightbor, community organization.
2. It must be cheap enough so that it fits the income capacity of most slum dwellers. This could be achieved if he could build his structure incrementally over time. So it should require minimum skills.
3. It should be labor intensive, as opposed to requiring complex process or machinery, and should have the ability to be constructed by as few people as possible - household.
4. The system should permit growth both vertically and horizontally.
5. It should be visually acceptable.
6. The material used should be locally available and should not take a long duration to place or form.
7. It should be fire resistant, water-proof, insect-proof, and be able to take strong wind.
8. The system should allow simple methods of making voids, i.e., windows, doors, ventilation ducts, etc.
9. The delivery system should be such that he should be able to fabricate it on site.

7.2 Guidelines for Comprehensive Development of Aurangi.

The programme for upgrading of Aurangi must incorporate a comprehensive policy which recognizes the need for a total environmental upgrading, of both the physical facilities as well as the socio-economic well-being of the individual. We can develop a set of guidelines, which incorporates a more comprehensive policy. Essentially the upgrading programme must recognize the need to stimulate vocational training programmes, self-employment opportunities - that is accept the owners may carry out economic activities from their homes - which would increase the productivity and income of residents. The community should not be isolated from the rest of the city and services, roads, transportation, etc., should be provided by the Government to integrate it within the Urban Fabric.

Issues of land tenure for those who squat on non-regularized plots must be resolved. One observes that the regularized plots have a faster rate of growth. Studies have shown that security of tenure is the one crutial issue in rapid upgrading of squatters and this is confirmed by reports on squatter upgrading in other countries. However issues such as the loss in opportunity lost to the landowner, public or private. Can policies of cross-subdidization be really effective. This remains as one of the more vital incentives for slum upgrading.

Provision of Services.

Government policies must address issues of providing roads, water supply, sewerage, drainage. The government should perhaps make these corrections only to each particular block and the dwellers can then be asked to complete the linkages to their homes. In this connection efforts should be made to tap the underground water sources.

Physical Layout.

The existing layout should be retained as much as possible without resorting to demolition to make paths or installation of services and hence minimize movement of houses may produce an irregular layout, but this provides a distinction of open to built areas. This is an uniqueness which reinforces communities' identity to the area.

Minimum Lot Size.

This is more of an issue with new plots. Past minimum plot sizes should not be less than 40 m^2 - 50 m^2. From my own observation, plot size of 120 m^2 - 160 m^2, though extravagant, provide adequate space for other economic activities at home; i.e., shop-ownership, small scale manufacturing; sub-letting.

Access to Finance.

Where lots are offered for sale, the Government should come up with a program of loans for the poorest families - for purchase of materials and other expenses for improvements.

Appropriate Technology.

There is no one appropriate technology - and none should be imposed. People should be allowed to build using any material they want, concrete block, brick, mud, fabric framed structures, etc., that thye feel is most appropriate to their skill and their income. Overtones of homogenity of material and the built environment should not be imposed arbitrarily or stringently in this area.

Slum Upgrading.

Public Participation.

Any Government intervention must be preceded by discussions with the squatters about the programme under consideration to insure that it has popular support. Otherwise the project would be doomed to failure. John Turner suggests a two-step process:

1. When an overall layout showing roads, foot-paths and facilities is prepared for a wide area, general meetings for all residents should be held;
2. When, as part of an overall scheme, a block is to be upgraded, specific details of movement, lot subdivision, etc., should be discussed with the families who live on the block.

Identification of Eligible Household.

Slums pose great difficulty in defining the ownership of the land or status of families who live there. Attention should be given to contesting parties for the same lot and a thorough investigation should be conducted before appropriating to dubious owners.

Building Codes:

Building codes should be tailored to the situation in squatter areas and should encourage initiative that lead to new methods of construction which offer better use of resources and encourages dweller participation in upgrading of housing stock and overall enviornment.

APPENDIX A

1. Cost-Estimation of Fabric Form Wall:

We assume that the wall is constructed from the following materials:

1 - stone

2 - concrete = cement

sand

gravel

We can determine the cost per sq. ft. of wall as follows:

1 - Stone: The size of stone is arbitrary but people generally cut stones in sizes of ≃12" x 9" x 6". This has a volume of V_s = 12" x 9" x 6" - .375 cu. ft. Let us assume a figure of V_s = .40 cu. ft. This is assumed to be cut or obtained by dweller himself.

2 - Aggregate: This will mean that concrete must have a volume of = 1.0 - .40

= .60 cu. ft.

If we assume that the cumulative volume of aggregate is 15% more than volume of concrete, we have total volume of aggregate

$$V_A = 1.15 \times (60) = (0.690) \text{ cu. ft.}$$

In Pakistan sand-cement blocks (known as 3% cement blocks) have a proportion of 1:10:20.*

This will give us the following volumes for the aggregate:

$$\text{cement} = \frac{.690}{31} \simeq .022 \; [\frac{0.690 \times 1}{1+10+20=31} = 0.022 \text{ ft}^3]$$

$$\text{sand} = .690 \times \frac{10}{31} = \underline{.22} \text{ ft}^3$$

$$\text{gravel} = .690 \times \frac{10}{21} = .44 \text{ ft}^3$$

. A bag of cement (1.25 cu.ft.) costs Rs. 55.00

. 100 cu.ft. of sand or gravel costs Rs. 270.00

*i.e., 1 part cement : 10 part sand : 20 part coarse gravel. It is more convenient for people to measure by volume rather than weight.

So cost of aggregate for every cu.ft. of wall:

$$\text{cement} = .022 \times \frac{55}{1.25} \simeq 1 \text{ Rs.}$$

$$\text{sand} = 0.22 \times \frac{270}{100} \simeq .59 \text{ Rs.}$$

$$\text{gravel (coarse)} = 0.44 \times \frac{225}{100} \simeq .98 \text{ Rs.}$$

Total cost of aggregate = 2.57 Rs.

Therefore, 1 cubic feet of concrete costs Rs. 2.57.

2. Cost estimation of catenary dome = Rs. 25/dome

Dimensions = 3' x 3'

A_c = Area of catenary surface

A_c = Area = $L_1 \times L_2 \times K$

(K = factor for different depths of catenary)

$A_c = 9\ ft^2 \times (\simeq 1.20) = 10.8\ ft^2$

[K = 1.20 for D = 6"]

Thickness of shell t = 1"

Volume of concrete in dome =

$A_c \times t_c = 10.8' \times \frac{1}{12} = 0.9$ cu. ft.

If we assume that the aggregate volume is larger by 20%* than the volume of concrete, we have:

volume of concrete = 0.9 cu.ft.

volume of aggregates = 1.08 cu.ft.

If we are using a proportion of 1:6 (i.e. 1 part of cement to 6 parts of sand by volume) we have for 1.08 cu.ft. of aggregate:

*Factor of 1.2 for expected volume of aggregate using only sand and cement mortar.

cement = .154 cu.ft. ; sand = 0.92 cu.ft.

cost of cement = $.154 \times \frac{1}{1.25^*} \times$ Rs. 55*

= Rs. 6.776

cost of sand = $0.92 \times \frac{1}{100} \times$ Rs. 270

= Rs. 2.48

1. cost of aggregates = Rs. 6.776 + Rs. 2.48

   = Rs. 9.256.

2. cost of gunny cloth:

   Total area of gunny cloth assumed for 3' x 3' catenary dome = 12 sq.ft. at .1 Rs./sq.ft.

   = Rs. 1.20

3. Cost of chicken wire mesh (edges and surface covered by double layer) ≃ 3 lbs. cost of reinforcement = Rs. 4,500/ton (2240 lbs) or Rs. 2.00/lb.

Total cost of chicken mesh = (Rs. 3) x (2.00)

= Rs. 6.00

4. Cost of bamboo edge frame = Rs. $\frac{128}{16}$

   = Rs. 8.00

   (two frames re-used for 16 domes)

   Total per dome = 1 + 2 + 3 + 4

   = Rs. 9.256 + 1.20 + 6 + 8 = 25 Rs.

*1 bag of cement has volume 1.25 ft^3 and costs 55 Rs.

3. <u>Cost Estimation of Beam</u>:

span = 11'

spacing center to center = 3'

<u>Loads</u>:

- live load = 40 psf x 3 = 120 pft (i)

- dead load =

. average top concrete (6" thick) =

70 psf x 3 = 210 p/ft (ii)

. beam = $\frac{5'' + 3''}{2}$ x 15" = 60 in^2 (cross-section)

weight = 60 x $\frac{1}{144}$ x 140 psf ≃ 60 p/ft (iii)

screed = 15 psf x 3' = 45 p/ft (iv)

total live + dead load = (i) + (ii) + (iii) + (iv)

= 120 + 210 + 60 + 45 =

= 435 pound per linear foot

= .435 Kips/linear foot

Bending Moment M = $\frac{0.435x(11')^2}{8}$ = 6.57 Kft.

= 78.84 K-in.

Allowable stress in the mild steel reinforcement - f_{all} = 24 Ksi

Beam height = h = 15"

Effective depth of beam = d

d = 15 - 2 = 13 in.

Arm of internal forces = 0.85 x 13 = 11"

Calculation of area of reinforcement bar:

$$A = \frac{M}{11 \times 24} = \frac{78.84}{11 \times 24} = 0.29 \text{ in}^2$$

[A = Area of Required Reinforcement]

Increasing a safety factor for variation in strength of reinforcement and its improper placing. We suggest an A = 0.29 x 1-1/3

$= 0.39 \text{ in}^2$

or 2 bars of ϕ 1/2" should be enough for the beams.

Weight of reinforcement =

0.67 lbs. x 2 x 11' (11' span) = 14.20 lbs.

(Price of Reinforcement = Rs. 2.00 per lb.)

(1) Cost of required reinforcement =

14.20 lbs x Rs. 2.00 = <u>Rs. 28.40</u>

Concrete used:

$$\text{Total area of beam} = \frac{5 + 3}{2} \times 15 \times (11 \times 12)$$

$$= 4 \times 5 \times 132 = 60 \text{ in}^2$$

$$\frac{60 \text{ in}^2}{144} \times 11' = 4.66 \text{ ft}^3$$

The volume of aggregates is 20% more than the volume of concrete:

volume of concrete = V_c = 4.66 ft^3

volume of aggregate = V_{AG} = 4.66 x 1.20

= 5.6 ft^3

The aggregate proportion is 1:2:4 (1 part cement : 2 parts sand : 4 parts aggregate by volume).

$$\text{cement} = 5.6 \times \frac{1}{7} = 0.8 \text{ cu. ft.}$$

$$\text{sand} = 5.6 \times \frac{2}{7} = \underline{1.56} \text{ cu. ft.}$$

gravel = 5,6 x $\frac{4}{7}$ = 3.12 cu. ft.

i. cost of cement at Rs. 55 per 1.25 cu. ft.,

= .78 x Rs. 55 x $\frac{1}{1.25}$ = Rs. 34.32

ii. cost of sand = 1.56 x Rs. 270 x $\frac{1}{100}$

= 4.21 Rs.

iii. cost of gravel = 3.12 x Rs. 270

x $\frac{1}{100}$ = 8.44 Rs.

(2) Total cost of aggregate = 46.97 Rs.

(3) Cost of burlap:

burlap used = 11' x 4' = 44 sq. ft.

price per sq. ft. = .1 Rs.

cost of burlap 44 x .1 = 4.4 Rs..........3

(4) cost of bamboo:

2 x 12' poles of bamboo used for 3 beams =

$\frac{2 \times 30}{3} = \frac{60}{3}$ Rs. = 20 Rs./beam.............4

(5) mild-steel wires for ties = 5 Rs.........5

cost of fabricating beam = 1 + 2 + 3 + 4 + 5

= 28.40 + 46.97 + 4.4 + 20 + 5 = 104.77 Rs.

4. Annual Costs:

Annual costs have been calculated by aggregating two sets of costs.

(1) Annuity costs which include foregone interest due to investment in house, plus depreciation over life span. This is given by the formulae:

$$c = \frac{p \times i}{1 - (1 + i)^{-n}}$$

where

c = annual cost

p = principal on investment

i = annual interest rate

n = number of years (life-span of building)

where $i = 7\%$ when, $n \geq 3$

$i = 6\text{-}1/2\%$ when, $2 < n < 3$

$i = 6\%$ when, $1 < n < 2$

This is added to:

(2) Periodical recurrent cost (maintenance costs).

This has been assumed on the basis of estimates currently used in Pakistan for various categories of buildings.

1/ Semi-Pucca I = 1% of principal.

2/ Semi-Pucca (with reinforced concrete slab) = 1% of principal.

3/ Juggi = .02% of principal (This figure is low for Juggi as depreciation includes various maintenance costs)

4/ Fabric-Form = 1% of principal (sand-cement)

5/ Fabric-Form = 3% of principal (soil-cement)

6/ Fabric-Form = 1% of principal (domed and reinforced concrete slab)

TABLE 16

ANNUAL COSTS

FOR DIFFERENT BUILDING TYPES

*All costs in Ruppees
Rs. 1.00 = US $.10

BUILDING TYPE	COMPONENT	(p) COST*	(n) LIFE*	(i) INTEREST RATE*	ANNUAL* COSTS (INTEREST + DEPRECIATION)	RECURRENT* COSTS (MAINTENANCE)	ANNUAL COSTS* PER YEAR	PER MONTH
Juggi-Type I Investment Cost = Rs. 757.20	.1. Bamboo 8 x 7' 2 x 12'	170	4	7%	50.18			
	.2. Reed Mats "Chatai" "Sarkanda" "Panka"	155	1	6%	164.30			
	.3. Bamboo 10 x 7' 4 x 10' 5 x 12'	359	12	7%	45.19			
	.4. Plastic	43.20	2	6-1/2%	23.72			
	.5. Miscel-laneous items and transport	30	12	7%	3.77			
TOTALS					287.16	15.0	302.16	25.18

TABLE 16.2

ANNUAL COSTS

FOR DIFFERENT BUILDING TYPES

*All costs in Ruppees.
Rs. 1.00 = US $.10

BUILDING TYPE	COMPONENT	(p) COST*	(n) LIFE*	(i) INTEREST RATE*	ANNUAL COSTS (INTEREST + DEPRECIATION)*	RECURRENT COSTS (MAINTENANCE)*	ANNUAL COSTS* PER YEAR	PER MONTH
Semi-Pucca I Investment Cost = Rs. 2631.25	All elements in which cement is used, woodwork, transport costs.	2220.85	15	7%	243.83	(1%** of principal)		
	Iron Sheets.	410.40	5	7%	100.09			
					343.92	26.31	370.23	30.85
Semi-Pucca (Pucca) With reinforced concrete roof slab. Investment Cost = Rs. 5803.25	All elements in which cement is used, woodwork, transport costs.	5803.25	25	7%	497.79	58.03 (at 1%** of principal)	556.00	46.30

**Assumed on basis of current estimating procedures in country.

TABLE 16.3

ANNUAL COSTS

FOR DIFFERENT BUILDING TYPES

*All costs in Ruppees.
Rs. 1.00 = US $.10

BUILDING TYPE	COMPONENT	(p) COST*	(n) LIFE*	(i) INTEREST RATE*	ANNUAL COSTS (INTEREST + DEPRECIATION)*	RECURRENT COSTS (MAINTENANCE)*	ANNUAL COSTS* PER YEAR	PER MONTH
Fabric-Form (sand-cement) With domed roof: Investment cost = Rs. 2384.0	All elements in which cement is used, woodwork, transport costs.	2384	25	7%	204.57	23.84** (at 1% of principal)	228.41	19.03
Fabric-Form (sand-cement) With roof-slab Investment cost = Rs. 2976	All elements in which cement is used, woodwork, transport costs.	2976	25	7%	255.37	29.76** (at 1% of principal)	285.13	23.76

**At 1% of principal.

TABLE 16.4

ANNUAL COSTS

FOR DIFFERENT BUILDING TYPES

*All costs in Ruppees
Rs. 1.00 = US $.10

BUILDING TYPE	COMPONENT	(p) COST*	(n) LIFE*	(i) INTEREST RATE*	ANNUAL COSTS (INTEREST + DEPRE-CIATION)*	RECUR-RENT COSTS (MAINTEN-ANCE)*	ANNUAL COSTS* PER YEAR	PER MONTH
Fabric-Form (soil-cement) Investment = Rs. 2304/	All elements in which cement is used, woodwork, transport costs	2304	15	7%	252.96	69.12** (at 3% of principal)	322.08	26.84

** 3% a higher figure because of higher maintenance costs.

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