Mud, Mud: The Potential of Earth-based Materials for Third World Housing

by: Anil Agarwal

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Housing may be the Third World's most intractable problem.

In most of the cities of Africa, Asia and Latin America, at least a quarter of the population has to live in ramshackle, makeshift shelters in slums and shanty-towns. In some cities, over half the population live like this - and the numbers are growing. And in the rural Third World, virtually all houses are far below the most minimal standards of health and hygiene.

Official housing programmes cannot begin to cope, because even in the cities from one third to two-thirds of all households are too poor to pay for the cheapest approved dwelling that can be built.

"The widespread addiction to cement and tin roofs is a kind of mental paralysis", according to President Julius Nyerere of Tanzania.

Mud, adobe, earth-bricks, soil-cement and other traditional building materials are cheap, readily available and can be made and used by the poor people themselves to build their own homes.

Mud is the most widely used building material in the world, yet it is almost invariably ignored by governments, development banks and aid agencies.

Mud has made palaces and cathedrals, vaults and arches. In the Nile Valley, some of them have stood for a thousand years.

Today, mud perhaps offers the only practical prospect for building the five hundred million houses which will be needed in the next twenty years.

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This publication was written by Anil Agarwal (formerly assistant director of Earthscan and now director of the Centre for Science and Environment, New Delhi) and edited by Jon Tinker. It was published with financial assistance from the United Nations Centre for Human Settlements, but does not necessarily represent the Centre's views, or those of any of the other agencies which financially support Earthscan.

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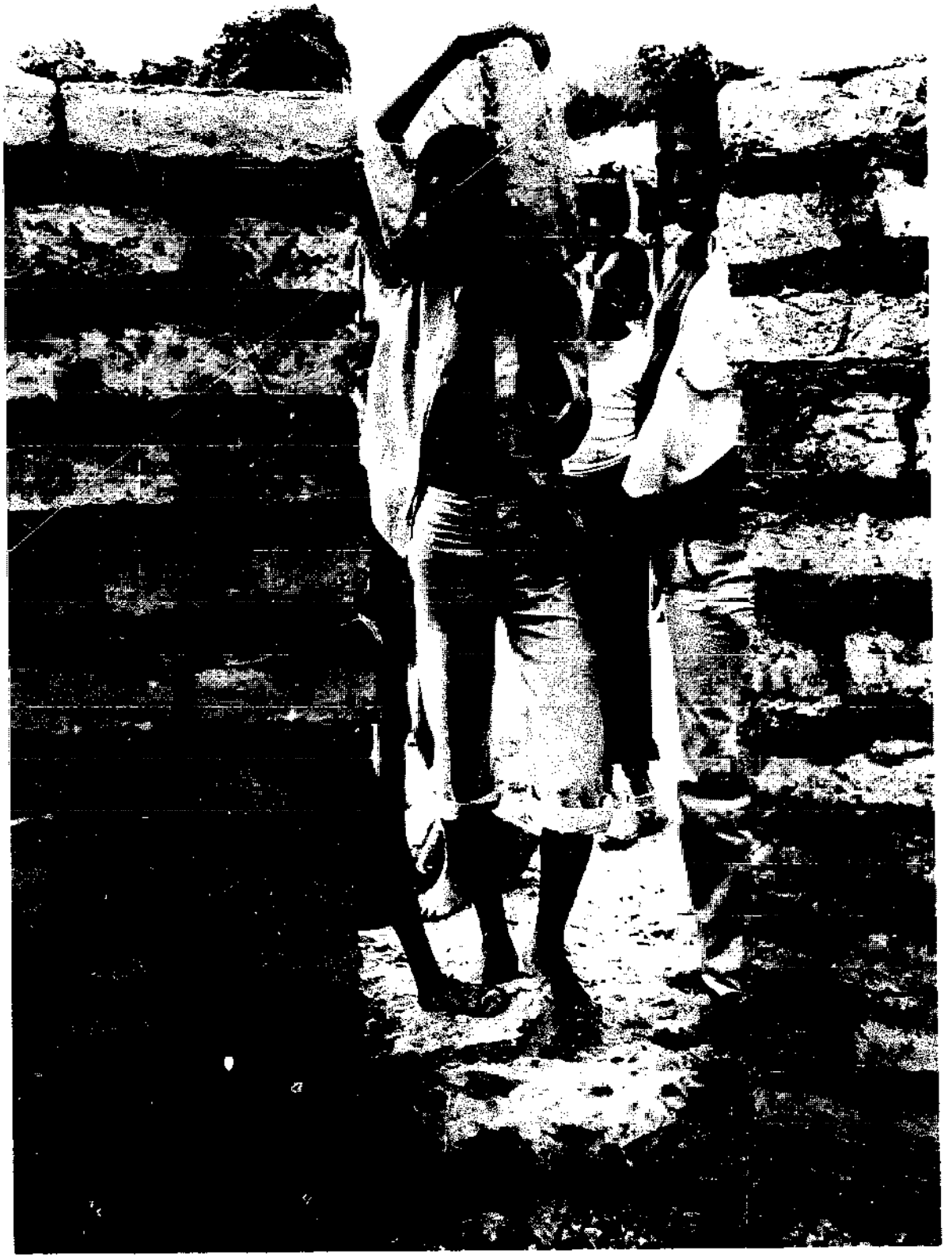
Bricks...they call 'em soil cement
Nice ones, so thick and heavy
So cheap, so strong
Ooh for building a house...
(song from shanty-town George, Lusaka, Zambia)

Building with mud, Mali. Photo: Sean Sprague



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CHAPTER ONE

INTRODUCTION

Third World housing may be the world's most unsolvable problem.

- This briefing document:
    * introduces the problems of Third World housing
    * examines the relative inability of accepted policies to solve them
    * reviews mud and other earth-based building materials in comparison with cement, bricks and other "modern" materials
    * examines the utility of mud-based materials in a score of countries in Africa, Asia, the Americas and Europe.

- Over half a billion houses have to be built between now and the year 2000 to house the people of the developing countries.

- It was estimated in the early 1970s that the Third World needed to build over 8 houses per 1000 people per year. In 1970 figures from 24 countries showed that they were building only 1.8. There is little reason to believe that the rate has improved substantially since then.

- The housing deficit - the number of new houses needed - has been growing in most countries.
    * In mid-1977, Morocco had a deficit of over 800,000 houses
    * The Philippines had a housing backlog in urban areas of about a million in 1977
    * Egypt's urban deficit in 1975 was more than 1.5 million housing units. Cairo alone had a shortage of 750,000 houses
    * Nigerian official estimates place the deficit in 14 cities at about 400,000 houses

- In most cities of the Third World, at least a quarter of the population (in some cities, over half) lives in ramshackle makeshift shelters in slums and shanty-towns.

- All Third World cities are divided into two parts. Maputo, capital of Mozambique, has a cement city with modern tall buildings, which the Portuguese colonisers built for themselves. There is a second Maputo, a cane city, where mud and cane houses are built for the African workers.

- In Ankara, Rio de Janeiro, Mexico City, Lima, Caracas, Guatemala City and in many other cities, the proportion of the slum and shanty dwellers in the total population has been steadily increasing.

- Third World governments have made many efforts to provide low-cost houses to the poor. These projects have almost invariably ended up becoming housing schemes for the middle-class.

- Poverty is so intense that between a third and two-thirds of Third World urban households cannot afford the cheapest modern dwelling on the market, says a World Bank study.

- Schemes aimed at clearing slums and re-housing slum-dwellers in high-rise, high-density, low-cost structures have failed, because they generally drive the slum-dwellers away from their jobs. A poor man cannot afford high transport costs. His first priority is proximity to work.

- Attitudes are now changing. Several governments already realise that the slums of the Third World are not slums of despair, as they are in the deteriorating inner cities of the developed world, but really slums of hope.

- Eventually, everyone finds some kind of shelter. It might be ramshackle, to begin with, built of tin, cardboard and pieces of sacking. But if there is security of tenure - if there is no threat of the house being bulldozed away one sudden evening - the slum-dwellers gradually improve their houses.

- The role of governments, it is argued, should be to provide the environment for this self-help process to flourish, not to build houses.

- According to one UN document: "The purpose of a housing policy is not to build houses, but house the population".

- In other words, governments should provide security of tenure, technical advice, help in acquiring small loans and cheap building materials. As one Indian building scientist puts it: "What developing countries need is not mass housing but housing by the masses".

- Slum up-grading schemes based on this approach can now be seen in several cities in the Third World: in Manila, Djakarta, Calcutta and Lusaka.

- In site-and-services schemes, the household is given a site with services like water supply and electricity. Each house is then constructed by its occupiers at the pace they want.

- Self-help needs a rational policy towards building materials.

- For a building material to meet the housing needs of the poor, and for it to aid the self-help process, it must have three characteristics. It must be:

  * cheap
  * readily available
  * easy to use.

- Traditional building materials, such as mud, timber, thatch and stone, have been used by people for centuries, and meet all these three criteria.

- For years, seminars of international experts have piously recommended more research into and more use of traditional building

materials. But there has been little serious interest from planners, research stations, governments or aid agencies.

- Everyone, it seems, wants to live in a modern house built with cement and steel.

- But cement, steel and bricks will not become accessible to all the people of the world until well into the 21st century - if ever. Cement and brick production is energy-intensive, and costs are likely to increase rapidly as energy prices rise.

- Cement production is a technologically sophisticated process, and plans to produce more have fallen behind schedule in most developing countries. Major housing programmes have repeatedly been sabotaged by rising cement prices.

- The majority of the world's people still live in houses built with traditional building materials, and they will continue to do so for long into the foreseeable future.

- This briefing document looks at the role which mud and other earth-based materials can play in meeting the housing needs of the poor.

- Over half the Third World's population lives in houses that use mud in one way or another. Mud is at once the most widely-used and the most neglected building material in the world.

- Builders, planners and governments are not really interested in mud because it is a low-status material. "The widespread addiction to cement is a kind of mental paralysis", wrote President Julius Nyerere of Tanzania in 1977.

- Architects who have tried to promote mud buildings have met with resistance and ridicule. Egyptian Hasan Fathy, who built a whole village with mud near Luxor in the 1940s, wrote a book called 'Architecture for the Poor' which has been translated into several languages. But until he received an Aga Khan award in 1980, Fathy was almost totally neglected - most of all in his own Arab world. Architects, however, continue to neglect him.

- Mud buildings are well suited to the hot climate of the developing countries; they are cooler in summer and hotter in winter than buildings of concrete.

- The state of New Mexico in the south-western USA is probably the main state in the world to have developed a regulatory code for mud buildings - mainly adobe (sun-dried mud bricks). At the moment, in almost every city of the world, a mud building will be denied a building permit.

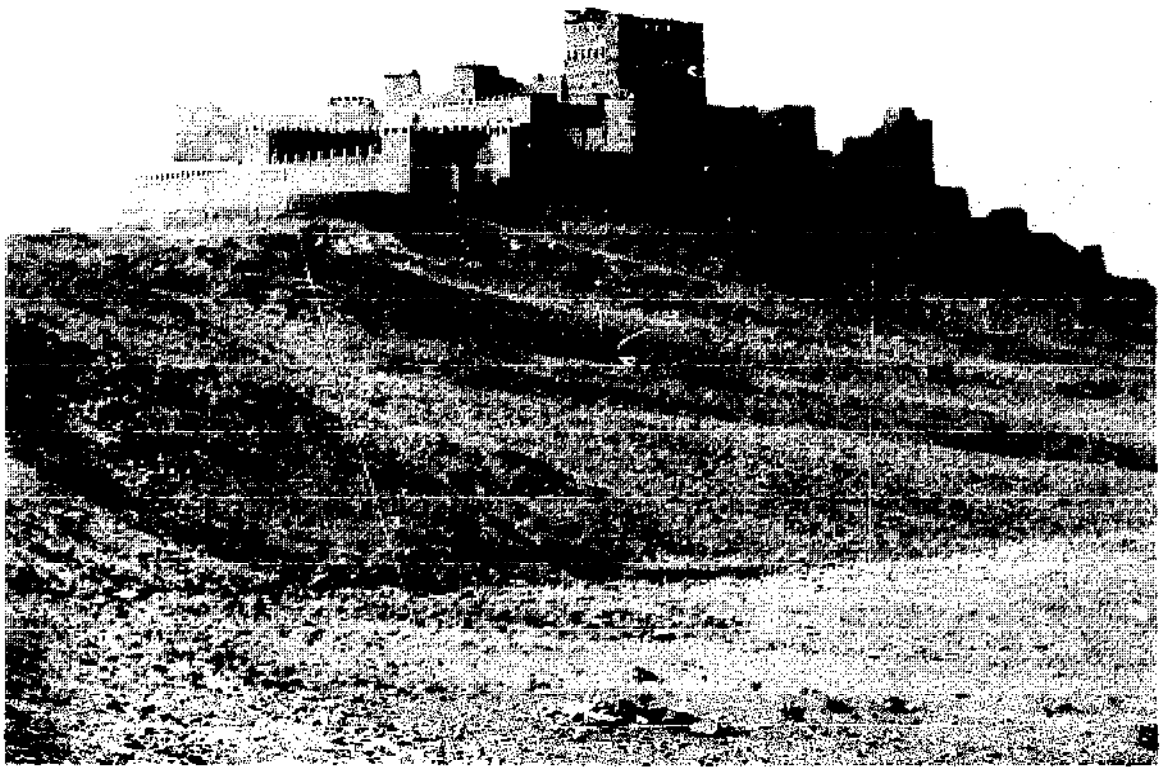
- The only technological problem with mud buildings is the threat of water - from rain or rising damp. But this is not an insurmountable problem.

  * By adding small quantities of cement, bitumen, lime or cowdung, mud's resistance to water can be greatly increased
  * an overhanging roof can cut exposure to rain

* in the arid regions of the Middle East, buildings with roofs made entirely of mud have withstood the elements for over a thousand years
* before the advent of cement, people used to live in mud houses even in the wet climate of England. The bottom part of the cob (mud and straw) walls was of stone and there was a big overhanging roof
* "All cob wants is a good hat and a good pair of boots", according to a traditional saying in south England, where mud buildings erected 50 years ago are still strong today.

In dry areas, mud buildings can last a thousand years or more. This fort (a 'ksar') is in the Ouarzazate region of Morocco.

Photo: Dominique Roger/UNESCO



CHAPTER TWO

THE HOUSING PROBLEM

Only about 3% of the world's population lived in towns and cities at the beginning of the 19th century. A hundred years later, this had increased to 15%.

- By 1975, the figure was 40%. The last two centuries have been the era of urbanisation.

The speed of urbanisation

The rich, industrialised North already has more than two-thirds of its population living in towns and cities.

- In the developing South, the proportion is still less than a quarter.

- But as the Third World has more people, it already has nearly as many city-dwellers as the developed world. And because Third World populations are growing rapidly, the developing countries will soon have more city and town dwellers than the developed countries.

- High growth rates in urban population are expected to persist all over the world.

  * Between 1975 and 2000, the urban population is expected to increase by about a third in Europe, by a half in Northern America and the Soviet Union, and by two-thirds in Oceania
  * urban dwellers will double in East Asia, increase two-and-half times in Latin America, and treble in Africa and South Asia.

- The urban population both in the developed countries and in the Third World is not simply increasing. It is gravitating towards larger cities.

- Between 1950 and 1975, the number of cities with over a million inhabitants rose from 71 to 181. While the number of these 'mega-cities' nearly doubled (from 48 to 91) in the developed countries, it nearly quadrupled (from 23 to 90) in the Third World.

- The percentage of the total urban population living in megacities is one measure of urban concentration. Between 1970 and 1975, this figure rose from 31% to 34% in the developed regions, and from 18% to 31% in the developing regions. 58% of East Asia's population (excluding China and Japan) was living in megacities in 1975.

- Overall population forecasts suggest an annual growth rate between 1975 and 2000 of 1.0% in the developed world and 2.2% in the developing world.

- But in the megacities, populations are expected to explode: by a staggering 5.4% in the developing world. This means a doubling every 15 years.

- City by city, the growth figures are dramatic. In the mid-1970s Mexico City and Sao Paulo were each growing by over half a million people a year. Jakarta and Seoul were each growing by over a quarter of a million people a year.

- The number of Third World megacities is also increasing rapidly. In 1950, only one Third World city, Buenos Aires, had a population of over 5 million, whereas 5 cities in the non-communist industrialised world had already reached that size.

- By the year 2000, the Third World will have about 40 cities of 5 million or more compared with an expected 12 in the industrialised countries.

- Some 18 cities in the developing countries will probably have more than 10 million inhabitants by the year 2000.

- Mexico City may well have over 30 million people by the end of the century.

- These intense accumulations of people generate enormous demands for public services and housing: for streets, sanitation, crime prevention, disease control, electricity, water, telephones, transport, etc.

- In a village, an open water system can serve people relatively hygienically, but in a city such a system is an unacceptable health hazard.

- One of the most expensive components of urbanisation is housing. And the supply of housing is falling so far behind demand that there appears to be virtually no solution on the horizon.

- Today, housing may well be the world's most unsolvable problem.

Figure 1: Anticipated annual population growth rate (population in millions) 1975-2000 Source: Reference 1

	Developed regions			Developing regions		
	1975	2000	rate	1975	2000	rate
Total population	1132	1361	1.0%	2835	4892	2.2%
Urban population	783	1107	1.4%	775	1996	3.8%
Megacities population	262	447	2.1%	244	916	5.4%

Housing needs

A global review of human settlements was presented to the UN Conference on Human Settlements (Habitat) in Vancouver in 1976 (Reference 1). It stated plainly: "Housing conditions have become significantly worse in most of the developing countries during the past 10 years. This is in direct contrast with the trends in the developed countries."

- A more recent study, 'Three Years After Habitat', by the International Institute for Environment and Development (IIED) (Reference 10) concluded that, if anything, the housing situation in most Third World countries has become even worse since 1976.

- A UN study in the mid-1970s estimated that in the decade 1970 to 1980, some 223 million houses would have to be built. The Third World alone would need 170 million new houses.

- These figures assume each house lasts 100 years - a very optimistic figure. And they also assume the Third World will continue to squeeze five people into each house.

- To meet the 1980 target, developing countries should have been building 8.1 houses per 1000 people per year. In fact, figures from 24 developing countries show that in 1970 they built only 1.8 houses per 1000 inhabitants.

- Five countries in Africa had an average rate of 1.3, eight countries in Latin America had a rate of 1.8 and seven countries in Asia had a rate of 2.7 new houses per 1000 inhabitants per year.

- Urban planners often talk of a 'housing deficit'. This can be a tricky concept. Even the poorest people find some kind of shelter, however precarious. A housing deficit really means a deficit in the number of houses built to a middle-class standard.

- Those who cannot find proper dwellings in the cities either move into existing slums, or build unauthorised homes and start new slums.

- Surveys show that 20-28% of the population of major Third World cities is living in slums and shanty-towns.

- In most cities, this proportion is increasing (see Figure 2).

- The names for these slums and squatter settlements vary:
    * callampas (mushroom cities) in Chile
    * bustees and jhuggis in India
    * favelas in Brazil
    * gounberilles in Tunisia
    * gecekindu (meaning they were built after dusk, before dawn) in Turkey.

- Lusaka's squatter settlements shelter about 40% of the population. Between 1969 and 1972, 22,000 houses appeared there. But only

Figure 2: In Third World cities, up to 80% of the population lives in slums, shanty towns and other uncontrolled settlements. (Source: References 1 and 4)

		Year	Population of city (millions)	Population in uncontrolled settlements	
LATIN AMERICA					
Brazil	Rio de Janeiro	1947	2.05	0.40	20%
		1957	2.94	0.65	22%
		1961	3.33	0.90	27%
		1970	4.25	1.28	30%
	Recife	1970	1.05	0.52	50%
Chile	Santiago	1964	2.18	0.55	25%
Colombia	Cali	1964	0.81	0.24	30%
	Bogota	1969	2.46	1.48	60%
	Buenaventura	1964	0.11	0.09	80%
Mexico	Mexico City	1952	2.37	0.33	14%
		1966	3.29	1.50	46%
Peru	Lima	1957	1.26	0.11	9%
		1961	1.72	0.36	21%
		1969	2.80	1.00	36%
		1970	2.88	1.15	40%
Ecuador	Guayaquil	1969	0.74	0.36	49%
Venezuela	Caracas	1961	1.33	0.28	21%
		1964	1.59	0.56	35%
		1970	2.18	0.87	40%
ASIA					
S. Korea	Seoul	1970	5.54	1.66	30%
Taiwan	Taipei	1966	1.30	0.33	25%
India	Calcutta	1961	6.70	2.22	33%
	Delhi	1970	3.52	1.06	30%
Indonesia	Djakarta	1961	2.91	0.73	25%
Iraq	Baghdad	1965	1.75	0.50	29%
Malaysia	Kuala Lumpur	1971	0.74	0.27	37%
Singapore	Singapore	1966	1.87	0.98	52%
Pakistan	Karachi	1964	2.28	0.75	33%
		1968	2.70	0.60	22%
		1971	3.50	0.80	23%
Turkey	Ankara	1965	0.98	0.46	47%
		1970	1.25	0.75	60%
AFRICA					
Nigeria	Ibadan	1970	0.74	0.55	75%
Ethiopia	Addis Ababa	1968	0.74	0.66	90%
Senegal	Dakar	1969	0.65	0.39	60%
Somalia	Mogadishu	1967	0.21	0.16	77%
Tanzania	Dar es Salaam	1967	0.27	0.10	36%
Morocco	Casablanca	1971	1.45	1.01	70%
Zambia	Lusaka	1969	0.28	0.13	48%
Ivory Coast	Abidjan	1964	0.44	0.26	60%
Cameroon	Douala	1970	0.25	0.20	80%

4000 conventional dwellings were built. Thus, unofficial housing construction was five times greater than official housing.

- The lack of houses in the Third World causes severe overcrowding. Several developing countries report that there are three or more people per room in more than 40% of their housing.

- Most developed countries, and the more developed of the developing countries, show a reduction in overcrowding. In the least developed countries overcrowding is increasing.

* In Usmania Mohajir colony, a Karachi (Pakistan) squatter settlement, 4% of households have more than 10 people living in one room; 24% have 6-8; 22% have 4-6; and 29% have 2-4 people in one room.
* In 1972, in Teheran, 92% of the squatter population lived in one-room tenements. The average size of a household was 4.7 persons, and one household in 40 (2.4%) had to share a single room with a second household. The average living space per person in Teheran's squatter settlements was 3 square metres (32 square feet).
* In the tugurios of Cali, Colombia, 77% of the population has living space of less than 10 square metres (108 square feet) per person. In Cartagena's tugurios, 23% of households have to share a dwelling with one or more other families
* In Kanpur, India, a survey recently showed that 58% of households had only one room and another 26% had only two rooms. Three-quarters of the houses had no windows, and 80% had no latrines. In heavy rain, 66% of households became waterlogged. Between 1961 and 1976, Kanpur's slum population increased by 133%.

- Why is housing getting worse in developing countries? The reasons include rapid population growth, heavy migration from villages, inflation, and the low purchasing power of most people.

- People with low incomes are particularly affected by inflation in housing prices. According to International Labour Organisation figures, poor urban households seldom spend more than one fifth of their incomes on housing.

- The World Bank has estimated that 35% of Hong Kong's households, 47% of Bogota's, 55% of Mexico City's, 63% of Madras's, 64% of Ahmedabad's and 68% of Nairobi's cannot possibly afford the cheapest house on the market (see Figure 3).

The neglect of rural housing

Third World planners have almost totally neglected rural housing. The problem is clearly so vast that most planners do not even want to tackle it.

- In 1950, 55% of the world's population lived in Third World villages. It seems likely that 46% will still be doing so in 2000.

Figure 3: In many developing countries, very few people can afford to buy a house *The table shows the monthly income required to purchase the cheapest complete housing unit then available (including a toilet and other services) in six Third World cities in 1970 (prices in 1970 US dollars). The figures assume that loans are available (usually they are not) and that interest rates are 10%. With interest rates at 15% (a common figure for 1981) the number of households unable to afford the cheapest 1970 dwelling would rise to 57% in Hong Kong, 61% in Bogota, 66% in Mexico City, 77% in Nairobi and 79% in Ahmedabad and Madras. Source: Reference 9*

	Cost of dwelling	Monthly repayment	Monthly income required	% of households unable to afford
Mexico City	$3005	$ 28	$ 184	55
Hong Kong	1670	15	103	35
Nairobi	2076	19	127	68
Bogota	1474	14	91	47
Ahmedabad	616	6	38	64
Madras	570	5	36	63

- In most developed countries 40-70% of the housing stock is in towns and cities. But in the Third World, 50-85% of the housing stock is in the rural areas.

- Argentina, Uruguay, Colombia, Brazil and Hong Kong are the few exceptions. Here, more than 50% of the dwellings are in towns and cities.

- Though housing conditions in rural areas are sometimes better than those in urban slums, most village houses are appalling, even by minimal standards of human health and hygiene.

- A survey conducted by the Institute of Development Studies, Mysore, India (Reference 12) reveals that in many Indian villages nearly half the existing houses need urgent repairs. Many houses, built of traditional materials like mud and thatch, have stood for more than 50 years. Very few repairs have been carried out. In some cases, even the straw matting on the roof had been replaced only once or twice in 50 years.

- "The proportion of houses that meet minimum standards in the rural housing stock is very low, and they are invariably the residences of village landlords, and other prosperous local people", says a UN report. It continues:

- "The bulk of rural people, comprising peasants, labourers, craftsmen, etc live in extremely bad conditions. About 750 million of them, one fifth of humanity, constituting the poorest among the poor of the world, live under leaky, makeshift, wormy roofs,

huddle on small lots at the mercy of village chiefs and landlords, and suffer the absence of such elementary services as latrines, safe water supply, roads, etc."

- The UN report also notes: "As many as seven out of ten homes in the rural areas of developing countries are currently so unsuitable for human habitation as to require replacement or major alteration."

- Better rural housing is urgent and imperative. But there are so many other necessities (food, clothing, jobs, health care, etc) that even the rural poor seldom demand housing.

- Governments also tend to neglect rural housing, not only because of lack of money but also because of its dispersed nature. Rural householders for that reason, too, find it difficult to combine and put pressure on centralised government systems.

- Only a very few countries have even tried to organise rural housing schemes. Among them are Cuba, Ghana, Ivory Coast, India, Tanzania, Venezuela and Indonesia.

The response of governments

Many Third World governments have set up housing corporations, to build or to finance houses, especially for the urban poor.

- Unfortunately, even the cheapest houses built or funded by these corporations have been too expensive for the poor. As a result, these institutions have come to serve the housing needs of middle-income groups.

- For example, Brazil's National Housing Bank - BNH (Banco Nacional de Habitacao) was set up by the government in 1964 to stimulate low-income housing. It was financed by a compulsory social insurance scheme, to which all registered workers were expected to contribute.

- BNH houses built during 1966-71 certainly went to Brazil's urban poor. The bank only gave credit to members of a trade union who did not own another house in the same area, and who had an income less than six times the minimum wage.

- The workers had been promised that their (compulsory) contributions would be protected against inflation. So the BNH was committed to making profits. Soon, the bank realised that the criteria it was using to select borrowers were not helping its profits. Pressures began to increase from housing entrepreneurs who preferred to build more expensive houses giving them more profit.

- As a result, in 1971 BNH transformed itself into a housing finance bank. It was left to local financial agents to assess credit-worthiness. The upper income limit and membership of trades unions were abandoned. Higher housing standards such as garages and maids' quarters were introduced. Better locations with higher land value were sought to ensure purchase of the houses by

highly-paid, low-risk candidates. Now, people applying for mortgages must have a minimum income.

- The BNH still claims it serves the needs of Brazil's poor. It draws its funds from a compulsory workers' social insurance scheme. But it is now effectively taking funds from poor workers and allocating them to the relatively rich.

Transfer of housing know-how

The housing policies of almost all Third World governments have been designed to build houses. Many experts now consider this is the wrong objective.

- Most Third World governments, following the policies of the more developed countries, have tried to industrialise their construction sector and organise mass housing schemes, often based on labour-saving prefabricated building components.

- It is now widely recognised that this strategy has failed. In many African and West Asian countries, it has resulted in large imports of building materials and a domestic construction industry that is heavily dominated by foreign firms.

- Houses built in this way can only be afforded by the middle class. The mass of the poor remains 'unhoused'.

- Another unfortunate result of this capital-intensive housing strategy is that, in times of economic crisis, housing programmes are often the first to be axed. Today, with oil imports taking more and more foreign exchange, Third World planners argue forcefully that governments must postpone investment in housing until the economic situation improves.

- Many housing and urban planning policies have been indiscriminately transferred from the industrialised countries to the Third World.

- UN agencies such as the Centre for Housing, Building and Planning, international agencies such as the World Bank, and bilateral aid agencies such as USAID, have helped transfer inappropriate policies and concepts, charges Ann Schlyter in a paper published by the Research Policy Program of the University of Lund, Sweden (Reference 14).

- Schlyter claims that by spreading inappropriate "solutions" to the housing problem, these aid agencies have had a negative impact on Third World housing conditions. They "have not been able to make any contribution to the improvement of the housing situation for the working classes", she says.

- For example, Schlyter pointed out in 1977: "Nearly all research on housing made in Zambia is done by expatriates". There are still very few trained Zambian researchers, and many experts in the ministries are expatriates paid by aid organisations. There is no school of architecture or of planning at the University of Zambia.

- International agencies have funded very few programmes designed to create indigenous planning and research capabilities in housing, or to develop housing technologies appropriate to the needs of the Third World poor, charges Schlyter.

- Schlyter criticises in particular the role in the Third World of international planning consultancy firms. She says that the master plan of Lusaka, Zambia, which was drawn up by the international firm Doxiadis, had a "direct harmful impact". The plan introduced "a town planning pattern without any adaptation to the local situation and a concept of living completely irrelevant to the working classes", she says.

- The preparation of master plans is a well-established approach to urban planning, and for the last decade the UN Development Programme has funded their preparation.

- But plans have often been drawn up by international experts who know little about the cultural, environmental and economic realities of the cities they plan.

- The completed master plans often gather dust on municipal shelves because local authorities do not have the resources to carry them out.

Slum clearance

Urban planners sometimes declare that houses built by the poor are below some arbitrary technical standards. So the planners bulldoze the slums, often without providing any real alternative.

- Bulldozing slums is still common practice in the Third World. Some Indian commentators have argued that instead of trying to remove property, this type of urban planning aims at removing the poor themselves.

- In India in 1976, slums were physically destroyed in many cities. The slum-dwellers were moved to areas far away from the city centres where they worked.

- Even where adequate alternative housing is provided, slum clearance programmes have rarely managed to rehouse more than a fraction of a city's slum population.

- Such schemes are also extremely costly. One of the more successful schemes has been carried out by the Tamil Nadu Slum Clearance Board, which was set up in Madras in 1971. The board issues each slum family with an identity card bearing their photographs, and provides new tenements in the original area within a period of nine months.

- The economic rent of each new 20-square metre (215-square foot) unit is US$5 per month, of which the occupant pays only a third. The rest is paid by the Tamil Nadu state government.

- During the first 7 years of its existence, the board has completed over 36,000 dwellings. But this effort is clearly inade-

quate to rehouse the 175,000 families living in the slums of Madras.

Housing standards

Housing standards have evolved in different ways in the developing countries and in the West.

- In the West, from the 19th century onwards, housing standards were intended to protect the weaker members of the community, notably the workers. They were instituted to prevent landlords and building speculators from ignoring minimum requirements for hygiene, safety and privacy.

- In the Third World, housing standards were generally instituted by the colonial authorities, to protect the European officials and settlers. The standards usually led to a replication of the type of dwelling enjoyed in the home colonial countries.

- After independence, national governments often adopted the former colonial standards, which usually bore no relation to the needs of the majority of the people, or to what they could afford.

- Third World housing standards have come to protect the needs of the wealthy, educated minority, not the interests of the poor.

- "Perhaps the most critical area where the operation of standards has affected the provision of shelter has been in the type of building material permitted", says a report prepared for ICSU (International Council of Scientific Unions) by three eminent urban planners from India, Nigeria and Argentina (Reference 4).

- For example, the Argentine government, in its 3-year development plan (1974-77), decided to build houses "for residents of shanty-towns, huts, boarding houses or precarious dwellings as well as for the inhabitants of frontier areas and for low-income tenants, provided that they have a steady job and are in a position to put aside 20% of their monthly income over a period of 30 years to pay for these dwellings".

- Argentina's material specifications included corrugated metal or asbestos sheets for roofs, paving tiles for floors, aluminium window frames, etc. "Unrealistic material specifications underline why such schemes invariably fail to meet the needs of the low-income classes", says the ICSU report.

- The ICSU report criticises existing official housing standards in the Third World on six grounds:

  * They are rarely based on current local experience. They have either been inherited from the colonial past or imported from developed countries in recent years, often at the insistence of international funding agencies
  * They pay little attention to local materials and encourage imports of cement and steel

* They often ignore the limited capacity of people or nations to pay for housing
* They reinforce social stratification
* Their western orientation has given them a strong urban bias
* They are extremely rigid and static, and in most cases cannot be enforced, except in houses for the rich and in public housing for middle-income groups.

- As well as official standards, says the ICSU report, there is another type of standard in operation in the Third World: cultural standards.

- Cultural standards are derived from traditional building practices that are found tolerable and acceptable to a large number of people. They represent the cumulative experience of people over hundreds of years.

- Cultural standards, argued the ICSU report, are more realistic in their approach to fundamental human needs than official standards, emphasise local resources and skills, and often offer the best environmental solutions to local constraints of resources. Cultural standards are preserved in the consciousness of the people, often even as religious values.

- Most important of all, said the ICSU report, cultural standards are flexible, in sharp conflict with the static, once-for-all approach of official standards.

- All over the Third World, cultural housing standards are in conflict with official housing standards, which are often seen a as irrelevant and inappropriate. But, said the report, "these standards continue to be enforced vigorously, if not effectively".

High-rise or low-rise

One housing concept introduced to the Third World from industrialised countries is high-rise development - now increasingly discredited even in rich nations.

- Indian architect Charles Correa summarises the dilemma: "Multi-storey tenements cost more to construct yet save on transport and other infrastructure costs...Low-rise housing costs less to construct but occupies more space." (Reference 16). Which should be built?

- The choice between low-rise and high-rise buildings involves markedly different lifestyles. Low-rise housing has many advantages for the Third World:

* An individual can build his own house
* A low-rise building has a shorter construction period, and involves less capital
* Low-rise housing can be extended as the occupant's income increases

* Low-rise housing has far greater variety, as each householder builds according to his choice
* Multi-storied buildings have to be built with scarce and expensive construction materials such as cement and steel. Low-rise houses can be built without government involvement out of mud, brick and thatch.

- In monsoon countries, houses built of mud, country tile and thatch will probably only last 10-15 years, while a reinforced concrete structure may last up to 70 years. For Correa, this opportunity for renewability is another advantage. As the nation's economy develops, housing patterns can change. Concrete, multi-storey tenements cannot be upgraded.

- "The five-storey concrete tenement slums built by housing boards all over this country are really the work of pessimists. What they are saying is: we aren't going to have any future", says Correa.

- The critical issue in most Third World cities is not to increase densities, but to decrease them, argues Correa. High densities have not been achieved by high-rise buildings, but by the omission of play spaces, hospitals, schools and other social infrastructure. In Bombay, there is only 0.1 hectares (0.25 acres) of open space per thousand people - and this includes traffic islands.

- Correa suggests reducing the residential density to 80 or 100 people per acre, which may allow cities to dispense with central sewerage systems and to recycle human and animal wastes locally to provide cooking gas and fertiliser. "Under Indian conditions", he says, "this would have the additional advantage of continuing the pattern of life which people are accustomed to: as though Mahatma Gandhi's vision of a rural India had an almost exact urban analogue".

- If this is to succeed in practice, employment must also be decentralised or efficient public transport must be provided. Funds for these steps are rarely available.

A new perspective: self-help and upgrading

The governments of the Third World have failed to satisfy the housing needs of either urban or rural poor.

- More and more planners are beginning to realise that "low-cost mass housing units" are never going to wipe out the "housing deficit".

- This disenchantment is now helping to focus attention on an altogether new approach to the housing problem. John Turner, William Mangin, Elizabeth and Anthony Leeds, and other Western academics who have been studying or working in shanty-towns, argue that these settlements should not be viewed as a 'problem', but as a 'solution'.

- Squatter settlements, they say, are not "rings of misery" or

"creeping cancers", but evolving communities.

- The residents of old inner city areas of the United States and Europe have reached the social bottom in what have been called "slums of despair".

- The new urban migrants of the Third World are, by contrast, struggling to better their conditions, and often moving socially upwards. They live in "slums of hope".

- Third World shanties, argue Turner(Reference 17) and others, represent not housing in deterioration, but housing in the process of improvement.

- Dr Anthony Seymour of Ahmadu Bello University in Nigeria (Reference 24) is critical of those who believe that squatter settlements are a 'solution' to the housing problem of low-income groups. Seymour dislikes the "optimistic and romantic overtones" characteristic of the approach of John Turner, William Mangin and their school.

- Seymour does not accept that squatter settlements are really "incipient" communities inhabited by people who are moving upwards socially and economically, and that housing policies should aim at helping this process. He argues that the poor move into squatter settlements because of the advantages of doing so - some of which are lost in legalised housing. Dr Seymour regards Lusaka's squatter settlements as neither a 'problem' nor a 'solution'. "The time has come", he says, "to develop more scientific analyses of the squatter phenomenon."

- Although Third World governments may have failed to provide people with houses, houses are nonetheless being built, both in the villages and the urban slums. This type of housing is built by self-help and with locally available materials.

- Sociologists have begun to paint a new picture of the slum dweller. Professor Janice Perlman of the University of California, Berkeley, published in 1975 an article entitled 'The slandered slum' (Reference 18). She claims there is no truth in the belief that Latin American shanty-towns lack internal social cohesion.

- She found that in the favelas of Rio de Janeiro the rate of participation in voluntary associations amongst slum dwellers was "astoundingly high", with extensive informal friendship and kinship networks. Eight out of ten people said their neighbourhood was more or less united, and that they could count on friends and neighbours when help was needed.

- Perlman also challenged the typical description of slums as full of gangsters and hoodlums. Very few favelados felt that crime was an important objection to city life. "In the year and a half I lived in Rio, I saw very little evidence of crime or violence and felt a good deal safer than I ever had in the streets of New York City or Boston."

- The new approach to housing the poor tries to capitalise on the desire of the homeless to house themselves. Governments, according

to this view, should concentrate all their efforts on helping people to help themselves.

- The poor can be provided with a low-cost core house, consisting perhaps of one room and sanitary facilities, on a plot of land. The family can build more rooms when it can afford to doso.

- Even simpler, the government can provide poor families with a site and with services such as water supply, drainage, roads and street lighting. It can also provide cheap loans and building materials. Families can then build a house at their own pace.

- These 'site-and-services' schemes can also be applied to existing slums. The government can legalise squatters' landholdings, provide the slum with essential services, and help the slum-dwellers gradually to upgrade their ramshackle dwellings into permanent structures.

- Site-and-services and slum upgrading are now advocated by the World Bank and being slowly adopted by a large number of Third World governments. In the seven years 1972-79, the World Bank provided US$1114 million to help finance 42 urban projects costing $2542 million in over 25 countries. Slum upgrading projects are being supported in Kenya, Tanzania, Upper Volta, India, Morocco, El Salvador, Bolivia, Egypt, the Philippines and elsewhere.

- By 1982, the World Bank expects to allocate 10% of its resources to urban projects.

- But a study of 9 multilateral development agencies by IIED (International Institute for Environment and Development) claims that "even if all of the World Bank's financing were allocated to basic housing amenity, excluding actual construction, these poorest elements of global society would have at their disposal about US$232 per person per year to upgrade their shelters" (Reference 20).

- According to the World Bank's own estimates, it costs $1000-1500 per unit to prepare a site, service it with rudimentary water supply, waste disposal and other essential services, and purchase materials for small, basic, self-constructed shelter.

- External assistance alone, therefore, will not solve the problem, argues the IIED report. "It should therefore be applied in ways most likely to stimulate government and local action."

- Many of the site-and-services schemes supported by the World Bank in the early 1970s have proved failures. To cut costs, governments bought land relatively far away from the city centres. But this land was also far away from employment.

- It is increasingly being recognised that nothing is more important to a slum-dweller than the location of his house. His first priority is a site from which gainful employment can be obtained. Many 'rehoused' slum-dwellers leave their new sites and return to their original place of squatting solely to be nearer to work.

- Recognising this, the World Bank now places a greater emphasis on slum upgrading schemes than on site-and-services schemes,

though many Bank-supported urban projects are a combination of both.

- But many Third World governments do not like the idea of upgrading slums at all. An upgraded slum is still a slum. It still looks like a slum, even though life may have become a bit better for the people living there.

- Slums are an eyesore to the ruling urban elite, and slum-dwellers are often perceived as layabouts and thieves.

- Other critics of slum upgrading see it as an attempt to curb social unrest without making any effort to restructure the economic pattern of society which is the essential cause of poverty and homelessness.

Can aid help?

External aid is pitifully inadequate compared to the size of the problem. Even when World Bank activities are expanded to the fullest extent envisaged, "two-thirds of the yearly total of new urban migrants will not be reached. Nor will the existing backlog of urban demand be met, nor the needs of rural areas", say Jorge Hardoy, Susana Schkolnik and Stuart Donelson in an IIED review of multilateral aid agencies (Reference 22).

- Over their entire period of operations, the 15 main multilateral agencies (the World Bank, UNDP and the regional agencies such as the Asian Development Bank and the European Development Fund) had by 1977 spent only US$1569 million on human settlements - a classification that includes housing, slum upgrading, site-and-services, urban development and urban transport.

- If one accepts the World Bank's conservative estimate that there are 200 million urban people living in inadequate shelter, then the 15 agencies had by 1977 together spent a totally inadequate $8 per person. A single city like Sao Paulo, Mexico, Cairo, Calcutta or Lagos could use the $1569 million spent by these agencies and still have room for improvement.

- The funds committed since their beginning to all types of project by all the 15 multilateral agencies come to $70,592 million. Only 2.2% of their finance, therefore, has gone to human settlements.

- The inadequacy of international funds points to the overriding need for stepping up local initiatives and domestic government attention. It is here that the work of the agencies is woefully inadequate, charges the IIED report.

    * First, there is an urgent need for urban land reform, so that every family has the right to a piece of land. Though an element of land reform is contained in those projects that the World Bank supports, the aid agencies do not normally insist or even recommend that urban or rural land reform should be a matter of national policy. Until this happens, projects supported by the World Bank and other agencies will have a limited impact.

* Second, national governments should have policies to tax the wealth generated by rising land prices. Most of this currently goes to private land speculators; it should instead be taxed to develop housing and service facilities which help the poor.

- A continuing problem, says the IIED study, is that inflation in the cost of land and building materials devalues a house owner's repayments on his loan. Funds cannot be effectively recycled, and housing finance becomes a 'bottomless pit', continually needing new money.

- The aid agencies may be responding to these circumstances by supporting projects which provide too little for the urban poor. From direct housing schemes, the agencies have moved to site-and-services and now to slum upgrading. How far can the level of assistance be reduced without making it meaningless?

- A recent World Bank project in Tanzania, for example, consists of 'surveyed plots', supplied only with water and plans for on-site services. Everything is to be furnished by the residents themselves.

- The cost per plot is only $25, compared with $385 for conventional squatter upgrading. This project is ultimately designed to help about 26% of the country's urban poor: more than 315,000 people. The Bank claims that in this project "the cost of services has been kept at a minimum to bring them within easy reach of the target group". It argues that the low level of the loans will enable all or most of the costs to be recovered, so that the schemes can be rapidly repeated.

Do they reach the really poor?

William Doebele and Lisa Peattie of the Massachusetts Institute of Technology, USA (Reference 23) make another criticism of site-and-services projects, which they warn may become "vehicles for the penetration and domination of middle and upper class suppliers".

- Real self-help, or 'auto-construction', seems to be true only of the very poor. More typically, the owner-occupier and his family supply much of the unskilled labour, and hire local craftsmen for the roofing, plumbing, carpentry and other more technical jobs. Construction materials, too, are often purchased from very small-scale dealers.

- If the site-and-services project itself begins to supply these skills and materials, dozens of marginal entrepreneurs may be replaced by a few middle-class project officials. For instance, bulk buying of building materials may seem economically worthwhile. But it may mean that "the large supplier, who normally has difficulty selling in low-income areas, is now able to penetrate this market and eliminate his small-scale competitors", say Doebele and Peattie.

- Some World Bank site-and-services projects try to work as much as possible with small suppliers. But deals with large suppliers

are easy to justify in terms of administrative efficiency and difficult to resist politically.

- The World Bank itself admits that it is difficult to help the bottom 10-20% of the urban poor with site-and-services projects, which inevitably attract the relatively better-off amongst the poor. This can leave the very poor even worse off.

- An IIED study of the World Bank, UNDP and regional development banks states categorically: "So far, the poorest fifth of the urban population has not been reached (by housing projects) and no one in any of the banks studied knows any way to reach them" (Reference 20).

- The only way, it seems, is to abandon any idea of cost recovery, and with it the idea of re-using the same funds several times over. But the upgrading project then indeed becomes a 'bottomless pit' for continuing subsidies, which are not available on the scale needed.

- The Indonesian Kampung Improvement Programme, for example, which the World Bank claims has reached some of the bottom 20% of the urban poor, is now starting to abandon the strict requirement of cost recovery.

- Cost recovery means that slum-dwellers have to make regular cash payments. The sum can be kept very small by reducing the services provided to a bare minimum. But for many slum-dwellers, who do not have secure employment and whose incomes fluctuate widely - casual labourers, street vendors, etc - a regular sum, however small, can be difficult.

- Some governments take strict measures to recover the loans, often creating severe problems for the poorest. On the one hand, rigidly-enforced repayments can exclude many poor families from a project entirely. On the other hand, nothing can be more disastrous for cost-recovery than the belief that the housing agency is not serious about collecting the dues.

Problems with slum upgrading

Slum landlords remain an important and widespread phenomenon. Upgrading can have the paradoxical effect (says a report from Nairobi, Kenya: Reference 25) of harming tenants now living in the slums. An upgraded environment can attract people with the capacity to pay a higher rent, and landlords therefore evict the poorer slum-dwellers. "We will have to take upgrading very slowly", warns Nairobi's chief city planner.

- Journalist Victoria Brittain recently described how in spite of precautions, middle class people are often the ultimate beneficiaries of schemes for housing Nairobi's poor.

- "The 3000 new houses recently built by the Commonwealth Development Corporation could each have been sold nine times over, according to the project's manager. And in the streets at the USAID housing complex, lower down the income scale, you can pick up

pamphlets from house agents offering the new householders twice what they have just paid for their houses".

- At Dandora, a current World Bank site-and-services project in Nairobi, a computer successfully allocated all the plots to people with low incomes of $45-90 per month. But the very high standard of building that appeared at Dandora startled the experts.

- An underground land market had been created where some plots were effectively sold to speculators. The original owner - officially not allowed to sell for 5 years by Nairobi's city council - remained the 'legal' owner, and presumably moved back to a slum.

- An underground capital market also sprang up in Dandora, to finance construction work. What happened was that a flood of money came in from the rural areas, from relatives of the person allocated a plot. The family would support, and eventually share the gains of, the lucky relative. The two-roomed house envisaged by the planners often became a six-roomed lodging house.

- Housing experts have listed other basic problems with slum upgrading schemes. They include:

* Terrain: existing slums are often situated on poor land, in ravines, on the side of a hill, or in swampy or easily-flooded areas. Such land is often difficult to upgrade; drainage costs, for instance, can be prohibitive.

* Density: some slums are extremely densely populated - the Tondo in Manila with 900-1200 people per hectare (360-490 per acre) for instance, and Klong Toey in Bangkok with 250 people per hectare (100 per acre). Upgrading there will always mean that some dwellers have to be moved to fresh sites. If attractive land is available nearby for the 'overspill', the slum-dwellers can be persuaded to move easily. Otherwise, there can be difficulties.

* Tenure: slum-dwellers need secure tenure of the land on which they live if they are to put their labour and meagre savings towards upgrading their dwellings. This can be a complex process. Many governments have no adequate records. The dweller may own his house but not the land. Landlords may exist, and if they are not compensated adequately, they may create political and legal obstacles to the project. Upgrading and site-and-services projects tend to work more easily in countries like Zambia and Tanzania where land is largely owned by the government.

* Participation and leadership: community participation is essential to a slum upgrading project, for making decisions about relocation, tenure, self-help programmes, tax collection, compensation, etc. But many governments mistrust any leadership from the poor, branding it subversive or communist. Some slum communities have clearly-identified leaders, but many slums cut across class, race, language and religions. Landlords and tenants in the same slum can also make local decision-making difficult.

- The Third World's housing problems may not be unsolvable, but they certainly have not been solved so far.

  * Rural housing is almost totally neglected
  * Megacities are growing like cancers, with most of their people in slums and squatter settlements
  * Government house-building programmes are a failure because most urban poor cannot afford even the cheapest house
  * Housing programmes for the poor end up supplying houses for the middle-income groups
  * Slums are still being bulldozed out of sight
  * Western-based housing standards are inappropriate in the Third World
  * Outside aid is totally inadequate
  * Self-help, squatter upgrading and site-and-services schemes offer the best prospects
  * But even these schemes rarely reach the very poor.

- In these circumstances, what have mud and other traditional building materials to offer?

In Third World shanty-towns, people must build their homes with what they can. Here, in Teheran, the materials are tin cans and mud.

Photo: Sean Sprague

CHAPTER THREE

BUILDING MATERIALS

Building materials are one of the most neglected aspects of the human settlements debate.

- Few Third World governments have tried to develop a local building materials industry. Instead, they launch massive construction programmes without any thought for where the building materials are to come from.

- This has led to the wholesale adoption of often inappropriate Western materials and techniques - even including the large-scale import of prefabricated or modular housing units.

- The oil-rich Arab countries in particular have tended to use imported industrialised building systems to mass produce houses. The director of a Saudi development corporation, Ibrahim al-Monif, has strongly criticised this trend. Speaking in Dhahran in 1978, al-Monif said these units were not suited to the Middle Eastern climate or culture and could not be maintained locally. Such imports, he argued, held back any local housing industry based on indigenous labour.

- One reason for this neglect of traditional architecture, building materials and techniques is that few countries have any locally-trained architects.

- The Aga Khan recently announced his support for a joint research programme into contemporary problems and history of Islamic architecture. Ironically, this programme is to be conducted by two US institutions: Massachusetts Institute of Technology and Harvard University.

- The Aga Khan warned (Reference 27) that in the last 20 years many parts of the Islamic world had seen increasingly rapid and ill-considered destruction of its architectural heritage, combined often with indifference to, or ignorance of, Islamic cultural traditions.

- In most of the Third World, there has been increasing reliance on the Western wonder substance: cement. Cement has become a status material, representing all that is modern and desirable in housing.

- Algerian architect Kamel Noui-Mehedi spent some months in the rural areas as part of the government's plan to build a thousand new socialist villages. He reported in African Environment (Reference 28) that the peasants knew precisely what they wanted: "A permanent house, in concrete, with concrete floors".

- "Compared to the stone and 'diss' (straw) buildings with which they have had unfortunate experiences all their lives, the solidity of concrete gives them the feeling of security", wrote Noui-Mehedi.

- The Algerian peasant focuses on concrete because that is what the rich and comfortable use for their houses. But Noui-Mehedi describes the experience of a peasant who was given a badly-built

concrete house by the municipal authorities. "Only a few months sufficed for the humidity to cause the whole family to flee from their home. Today, that family is living in a house with a thatched roof and is keeping its cattle in the concrete house."

Cement: material for all seasons?

The type of cement most widely used in the world today should strictly be called Portland cement. It was developed in the 1820s in England.

- Typically, Portland cement consists of a mixture of limestone and clay, which is ground to a powder and heated to about 1500°C. Gypsum is added and the mixture ground once again.

- Cement is normally mixed:
  * with sand to form mortar
  * with aggregates (small stones or gravel) to form concrete
  * with asbestos to form roofing sheets.

- Today, Portland cement is the world's most important building material. Global output of cement reached 700 million tons in 1974-75: an average consumption of about 175 kilograms (385 pounds) per head.

- Most of this cement is used in the industrialised countries. In Denmark in 1973, the per capita consumption of cement was 520 kg (1140 lb) while in India in 1974 the figure was only 24 kg (53 lb).

- The bulk of cement is made in Europe, North America and the USSR which, in 1966-67, between them manufactured 72% of the world's cement.

- In 1973, the Third World paid $405 million for cement imports. Only two years later, the figure was $1030 million. Because most developed countries make their own cement, imports by developing countries accounted for 80% of the world's cement trade in 1975.

- The Third World's leading importers of cement are, of course, the oil-rich OPEC countries, which have been witnessing a massive construction boom. Leading importers in 1975 were Libya, Nigeria, Saudi Arabia, Algeria, Iran, Indonesia, Hong Kong, Singapore, Kuwait, Syria, Tunisia, Ivory Coast, Ghana and Malaysia.

- The leading exporters of cement are Japan (which in 1976 accounted for over 15% of the world's cement exports) and Spain, Greece and South Korea (each of which accounted for about 10% of the world's cement exports). Other exporters are France, West Germany, Italy, Thailand, Philippines, Pakistan, Turkey, Colombia, Kenya, Cyprus, Bahamas, Mexico, Norway, Iraq, Malaysia, Lebanon, Egypt, Belgium, Romania and North Korea.

- "The most striking feature of world cement trade during the past 10 years", says a study by India's Cement Research Institute, "has been the efforts made by the more industrialised developing countries which have invested in new cement plant to supply the rest

of the Third World".

- To reduce the cost in foreign exchange, several developing countries are trying to increase their own cement production. In all the developing regions of the world, cement production virtually doubled between 1966 and 1975, while that of the developed countries increased at most by about half.

- Some particularly remarkable increases in production were in Sri Lanka (up 390%), the Philippines (up 175%) and China (up 172%).

- Despite these rapid increases, there is a cement shortage. In many Third World countries, building activity goes in cycles depending on the availability of foreign exchange for cement

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A builder adds a cement coating to protect the mud brick walls of a new house in a Bamba village in Senegal. In Europe, even a poor man can buy ten bags of cement with a day's wages. A rural African has to work ten days to buy one bag. *Photo: Sean Sprague*

imports. "Throughout the developing world precious resources are wasted in half-completed projects which cannot be finished because there is no cement", says the Intermediate Technology Development Group.

- There are four main reasons why cement is unable to satisfy the Third World's housing needs:

  * cement production is capital intensive
  * cement is an energy-intensive product to make and use
  * the necessary raw materials are not always available
  * cement production is at present almost always a large-scale technology.

- Cement production requires capital investment. Indian planners estimated that an investment capital of $650 million would be required to meet the projected increase in cement consumption from 24 kg (53 lb) per capita in 1974 to 50 kg (110 lb) by 1978-79. And to make the cement plants run efficiently, further investment is required in coal mining, power generation and rail transport.

- India has failed to reach, in each of its 5 national development plans, the projected cement production capacity. Supply of cement has as a result always fallen behind demand, causing hoarding, blackmarketing, and soaring prices. The government tries to control prices, but cement is seldom available in the market at the government-fixed figure. This picture is common throughout the Third World.

- Cement production is also a highly energy-intensive process. Fuel costs make up between one third and one half of basic cement production costs.

- In Denmark, the cement industry accounts for about 2% of the national energy bill. And in Jamaica, oil and other imported energy makes up 60% of the cost of a bag of locally-produced cement.

- Rising energy costs also affect cement prices via transport. In India, for instance, the main raw materials for cement are found in the south and east-central parts of the country; coal reserves are in the east; and most cement consumption is in the north and west. So, enormous amounts of coal and cement must be transported across the country.

- The energy consumption involved in the transport of cement always shows up in the selling price. According to studies by the Intermediate Technology Development Group in London (Reference 31):

  * the price of cement in up-country Tanzania is often 2-3 times more than at the cement factory in Dar es Salaam
  * in Indonesia, the price of cement is rarely below $100 per ton, and in parts of Sumatra it is often as high as $500 per ton.

- Cement is particularly expensive in rural areas of the Third World. In Botswana, Sudan and Honduras transport costs exceed

the depot price of cement after 100-200 miles (160-320 km) over poor roads.

- The third problem in cement production for the Third World is limited availability of raw materials. Portland cement requires limestone (or oyster shells, or marl, or chalk); clay or shale, sand, blast furnace slag or fly ash from coal-fired power stations; and gypsum.

- "Ideal raw materials are becoming steadily more scarce", warns the Cement Research Institute of India (Reference 32). This has "forced cement producers to consider limestones of inferior quality".

- Dr G.M. Idorn, a Danish cement expert, is particularly worried about the future supply of raw materials for the manufacture and use of cement. He estimates that by the year 2000, some 1800 million tonnes of cement will be produced annually. To turn that into concrete, 700 million tonnes of water and 17,000 million tonnes of aggregates (pebbles or gravel) will be required.

- Idorn argues (Reference 29) that the limestone, clay and gypsum for 1.8 billion tonnes of cement annually can probably be found. But he doubts that 0.7 billion tonnes of fresh, clean water can be reserved for making concrete, or that 17 billion tonnes of aggregates can be quarried and used, "however inexhaustible the visible deposits of sand, gravel, and rocks may seem today".

- "Europe and the United States are already feeling shortages of traditional quality concrete aggregates", says Idorn. "Furthermore, in several developed countries, fresh water is now becoming a priority material...competing demands on water for irrigation and civil consumption will soon appear."

- The answer, according to Idorn, is intensive research and development, which is today missing in the cement industry. In 1974, R&D expenditure by the US cement industry was less than 0.5% of cement sales. Idorn believes that materials, energy and capital consumption could be reduced to a half or even to a third by 2000, given adequate research.

- The fourth problem that inhibits the rapid expansion of cement production in developing countries is the inappropriate scale of the technology.

- The worldwide trend is to put up very large cement plants. But many experts feel that such large plants are not suitable for developing countries.

- Most of the cement plants set up in India in the 1950s and 1960s had a capacity of 300-500 tonnes per day (tpd). More recent plants are of 600 tpd capacity, and India's National Committee on Science and Technology has been investigating plants of 2000 tpd capacity.

- Such very large cement plants require massive reserves of raw materials; they need a considerable transport infrastructure; and their machinery has to be imported.

- Large plants require a level of financial commitment that few developing countries can make. In practice, only governments or foreign investors can set up cement plants. The delay that usually takes place in arranging such large sums of money required is, according to ITDG, "one of the main reasons why expansion in production so frequently lags behind demand, causing the almost universally experienced cement scarcity".

- But the general trend is still towards large plants. China, by contrast, has widely used small-scale cement plants with a capacity of around 100 tpd. According to Jon Sigurdson, director of the Research Policy Institute in Sweden, more than half of China's annual output of cement was recently being produced in about 3000 small-scale plants, one for almost every commune. Unfortunately, few technical details are known outside China.

- At least three different institutes in India have been involved in R&D on small-scale cement plants since the mid-1960s. But they still play no significant role in India's cement production.

- George Fernandes, Minister of Industries in the recent Janata government in India, said that "the mini-cement plant...has always been sabotaged by big business interests". Under Fernandes, the government gave special incentives to entrepreneurs interested in setting up small 100 tpd plants, which can be built near minor limestone deposits that would otherwise be unused. About 100 such sites were identified in India, and more than 40 entrepreneurs responded to government incentives to build such plants. Within 5 years, India could build enough mini-cement plants to add some two million tonnes (about 10%) to current annual capacity.

- Third World cement production is unlikely ever to rise to a level that can meet the housing needs of the 4-5 billion people who will be living in Asia, Africa and Latin America by the year 2000.

- In other words, a cement famine is likely to remain a regular feature of developing countries. This scarcity, together with rising energy prices, is bound to push cement prices up.

- As a result, it is almost impossible for the Third World poor to acquire a modern cement or cement-based house.

- In the late 1970s, while a worker in northern Europe could buy 10 bags of cement with a day's wages, an urban Latin American could only buy one bag. And a rural African needed to work for ten days for a bag of cement.

The alternatives: traditional building materials

Developing countries cannot do without cement. Its use is essential for dams, canals, roads and other important development projects - which usually have first call on cement supplies when there is a shortage.

- So it is imperative that Third World planners start to minimise the use of cement in housing. This is especially so if they want

to meet the housing needs of all their people - including the poor.

- This realisation is slowly starting to spread. Countries which still use concrete blocks to build houses are now beginning to look towards the establishment of a brick industry - especially small-scale, labour-intensive, non-mechanised brick units, which can be established in villages.

- Brick manufacture, too, poses problems. Firing (baking) bricks is an energy-intensive process, which can raise the cost of fired bricks beyond the reach of the poor.

- Lime, an alternative to cement used widely in ancient times, is now receiving increasing attention. The Romans used lime-pozzolana mixes to make mortar for their magnificent bridges and aqueducts, many of which still stand.

- Pozzolanas are materials that are not themselves a cement, but react to lime and water to form a material that sets and hardens like cement. Various pozzolanas exist in nature, and occur in most countries. The Romans used the volcanic ash from Mount Vesuvius as a pozzolana. Lime manufacture - which involves roasting limestone - can become a good village-level industry.

- These developments should help provide cheaper and more accessible alternatives to cement. But efforts are also needed to develop traditional building materials such as mud, thatch, bamboo, reeds or stone.

- "Traditional building materials are an area which has received little attention even from the so-called appropriate technology movement", says Jorge Hardoy, the Argentinian urban planner.

- Since the UN Conference on Human Settlements in Vancouver in 1976, the housing literature is full of expert reports recommending the use of traditional materials.

- The regional paper for West Asia presented to the UN Conference on Science and Technology for Development at Vienna in August 1979 (Reference 38) said: "Though there exists a rich heritage in design and construction (based largely on mud) from Hadhramut to Nubia, there is very little concern for these technologies that may be within the reach of the bottom 70% of the population of the region. These beautiful structures often decorate travel literature but apparently little engineering attention has been devoted to studying and developing traditional forms."

Nyerere and Gandhi

In his 1977 assessment of the Tanzanian economy, President Nyerere of Tanzania said (Reference 39): "The widespread addiction to cement and tin roofs is a kind of mental paralysis".

> ***"People refuse to build a house of burnt bricks and tiles; they insist on waiting for a tin roof and 'European soil' - cement. If we want to progress more rapidly in the future we must overcome at least some of these mental blocks.***

"Not very long ago, it was estimated that to build an improved traditional house - that is one with a permanent roof, insect-proofed woodwork and a thin cement floor - cost about 7000 shillings. A smaller cement block house costs at least 18,000 shillings to construct. Yet, although we know that most of our people cannot afford the mortgage or rental costs of the cement house, we persist in promoting its construction. Obviously, it is more comfortable, and lasts longer. It is a case of the best being the enemy of the good.

"For most people the only effective choice is between an improved and an unimproved traditional house - they cannot afford the cement house. So, if we do not help them to build an improved house of traditional materials, or of burnt bricks and tiles if they have a little more money, then we shall not be doing anything to help them live in a decent house", concluded Nyerere.

- The Indian Prime Minister, Mrs Indira Gandhi, also argues in favour of houses built with traditional building materials (Reference 40). "All the new houses", she pointed out in a 1980 interview with Earthscan, "are built for energy consumption. They are hot in summer and cold in winter, whereas our old houses are not."

"The ancient house in which I was born and lived contained no cement, so probably it was cheaper to build. It never leaked in my memory. But when this house came under the purview of the Jawaharlal Nehru Memorial Fund, they said Oh! the ceiling might fall on the children, because it was(converted by them into) a children's home. So then they got engineers and they found it was only made out of bran and lime and various things like that, and it was at least 100 years old then. But it has never fallen yet.

"So we have not only to have new technology, but look a bit to the old technology. There is much sense in what people have evolved over the years to suit their climate, their environment, their way of living. You can't keep all of it because our way of life has changed, but I think a lot of it can be adapted and made more efficient."

The aid agencies

What role have the aid agencies played in the choice of building materials in developing countries? A report prepared by IIED (Reference 22) points out that though many developing countries are dependent on imported building materials, aid agencies give few loans towards these. Loans for building materials from the multilateral agencies since they started totalled only $417 million, a mere 0.6% of their total spending, up to 1977.

- "Virtually all of the identifiable loans for building materials have been for cement plants", says the IIED study. Only UNDP has devoted any money at all for other types of building material: funds for roofing tiles and brickworks.

- The World Bank, for example, is a strong supporter of site-and-services projects and of self-built houses. But the IIED report states that despite the World Bank's repeated emphasis on "basic needs" it found "no evidence at all of loans for research into alternative building materials or technologies".

- Similarly, the European Development Fund has not provided any loans which could have directly benefitted the building materials industry. But a study carried out by the agency itself shows that its shelter and infrastructure programme spends excessive amounts on concrete foundations, cement walls and steel frames.

- The Inter-American Development Bank (IDB) has given loans worth $77 million for the development of building materials industries, mainly for cement plants (in Peru, Costa Rica, Argentina, Uruguay, Brazil, Bolivia and Ecuador). IDB also supported a plant for manufacturing cement blocks and another for prefabricated building materials (both in Argentina).

- The Central American Bank for Economic Integration, the Latin American Savings and Loan Bank, the African Development Fund and the OPEC Special Fund had by 1977 not made any loans at all for the development of a building materials industry.

- The Andean Development Corporation has provided a loan to Ecuador for a cement plant, for studies on the building materials industry in Bolivia and on two cement plants in Ecuador.

- The Asian Development Bank has provided relatively large loans to Nepal and Indonesia for cement plants; it has also provided a loan to Taiwan for a mill to produce aluminium products, which could produce items for the construction industry.

- The African Development Bank and the Arab Bank for Economic Development of Africa have each provided only one loan, to the CIMAO regional cement plant in West Africa.

- The Islamic Development Bank has given loans for cement plants in Malaysia, Guinea, Morocco and Yemen.

- The Arab Fund for Economic and Social Development has given a cement works loan to Egypt.

- The IIED study recommends that international agencies should do far more to support the construction industry and to develop both traditional and unorthodox materials.

- Likely areas of research (for which the IIED study says there is "a desperate need") are stabilisation of mud, improvement of bamboo and other wood varieties, and research into new ways of making cement.

- "Given the fact that such a large percentage of low-income housing in urban areas is made of cardboard, it might also be useful, even if potentially difficult, to provide money for paperboard manufacture, including lacquer for cardboard waterproofing", says the IIED study.

Adobe, a mixture of mud and straw baked in the sun, is the traditional building material in much of Latin America. Here adobe blocks are being made in Sucre, Bolivia. *Photo: Sean Sprague*

CHAPTER FOUR

THE CASE FOR MUD

If the 600 million houses required by the end of the century were to be built in a single row, they would go around the circumference of the Earth nearly a hundred times.

- It is unlikely that even half these houses will be built with modern building materials such as bricks, cement and plastics. Traditional building materials such as bamboo, wood, soils, grasses, lime, various types of local pozzolanas, stone, cloth and animal skins will, therefore, continue to be used.

- Already, the majority of urban households in the Third World cannot afford to purchase even the cheapest modern house. In the rural Third World, this proportion is probably well over three-quarters of households. If the world economy continues to worsen in the 1980s, and cement and brick prices fuelled by rising energy prices continue to rise, the small proportion of households who can afford modern housing will become even smaller.

- It is, therefore, important for housing planners to stop paying lip service to traditional building materials and to start using them.

- Of the various types of traditional building materials available, mud is the most widely used and will remain so long into the foreseeable future.

- Over half the Third World's population now lives in mud buildings of one form or another. Different societies have used mud in different ways, and have given the technique many names.

Figure 4: Some different names for various uses of earth in building

Word	Used in
Adobe	Mexico, southwest USA, Spain
Bauge	France
Cajon	Spain
Chika	Ethiopia
Cob	England and Gambia
Jalous	Sudan
Kacha	India
Nogging	England
Pise	Israel, USA, Zimbabwe, France
Sod (soddys)	Nebraska and Kansas, USA
Swish	Ghana
Tapia	Africa, Australia, Zimbabwe
Teroni	Mexico
Torchis	France
Tubali	Nigeria, West Africa
Wattle and daub	England

Advantages and disadvantages of mud

Mud, as a building material, has the following advantages:

* It is cheap, and in most parts of the world, it is readily available - one reason why it is so widely used
* It provides excellent heat insulation, so inside a mud building is cooler in summer and hotter in winter than a building made with steel and concrete
* It is strong in compression (ie difficult to squash) and so makes good walls.

- But mud also has some serious disadvantages:

* It is eroded easily by water, which makes its use difficult in areas with high rainfall or possibilities of flooding
* It has a low tensile strength (ie is easy to pull apart), which means mud roofs are difficult to make
* It is susceptible to mechanical damage. Rodents can easily make holes in mud walls and under the floor, or thieves can dig their way into the house
* Mud does not grip wood properly, so gaps often develop around wooden doors and windows in mud walls. Consequently, mud houses often have few openings and are badly ventilated. Where walls are made of reinforced mud, wattle plastered with mud, or sun-dried mud bricks, this problem is not so severe
* Mud soaks up water and becomes very heavy. Consequently, wooden beams supporting a mud roof begin to sag, the mud cracks and the roof starts leaking. To reduce sagging of beams, many villagers in the states of Uttar Pradesh and Punjab in India build very narrow rooms, across which even a bed cannot be kept. But even these rooms tend to leak in heavy rains.

- Most of these disadvantages can be overcome by suitable improvements in design and technology:

* Stabilisation: other materials (eg bitumen or cement) can be added to mud to improve its strength and resistance to water. This technique is known as soil stabilisation.
* Architecture can be used to enhance the advantages and reduce the disadvantages of mud. Narrow streets and closely packed houses can produce a cool environment in a hot region, and overhanging roofs can reduce erosion caused by rain.
* Structural techniques, too, have been used to enhance the characteristics of mud. For instance, in several parts of the world, walls of earth are traditionally made by ramming successive layers of earth between shuttering, which makes a wall that can take the weight of the roof.

Mud walls

* Sun-dried bricks: walls made when wet mud is moulded into

bricks, which are left to dry in the sun, can be found in many parts of the world. Sun-dried mud bricks are known as adobe in Mexico and the USA.

* Wattle and daub: in this technique, mud is daubed (plastered) over a structure or mat made of sticks (known as wattle).
* Walls are also often made with simple lumps of ill-formed clay placed one on top of another, and the wall is then plastered with a coat of mud mixed with some organic material such as cowdung.
* In the rammed earth technique, mud is rammed manually between two shutterings (vertical frameworks) on either side of the wall. After one layer has been rammed, the shuttering is raised, a second layer of mud rammed onto the first layer, and so on.
* Building blocks can be made by compressing earth into a solid block in a machine called the Cinva Ram.

- More recently, walls have been made with stabilised soil. Mud stabilisation can be done with cement, bitumen or lime:

* soil stabilised by adding cement to it - the mixture is often called soil-cement
* bitumen (asphalt) improves the resistance of soil to water but does not alter its strength
* bitumen soil blocks can be easily made in a simple wooden mould and then dried in the sun
* lime is in many parts of the world more easily available and cheaper than either cement or bitumen.

- Lime-stabilised soil is not as strong or water-resistant as cement-stabilised soil but it is certainly an improvement over plain soil. Soil stabilised with cement or lime can be further compacted in a Cinva Ram.

- Various materials ranging from plant juices to cowdung have been mixed with mud, or used for rendering (painting on the outside of the wall) to make mud walls more waterproof.

* In Northern Ghana, an extract of boiled banana (or plantain) stems is mixed with lateritic soils.
* In Upper Volta and Northern Ghana, a plant extract locally known as 'am' is used as varnish. It colours the walls red.
* In Northern Nigeria, 'laso' (an extract from the vine *Vitis pallida*, locally known as 'dafara') and 'makuba' (made from the fruit pod of the locust bean tree) are used for waterproofing mud walls.
* Sap from *Euphorbia lactea* mixed with lime has been used, as has sap from the *Opuntia* cactus. Agave leaves also provide liquid for finish.
* Cowdung mixed with clay has been used in Ghana and very widely in India.
* In the Sudan, 'jaloos' (mud) houses are treated with 'zibla', a local waterproof material made from cow or horse dung.

The same material has been used in Botswana.

* Straw has been mixed with mud since Biblical times, especially in West Asia. In Ethiopia, straw (preferably 'chid': the straw of millet) is used in mixing 'chika' or soil paste.

Mud roofs

Mud roofs are made in several parts of the world by plastering mud over a mat of thatch or bamboo sticks supported by wooden beams. The problem is that these roofs become damp and heavy.

- Making strong roofs entirely with mud has proved to be an extremely difficult task. The only technique by which a roof can be made entirely with sun-dried mud bricks was invented over 6000 years ago in the Middle East: the vault. Some ancient vaulted roofs in the arid Middle East are now over a thousand years old and are still intact.

- Dr A.A. Hammond of the Building and Road Research Institute of Kumasi, Ghana, has made a study of the common defects found in mud buildings (Reference 41). The main causes of deterioration are shrinkage, cracks, erosion, underscouring and mechanical damage, due directly or indirectly to water.

- By using a suitable mix of appropriate architectural elements (eg stone foundations), structural techniques (eg overhanging roofs), stabilisation measures (eg the correct proportion of clay or cement in the mud) and care in siting (eg with good drainage), mud buildings can be successfully built in almost all types of climatic regimes, and with proper care and maintenance, they should last for decades.

The Earthscan questionnaire

In 1979, Earthscan sent a questionnaire to about 110 institutions and individuals thought likely to have an interest in the use of mud as a building material:

* international and bilateral aid institutions (eg the World Bank and USAID) which have funded low-cost housing schemes in developing countries
* various building research institutes and architectural departments of universities
* groups and institutions listed by UNEP's Infoterra system as having an interest in traditional building materials
* several well-known appropriate technology organisations.

- Only 20 out of 110 organisations and individuals replied. All but one stated that mud and other traditional building materials can make an important contribution to the pressing housing problems in developing countries, giving the following reasons:

* easy and wide availability
* low cost

Egyptian architect Hasan Fathy was given a special Aga Khan architectural award in 1980 for his lifelong work to promote traditional Arabic design and building techniques in mud. Mud-brick arches, vaults and domes have been used in the Nile Valley for six thousand years. Below, a general view of mud roofs in Iran. *Photos: Hasan Fathy*

* suitability for labour-intensive construction techniques
* construction techniques using traditional building materials are simple, so no sophisticated equipment or expertise is required
* people are already familiar with these techniques and materials
* they can be handled by local people and are thus amenable to self-help housing construction
* materials like mud are climatically suited to the needs of developing countries
* they require less energy in manufacture than modern building materials such as cement
* well used they are aesthetically pleasing, and assert cultural identity
* they can release scarce modern building materials for important development projects
* their use reduces the demand for foreign exchange.

- Professor Witold Rybczynski, of the Minimum Cost Housing Group at McGill University, Montreal, commented that the main potential of mud and other traditional building materials is in the rural areas. Most earth techniques are extremely labour-intensive; if labour costs have to be paid, mud is more expensive than cement blocks.

- But despite the acknowledged importance of traditional building materials, most institutions have never conducted or funded research on local traditional building materials.

* The National Environment Secretariat, Kenya, said it was planning to work on wood, mud bricks, and clay tiles.
* The Cottage Industries Division, Bangkok, Thailand, is planning to work on mud bricks and bamboo.
* The World Bank replied that it neither carries out nor sponsors building materials research, but claimed to be keeping itself "abreast of technical trends which influence development".
* Nicolas Jequier, principal administrator of the Development Centre, OECD, Paris, said that traditional building materials was "a vital area of research. Very little is done in this field".

- Very few aid agencies replied at all. This tends to confirm the charge that the aid agencies have neither tried to use traditional building materials nor to fund research on them, despite their professed support for low-cost housing programmes.

- This neglect is surprising when considered against the dozens of expert group meetings, symposia and conferences, including the 1976 UN Conference on Human Settlements (Habitat) in Vancouver, which have recommended greater research on and use of traditional building materials.

- But Mr P.A. Campbell of the Royal Melbourne Institute of Technology, Australia, commented: "I cannot see any purpose in doing research into mud bricks...There is enough information to design with these, so why do research?"

- Some of the institutions said that they had done research on traditional building materials. But their results had only "slight", "limited" or "no" effect on the housing policy of their country.

- The Housing and Urban Development Corporation (HUDCO) in New Delhi, a housing finance corporation, said it collects information about research on low-cost techniques, and tries to incorporate the results into the low-cost housing projects it finances. HUDCO has advocated the use of mud as masonry mortar, and of stabilised mud for walls and floors.

- HUDCO has financed about half a million dwelling units, out of which 86% have been reserved for families with monthly incomes not exceeding 600 rupees (Rs) ($75). It says that low-cost techniques developed in India have helped it to reduce the use of materials by over Rs11.5 million ($1.4m). This figure, though, is relatively small against the Rs1300 million ($163m) of loans which HUDCO sanctioned in 1979-80.

- Most of the replies to the Earthscan enquiry claimed that housing planners and researchers are not giving adequate attention to traditional building materials. Why not? Various reasons were advanced:

* "Most of the serious research on building materials has been done in developed countries by experts who had a marginal interest in the less developed countries" (Professor Fred Moavenzadeh, Massachusetts Institute of Technology, USA)

* "House planners and researchers in most developing countries are often expatriates, knowledgeable in their own technologies. Often they do not stay long enough anywhere to get acquainted with local idioms and very often they have to fight against local counterparts who see progress only in terms of the 'latest'." (Erica Mann, Kenya Architectural Association, Nairobi)

* "Discouraged by existing by-laws and regulations which prohibit use of mud as a building material....overwhelming influence of modern materials imposed by the public relations media and promotional campaign....lack of proper knowledge about traditional building materials; and prejudice of both common people and decision-makers... local building materials being regarded as inferior, temporary, unhealthy and ugly." (Naigzy Gebremedhin, United Nations Environment Programme, Nairobi, Kenya)

* "Good salesmanship (of modern building materials); lack of indigenous education; aspirations; urban magnetism" (H.S. Murison, Department of Architecture, University of Queensland, St Lucia, Australia)

* "Most traditional materials require high maintenance and

> so do not fit into monied economies very well. Traditional houses...are difficult to keep clean - by any definition you like - so local authorities don't like them. They have a low status. The only people who like mud bricks are middle-class dropouts in developed countries..." (Dr. P.A. Campbell of the Royal Melbourne Institute of Technologies, Australia).

- In sum, the replies suggest that a number of factors are responsible for the neglect of traditional building materials:

  * misplaced fascination with modern materials
  * the distorting influence of western and western-trained architects and engineers
  * the adoption of inappropriate building standards from colonial periods.

- A curious vicious circle is operating. Housing planners dismiss traditional building materials because they are inferior. And researchers do not spend time on improving them, because housing planners are not interested.

Mud must be protected from water, otherwise it cracks and crumbles. This company-owned house on a tea estate in Bangladesh uses jute sticks with a mud coating, but stands on a more solid plinth to protect it against rising damp. *Photo: Tom Learmouth*

CHAPTER FIVE

COUNTRY SURVEYS

Third World architecture has evolved over thousands of years. It reflects the accumulated expertise of the people - on how to build cheaply with available resources, in ways appropriate to the social, cultural, economic and environmental conditions.

- The old city centres of Isfahan, Cairo and Delhi can still teach modern architects a number of lessons: a sense of scale and proportion; the juxtaposition of open and closed spaces; shaded streets, oriented according to the sun's angle or to catch prevailing winds; the ability to achieve high densities with low-rise buildings.

- Unfortunately, modern Third World architects ignore indigenous architecture when they do not treat it with outright contempt. The Third World has imported Western architectural concepts wholesale. They are usually inappropriate.

- Traditional styles are usually confined to mimicry in the design of the facade. Only very rarely is a serious assessment made of the functional elements of indigenous architecture: the use of courtyards, for example.

- The country surveys that follow are not complete. Latin America and francophone Africa are badly under-represented, because the original research was done in English. But the purpose of this chapter is not to give a comprehensive survey, but to demonstrate the potential of earth-based architecture in a variety of cultures and climates.

India

Mud is one of the most widely used building materials in India: probably more than half of all Indian houses are made from mud. Even in the urban areas, mud is often used by slum-dwellers to build their shelter.

- India's population, now over 600 million, may be about 900-1000 million by the year 2000. About 80% of the existing population lives in rural villages.

- "It is not easy to visualise how these people can be housed", admits Dr Surya Kant Misra, assistant director of India's Central Building Research Institute (CBRI).

- The CBRI estimates that just to meet the 1977 housing shortage, 12.1 million new houses would have to be built in the rural areas, and 4.7 million in the urban areas. "Assuming an average modest cost of 3000 rupees (Rs) ($375) for a rural house and Rs1200 ($150) for an urban house, the financial requirement works out Rs92,700 million ($1,160)...an extraordinary sum for any government to provide", says the CBRI (Reference 43).

- A study for the UN Economic and Social Commission for Asia and the Pacific (ESCAP) estimates that India will need a minimum investment of $1.3 billion in housing in urban areas alone every year between 1975 and 1995 to meet the existing backlog and future demand.

- Like some other developing countries, India has launched several low-cost housing schemes, but they have all turned out in practice to be middle-class housing programmes.

- Devendra Kumar, director of the Centre of Science for Villages, complains: "Architects talk of building low-cost houses, but the majority of the people can only afford no-cost houses". The CBRI states that 60-70% of the urban population cannot afford to buy even a basic house with about 20 square metres (215 square feet) of floor area.

- There is a great scarcity of building materials, particularly cement and steel. Little effort has been made to find materials suitable for low-cost housing.

- In India, labour is cheap, so building materials can form as much as 60-65% of construction costs.

- Mud houses provide shelter to the majority of India's population today, and will continue to do so in the immediate future. Unfortunately, government housing programmes think only in terms of brick and cement.

- Except for some extremely scanty reports prepared by the Census of India, very little information is available on mud housing. Mud is looked upon with contempt by planners, architects and civil engineers.

- "Mud is considered unsafe, unhealthy and impermanent", says Dr. B.S. Bhooshan of the Institute of Development Studies, Mysore (Reference 46). "The result is that official programmes do not take mud seriously. But experiences and some reports show that mud houses can stay even up to 50 years if properly constructed".

- Bhooshan argues that bricks and cement cannot satisfy India's housing needs. "First of all there is no money for this and, secondly, there is a scarcity of such materials. Therefore, the main criteria for housing in rural areas should be economy in construction, and the use of local material. A third criterion is that housing programmes should be non-paternalistic in nature." In other words, they should promote self-help.

- "Mud construction techniques satisfy all these criteria", argues Bhooshan. "Mud is cheap and available everywhere, and mud houses are highly labour-intensive. Normally the material cost of a mud house will be less than 25% of the total cost...the cost of many mud and thatch hutments in rural India seldom exceeds Rs150 ($19).

- "As very little skill is required, villagers can join together and lend hands in constructing houses...House building in the rural areas thus never achieves the character of an industry, and does not require large corporations to manage it", asserts Bhooshan.

- Mahatma Gandhi once remarked: "What India needs is not mass production, but production by the masses". Dr. S.K. Misra, assistant director of CBRI, adapts this saying to point out: "India does not require mass housing but housing by the masses".

*** Techniques

Unlike in arid West Asia, houses built completely of mud are uncommon in India. Mud is used mainly for constructing walls and floors, and as a plastering material. It is used as a roofing material only in areas with low rainfall, normally below 25 inches (640 millimetres) a year. The most common rural house in India is a house with mud walls and a thatched roof.

- According to the National Buildings Organisation in New Delhi, 43½% of India's rural population lives in kutcha houses (temporary houses with mud walls and thatch roofs), 37½% in semi-pucca (semi-permanent) houses, and 19% live in pucca houses.

- The techniques of mud wall construction vary enormously. Walls made of mud lumps are the most common. To make such walls, mud is kneaded by foot to make a paste. Ash (as in Karnataka), straw (as in Punjab and Uttar Pradesh) or cowdung is sometimes added to improve the consistency. The mud paste is then placed in horizontal layers to form a wall.

- In southern parts of West Bengal, where fine clay is available, the paste is cut up into chunks with a spade, which are then laid one on top of another almost like crude unfired bricks.

- Normally, such walls are about 18 inches (48 centimetres) thick and are constructed in layers varying from 1 to 3 feet (30 to 90 centimetres) high. Each of these is laid only after the lower layer has dried. In some places, as in Rayalasema in Andhra Pradesh, twigs and palm leaves cover the mud wall to protect it from rain.

- Many locally-available materials are used by Indian villagers to reinforce mud walls. In areas where reeds or bamboos are used as reinforcements, the load of the roof is usually borne by wooden poles instead of by the walls. The normal practice in Karnataka and Andhra Pradesh is to press moist mud on either side of a frame of woven split bamboo, which is nailed or tied to vertical poles.

- In parts of north Karnataka, Uttar Pradesh, Orissa, Punjab, Andhra Pradesh and the Brahmaputra valley, a layer of mud (mixed with ash or straw) is plastered over a wall of bamboo or reed wattle.

- In some areas of Maharastra, walls of intricate basketwork are daubed with a mixture of mud, stone and clay.

- On the banks of the Godavari river in Andhra Pradesh, date palm or palmyra leaves are used to make a wall and then mud is plastered over them.

- Rammed earth walls are found in hilly Himachal Pradesh. Moist

earth is mixed with small stones and clay. Two wooden planks form a shuttering, and the moist mud and stone mixture is rammed between them. This is left to dry for a day or so, the wooden planks are removed and placed above the dried portion, and the process is repeated until walls of a desired height are obtained. Doors, windows and other openings are fixed as construction progresses. Sometimes split bamboo sticks are inserted in the walls during construction to protect against possible burglaries. Such walls are usually 18 inches (45 centimetres) thick.

- Sun-dried mud bricks, usually hand-made, are now becoming common in rural India. They are normally larger than kiln-fired bricks, but do not conform to any standard size. Sun-dried bricks usually make stronger walls than mud.

- Mud roofs are not as common as mud walls. But they are still widely found in a belt from Kashmir in the north to the Deccan plateau in the south, covering southern Kashmir, Punjab, Himachal Pradesh, some areas in Uttar Pradesh and Madhya Pradesh, Rajasthan and central parts of Maharastra. In the south, mud roofs are found only in some parts of Karnataka and Andhra Pradesh.

- Indian mud roofs are normally flat, with the mud used to cover a supporting platform of wooden planks, reeds, bamboo matting or stone slabs. Mud is beaten down and occasionally plastered with an emulsion of cowdung. Layers of leaves may sometimes be added to prevent the mud from dropping through.

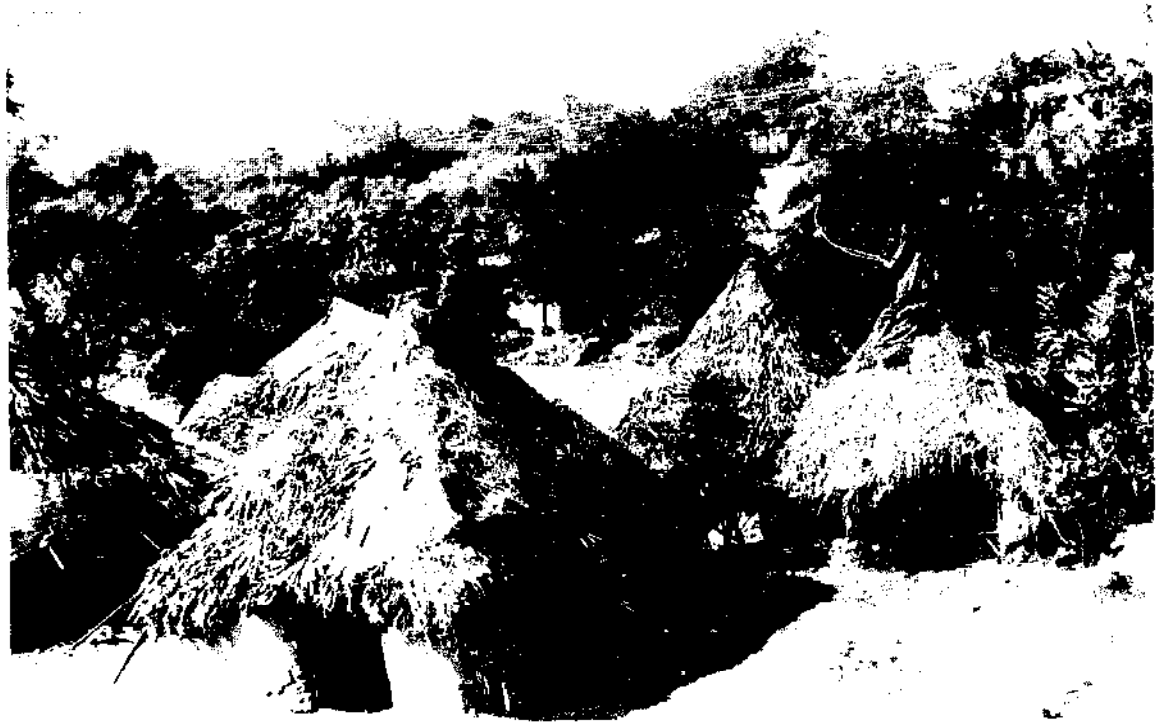
- A unique double-skinned sloping roof is reported from Orissa. In this case, the mud roof acts as a ceiling to protect the house from fire. A second, outer roof is constructed of grass and leaves over the sloping mud roof, to protect it from being washed away by rain.

- In the Kurnul area of Andhra Pradesh, flat roofs are formed by spreading sheets of stones over wooden beams and covering them with saline clay.

- In northern districts of Karnataka, a layer of mud 1 inch (2½ centimetres) thick called 'melmudde' is rammed over a matting of bamboo or reeds placed on wooden joists. Such a roof requires repairs once in three years.

- In the wet climatic conditions of Kinnaur district in Himachal Pradesh, a flat mud roof known as 'khayap' is common. Layers of large leaves and local bushes are spread over thick wooden planks. On this frame, a 6-8 inch (15-20 centimetre) thick layer of mud is carefully spread, and beaten by small wooden clubs. The masons and others press the mud by walking about on the roof; children are sometimes asked to play on the roofs under construction. Once the mud layer has been smoothed and pressed, water is sprinkled on it. These roofs tend to leak in heavy rains, and snow has to be shovelled off quickly, to avoid leakage or collapse.

- In some parts of Karnataka, mud is skilfully used to make the roof even without the lower support of bamboo matting or reeds. Wooden joists are placed at intervals of about 9-12 inches (23-30 centimetres) and small lumps of mud are placed horizontally



India has a vast variety of traditional designs for village houses, reflecting the different materials locally available. Below: flat mud roofs over stone walls in North Karnataka. Above: square mud huts with tall grass roofs in Andhra Pradesh.

Photos: Anthropological Survey if India

on them. Inch by inch, the mud cantilever grows till it covers the space between the two beams. Holes are often made in such mud roofs for light. During rains, these holes are covered with earthen pots. In the Dharwar area in Karnataka, beautiful pottery chimneys are used to allow the smoke to escape.

- In houses with mud, stone, wood or brick roofs, the roof does not form a major visual element. By contrast, in houses with mud walls and sloping thatched roofs, the roof is the dominating feature.

- Mud architecture in India is visually rich. It forms an important component of the country's peasant culture. Even the interiors of mud walls are often decorated. Beautiful examples can be found in northern Karnataka, Uttar Pradesh and Punjab.

- Rooms in mud houses are often dark and badly ventilated, but they provide comfortable living in the extremes of the tropical climate - warm in winter, and cool in summer. Mud houses thus represent the best used of local resources and adjustment to local climate, for the level of affluence found in most parts of rural India.

*** Sarvatogriha

The government-sponsored Central Building Research Institute (CBRI) has conducted extensive research on housing for the poor (Reference 48). Based on the traditional West Asian building technique that has in recent years been promoted by Professor Hasan Fathy of Egypt, the CBRI has built a new type of house called a 'sarvatogriha' (house for all), one at Roorkee and another at Hyderabad.

- The end walls of a sarvatogriha are built first, to the full height of the room, and then the side walls up to a height of 1.20 metres (4 feet). Two identical parabolas are then drawn on the end walls and guiding threads stretched between them.

- Roofing bricks are laid in mud mortar in alignment with the parabola. Care is taken to see that continuous joints do not occur between successive courses. This forms a strong vaulted roof.

- Once the main shell is complete, a layer of mud and straw 5 centimetres (2 inches) thick is applied over the shell for heat insulation, followed by a layer of brick tiles 3½ centimetres (1½ inches) thick for rain protection. The external surfaces are painted with lime and surkhi (powdered bricks), and mud mixed with wheat straw is used for internal plaster.

- The CBRI has used burnt bricks instead of the sun-dried bricks used by Professor Fathy in Egypt; this gives the structure greater strength, which is necessary for a rainy climate.

- The burnt bricks do not necessarily have to be produced in a mechanised brick-making plant. Bricks are often produced in Indian villages; they are hand-moulded and then fired using easily available fuels like cowdung, grass, leaves, firewood or coal.

The materials used in a sarvatogriha are thus, despite the use of burnt bricks, within the reach of some villagers. There is no use of cement or steel.

- "Sarvatogriha holds promise of a technology which suits the cultural temperament of India's villages", says Dr. S.K. Misra, assistant director of CBRI. "The speed of construction is slow and human. The building can be left unfinished at any stage to be taken up later for completion, and all members of a household can work on it."

- The cost of a sarvatogriha is lower than that of a conventional house even when it is built using hired labour. The roof was estimated in mid-1976 to be 46% cheaper than a conventional reinforced brick roof. A sarvatogriha house with 2 rooms of total area 21.6 square metres (232 square feet) costs Rs5210 ($650).

- The CBRI found that a sarvatogriha is significantly more comfortable in the summer than a cement and brick house with a flat roof; temperatures inside the sarvatogriha are on average 2°C lower than inside a conventional house.

- Another type of low-cost house developed by CBRI in which mud can be used directly is based on the skeleton system of construction. A skeletal structure consisting of a pre-cast roof supported by pre-cast beams and columns is built first. The walls can then be filled in by the owner with whatever material he can afford: mud, sun-dried bricks, substandard burnt bricks, bamboo matting, or more modern materials. Since the load is taken by the beams and columns, the strength of the wall is not important. Yet the structure is durable.

- The prefabricated elements need not necessarily be produced in a modern factory, but can be made on a relatively decentralised basis in small towns, and then transported to the construction sites.

- Using this technique, the CBRI built 2500 village primary schools in Uttar Pradesh in a record time of three years: two to three schools a day. All the components required to build a school could be loaded on to a single truck.

- But like all new types of low-cost houses, sarvatogriha and skeleton housing have still to penetrate the villages and become accessible to the poor. In India, the average yearly per capita income is Rs1000 ($125). If 15% of this were invested in housing, it would still take more than 30 years for the average citizen to meet the cost of a sarvatogriha house.

*** Research and development

Protecting mud walls against rain has been the subject of CBRI research for many years. The institute has developed a waterproofing technique by spraying a mixture of bitumen and kerosene using an insecticide sprayer.

- Bitumen is heated in a drum until it melts. The molten bitumen

is then slowly added to another drum containing kerosene and vigorously stirred. The mixture is sprayed on while it is still fluid. The cost of this technique is about Rs1.30 (16 US cents) per square metre, and the wall's life is increased by 3-4 years.

- To protect the walls of the average house using this bitumen-kerosene technique, the Centre of Science for Villages at Wardha (Reference 48) estimates the cost at Rs30-45 ($4-6). The average village house owner spends Rs50-150 ($6-19) per year on maintenance, so this technique should be economically viable.

- The CBRI claims that bitumen-stabilised mud plasters can be used to protect certain types of roof as well. But there are possible drawbacks. Damp rising from the ground can do as much damage as rain, and it is feared that the normal evaporation of this rising damp will be hampered by a waterproof layer of bitumen paints outside the wall.

- Another problem, says the CSV, is that the lower part of a mud wall can be eroded by flowing surface water in the rainy season. The solution proposed by the CBRI is that villagers should build a brick and cement mortar wall up to plinth level, and then build the rest of the wall with mud.

- The CBRI has recently brought out an even cheaper method of protecting mud walls. A mixture of soil, paddy straw cuttings and used motor oil is mixed thoroughly and applied thinly to the wall by hand, and allowed to dry. Then a paste of cowdung, clayey soil, old oil and water is plastered over the first layer.

- The CBRI claims that this technique has been effective on a large number of rural houses, and only has to be repeated every five to six years.

- Since 1958, the National Buildings Organisation (NBO) in New Delhi has established 8 rural housing centres. Based on social and economic surveys in over 100 villages, the NBO has developed over 200 house designs to suit different regions, and supplied them to state governments. Among the techniques promoted are soil stabilisation, waterproof mud plaster and fire-retarding chemical treatment for thatch roofs (Reference 49).

- Under another scheme, the NBO joins with a state government to build a village cluster of low-cost houses for landless agricultural workers. Local building materials are used, and the landless workers contribute their labour. The clusters, over a dozen of which have already been erected, help to demonstrate improved techniques to the surrounding villages.

- The government of India, under its minimum needs programme, has a scheme to supply house sites to landless agricultural labourers. The scheme aims to help 17 million rural households; so far, 7 million landless families have been allotted free house sites.

- The NBO has developed two types of one-room house for these landless workers. One has sun-dried brick walls with waterproof mud plaster and a thatch roof treated with fire-retarding chemicals. The other has burnt brick walls and a tiled roof.

- The first type of house was estimated in 1974 to cost less than Rs1500 ($190) when built with self-help, and the second about Rs2000 ($250). The plinth area of each house was 20 square metres (201 square feet). These designs have been used to build 4000 houses in Punjab recently, says the NBO.

*** Low status of mud

Despite all these efforts, success has been very limited, both for the NBO and the CBRI. Very few of these low-cost techniques have been adopted by villagers. The NBO admits that "despite the use of preservative treatment and stabilising agents, soil has not become a popular building material".

- The Appropriate Technology Development Association at Lucknow is not convinced that villagers will ever adopt such techniques. "The villagers look to the house not in terms of 3-5 years but in terms of 50-100 years. These techniques only made houses slightly more stable, but did not improve them much otherwise."

- Status is at the root of the problem of non-acceptance. Mud houses are associated with poverty.

- If anybody can afford a better house, he is almost certain to think of a good permanent structure built of cement, bricks and steel. He is hardly interested in spending money on improving his mud house.

- For those who can afford it, construction of a pucca (permanent) house is started soon after harvest, on the income generated by a good crop. If money is insufficient, the building is completed over a period of years. Bricks will be purchased in one year, part of the house will be constructed the next year, and so on, until the full house is completed.

- The cost of this is prohibitive for the majority of villagers. So while the rich villagers live in pucca houses the poor villagers continue to live in mud houses, dreaming all the time that they may own a permanent house themselves one day.

- Many villagers who cannot afford a well-built pucca house try to economise by degrading construction specifications. A mortar will be used containing too little cement. The breadth of the foundation and the thickness of the wall will be reduced.

- The Planning Research and Action Institute (PRAI) at Lucknow found this was a widespread practice in village houses. The walls and roofs of many such cheap pucca houses had cracked, and the floors and plaster had started to wear away. Because the walls were too thin, the house was uncomfortably hot in summer. Houses started to look shabby in only 3-5 years. But as only such economising could put pucca houses within the reach of villagers, these houses were still being built.

- PRAI tried to develop cheap construction techniques that did not have these disadvantages. Villagers usually make a 9-inch (23-centimetre) wall entirely of baked bricks. In one experi-

mental wall, half the baked bricks were replaced with sun-dried mud bricks. The bricks were placed in an interlocking arrangement and the wall thickness kept at 13½ inches (34 centimetres). This improved the stability of the house and kept it cooler, but the cost of the 13½-inch (34-centimetre) wall turned out to be the same. The wall was kept standing for two rainy seasons without any roof but no deterioration could be noticed.

- In another experiment, the sun-dried bricks were replaced with simple mud mortar, which was filled in between the baked bricks. This wall was also found to be stable, and was 20% cheaper than the mixed brick and baked brick walls.

- In southern India, Mr Popposwamy of the Aurobino Ashram at Pondicherry has been trying to promote the rammed earth technique of building houses. This traditional technique, which originated in Morocco, is used in India only in a few northern hill regions like Ladakh and Himachal Pradesh.

- Popposwamy believes that the best way to provide low-cost housing is to suggest improvements to the materials and techniques that villagers already use. He advocates load-bearing rammed earth walls to eliminate the use of wooden posts placed in the ground, which are very susceptible to attack by termites. Rammed earth walls are four times stronger than traditional walls of the same thickness, he says (Reference 51).

- He also suggests that windows, including lintels, which are usually made from expensive wooden frames (susceptible to termites) be made instead with fired bricks. This approach helps to get over the problems caused by mud's inability to grip wood. In many village houses, there are gaps around wooden window and door frames.

- At Mahaveerpuram, a new village in Tamil Nadu, more than 25 houses have been built using the Popposwamy rammed earth technique. Each house costs about Rs1000 ($125) including labour.

- To reach the vast millions who live in India's villages, these techniques will have to be demonstrated and taught. Will the various Indian housing agencies take up this task?

- In 1972, the Kerala government launched a pioneering scheme to provide adequate dwellings for 96,000 landless agricultural families. Each family was to get a semi-permanent three-room house (kitchen, bedroom and living room) with an area of 250 square feet (23 square metres).

- Construction materials were random rubble in mud mortar for the basement and foundation, cement topping on a consolidated gravel base for the floor, sun-dried mud brick interspaced between columns of burnt brick for walls, and tile set on forest timber for the roof.

*** Practical problems

A study of this scheme by the Centre for Development Studies (CDS)

at Trivandrum gives a good insight into how difficult it is to organise rural housing programmes.

- The construction cost of the house-type chosen by the Kerala state government was estimated in 1971 to be Rs1250 ($156), inclusive of the cost of unskilled labour. The village councils were asked to raise voluntary public donations, and each allottee was asked to pay a total of Rs110 ($14) in 11 equal monthly instalments - less than 10% of the total cost of the house - to ensure a sense of participation. Unskilled labour was to be supplied free on a voluntary basis. The Kerala government agreed to supply free tiles, timber and cement.

- But the scheme soon ran into problems, partly due to the choice of scarce building materials. Construction costs began to rise. By the end of 1974, the cost of each house had doubled to Rs2400 ($300).

- What the experience with this scheme has shown, says the CDS report, is that a large-scale programme should try to build "houses which make smaller demand on the relatively scarce materials in the economy, such as cement and timber".

- Kerala has no Portland cement works, although there are a number in neighbouring Tamil Nadu. But instead of cement, mortars made of lime and local pozzolanas might have been used. But was that an easy option? The CDS report discussed the point: "Lime is produced in very small labour-intensive units all over Kerala, and considerable social benefit would derive from a greater substitution of lime for cement. But there are two serious obstacles to such a change. The first is that the quality of the lime produced in these small units is very variable...the second... is that supply is inelastic. Increased demand tends to result in price increases rather than in increased supply."

- The scarcity of construction timber turned out to be even worse than that of cement or steel, and the Kerala Forest Department concludes that timber will become even more scarce in the future. If instead of tiles-on-timber the roof had been made of thatch supported by the more readily available coconut wood, it would have reduced the house price by about 10%.

- The question of building materials is complex. "A straightforward reversion from the 'modern' (reinforced concrete) to the 'traditional' (tile-on-timber) cannot...be contemplated", says the CDS report. "A rational longer-term approach would be the development of new sources of constructional timber by the treatment of country timbers, today used only for firewood, and the development of 'intermediate' roofing types which replace some cement and steel by tiles or other clay products."

- The report recognises that the technology chosen by the Kerala government was very cheap compared with other means of providing a permanent structure. But how many people can afford to pay even 100 rupees per square metre? Are there not still cheaper technologies to provide satisfactory housing?

- There is, of course, palm and grass thatch, but this only

produces impermanent structures. Moreover, thatch has a high rate of decay. "Thatch of coconut palm is generally made of double thickness, half of which must be replaced every year", says the CDS report. "Chemical treatment of thatch to prevent decay is possible, but the cost of treatments proposed so far is prohibitive."

- An expert committee was set up by the government of Kerala to look at ways of lowering the cost of houses, utilising local materials and labour to the maximum extent possible. The committee's 1974 report commented: "Many rich clients want their houses to be ostentatious, for this gives them 'status'. Such ostentatious houses have increased the prices of housing beyond the reach of everyone else."

- The committee's recommendation was simple (Reference 53). "These prevailing tendencies towards waste of resources, along with considerations of equity, force us to state categorically that the time has come for a strong campaign towards simple and comparatively less expensive building for all. We decry any move towards Low-Cost Housing for 'the Poor'. Reform, rethinking, replanning and redesigning must start at the top and spread through all strata of society."

- The Kerala committee criticised the government's own "very unrealistic pattern of accommodation based entirely upon status and social position...A comparatively elderly man at the peak of his profession, with his children grown up and already living and working elsewhere, is provided with a large area of unwanted floor space, while his younger assistant, usually with not only a number of growing children but often with aged parents or other dependents as well, has to live as best he can in one or two small rooms with inadequate cooking and sanitary facilities".

- To the committee, cost reduction was an "easy" job. "It is our belief," the committee stated, "that by proper selection of known techniques and material and by a careful examination of each item of construction for its functional need, we can substantially reduce the cost of construction below current costs".

- The committee suggested the use of burnt bricks and tiles, laterite, lime and country wood (ie non-forest timber) - materials which are strong, functional, locally available, cheap and aesthetically attractive.

- But like the recommendations of previous bodies, the report of this committee has had little effect, either in Kerala or in other parts of India. It has simply become an important footnote in academic papers on low-cost housing.

- The Hindi newspaper Nai Duniya recently warned (Reference 54) that housing, like clothing, had become a matter of fashion. "It is only in the matter of food that we still retain our Indianness ...How can cement be strengthened by steel is a subject on which our civil engineers read whole treatises. But how can mud walls be strengthened by bamboo is a subject that only those villagers know who suffer from floods every year."

- "If the eskimos of the arctic tundra can make houses of ice which suit them and keep them warm, why can't we make houses which suit our environment?", asked Nai Duniya.

- It is interesting to note that only one leader in the Third World, who had the option not to live in a mud house, actually chose to live in one. That was Mahatma Gandhi, who led India to independence. The wattle and daub structure in Sewagram Ashram, where he lived during the 1930s, is today a national monument for Indians.

Iran

Even in oil-rich Iran, modern construction techniques are failing to keep up with the housing demand. Official policy under the Shah (this section does not deal with events since the Islamic Revolution of 1979) was to provide one housing unit for every family. This means 7.8 million houses by 1992 - an increase of 6.7 million units.

- The Shah's government believed that building industrialisation and mass production of building materials was the only way for Iran to achieve its housing objectives. Investment in prefabrication grew rapidly, especially by foreign companies.

- In an article entitled "Bottlenecks in the adoption of appropriate technologies - the case of Iran", Ron Alward and Robert McCutcheon claimed that the fascination with steel and concrete buildings in Iran had reached a position where the peasant "regards his home with distaste despite its manifest appropriateness to climatic, social and economic conditions" (Reference 57).

- This was one of the important forms of "cultural pollution", said the Group for Studies on Iranian Problems in 1977.

- The Teheran newspaper Kayhan International wrote in 1978: "The most acute problem in Teheran is its increasing division into two cities: the neglected and decaying south and the opulent and developing north". The north had beautiful, wide, tree-lined boulevards, fine houses with gardens, and beautifully sculptured buildings; the south had narrow and twisting lanes, pools of dirty water and dilapidated and crumbling mud brick houses.

*** Vault and dome

The mud brick vault-and-dome building system evolved centuries ago in West Asia. It was a response to necessity, for roof-spanning materials such as timber and reeds became more and more scarce as populations grew in the hot, semi-arid regions.

- Although in Iran and elsewhere in West Asia, mud-brick buildings have reached an extremely sophisticated level, in public and domestic architecture alike, they have in recent time been totally neglected in favour of Western architecture.

- As a result, highly-skilled traditional masons can no longer

find work, and new apprentices are not being trained in indigenous techniques. The skills are in danger of being lost altogether. The Development Workshop in Iran, a small non-governmental group, has for several years now been seriously studying the possibilities of using the indigenous building technology of mud brick vaults and domes as a possible solution to low-cost housing in the Third World.

- The Development Workshop researchers have found that concrete and steel are imported at exhorbitant prices into many rural areas of Iran. Reinforced concrete roofing puts the price of housing out of reach of the majority. A corrugated iron roof is less expensive, but without expensive air-conditioning it turns the interior of the house into an inferno.

- "Sun-dried brick is probably the most widely available and commonly used building material in the Third World", argues the Development Workshop. "In regions such as Iran and Egypt, where timber and other organic materials are scarce, (vault and dome) technology has been developed to a high degree and is capable of spanning all kinds of spaces."

- Vault-and-dome is the unique response of the ancient West Asian architects to the fact that sun-dried mud brick has strength in compression but not in bending or tension.

- The traditional Middle East vault has the shape of an inverted catenary. The catenary is the pure tension curve that a chain or heavy rope takes when it is allowed to hang free, suspended by both ends.

- In Europe, vaulting always involved laying masonry over a wooden framework, which was later removed when the vault became dry. But in West Asian construction, no supporting formwork was required for fired or sun-dried brick.

- If sun-dried brick is used with mud mortar, the bricks fuse together on drying, since they are of the same material. This gives the vault additional strength.

- Mud brick's greatest advantage is its cheapness and availability. A team of three men can make 2000-3000 hand-moulded bricks a day.

- A research and training workshop for upgrading the skills of rural builders was organised by the Development Workshop in 1977. Builders from villages throughout Luristan province came together to experiment with improvements to their local materials and building technologies. Workshop participants included village builders, architects and master builders from other regions of Iran. Village housing problems were discussed, and the solutions then tested in practice. Experiments were carried out on local materials like timber, stone and mud brick; soils were tested using simple sedimentation techniques that could be mastered by any local builder. Stabilisers for mud brick and rendering for improved earth walls against rain and wind weathering were developed for local soil types.

- Village builders were looked upon both as a valuable source of

In Herat, Afghanistan, a mud-straw mixture is mixed on the ground and then carried up to resurface the roof of a house. *Photos: Sean Sprague*

experience on indigenous building methods, and also an appropriate channel for the introduction of improved indigenous building techniques. Evening literacy classes were held so the village builders could keep their own records.

- A major criticism of mud brick vaults and domes by professional architects in Iran is their susceptibility to earthquake damage.

- In most of the earthquakes that have struck Iran over the past 15 years, officials and architects have reported that mud-brick houses were least resistant to earthquakes. Buildings with mud-brick vaults were a major cause of the 25,000 deaths in and around Tabas in 1978.

- In the Tabas region, most houses are single-storey structures with beautifully vaulted roofs, supported only by mud-brick walls. The inhabitants usually apply a new layer of mud to all the outsides of the village houses every autumn, so the vaulted roofs can become a metre (3 feet) thick, weigh many tonnes, and easily collapse under even small tremors.

- The Iran Development Workshop, however, counters this criticism of indigenous buildings. Surveys in the Bandar Abbas and Zarand areas, where earthquakes have occurred recently, have shown that all types of building - whether built of stone, mud brick or modern concrete - had collapsed during the earthquakes.

- In some cases people had used rounded stones to build their houses. The stones were split into halves and laid onto a flat mud surface, with mud packed between them. The stones were thus simply piled one on top of the other. During an earthquake the walls disintegrated and collapsed in a heap.

- Mud-brick houses, on the other hand, tended to collapse much more intact. This, the researchers explained, was because the domes and vaults become a "kind of homogeneous mass", which tends to hold together as a single unit during earthquakes. Interviews with people in Zarand revealed that "the process of collapse in mud-brick houses was much slower", the Development Workshop claimed.

- Poor foundations, openings in walls near the corners which cause zones of weakness, short timber lintels for doors, and walls which fell outwards during an earthquake, are all contributing factors to earthquake-proneness, the researchers said.

- "We are not saying that by just improving the construction we can make earthquake-proof buildings", the Development Workshop team said. "We're just suggesting that by upgrading the local buildings or improving the local building techniques, we can save more lives."

Afghanistan

In Afghanistan, settled villagers construct walls 30 feet (9 metres) high without the use of scaffolding or shuttering, by hand-packing a moist mud-straw-pebble mixture in horizontal layers 2½ inches (6 centimetres) deep. Three men can construct a 10 feet (3 metres)

high, 30 feet (9 metres) long wall in 16 hours.

- For floor and foundation designs, too, rural Afghans use stone or adobe blocks covered with thin coatings of linseed oil, instead of concrete slabs.

- Urban and rural Afghan houses use underground heating systems, with floor ducts heated by hot charcoal. Construction is simple and labour-intensive.

- Rafi Samizay, an Afghan architect, says that his country is "blessed with a wide variety of vernacular architecture and folk housing, which is characterised by a subtle balance between the man-made form and the surrounding natural environment" (Reference 60).

- The common town house in the Herat region, for example, is made of sun-dried mud bricks faced with a layer of fired bricks. An additional layer of gypsum is plastered on the interior walls. Climate control is achieved by elements like the central courtyard, and by wind-scoops on the roof which funnel the cool north wind down into the main rooms.

- "Afghanistan is still 90% rural and the country has hardly been touched by 20th century technology, with the result that traditional building methods are not a part of history but a continuing craft", says Rafi Samizay.

Pakistan

Pakistan, too, has evolved its own traditional building solutions over centuries. Wind-scoops, for instance, are a prominent feature of the lower Sind district in West Pakistan, where temperatures range from 95°F to over 120°F (35-49°C) between April and June.

- Wind-scoops are installed on the roofs, one to each room to channel the afternoon breeze, explains Bernard Rudofsky in his book 'Architecture without Architects'. In multi-storied houses the vertical ducts double as intramural telephones, a mechanism which has been in use for at least 500 years.

- Thatta, 60 miles north of Karachi, is an old town with narrow winding streets and several three-to-four storey mud and bamboo houses. The walls of these 30-foot (10-metre) high buildings consist of nothing more than small 2-inch (5-centimetre) thick strips of wood and bamboo covered with reed mats and caulked with mud.

- Pakistan, unlike Afghanistan, is a relatively advanced country in terms of modernisation and industrialisation. Ghulam Kibria, former director of the Appropriate Technology Development Organisation (ATDO), points out how difficult it is to get people to accept even modern-looking low-cost housing solutions (Reference 62).

- ATDO's low-cost strategy was based on two basic concepts:

* Burnt brick was replaced by blocks of soil stabilised by adding either lime or cement, and pressing them in a Cinva ram
* Hollow concrete blocks were used instead of solid ones, which helped to save materials and provided better insulation.

- Roofs were made with reinforced cement battens and slabs, which had one limitation, that their span could not exceed 10 feet (3 metres).

- ATDO built a low-cost house in Karachi in 1976 at half the current construction costs. Two cooperative societies volunteered to adopt ATDO's suggested system of construction. But when detailed consultations were held, the president of one of the societies, a prominent trade union leader, told ATDO that its plans were unacceptable because they did not provide a drawing room. "Where will the workers keep their sofa sets and TV?", he asked.

- "I was stunned", wrote Kibria later. "What dawned on me that day was that housing cannot be detached from lifestyle."

- "Technology for low-cost housing is available", says Kibria, "and can reduce cost to half or even one third, but social attitude kills the benefit obtained from the technology." Housing, he argues, has become a status symbol rather than a mere necessity.

- In its attitudes towards slums, at least, the Pakistan government has slowly been changing away from low-cost housing and site-and-services schemes which only benefit the middle classes, to slum upgrading.

- Karachi has since 1975 taken the lead in Pakistan to legalise land tenure in some of its 'katchi abadies' (literally, impermanent settlements, the local phrase for slums). Some 1.6 million people are estimated to live in the illegal slums of Karachi.

- Karachi is particularly suitable for slum upgrading and legalisation of landholdings, because, unlike in many other Asian cities, most of the urban land is government-owned.

China

Comparatively little seems to be known about China's construction industry and state of housing. But it is one Third World country that has managed to provide every family with a decent, though still very spartan, habitat.

- In 1974, a group of US architects, the first to visit China since the Revolution in 1948, was told by Chinese architects that building houses for the rural population had been a three-stage process.

- In the first stage, simple shelter - typically a small house with bamboo and mud walls - was made available to all.

- In the second phase, efforts were made to ensure that everyone

was living in a permanent building with heat, running water, electricity, toilet and shower. The Chinese architects told the visiting team that "except perhaps in the small towns of the far west" everyone was now living in a permanent building.

- In the third phase, new houses were to have more space per family, with individual kitchens and baths. As families move into these, the older units were to be remodelled to meet the new and better standards.

- Building materials in China come from various sources, and housing designs vary according to the local materials available. Traditional materials such as bricks, mud, timber and clay tiles are used widely. Small factories and workshops produce building materials like burnt bricks and lime from local resources.

- On the loess highlands of northwest China, says a 1973 Architects' Journal report (Reference 64), loess soil is used to bake bricks in kilns, and on the outskirts of cities, industrial wastes like furnace slag are used to make bricks.

- Mud brick is a major construction material in China. In a commune near Sian, the capital of Shensi province, walls of houses are mainly made of smoothed mud bricks. But the houses have a plinth made of fired bricks which gives them a strong foundation and protects them from erosion.

- The roofs are made of clay tiles on timber poles in a contemporary 'modified shed-roof' form. Single-storey houses, combining traditional and modern techniques, and closely packed together to save precious agricultural land, are typical of rural China.

- In China's towns and cities, however, there has been a total break with tradition. New houses are thoroughly Western in character. Typically, they are closely packed three or four storey apartment blocks with stereotyped layout patterns, which reduce building costs to the minimum. In appearance, they are usually monotonous and uninspiring. Brick, concrete and prefabricated elements have frequently been used.

- The government in China is interested in further modernising and industrialising the construction industry. Advanced foreign techniques in construction are to be introduced and factory equipment for building houses to be imported. The government hopes that urban Chinese will have considerably improved living conditions by 1985.

Egypt

Hasan Fathy's book 'Architecture for the Poor', published in 1969 (Reference 66), was the first serious attempt to focus on mud architecture.

- Fathy's fascination with mud began when he was a young man, seeing the peasants' homes on his father's farms. "The peasant built his house out of mud, or mud bricks, which he dug out of the ground and dried in the sun...We, with our modern school-learned ideas,

never dreamed of using such a ludicrous substance as mud for so serious a creation as a house."

- Fathy as a young architect started using mud as much as he could. His first buildings, built in the late 1930s, had mud-brick walls with timber roofs. But the ancient Egyptians did not import timber, and their mud-brick vaults and roofs were built without the support of any wooden beams or columns. Fathy tried to do the same, but the vaults fell down.

- Then Fathy heard of craftsmen in Nubia (south Egypt) who could build mud-brick roofs without any support. On his first visit to Aswan to find such people, he discovered that "every man in a village, whatever his usual job, was able to run up a vaulted house for himself".

- Close to Aswan, Fathy found the monastery of St Simeon, a Coptic building of the 10th century. Its refectory, a 2-storey building, was supported entirely upon an ingenious system of mud-brick vaults. After a thousand years, this monastery is believed to be the earliest surviving mud-brick structure to use vaults (arches) to support an upper floor.

10th century Coptic church in Aswan, Egypt. Modern architect Hasan Fathy uses the ancient technique of mud vaults to help solve the housing needs of today.

Photo: Hasan Fathy

- "The solution to Egypt's housing problem lay in Egypt's history", wrote Fathy. At Luxor, he found granaries built of mud bricks 3400 years ago. At Touna el Gebel, he found more vaults, 2000 years old, one supporting an excellent staircase.

- "In one short tour", writes Fathy, "I had seen standing proof of the prevalence of vaulting throughout Egyptian history, yet, from what we had been taught in the School of Architecture, I might never had suspected that anyone before the Romans knew how to build an arch".

- The first use of mud brick for vaulted roof construction in Egypt is believed to be in some early graves thought to date back more than 6000 years. While the span of these vaults is less than 30 inches (76 centimetres) they use perfectly the method of all later vault construction.

- Fathy finally found two craftsmen to build him a traditional mud-brick vault. They used a special kind of brick, made with more straw than usual, for lightness, and measuring 25 x 15 x 5 centimetres (10 x 6 x 2 inches). They were marked with two parallel diagonal grooves, drawn with the fingers from corner to corner of the largest face. These grooves were very important, for they enabled the bricks to stick to a muddy surface by suction.

- The masons used no measure, but by eye alone traced a perfect parabola, with its ends upon the side walls. "The whole vault was built straight out in the air", wrote Fathy, "with no support or centering, with no instrument, with no drawn plan. There were just two masons standing on a plank and a boy underneath tossing up the bricks, which the masons caught dexterously in the air, then casually placed on the mud and tapped home with their adzes. It was so unbelievably simple."

- All that now remained was for Fathy to go out and apply the methods of the Nubian craftsmen throughout Egypt. This proved a difficult task.

- Eventually, in 1945, he was given the job of building a whole village for 7000 peasants living near Luxor in a village called Gourna. The Department of Antiquities wanted the villagers moved as they had become entirely dependent on tomb-robbing for their livelihood. The peasants were getting 50,000 Egyptian pounds in compensation. About 1000 houses were to be built, which gave Fathy E£50 per house, a reasonable estimate if his method of building mud houses was employed. But the department had allocated nothing for roads, schools, mosques, and other necessary public buildings and services.

- Fathy decided to use self-help. "We would make our own mud bricks, we would build kilns, quarry stones, burn lime, bake bricks for sanitary units...The village would, I hoped, show the way to rebuilding the whole Egyptian countryside. Once it was seen how cheap good housing can be, I hoped that there would be a great movement of do-it-yourself building among the peasants."

- Fathy was to be greatly disappointed. The Gournis were not keen to move. Proximity to the tombs gave them an easy liveli-

hood, and they were loath to give it up. Far from playing an active part in planning and building their own village, they tried to sabotage Fathy's scheme.

- From 1945 to 1948 it was a constant battle. Funds would flow in too slowly and work would often grind to a halt. There would be procedural objections to the purchase of raw materials such as straw. Finally, Fathy gave up. He built several public buildings and peasant houses, but the Gourna experiment failed and the village was never completed.

- Fathy's experiment left him bitter and disappointed. "What interest can we expect a senior official to have in revolutionary proposals, to commit his department to major schemes involving untried techniques and unsound-seeming methods of finance? He has achieved his position after a lifetime's cautious progress up the hierarchy, and now sits heavily at his desk, concerned only to avoid mistakes."

- Fathy still believes strongly in traditional materials, self-help and cooperative construction. "One man cannot build a house, but 10 men can easily build 10 houses", he says.

- Fathy cites an example of what people can do by themselves - and what government planners and architects cannot do for them. When some villages in Nubia were to be flooded by the Aswan Dam in 1934, the villagers had to build 35,000 houses in the year before their houses were submerged. Using mud bricks and vaulted roofs, all the villages were completed "without the assistance of a single architect or engineer. Self-help and local building materials did everything."

- "The villages turned out to be remarkably beautiful. Each village had its own character and each house was different from the other. The houses were spacious, beautiful, clean and roofed neatly with

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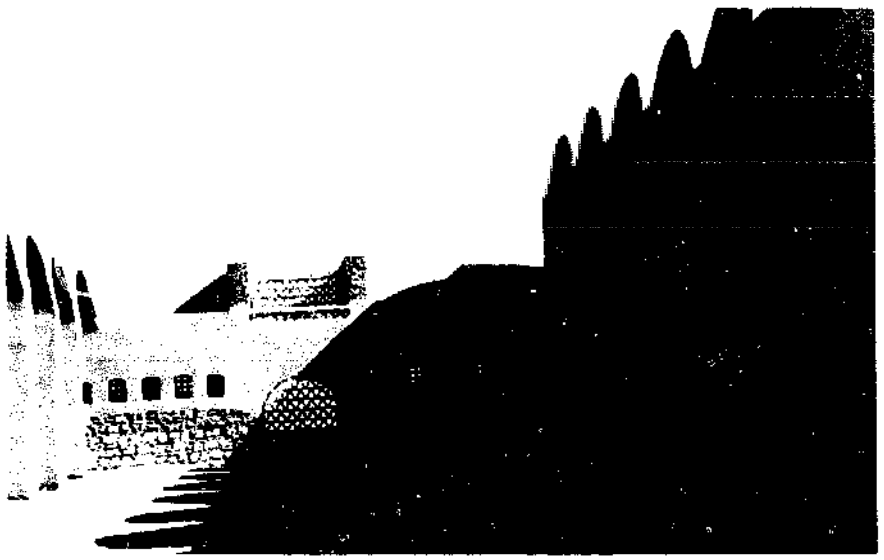
Egyptian architect Hasan Fathy uses mud walls, domes, vaulting and other traditional Nubian techniques to design a mosque. Photo: Hasan Fathy



brick vaults. Each house had a large courtyard in front and a guest room. The facades and doorways reflected peasant architecture at its best, exquisitely decorated with cloisterwork tracery and mouldings in mud."

- The same region was reflooded in 1965, because of the Aswan High Dam. Professional architects were called upon to build the new villages. They produced "one monotonous, flat roof house-type built in stone and concrete", says Fathy, "which was then repeated identically all over the region. Because of the shortage of materials and labour provoked by this project, building activities were held up in the rest of the country. And when funds were short, the architects simply responded by reducing the height of the walls. The low roofs in the blazing desert sun turned these stone and cement houses into ovens, and reports poured in of increased infant mortality."

- Even by standardising housing, says Fathy, architects and planners are unable to reach the poor. A survey of 14 typical villages in Egypt revealed that 27% of the rooms had no roof, because the peasants could not even afford to buy reed stalks, the most common form of roofing.

- Fathy's work has attracted worldwide attention but he is still unrecognised in his own country. "We are all bent upon reducing ourselves from super-Arabs to sub-Westerners", he laments.

- In 1980 the Aga Khan presented 80-year old Hasan Fathy with a special $100,000 award for his lifelong contribution to Islamic architecture.

Saudi Arabia

Saudi Arabia has become a paradise for construction companies from Holland, Britain, West Germany, USA, South Korea and Taiwan. Construction expenditure was estimated at $11,845 million in 1978.

- This building boom has produced a kind of architectural colonialism. Designers based in Western countries make quick visits to Jeddah, Riyadh, Dhahran or Damman and then produce expensive and unsuitable schemes in materials which have to be imported almost to the last door handle and glazed tile.

- Most of the local architecture is vanishing. The tall houses in the centre of Jeddah which T.E. Lawrence saw in the 1920s have been demolished. Their architecture was strongly influenced by the harsh climate. Houses were set at odd angles in narrow streets to catch the wind. Pots of water were kept on window sills to cool the air that passed through.

- Saudi Arabia is mainly a Bedouin society, with few tangible symbols of history. But few Saudis today seem to care about their architectural heritage.

- Saudi vernacular architecture "is one of the most arresting in the world", wrote Dr Ronald Lewcock in the Financial Times in 1978 (Reference 70).

- "With few other material possessions to be proud of", wrote Dr Lewcock, "the sheikhs and merchants had evolved, after hundreds of years of development, houses and forts with unique qualities of strength, order and utility. They maintained these largely mud-brick buildings in their pristine state by frequent replastering and painting, which imbued the obviously perishable materials with the qualities of human care and concern we normally associate with the works of the potter or the sculptor."

- This splendour was brought to an end by cement, now widely used to coat old buildings, reducing them to anonymity. The final blow came when land prices in the centres of old towns like Jeddah and Riyadh began to rocket. Bulldozers came to provide space for inelegant highrise towers or flat-roofed international bungalows.

- Even in the remote rural areas, concrete buildings are creeping in as mud houses are demolished. In the extremely compact towns of the Al-Qasim region of north-central Saudi Arabia, traditional building takes the form of solid blocks of 30 or more mud-brick houses, connected via flat roofs and bridges (or qubbash).

- These houses are usually two or three storeys high. Their bricks are made of mud mixed with wheat straw to resist moisture, and the walls are plastered with mud which is also mixed with straw. Limestone rock, or other local rocks, are used for the foundation and supporting columns. Palm and tamarisk provide timber for the roofs, doors and windows. Thus all materials used are available locally. In this arid region, a mud house lasts for decades.

- But the Saudis seem unlikely to preserve their disappearing heritage. And other, poorer, Arab countries are showing the same contempt for their mud architecture.

- Saudi Arabia says it needs 338,000 urban housing units for 1975-80, compared with 75,000 houses built in 1971-75.

- But a UN study (Reference 71) points out that the "present good quality housing (a house of 200 square mettres is estimated to cost $62,000) is beyond the means of the average Saudi Arabian urban dweller".

- The new houses are often uncomfortably hot. Insulation is expensive and therefore avoided, and air conditioning has to be paid for by the tenant, not the landlord.

- Mud, particularly suitable for the Saudi Arabian climate, is disappearing as a building material. Some work on bitumen-stabilised mud has reportedly been done by the small-scale industries department of the oil company ARAMCO, but it has been little used in Saudi Arabia.

The Yemen Arab Republic (North Yemen)

Yemen is probably the only country in the world where one can find find five or six storey houses made out of mud.

- These houses suit the climate as well as the local traditions.

In rural areas these houses are usually made of compacted mud reinforced by straw and cowdung. In urban areas, sun-dried mud brick is used more extensively. And in the cities, the first one or two storeys are made of stone and the higher storeys of mud.

- Western-type windows are now being purchased and introduced in cities, but rural dwellings remain unchanged. Supports for the floor, which were previously of rough timber and now increasingly of better prepared wooden beams, are becoming difficult to obtain. In the Sana'a area, trees have been planted to produce wood for construction purposes. A report prepared for UNESCO states that more could be done in this way to help traditional architecture.

- Money from Yemenis working abroad, particularly in neighbouring Saudi Arabia, is now said to total $1.4 billion annually. As a result, new houses are being built in virtually every village of North Yemen.

- The government, however, only builds Western-type dwellings. Housing is a major priority of the North Yemen government.

- Outside Sana'a, a Kuwaiti real estate developer is building prefabricated houses, and a 2000-unit township is being built by a Spanish company. The government is planning a second township of about the same size.

- As most of the materials required for Western-style houses are not locally available, extensive imports have become necessary.

Jordan

A construction boom is under way in Jordan. Land prices have risen 20-fold in the late 1970s. A great number of building materials have to be imported, and the construction industry suffers from scarcity of specialised labour and materials.

- All new housing in Jordan is of modern design along western lines. Cement and cement-based products dominate the market.

- In the countryside, houses which were once built entirely of mud are now being replaced by concrete. The government intends to construct 36 new western-style settlements for farming communities, largely to discourage migration to cities. Jordan needs at least 20,000 new houses per year for the next decade.

- In the next two years, the national cement company, which enjoys a government-protected monopoly, will import 500,000 tons of cement every year from Europe. Cement demand is rising at the rate of 15% every year. Plans to build a second cement plant have been approved, but its one million ton annual output will all be exported to Africa.

- At present, there is a surplus of de luxe housing in Amman, and a shortage of lower-cost accommodation. Even the cheapest concrete houses cannot be afforded by unskilled urban workers.

- Dr R.L. Sharif, director of the Royal Scientific Society in Amman, says that studies in Jordan have shown that bitumen-stabilised soil blocks would be technically suitable. But the bitumen is sold by the local refinery at prices that makes its use uneconomic.

Iraq

In 1957, 39% of Iraq's population lived in towns; by 1975 the figure was 59%. Baghdad alone contains 40% of the country's urban population.

- Shanty-towns, lacking basic urban services, have grown up around the cities. And overcrowded old dwellings in the heart of the cities have become slums because of inadequate repair and maintenance. Two-thirds of Iraq's urban population lives with more than two people per room.

- The cost of a conventional low-cost house in Iraq is about $12,000. A family incomes survey in 1977 showed that (assuming a family should not purchase a dwelling costing more than three times its annual income) a conventional low-cost house was beyond the reach of 75% of all households.

- The 1965 census revealed that the main dwellings were brick houses, mud houses and tents. Mud houses and tents accounted for over 27% of the total dwellings. But, according to the Ministry of Planning, these "are considered as substandard".

- There is little effort to develop indigenous building materials. For speed of production and public image reasons, Iraq is developing a prefabricated housing industry. Four industrialised housing factories are being established using the French CAMUS system.

Sudan

Mud houses are common in Sudan. In northern Sudan, David R. Lee wrote in 1974 in the journal 'Ekistics' (Reference 74): "Rooms are covered by a flat roof of sticks and beaten earth. The walls are built of mud - not mud bricks (as in Egypt) or rammed earth (as in ancient Europe) but wet, sticky mud laid in successive tiers."

- "In Sudan this technique is called jalous, and is roughly comparable to cob construction of western England. Wet mud, 18 inches (46 centimetres) high and equally wide, is placed on the ground and allowed to dry. When this tier has hardened a second is added then a third and so on until a solid wall of mud has been built."

- In the dry areas of northern Sudan, jalous walls last for years when they are protected with traditional plaster: a mixture of mud, straw, and animal dung.

- And, says Lee, "the massive mud walls effectively reduce interior temperatures during the stifling summer months, when daily maximums

above 100°F (38°C) are not uncommon".

- Most of the jalous houses in northern Sudan are single-storey structures. But (writes Lee) there were some remarkable two-storey houses as well, particularly in the Berber district. These were said by local people to have been built about 70 years ago.

- "The uniqueness of these structures is that they all have walls of some 18 feet (5½ metres) high of solid jalous with no reinforcing elements: no bricks, no frames, no concrete to strengthen the wall. For jalous to support itself above about 8 or 10 feet (2½-3 metres) extreme craftsmanship is required lest the wall of mud should topple." To provide strength, the walls are tapered: thick near the ground and thinner towards the top. Impressive buttresses of solid mud sometimes reach from ground to roof.

- Building costs are very high in the Sudan. Timber, stone, sand, clay and asbestos are plentiful, but concentrated in a few areas. Limited transport causes repeated shortages.

- Sudan imports 40% of its cement and all its ceramic tiles, aluminium, zinc sheets, steel section, and kitchen and bathroom fittings. These materials have to be ordered 6-12 months in advance and bought at exhorbitant prices on the black market. A house built by contractors may take up to 5 years to construct. Yet there is no serious effort to develop the local construction industry.

- Sudan's National Building Research Station has been trying to improve local materials: burnt bricks, sun-dried bricks and vaulted houses. But little has yet been done to apply these experiments on a large scale.

- More recently, the UN Centre for Human Settlements (UNCHS) and the UN Environment Programme have helped the Sudanese government to start a $1 million project to produce asphalt-stabilised mud blocks ('asfadobe').

- The project will involve a mobile asfadobe plant, producing 20 million bricks a year, as well as the construction of a settlement of 200 houses for low-income families in Khartoum. Large quantities of asphalt can be obtained within Sudan relatively cheaply from the oil refinery at Port Sudan.

- According to UNEP, asphalt-stabilised earth is an ancient technique, first used in Babylon in 3500BC.

- In more recent times, asfadobe has been developed and promoted by Hans Sump of Fresno, California, and used in some of the most beautiful and prized homes in California.

- In Sudan, burnt bricks cost $20-32 per thousand. This means heavy pressure on the country's meagre resources of firewood; deforestation has already reached environmentally disastrous proportions.

- Cement blocks are three times as expensive as burnt bricks.

Locally-produced cement costs at least $85 a ton and imported cement costs twice as much.

- By contrast, experiments with asfadobe bricks (2-4% asphalt by weight is added to soil which is 40% clay and 60% sand) showed they could be produced in the Sudan at $12 per thousand; the price could probably be reduced further by mass production.

- "The dependence of low-income families on some form of soil construction is likely to continue for several generations", comments Mr S. Karim of UNCHS. "The asfadobe technology, which Sudan is in the process of developing, could serve as a model for the rest of Africa, particularly for those countries with oil refineries."

Kuwait

Kuwait, which has the highest per capita income in the world, gives high priority to building and housing. A recent development plan allocated 68% of total investment to housing.

- Kuwaiti housing policy, however, gives priority to Kuwaiti citizens. The majority of foreign workers in Kuwait, who are not allowed to own land, are poorly housed.

- Income distribution figures are not easily available in Kuwait. But a study by UNEP and the UN Economic Commission for West Asia estimates that nearly 80% of wage earners in Kuwait cannot afford to purchase the lower income housing type provided by the Kuwaiti National Housing Authority.

- Before the oil boom, houses in Kuwait were made from sun-dried mud pallets or lumps of coral rock taken from the shore. With the disappearance of mud construction, the old art of making thermally-efficient buildings has deteriorated, says the UN study.

- Poor insulation building materials have become a matter of major concern to the Kuwait Institute of Scientific Research (KISR). In the heat of summer up to 66% of Kuwait's installed electricity capacity, says the UNEP/ECWA study, is utilised for cooling.

- Iron and steel required for residential construction is largely imported from Japan. Since the rise in oil prices, the cost of cement has increased by 4½ times. The sand-cement block, which is the most common walling material, "has now become too expensive for most builders of homes", says the UNEP/ECWA report.

Algeria

Algeria plans to build a thousand new villages. The UN University and the Algerian National Organisation for Scientific Research are developing the world's first integrated solar village, which by the end of 1982 should be home to 1500 people. The houses, near Bou Saada in M'sila province, conform to traditional community lifestyles and will be built by local masons (Reference 76).

- The relationship of the village architecture to solar energy use will be of special interest. 'Active' solar energy systems like solar hot water heaters will be used, but so also will many features of traditional Algerian architecture which constitute a 'passive' use of solar energy.

- For example, traditional houses are built with thick mud walls to keep out the heat, with many small windows to let in breezes but shut out the sun, and with indoor fountains for cooling. The work of Professor Hasan Fathy of Egypt is expected to influence the architecture of Bou Saada.

Tanzania

In Tanzania, about 60% of all houses have walls partly or wholly constructed from earth. This proportion is increasing, as many of the traditional grass and pole walls in most of the remaining 40% of the houses are being replaced by earth walls.

- Brick and cement walls, or walls made with soil-cement blocks, form only about 5% of house walls in Tanzania, and are found mainly in towns.

- There are several reasons for this growing shift from grass to earth walls:

  * mud walls are more durable - there is no decay and insect attacks are reduced
  * sun-dried earth walls are load-bearing structures and so no wooden poles are required to support the roof
  * mud walls reduce temperature variations inside the house
  * mud walls are cheap.

- In 1977, President Julius K. Nyerere wrote (Reference 39):

> *"We are still thinking in terms of international standards instead of what we can afford and what we can do ourselves...It is no use expecting the National Housing Corporation to supply all the houses we need...Instead we should concentrate on site-and-services projects, so that people can build for themselves houses which are appropriate to their income, and which can be gradually improved over time."*

- Six Tanzanian housing officials wrote in 1978 (Reference 77) that a village house is only considered good when built of concrete blocks, with a corrugated sheet or flat concrete roof. "Even a burnt brick wall has to be given a thick concrete plaster to give it respectability", they said.

- The 1978 price for corrugated roof sheets alone for a 3 or 4-bedroomed house was at least 1200 shillings ($135). Tanzania's per capita GNP was also 1200 shillings. "The building and construction industry", say the six authors, "exists only for the monetised sector".

- Tanzania has no official standard for traditional housing in rural areas - where 95% of the population lives. And as the

Housing Bank gives loans only for improvement of houses of a certain standard, it means that the bank in effect only grants loans to houses built mainly of cement.

- But banks do not usually like to give very small loans, and they also demand collateral (security) which many villagers cannot offer.

- The building regulations in force in Tanzania in mid-1978 were issued in 1930 with some later amendments. These rules do not refer to traditional houses, locally available building materials, new low-cost building methods, etc.

- The Tanzanian Building Research Unit has worked extensively on low-cost housing and use of local building materials. It recognises that soil is still one of the most important building materials in Tanzania, and has carried out extensive tests on soil stabilisation by adding cement, lime or pozzolana, and on weatherproofing mud walls.

- The BRU is trying to develop roofing materials to replace corrugated iron sheets. One option is to use sisal-reinforced concrete sheets, which are based on a local materials and could be relatively cheap.

- In 1977, 85-90% of rural houses were built entirely of local materials such as soil, wood and grass. And as more and more land is cleared for agriculture or zoned off as reserve forests or national parks, building poles, thatching grass and other natural building materials are becoming scarce.

- Even in urban areas, houses are still being built with traditional materials. The BRU reported in 1973 that about 4000 new squatter houses were being built in the capital each year - a yearly growth rate of 24%. Most of them were built in the traditional manner, with mud, poles and perhaps plaster on the walls. As the demand for bush-poles increased, so did their price, and they are becoming harder to obtain.

- The 1977 BRU report (Reference 78) compared the costs of various methods of building houses. The lowest costs were using mud, pole and plaster, closely followed by soil-cement and sand-cement blocks. But the latter produced much more durable houses, and were cheaper over a period of years. The use of soil-cement is spreading in Tanzania, especially in urban areas.

- Few Tanzanians have enough money to build a house all in one stretch. "The erection is divided into a number of separate tenders for which the potential house owner can hire various fundis (local craftsmen). These will often hire their own labourers if need arises, although the house-owner himself can occasionally lend a hand. Erection of poles for walls and roof, application of mud, plastering, flooring, fixing of roof sheets, making the pit and the outhouse, etc can all be separate tenders... Up to 9 different fundis might in some cases be hired for the completion of a house", said the BRU report (Reference 78).

- Mud, pole and plaster construction is well-adapted to this

stage-by-stage approach, which may extend over one or more years. The owner can buy the poles and hire a fundi to erect them. The poles cannot now be easily stolen, and the owner can wait until he has enough money to buy the corrugated iron sheets. Perhaps some months later when the roof has been finished, mud can be applied to the walls. The house is habitable once the doors and windows have been mounted. Later, the walls can be improved by plastering and laying the floor.

- Houses built of blocks are better and more durable, but the initial cost must include the full cost of the walls, floor and the foundations.

- A 1978 Tanzanian national seminar on science and technology for development noted with alarm that while the urban population was increasing by at least 2.7% per year the housing stock was increasing at only 0.5% per year. "This makes the housing problem in our urban areas very frightening."

- Tanzania's BRU has prepared a book to teach primary schoolchildren traditional building techniques, under the "Education for Self-Reliance" concept. The difficulty, however, is that Tanzanian schoolchildren are already overloaded with other self-reliance courses.

Zambia

Soil-cement may not seem anything to sing about. But the people of George, one of Lusaka's largest shanty-towns, have a song:

Those of George
Have made bricks
Bricks
They call 'em soil cement
Nice ones
So thick and heavy
So cheap
So strong
Ooh for building a house
Ooh for building a house.

- George is today one of the best upgrading projects in Africa: an attempt to make the slum habitable for the people who live in it. The philosophy is to help people to help themselves.

- It has not always been like that in Lusaka. The Zambia News wrote in May 1970:

> *"The demolition of squatter compounds...is a necessary exercise which has got to be undertaken. Our cities, and more particularly our capital, must rid themselves of the scars of such squalid settlements, thus removing the liability from the municipal authorities who are doing their best to plan the most effective future building schemes...*
>
> *"If these people living in these terrible areas which are, of course, perfect havens for the criminal element, use more initiative instead of sponging from the community to which they are contributing nothing, they need not suffer in any way by being moved away from their hovels.*

"In a growing city or town there is no place for the layabout. Either he helps himself or gets out...".

- Essentially, this attacks the poor for being poor, and demands that they go and live somewhere out of sight. Similar statements are still made with monotonous regularity in many, if not most, Third World countries.

- This view is no longer held in Zambia. Seven years after this vehement attack, the Sunday Times of Zambia, on May Day 1977, carried a long story entitled: "Squatters: are they illegal settlers on their own motherland?"

- Articles in the foreign press summarised the nation's new attitude towards slum-dwellers: "Zambia turns its squatters into citizens" (Reference 81).

- What had happened? First, the government had moved towards a people-oriented development strategy. Second, the government had realised that it was illogical to have one policy for building houses for everyone, and another for bulldozing those who had somehow acquired a roof over their heads.

- Third, the government realised that slum-dwellers are not the excrement of society, but in many ways its mainstay. They provide essential services to society very cheaply. As in any other part of the Third World, those who build houses for others in Zambia can seldom afford to build houses for themselves.

- The 1960s copper boom made Lusaka one of the fastest growing cities in the world. By 1979, it was still growing at about 7½% a year, and its total population was over 500,000. Today, Lusaka has 4 times as many citizens as it had less than 20 years ago. By 1990, at present rates of growth, it will have over a million.

- By the turn of the century, half of Zambia's population will be living in urban areas. One in eight Zambians will be living in Lusaka alone.

- Over 80% of the 1963-4 growth was caused by people moving from the rural areas into Lusaka looking for work. They had no place to go but to the shanty-towns. Lusaka's slum and shanty-town population was 17% of the city's population in 1965, and 50% in 1970.

- The shanty-town George grew from 300 thatched huts in 1965 to 2400 dwellings in 1967. By 1973 it had 8584 houses, and by 1977 12,750.

- Between 1964 and 1974, Lusaka's population increased by over a quarter of a million. These people were calculated to need about 56,700 houses. But during that period the Lusaka City Council built only 6934 houses, and about 12,500 officially-sanctioned houses were built by others. Thus about 37,400 families needed, but were not officially provided with, houses.

- During that same period, 27,000 houses were built illegally in so-called squatter settlements, almost 4 times the houses the

city council had been able to build. And, according to government policy of the 1960s, these squatter settlements were all supposed to be bulldozed away.

- In 1972, the ruling party, the SNDP, changed course. "Although squatter areas are unplanned, they nevertheless represent assets both in social and financial terms."

- The people in Lusaka's squatter settlements are not layabouts: over 90% of the people in George have jobs. In fact, in 1976 figures show that there were fewer unemployed in George (5.2%) than in Zambia as a whole (11.3%).

- In 1976, according to a study by Robert Ledogar, the residents of George were benefitting from government expenditure worth 475,648 kwacha ($600,000) through schools, health services, police, food subsidy and municipal services. But they were paying K984,000 ($1,200,000) to the government, through income tax, personal levy for employment, licences for trading, sales tax and excise duty.

- A publication released in the early 1970s called 'Squatter Manifesto' said: "The true significance of the squatters is... that being outside the law they have shown the irrelevance of the law. They are evolving a new way of living that is related to Africa, and not to local authority by-laws evolved by 19th-century Britain."

- In 1975, the government started a $41 million upgrading project with the World Bank, covering 70% of the squatter settlements. It will:

  * Upgrade 17,000 dwellings in 4 of Lusaka's biggest squatter townships: Chawama, George, Chaisa and Chipata
  * Prepare 7,600 new plots in 'overspill areas'
  * Provide residents with technical assistance and small loans to build or upgrade houses
  * Provide community schools, health clinics, markets, community and children's centres, piped water, all-weather access roads, street lighting and drainage.

- This is a self-help approach. The project estimates that it takes K130 ($150) to service one plot and K400 ($500) to build a core house with two rooms and pit latrine. The cost of a conventional city council house (three rooms, kitchen and flush toilet) is estimated at K6500 ($8100). The project provides a loan of K400 ($500) and helps by bulk purchasing building materials.

- The community participates in planning the new township. For instance, the community decides which families must leave the township for an overspill area to make way for a road or to reduce overcrowding, and provides free transport when they move.

- When the Lusaka squatter settlements began in the early 1960s, they had a rural character, with sun-dried mud brick walls and grass thatched roofs. The holes which had been dug to make the mud bricks had been filled with refuse, or turned into composting pits for vegetable or flower gardens. Sometimes banana trees had

been planted on these pits. So most houses had a small garden.

- But by the end of the 1960s, many of the buildings looked more urban: some had galvanised iron roofing, and others were made of concrete blocks and stone.

- The Lusaka project is now promoting the use of compressed soil-cement blocks for upgrading housed. There are several reasons:

  * The price of soil-cement has grown relatively slowly compared to other materials. Between 1st July 1975 and 1st April 1976 (nine months), prices of cement in Zambia went up by 60% and of concrete blocks by 48%. But self-made soil-cement blocks (14:1 by volume) went up only 30%.
  * Soil cement is also cheaper. A three-roomed house built with concrete blocks costs K240 ($300); one made with purchased soil-cement blocks costs K130 ($160); but one made with self-made soil-cement blocks costs only K90 ($110).
  * Making soil-cement blocks uses less time and energy than burnt mud bricks, and they can be made by women.
  * Sun-dried mud bricks are weak and dissolve in rain unless protected by an overhanging roof and strong foundation. Soil-cement blocks are strong enough for high buildings up to three floors, and resist the weather.
  * Soil-cement blocks are thicker than concrete blocks, providing better insulation against heat and cold.

- Compressed soil-cement blocks are made with a machine called a Cinva ram, made at the University of Zambia from a design originally developed in Colombia. One ram is distributed to a group of 5 houses, which passes it on to other households after making their blocks.

- Many households have not liked the Cinva ram, which is slow and makes very small blocks. Instead, they have used simple wooden moulds to make soil-cement blocks, in a soil:cement ratio of 5:1 instead of the 14:1 ratio used in the Cinva ram.

- The Zambian National Science Council has developed a new machine which, although it is rather expensive (K400; $500) is faster than the Cinva ram, makes bigger blocks and uses less cement (16:1 ratio).

- Another Zambian group is trying to build houses in which the corrugated iron roof is replaced with arches of soil-cement blocks. The arches are built in the style advocated by Hasan Fathy of Egypt. Another experiment involves houses made with sun-dried mud bricks and plastered with sand and bitumen.

- Housing standards are an emotive issue in Zambia. Project officials claim that the Zambian authorities have adopted "realistic" and not "idealistic" standards for the upgrading of squatter settlements.

- But there is some criticism that these standards are far too low.

The upgraded squatter settlements still look like squatter settlements, even though they now have roads, water supply, lighting, schools and better constructed houses. It is alleged that the Zambian elite is only upgrading squatter settlements far from the prestigious town centre. Those settlements which are close to it may still be removed entirely.

Kenya

According to Erica Mann of the Kenya Architectural Association: "The planning authorities here - like in other developing countries of Africa - look upon mud and any other traditional building materials, as a left-over from their past, and are not very sympathetic to its re-introduction".

- The Housing Research and Development Unit at Nairobi University tried several years ago to test various processes of soil stabilisation, says Mrs. Mann. This was abandoned, mainly because of lack of facilities and trained personnel, but also because of "the reluctance of local students to being drawn into this sort of 'backward' exercise".

- Professor R.B.L. Smith of the Civil Engineering Department of the University of Nairobi is currently working on sisal-cement rendering of mud brick walls. He considers it will provide cheap construction which will weather well and look good, as well as being more hygienic than mud.

- UNICEF's Village Technology Unit in Nairobi runs regular courses in the production of compressed soil-cement blocks using Cinva rams; the rams are manufactured locally in Nairobi. The unit trains instructors for Kenya's rural polytechnics, who then are expected to disseminate their information to the rural people.

- Mobil and other oil companies in Kenya have recently become alerted to the potential of asphalt in the building industry, and a conference was held in Nairobi in December 1979. A stable, rapid-curing asphalt emulsion for the production of asfadobe is now being made in Kenya and transported by tankers to a development project in Juba, southern Sudan. A demonstration house may be built soon in asfadobe, in Dandora, a 6000-unit World Bank-supported site-and-services scheme in Nairobi.

Mozambique

After Independence, the Mozambique government declared urban housing a national priority. But it found that even low-cost housing was too expensive for most of its urban population. Such houses usually go to the middle classes, especially civil servants.

- The Mozambique government is therefore encouraging self-help traditional building materials. Efforts are being made to improve the design of traditional 'pau a pique' or cane houses. These houses are built with a frame of wooden poles or canes, spaced about 50 centimetres (20 inches) apart, with the gap filled by stones and mud.

- Pau a pique houses last only five years, but improvements are being introduced which are expected to extend this to 30 years:
  * a slightly raised base to improve drainage
  * a ceiling to improve temperature control
  * larger windows to improve ventilation
  * walls coated with cement to preserve the mud and wood
  * orienting the house north-south and painting it white, to reduce heating.

- A three-bedroomed house of the improved type costs about $1,600. But there are still two serious problems that have to be overcome: protecting the wood from termites, and replacing the thatch with a more permanent roof. Metal sheets are increasingly being used as roofs, but they become very hot in summer.

- The Portuguese left behind a prefabrication industry in Mozambique. The government is now trying to make best use of its products, as it does not want to dismiss the industrial workers, no matter how inappropriate the products they are producing.

- So some prefabricated components are encouraged even in traditional houses: pre-stressed roof beams, concrete slabs for kitchen and bathroom sinks, prefabricated sinks and shower bases.

- For upgrading Maputo's canico areas (the 'cane' city), the government is encouraging soil-cement blocks (Reference 81).

Ghana

Ghana has one of the most rapid rates of urbanisation south of the Sahara. Its urban population is growing nearly twice as fast as the national population increase.

- In 1970, 30% of Ghana's people lived in towns with populations over 5000. The capital, Accra, grew by 40% between 1970 and 1976.

- Most of the urban population is poor. Half the households in Accra had an annual income less than 1900 cedi ($650) in 1977. Few can afford to pay more than 10-15% of their income on housing, so their houses are largely built of traditional materials.

- Since Independence in 1957, Ghana has had many housing schemes - but none has made any major impact.

- The two government housing corporations and the official Low-Cost Housing Programme generated about 4000 new houses every year between 1972 and 1976. These houses received high government subsidies, but were still acquired by relatively rich households.

- The 1975-80 Five Year Plan recognised that there had been "no consistent direction in housing programmes for many years".

- A large proportion of Ghana's urban houses (54% in 1960 and 43% in 1970) and most rural houses (94% in 1960) are made from a clay material called 'swish' or 'atekepame'.

- Compacted laterite (a well-weathered, iron-rich soil) is formed into balls and laid in smoothed layers of about 1½ feet (46 centimetres). A swish house can last for 25 years or more.

- Swish was introduced to Ghana in the mid-1880s, but has never been truly Ghanaian. It is built by itinerant builders, usually from neighbouring countries. Since the Aliens Compliance Act of 1969, the number of swish builders has decreased substantially.

- Swish, unless it uses stabilising materials, is now much less used for new urban building. Many houses are now built of soil-cement or sandcrete - laterite-stabilised cement at a ratio of 12:1 to 24:1. Sandcrete blocks, manufactured by simple machines in small factories, vary widely in quality.

- The UK Building Research Establishment took soil containing 6% lime to make blocks in a Cinva ram at Kumasi. Walls constructed with these lime-stabilised soil blocks show negligible erosion after standing out in the rains for a year, while similar walls of unstabilised soil blocks had eroded appreciably.

- Cement production severely limits the construction industry in Ghana: cement products account for 30-60% of total building expenditure.

- The cost of a simple one-room house using sandcrete blocks and asbestos-cement roofing sheets has increased by 170% since 1967. This has made it more and more difficult for low-income earners to buy a house. The same one-room house built with fired clay bricks or sandcrete (stabilised soil) costs 15% less.

- The Ghanaian roof loan scheme provides loans for building materials to members of approved village housing societies.

- Low-income households are generally able to build their houses using traditional techniques and materials, but cannot afford the roof.

- Loans in 1970 averaged about $130 for a dwelling of about 260 square feet (24 square metres). But the roof loan scheme ran into a high default rate, with one in three loans reported in arrears. If the loan agency tried to sell the house, neighbours were not willing to purchase it and contribute to the eviction of a fellow villager. The security of the loan was thereby diminished and the scheme has had little impact on rural housing.

- Ghana has probably done more research on traditional building materials than other sub-Saharan African countries. But the government has never planned seriously for their use.

- A.A. Hammond, chief technical officer of the Building and Road Research Institute at Kumasi, wrote in 1973: "People will continue to live in mud houses for some time...This being the case, governments of developing countries must undertake to help reduce the deterioration of these houses and to improve their durability" (Reference 84).

- Austin Tetteh, dean of architecture at the Kumasi Institute of

Science and Technology, in a lecture during the 1976 UN Habitat Conference, called for much greater use of local materials. Third World countries were not going about this in the right way. "We search for local sources of cement...establish cement factories and industries for the production of aluminium roofing sheets. The fact that these materials are produced locally reduces the cost by only a small margin."

- "We have much to learn from the traditional methods of house construction", he continued. "The main problem with using mud in house-building has been that it absorbs a lot of water and collapses very easily. However, we have been able to protect walls against absorbing a lot of water, and can build mud houses which can stand for more than 50 years. If we look at this as an alternative source of building material, I think it will go a long way to solving our housing problems."

- "If we are to enable our people to use local materials", claimed Tetteh, "then the elite, the planners, the people who have been educated abroad or in the mould of the developed countries, have to learn not to denigrate traditional materials" (Reference 86).

Nigeria

Nigeria is one of the wealthiest and most rapidly urbanising countries in Africa.

- "Solving Nigeria's housing problems by just 'building more houses' is not only an over-simplification of the central issue, but it is also easier said than done", says Adenrele A. Awotona, lecturer in architecture at the University of Lagos (Reference 87).

- Should the government try to build all the necessary houses itself? "Until the petrodollar economy", says Dr David Aradeon of the School of Environmental Design, Lagos, "no Nigerian government could have thought it possible to do so" (Reference 88).

- In 1975, the Nigerian government unveiled its massive 30 billion naira (N)($6 billion) Third National Development Plan. This included a projected investment of N1.5 billion ($300 million) for 60,000 low-income houses.

- "To have invested that huge amount of money within such a short period is proving to be an unworkable experiment...almost beyond the meaningful financial capacity of the nation", comments David Aradeon.

- Nearly 80% of any construction project in Nigeria depends on imported building materials. The Association of Housing Corporations calculated that the government would need to spend N3.8 billion ($750 million) to provide low-cost housing for all the country's urban poor.

- Aradeon suggests that the role of the Nigerian government should not be to build houses but to stimulate people to invest their own resources in building.

- The Nigerian government is now becoming interested in site-and-services programmes, and upgrading squatter settlements. The Federal Housing Authority, which is particularly interested in the use of stabilised soil,has to import most of its cement.

- Kaizer Talib, an architect at the University of Lagos, distinguishes between two forms of traditional building in the tropics: thick-walled mud buildings of the hot-dry regions and the bamboo, palm fronds and mud-plastered buildings of the hot-humid regions. Both these forms exist in Nigeria and exhibit distinctive cultures, building forms, techniques and traditional use of materials (Reference 90).

- Architect Stevens Ehrlich has (except for the concrete base) used mud in the construction of the Ahmadu Bello University studio theatre, together with domes and grass roofs.

- "Aesthetically, one need only recall the attractive mud buildings of...Northern Nigeria to refute the notion that mud is ugly" said an expert group on human settlements technology organised by the UN Environment Programme in 1976. Skilled Hausa craftsmen have used mud for palaces and houses.

- Talib has built a modern two-storey house to suit the warm humid climate of Lagos. It has an upper floor with light concrete walls. The lower floor,whose undulating walls are made of mud reinforced with bamboo and reeds, is shaded by the upper floor, so inner temperatures remain constant and the mud walls are protected from rain. Light bamboo screens give good ventilation throughout the building.

- This is a rich man's house. But construction through self-help and family labour, and the use of mud and thatch courtyards could help to make traditional buildings cheaper and climatically more suitable.

Upper Volta

Ouagadougou was described as the 'city built with mud' by the French colonial explorer Louis Gustave Binger in 1886. It still deserves this nickname, for even today 40% of the people of Upper Volta's capital live in houses of 'banco' (wet mud) and timber.

- A 1973 UN project for low-income housing concluded that the use of timber for building was clearly irrational in Upper Volta. Wood, the main source of energy in the country, is extremely scarce and is also attacked by termites.

- O.D. Ouedraogo of the Voltan Centre for Scientific Research (CVRS) supports the use of local building materials and popular participation in construction. "This is in no way a fantasy of returning to building idealised precolonial dwellings", he argues (Reference 92). Banco, he says, is the only solution.

- The Ministry for National Education used stabilised and compacted earth for 200 dwellings for schoolteachers. Thus, believes Ouedraogo, "every schoolchild is impregnated with the idea that

mud is an acceptable building material".

- The Centre for the Research and Application of Earth Technology (CRATERRE) of Haut Brie, France, has collected over a thousand publications on earth construction, and its experts have built over 40 earth houses. CRATERRE is currently involved in Upper Volta and Mauritania with what it claims are "the two biggest earth construction programmes in Africa".

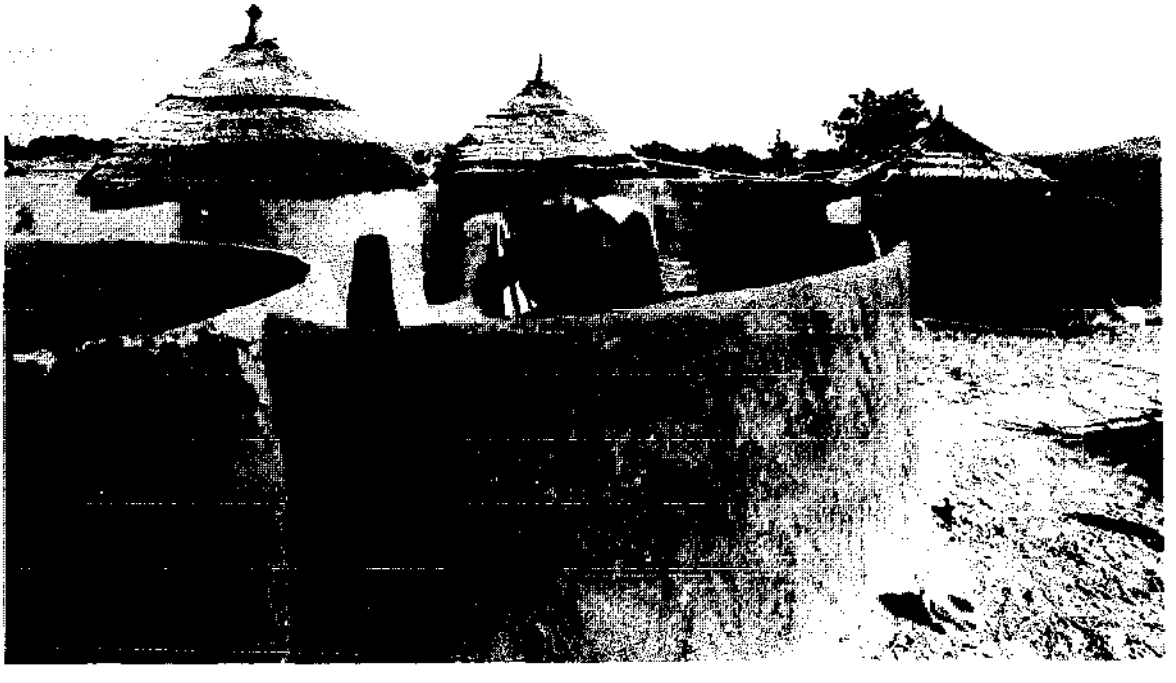
- The Frobenius Institute in Frankfurt, West Germany, is compiling a record of the various forms of mud architecture in Africa to form part of an 'Atlas Africanus', a comprehensive documentation of African cultures.

- Centuries-old mud monuments can still be found in Upper Volta, Mali, Benin, Niger, Nigeria, Morocco, Tunisia and Libya. They reveal the power and wealth of Africa's kingdoms, many of which were as wealthy and technologically advanced as European countries until the end of the Middle Ages.

- "We have set out to record an important testimony to African creative powers before these buildings vanish", comments Professor Eike Haberland, director of the Frobenius Institute.

Mud can be extraordinarily versatile. Mud walls and woven grass roofs form a series of huts and family yards in Upper Volta.

Photo: Sean Sprague



Adobe building reached a peak of variety and magnificence in Peru where the cathedral in Lima is said to be the largest mud building in the world. Above: a typical adobe courtyard and, below, Torre Tagle Palace, Lima.

Latin America

The World Bank estimated in 1970 that 55% of the people in Mexico City and 47% in Bogota could not afford to buy the simplest modern house - even if no deposit were required, mortgage repayment was spread over 25 years, and interest rates were only 10%.

- The slums and shanty-towns use little or no manufactured materials to build their homes. Self-constructed houses are mainly made of cardboard, wood, sheetmetal and occasionally clay roofing tiles. Any materials that have to be paid for are purchased slowly over a period of time.

- What is the future for housing in Latin America? The potential to meet everyone's needs is there, as a study on human settlements in Latin America conducted by the International Institute for Environment and Development (IIED) in London points out (Reference 93).

- "The land exists; the resources exist to fabricate the construction materials...professionals abound...The 'problem' of human settlements is, after all, the problem of poverty."

- Mud houses are very common in the Venezuelan and Colombian Andes. The people there have used the rammed earth method for constructing walls for centuries. Wooden frames are used to hold successive 3-inch (8-centimetre) layers of a slightly moist mixture of small stones and mud, which are rammed down with a 4 x 4 inch (10 x 10 centimetre) wooden post. Non-organic soil with a high clay content must be used.

- The richest tradition of using adobe (sun-dried mud) as a building material comes from Peru, a country with an extremely dry climate.

- A. Hyatt Verrill wrote in 1930 (Reference 94): "In no part of the world...has adobe construction reached such a state of development and attained such heights as in Peru. Long ages before the Spaniards first set foot on Peruvian soil, the Incas and the pre-Incan tribes had learned the use of mud as a building material. Enormous walls, great mounds, countless dwellings, vast temples, and massive forts were built of sun-dried mud bricks and blocks and many of these still remain, little altered by time and elements."

- "The Dons followed their example and used the cheap and easily obtainable adobe in erecting their buildings", he continued. "Their palaces, forts, homes and churches were made entirely of mud, and through the centuries these have endured and remain today as imposing and as beautiful as in the days of Pizarro."

- "The world's largest mud building, the old Lima cathedral, is built of adobe blocks without reinforcement of any kind. But it now has a concrete coating at the base of its walls."

- "Wherever there is available mud, one will see the natives industriously engaged in making adobe bricks", wrote Verrill in 1930. "The mud, dug from any convenient spot, is mixed with sand

and usually with some chopped straw or dried manure. The resultant pasty mass is then pressed into wooden forms or frames. The shaped blocks are then removed and placed in the sun to dry and in a day or two are ready for use."

- "The penniless brick-maker needs little more than his bare hands. With his wife and children, and his worldly goods...he camps upon the selected site...In a few days the brick-maker and his family are surrounded by brick walls...Here they remain as long as bricks can be made and sold on the land."

- Few rich people in Lima today build adobe houses, but the poor still use mud as the most important building material, especially in the squatter settlements.

- The Cinva ram, which has now been used in several places in Africa to make compressed soil-cement blocks, was first developed in Latin America at the Inter-American Housing and Planning Center (CINVA) in Bogota, Colombia, in 1952.

- The University of Kassel in West Germany has developed a special type of shuttering that allows a rammed earth wall to be reinforced by vertical bamboo sticks, a type of wall which in Guatemala has proved to be earthquake-resistant.

- Improvements have also been made to a traditional construction method from Latin America known as 'bajaraque', in which clay is filled into a skeleton bamboo structure.

- The West German aid agency GTZ has been working in El Salvador "to build solid and cheap houses made of soil for the poorest inhabitants in self-help work". Here, extensive deforestation has caused an acute shortage of timber and thatch. Several demonstration houses have been built using lime-stabilised soil bricks which are said not to show any appearances of dissolving even after a month in a water bath.

United States

Individuals in the USA have for a long time talked about using adobe as a building material on an extensive scale, but have never had much success. The reasons have been similar to those advanced today in developing countries (Reference 95).

- In April 1924, an article in 'Scientific American' described how an experimental house was being built in Kansas City using the rammed earth or pise technique imported from Europe. Juanita Porter listed the manifest advantages of pise as a building material: extreme cheapness, untrained labour, saving in transport costs since soil is always near at hand, comfort, cooler in summer than brick, warmer and easier to heat in winter, practically indestructible, low upkeep, practically fireproof.

- In December 1942, 'Business Week' described a Detroit cooperative formed to make houses using rammed earth. Its members were mostly factory workers and followed Egyptian Hasan Fathy's argument that while one person cannot build a house, ten persons can

build ten houses. "Work at night under impromptu floodlights is not uncommon", reported Business Week. The pooled labour made the houses far cheaper than orthodox brick, and stone and wood.

- Frank Lloyd Wright designed several luxury houses built in adobe around that time. One in El Paso, Texas, blended into the desert environment with piles of sweeping sand all around it.

- "We lived in a rammed earth house", wrote Robert Cook to The New Republic in September 1943. "How do I know that my house of earth won't fall around my ears the next time it rains? It hasn't yet and there have been many good downpours since 1928 when we moved in. In fact, the first night...we had 8 inches (200 millimetres) of rain driven by a near gale. I didn't sleep much that night, but the earth walls stood. They have stood ever since.

- "If the time ever comes when the American people at last make up their minds to cut through some of the vested interests and accumulated nonsense surrounding housing and really have low-cost houses, then rammed earth is going to be an important element", wrote Cook (Reference 97).

- The vested interests which Cook talked about in 1943 were "the 'thumbs down' of the building trade and the house-financing trade, and the veto of no building permit" - the same interests which still militate against the use of earth in the Third World as well a the USA. "If I were ever to have a house of earth I would have to build it myself and finance it without benefit of building-and-loan", wrote Cook.

- Several state universities, the US Department of Agriculture, the US Bureau of Standards, and the US Indian Service have issued publications on rammed earth and other forms of adobe construction.

- Based largely on this work in the 1940s and earlier, the US Agency for International Development (AID) published 'Earth for Homes' in 1955 (Reference 99). In a spirited introduction, AID said:"War, preparation for war, great migrations, and many other reasons...(have) resulted in a revival of earth home construction, as evidenced by its widespread use, for instance in Australia where over 9000 earth wall houses were recorded as far back as 1933...".

- Around the same time, AID released another report: 'Handbook for Building Homes of Earth' (Reference 99). "It is possible, even with a little skill, today to build a beautiful, inexpensive and durable home using the oldest construction material known, the earth around us", said AID.

- But mud has seen the revival which AID hoped for in the 1950s neither in the developed countries nor in the Third World.

- But with soaring energy costs, that may be changing. Adobe is becoming a subject of greater interest. In December 1974, soon after the first oil crisis, 'Adobe News' started in New Mexico.

- Its first editorial said: "There is no better material with which to build a home in the southwest than earth bricks: cool

in summer, warm in winter, soundproof from one room to the next, solid yet married to the earth from which it springs, an adobe generates a way of life in harmony with those human values we all sense as righteously desirable".

- Today, hundreds of adobe houses are being built in the USA each year.

- New Mexico has drawn up an adobe buildings standards code, and New Mexico State University has begun an adobe design and construction course.

- Recently, under President Carter, US Assistant Secretary of Agriculture Alex Mercure called for "relatively simple guidelines for financing of homes built with adobe". He called for federal "committment to the use of adobe as well as other less conventional materials which are cost effective".

- The white population may now be making up its mind about adobe. But the indigenous peoples of the USA have always used mud for buildings, and admire it even today.

- The Hopi, Zuni, Acoma and other Pueblo Indian tribes live in the semi-desert plateaux of Arizona and New Mexico. Their pueblos are 3 to 5-storey buildings, with numerous rooms - sometimes hundreds. Each flat-roofed and terraced upper storey is set back from the lower one, but with one multi-storey perpendicular wall at the rear.

- The pueblo is an additive and cumulative building structure that accommodates more or less people as new additions are made or dilapidated sections are demolished.

- The thick walls of the pueblo are built of adobe brick or stone laid in adobe mortar. The walls are plastered with clay mud, and the interior is whitewashed with fine white clay or decorated in colour.

- A roof is made from cedar beams about one foot (30 centimetres) in diameter, laid with small poles, followed by brushwood, grass and a 3 to 4-inch (8 to 10-centimetre) coat of adobe.

- The main floor beams are precious building materials in an arid region. They are constantly re-used and the excess length sticks out beyond the exterior wall to give the pueblo a characteristic appearance.

- The Pueblos are amongst the few US Indian peoples which have managed to retain their culture and their traditional housing systems. Other tribes which have changed their ways are now reported to be keen to revert to their own traditions.

- The Arizona Daily Star reported in December 1977 that the Papagos Indians want to go back to houses which use their ancient building techniques and design. A survey had shown that most of the Papagos were unhappy with the houses that the US government was building for them. One comment was: "It makes us sick to stay in a house of cement. It gives us colds in the winter time".

- The Papago Tribal Council hired an architect, George Myers, to design a low-cost model house that the Papagos could build themselves. He designed a rammed earth house in which the earth had been stabilised by adding 8% cement.

Britain

Europe, despite its cold and wet climate, has had a long tradition of earth houses. Earth buildings can still be found in England, Scotland, Ireland, Iceland, Scandinavia and Greenland.

- There is an old saying in Devon, England: "All cob wants is a good hat and a good pair of shoes". Cob is an English term for mud mixed with chopped straw, lime and sometimes a little aggregate (small stones).

- Walls of cob buildings were kept dry by a generous roof overhang usually made of thatch (the hat); a waterproof plinth would be made to protect the walls from ground damp (the pair of shoes).

- The composition of these plinths varied from region to region: stone and pebbles in Devon, flint and bricks in Norfolk.

- Building in cob was a living craft until recently in many parts of Britain, particularly in Devon and South Wales. Sometimes lime-stabilised mud blocks were also used and they were extremely sturdy.

- But despite its qualities of strength and thermal comfort, mud could not withstand the onslaught of modern building materials. In Victorian England, mud block was gradually relegated to being a poor man's material. Householders anxious to display their affluence would build all their walls of mud except those facing the road, which would be of brick. An observer at the turn of the century noted that half the "brick" cottages in Norfolk were in fact built of mud underneath their 'skin'.

- The decline in popularity of mud was temporarily reversed after World War I. British architect Clough Williams Ellis wrote a book in 1919 called 'Building in Cob, Pise and Stabilised Earth', which still remains one of the best technical works in this field (Reference 104).

- In 1920, the UK Ministry of Agriculture and Fisheries built a number of cottages using various types of building materials available on site, including mud, on the outskirts of the village of Amesbury in Wiltshire.

- The technique used was mainly the rammed earth construction technique; the local soil used had a varying proportion of chalk in it. Most houses had overhanging roofs, and the foundation walls made of brick and concrete rose in some cottages to about one foot (30 centimetres) above the ground.

- A review of these houses by the Department of Architecture at the University of Cambridge in the 1970s noted: "The houses... have remained in very good condition except in some minor details

...The chalk pise (rammed earth) walls appear very sound even though the rendering is missing in places".

- "The maintenance", the report pointed out, "that had been necessary for the houses visited was no more than would be expected in any 50-year old house".

- The people living in these houses said that because of the thick chalk walls, they had installed smaller heating systems and had lower running costs "than in a conventional 275mm cavity brick house". One owner pointed out that "the damp was nothing compared to the damp patches (from condensation) seen in the brick council houses opposite".

- The study concluded: "...The success and teachings of the Amesbury experiment provide good grounds for further thought on building houses of earth".

- The Intermediate Technology Development Group (ITDG) operates a workshop in Warley, West Midlands, which has helped the Bicton Agricultural College in Devon develop a method of waterproofing mud brick walls by coating them with a glass-reinforced cement. A store for the Westbrick Company in Exeter has been built with this technique which has stood well despite two winters of heavy snow and severe frost. Studies are now being made to see to what extent it saves energy.

Mali mud granaries are protected from rain by an overhanging grass roof, and stand off the ground to avoid floods and rising damp. (Note the simple ladder for repairing the roof.)

Photo: Sean Sprague

CHAPTER SIX

CONCLUSIONS

If there is one problem in the world to which no satisfactory answer exists, it is housing in developing countries.

- This document has not been written with any romantic notion about earth buildings or about living in harmony with nature.

- Traditional building materials like earth are important because nearly half of the world's population today lives in earth buildings.

- Conventional houses are so expensive that it is unlikely that people who now live in earth houses will be able to move out of them for decades to come. Millions more will have no choice but to move into ramshackle huts made of cardboard, tin cans, sacking or any refuse material they can find.

- With inflation and rising energy costs, the price of conventional materials such as cement will probably continue to increase faster than the purchasing power of the poor. In other words, it is possible that an even smaller proportion of Third World citizens will be able to afford conventional housing in the future than at present.

- In many Latin American countries, by the early 1970s it was not possible for an industrial worker with an average income to afford the lowest-cost dwelling without a substantial government subsidy. The rural peasant was far worse off.

Figure 6: Housing costs and income levels in Latin America, early 1970s (in US dollars) Source: Reference 16

Country	Lowest-cost dwelling	Minimum income required for purchase	Annual income of manufacturing worker, 1973
Bolivia	4000	1920	731
Colombia	5135	2465	858
Ecuador	1000	480	915
Guatemala	5500	2640	975
Guyana	3705	1778	1000
Argentina	3000	1440	1406
Mexico	3440	1651	2114
Venezuela	5700	2736	3050

- Where large housing programmes were launched with government subsidies, benefits went largely to the rich.

- Traditional construction techniques and materials offer one new approach.

- Greek architect Constantin Doxiadis once calculated that only 4% of the world's buildings had received any input from trained designers. But little is known about the 'non-pedigree' architecture which is responsible for the other 96% of buildings. It does not even have an accepted name: vernacular, anonymous, spontaneous, indigenous architecture.

- Even though interest in housing programmes for the poor is growing, any widespread or sustained move from modern to traditional building materials has yet to take place.

- Why do the poor not want to live in mud houses? Why do they prefer to move into substandard and uncomfortable modern houses?

- Housing is not a high priority for the poor of the Third World. In tropical countries, unlike the rich temperate countries, shelter is not a prime physical necessity. Food, jobs, water, clothes and health services are more important. This is especially true of the rural poor; even for the urban poor, the quality of a house is less important than a house which provides easy access to jobs.

- Economic gain as well as status induces the poor to want to live in permanent concrete houses. As time goes by, the value of a rich man's concrete house and the land on which it is built increases, especially in the urban areas. A concrete house is an investment, which often increases even faster than inflation.

- But a poor man's thatch and mud hut crumbles and decays with time, and its value continually drops.

- So far as housing in the Third World is concerned, the rich man becomes richer and the poor man becomes poorer.

- Cement is in many ways similar to electricity. Its use is concentrated in towns and among the rich.

- Bangkok, with under 10% of Thailand's population, uses 85% of the nation's electricity. An urban Indian uses 28 times more electricity than his cousin in a village.

- The same is true of cement. The average Indonesian uses only 25 kilograms of cement each year, but the average citizen of Jakarta consumes almost 125 kilograms. A Dane uses over half a ton of cement a year.

- An Indian uses only 24 kilograms of cement a year while a Dane uses 22 times more - over half a ton.

- The era of cheap energy is coming to an end. This is forcing governments, industry and individual people all over the world

to reconsider their energy policies. Britain is switching from imported oil back to home-mined coal. And throughout the Third World the poor are being forced to shift from kerosene (paraffin) to firewood and charcoal.

- The cheap cement era - itself a product of cheap energy - is also coming to an end.

- Energy planners are looking again at simpler technologies and more traditional energy resources.

- And housing planners may have to consider new building materials and technologies, and reconsider traditional materials such as mud.

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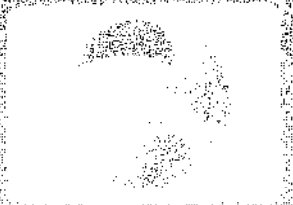

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