SOCIAL AND ECONOMIC CONSTRAINTS TO MODIFICATION AND OBSTACLES TO TECHNOLOGY TRANSFER FOR MAKING MUD HOUSES RESISTANT TO SEISMIC FORCES

By

G.C. MATHUR,
DIRECTOR
NATIONAL BUILDINGS ORGANISATION.
(Ministry of Works and Housing)

&

U.N. REGIONAL HOUSING CENTRE, ESCAP,
NEW DELHI (INDIA) - 110001.

SOCIAL AND ECONOMIC CONSTRAINTS TO MODIFICATION AND OBSTACLES TO TECHNOLOGY TRANSFER FOR MAKING MUD HOUSES RESISTANT TO SEISMIC FORCES.

By

G.C. MATHUR,
DIRECTOR,
NATIONAL BUILDINGS ORGANISATION,
(MINISTRY OF WORKS AND HOUSING),
&
U.N. REGIONAL HOUSING CENTRE, ESCAP,
NEW DELHI-110001.

ABSTRACT:

Great significance is attached to improvement of mud houses in developing countries particularly in areas which are subjected to earthquakes. In India over 72 per cent of the dwellings employ mud as principal building material and two-third of the country lies in seismic zone of moderate to severe intensity. Construction techniques for imparting greater earthquake resistance to mud houses and buildings have been briefly described. Social and economic constraints to improvements of mud houses and obstacles to transfer of technology have been indicated. Appropriate technology being propagated by N.B.O. is briefly described.

SOCIAL AND ECONOMIC CONSTRAINTS TO MODIFICATION AND OBSTACLES TO TECHNOLOGY TRANSFER FOR MAKING MUD HOUSES RESISTANT TO SEISMIC FORCES.

An abode to live in ought to fulfill the basic requirements of living particularly that of structural safety and protection from natural disasters like earthquakes. As such the proverbial 'mud-hut' which abounds in developing countries symbolising simple way of life, needs to be upgraded by application of science and technology to serve the modern requirements of living as well as to resist earthquake forces to the extent possible.

MASSIVE POPULATION AFFECTED

It has been estimated that in India, as per 1971 Census there was a total housing stock of 93.0 million dwelling units in the rural areas. Out of this 72.2 per cent of the dwelling units i.e., 67.1 million, employ mud as the principal building material, particularly for walling in one form or the other Taking an average of 5 6 persons per dwelling unit, the total population in India living in mud houses amount to 376 million. It is evident that to meet the modern requirements of living, the mud houses needs to be upgraded with a view to improving its performance, particularly from the point of view of durability and resistance to earthquakes.

Considering the fact that a large majority of population in India, as in other developing countries, lives in mud houses. there is great need to undertake intensive research and development work to evolve appropriate technology for improving mud houses including its earthquake resistance. However, uptill now not much attention has been given to this problem and mud houses continue to be vulnerable to various hazards, including destructive effects of earthquakes thereby endangering the lives of millions of people.

The gravity of the problem is not realised until a major earthquake is struck, when people think seriously about this problem and lament. Great importance should, therefore, be attached to creating social awareness of the problem and for taking preventive measures to avoid loss of life and property. In this work great significance is to be given to improvement of the technology of mud houses in order that they resist earthquake forces adequately.

It is equally important to draw up a programme of preparedness to meet the eventualities so that soon after the earthquake is struck, re-construction programme could be undertaken with utmost urgency and speed. In fact the reconstruction programmes provide an opportunity to take advantage of improved technology of construction of mud houses and buildings to resist earthquake forces adequately. It is often seen that such opportunities are not fully utilized as due to exigencies of situation, reconstruction programmes cannot be delayed and traditional techniques, that are deficient in many respects from earthquake resistant point of view, are per force adopted. Such a situation should be avoided by advance planning.

MUD HOUSE TYPES

Several types and modes of construction have been adopted in different parts of India for building low cost houses and buildings using mud as a principal building material. Several local variations are noticeable in the construction techniques depending upon the type of dwelling including the size of rooms and openings, the characteristics of soil, the geographical requirements such as extent of erosion from rainfall, subsceptability to flooding, vulnerability to cyclones and earthquakes, etc.

Basically, the use of soil is made for construction of walls which are either non-load bearing or load bearing. Often the foundations, plinth and superstructures are made of the local soil. The roofing may also consist of mud construction or other types of traditional roofing such as use of grass, thatch, palmyrah leaves, clay roofing tiles, etc.

SEISMIC RESISTANCE

In India almost two-thirds of the country lies in seismic zone of moderate to severe intensity. In the past, several catastrophic earthquakes have struck causing large scale damage and destruction to houses and loss of many lives. The human habitations both in urban and rural areas, are becoming very dense and congested due to fast rate of increase in population, which is of the order of 2.5 per cent per annum. It is, therefore, becoming increasingly important to ensure that in the event of earthquake damage and destruction to houses should be minimised to the extent possible. Obviously the mud houses which are in existence in large numbers, particularly in the earthquake zones, need to be strengthened to resist earthquake forces adequately and in the construction of new houses using mud, due attention should be given to improve its resistance to earthquake forces.

DESIGN AND CONSTRUCTION OF MUD WALLS

In olden days some traditional types of construction technologies had been developed by adoption of which earthquake resistance houses using soil as a building material could be made more resistant to earthquake forces.

For example, in the State of Jammu & Kashmir in India, which lies in earthquake zone V (severe intensity) in the construction of mud houses the traditional method of 'Dhaji Diwari' technique is adopted to minimise the destruction during earthquakes. The method of construction comprises of making in-built timber frame construction with diagonal braces in the body of the mud walls, which imparts greater rigidity to the structure.

In Assam, which also lies in earthquake Zone V (severe intensity) the system of 'Ikra' walling is adopted, which resists earthquake forces admirably. This structure is light comprising of timber frame construction with in-fill panels of reed or split bamboos having mud plaster on either side.

In other areas in earthquake Zone IV (moderate intensity), twigs and branches of trees are incorporated in the mud wall by way of reinforcement to offer greater resistance to earthquake.

Instead of using lumps of mud for construction of walls, use of sundried bricks is made for masonry work or rammed earth construction is adopted which provides better performance in the event of earthquake.

In addition to the above, some traditional design and construction practices pertaining to height thickness and length of walls, distribution of roof load on walls, placement of openings for doors and windows in walls, etc. are in vogue which are based on considerations for imparting greater resistance to earthquake forces.

In olden days use of sun dried bricks was also made for construction of domes and vaults, taking advantage of arch action for resisting horizontal forces which are a major cause of destruction during earthquakes.

It is necessary to scientifically analyse these construction practices in terms of their behaviour during earthquakes to identify and also evolve rational design and construction practices that are economical for wider adoption.

ROOF STRUCTURE AND COVERING MATERIAL

The structural behaviour of the roof over-the-head, including the covering material and the supporting structures for the roof have great significance in the design and construction of earthquake resistant houses and buildings.

Thatch roof is most commonly adopted in India and light structure for supporting roof structure transfers the roof load to the mud walls in a manner that in the event of earthquake least damage and destruction is caused to the mud walls and by preventing their collapse, injury to the inhabitants is avoided to the extent possible.

Light roof coverings of shingle or wood veneers having light structure of timber for supporting the roof are constructed in areas prone to earthquake of moderate to severe intensity.

Sloping roofs are made of clay tile coverings or stone slates are more vulnerable to earthquake forces as the tiles and slates are easily dislodged.

The use of roofing sheets such as galvanised iron sheets and asbestos sheets over proper supporting structure offer better resistance to earthquake forces as the sheets are light and in the event of earthquake they may be dislodged but they do not fall down immediately.

However, flat roof construction using mud as a roofing material is also adopted in earthquake regions. The roof is generally constructed with timber rafters spaced at short intervals on which wood flats are placed to cover the gap. over which a layer of mud is spread to form the roof covering. This type of roofing also offers better performance during earthquakes as it prevents the collapse of the entire roof and only portions of it are damaged.

RESEARCH ON MUD HOUSES

Mud houses are built by people themselves through self-help. Mud or soil that is locally available is the principal material for construction particularly for walling. Thatch, jungle wood and bamboo are often procured by the people from nearby forests at very little costs. As such low cost mud houses can be said to be in a way "no cost" houses. However, such houses require frequent repairs as mud walls are damaged due to heavy rains and thatch is required to be replaced due to decay and is vulnerable to fire. As a result of research and development work undertaken in India, simple and inexpensive techniques for protecting mud walls and extending the service life of thatch and minimising fire hazard are being widely propagated by National Buildings Organisation, New Delhi, India which is also functioning as United Nations Regional Housing Centre for ESCAP.

SOCIAL AND ECONOMIC CONSTRAINTS TO MODIFICATION

In any large scale programme of improvement of houses particularly to improve their earthquake resistance of mud houses, which are existing or are being put up in large numbers it is important to identify social and economic constraints which come in the way of modifications evolved as a result of research and development of science and technology. Figure 1 presents important social and economic constraints. The social constraints include:

(a) Lack of Awareness: A vast majority of population, particularly in the low income groups, is oblivious of the potential hazards to houses and buildings in the event of earthquakes. It is necessary to bring home to them the implications of earthquake disasters and the difficulties and costs involved in undertaking large scale re-construction work. Information about past case histories of incidence of earthquake damages can be an eye opener in creating in them an awareness for effecting improvements to their existing houses and for building more earthquake resistant houses.

(b) Attitudinal Change: The mass of population is largely tradition bound and offers resistance to change due to several inhibiting factors. Through dissemination of information, personal contacts and community action. attitudinal changes have to be brought about so that the people become responsive to modifications required to make buildings and houses more resistance to earthquake forces.

(c) Illiteracy: Large population in developing countries is not literate. As such they are unable to appreciate scientific and

technological developments and the advantages accuring thereof. Their backwardness can be substantially eliminated through a programme of literacy. Emphasis would have to be laid on non-formal methods of education and greater importance would have to be given to audio-visual media in imparting education and presenting information regarding prevention of damage and destruction to earthen houses and buildings most commonly built by them.

(d) Lack of Motivation: Unless the people particularly in the low income groups, see for themselves benefits accuring from proposed modifications to the existing houses or in the construction of new houses to improve their performance in the event of earthquake they do not come forward to adopt improvements. It is therefore necessary to motivate them so that they themselves are willing to adopt improvements and this calls for a programme of motivation through several means.

(e) Lack of Community Action: It is often seen that individuals may not come forward to accept modifications to safety of houses in the event of earthquake. However, community action can be taken advantage of to bring about desired improvements. For this the local community organisations would have to be activised and the local leadership appropriately oriented. This will greatly promote the programme of housing improvement through mutual help and cooperation.

The important economic constraints to modifcation include:

i) Acute poverty: In most developing countries a vast majority of the population lives below povery line and their consumption level is below subsistence level. They have per force to stay in improvised shelters made practically at no cost using locally available materials. Poverty is the predominant inhibiting factor which makes them averse to any modifications to improve their houses.

ii) Poor occupational base: There are several factors which contribute to poverty and important among them is the poor occupational base on account of which the poor have no option to increase their level of income, without which it is difficult to undertake any effective programme for improvement of existing houses to withstand earthquake forces.

iii) Lack of Credit Worthiness: As poor people and those in the low income groups have hardly any assets or very low assets in the form of land and houses, they are not in a position to borrow any money from credit institutions like Banks, Cooperatives etc. for improving the earthquake resistance of their houses. Unless they are able to procure some finances at low interest rates, they will not be able to adopt appropriate modifications.

iv) Non-availability of Materials: Often improved construction techniques involve use of specific types of materials, products and

techniques. Non-availability of such resources as well as appropriate skills prevents adoption of modifications. Even though these may be available obviously, some extra cost may be involved in their adoption which the poor people are not in a position to afford.

Although research and development work to some extent has been undertaken to tackle technological problems of improving the resistance of mud houses to earthquakes, not much research and investigations have been undertaken. To eliminate or reduce the impact of the social and economic constraints to modifications as mentioned above, there is great need to undertake studies in order to investigate and establish the relevance of technology in terms of social and economic change.

OBSTACLES TO TRANSFER OF TECHNOLOGY

The vast majority of population who live in mud houses are tradition bound. They have been adopting age old techniques for building their houses using the local soil. In order to improve the durability and performance of mud houses, particularly their resistance to seismic forces, some innovative techniques of design and construction of houses have been evolved which have been briefly mentioned above. The work involved in transfer of technology is faced with many obstacles arising mainly out of

(a) the extensive area to be covered as human settlements are scattered far and wide and many villages are in remote areas;

(b) the villages to be reached are colossal in number as in India where there are more than 7,000,000 villages;

(c) a wide variety of climatic and topographical conditions are to be encountered which have far reaching impact on the type of houses and materials used for construction;

(d) lack of awareness and non-availability of required technical know-how and skills as regards improvement of seismic resistance of mud houses;

(e) absence of financial and institutional support to promote improvements in mud houses etc.

To surmount the obstacles a comprehensive programme for transfer of technology therefore needs to be evolved to bring about improvements in mud houses. The ingredients of the programme and their interaction are illustrated in Figure 2 and briefly described hereunder.

i) Providing Incentives: Motivate the rural people in improving their mud houses for which greater awareness regarding the draw backs of dilapidated mud houses and structural deficiencies of such constructions and possible damage to these in the event of heavy rainfall, earthquakes etc. should be brought to their notice.

ii) Provision of Financial Assistance: Financial assistance to the villagers for improving their houses could be in the form of subsidy or loan on easy terms. Instead of this required building materials could also be supplied to them if possible free of cost or at low cost.

iii) Technical Guidance: Technical guidance in adopting improved mud construction techniques by dissemination of information, demonstrations, exhibitions etc.

iv) Demonstration Projects: Demonstration rural housing projects should be taken up to create an impact of improved mud construction techniques so that the villagers can appreciate the proposed improvements.

v) On-the-job Training: On-the-job training should be imparted to unskilled and skilled villagers in the techniques of improved mud construction.

vi) Organising Communication: A proper system of communication between research and development organisations and the village community should be established to bring to them the potentialities of new construction techniques for improving mud houses.

vii) Institutional Support: Institutional arrangements should be made to organise, support and propagate improvements in mud construction and for channelising necessary financial and technical assistance.

viii) Undertaking Research and Development: Research and development work should be undertaken in tackling local problems that are involved in effecting improvements in mud construction in different regions.

APPROPRIATE TECHNOLOGY OF IMPROVED MUD HOUSE:

The National Buildings Organisation. New Delhi which is also U.N. Regional Housing Centre of ESCAP has evolved a typical design of an improved low cost mud house as shown in Figure 3 and which provides a plinth area of 20 sq.m. having one room, a separate kitchen and a platform. A built-in latrine and a bathing place is also provided. The house is intended for the landless rural families whose number is estimated to be 17.6 million in India. Each of these families are being allotted

100 sq. yd. plot of land free of cost for putting up a modest house largely through self-help making improved use of local materials like mud.

The walls of the house are to be constructed with sun-dried bricks produced from the local soil which improves its structural performance including earthquake resistance. Also waterproof mud plaster is to be applied on the walls to protect the mud walls. It is prepared by mixing upto 5 per cent bitumen emulsion with ordinary mud plaster with straw and cow dung. To prepare bitumen emulsion 80 per cent of 80/100 grade bitumen is mixed with 20 per cent keroscene oil and creosote oil and heated upto 100° C. One per cent wax is also mixed with kerosene oil.

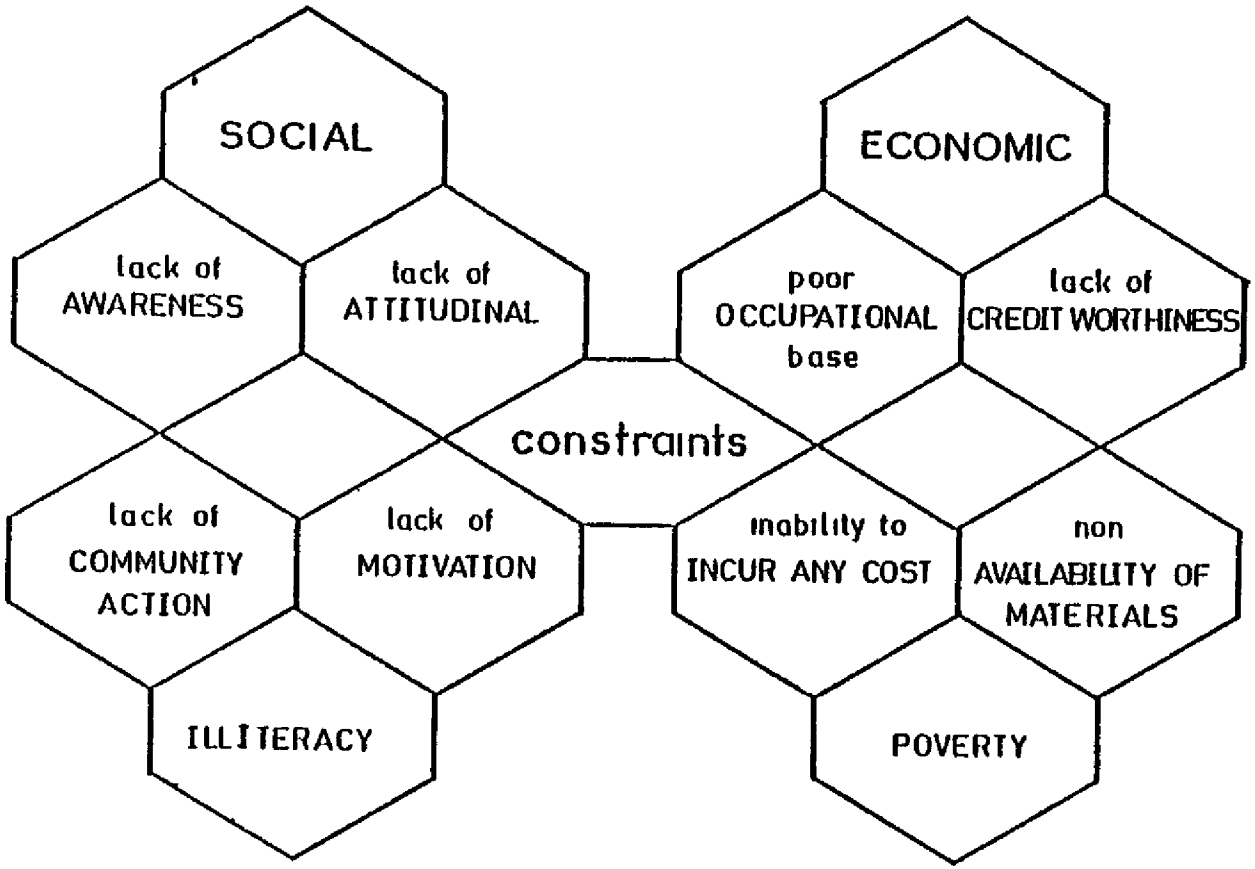
The roof is made of thatch over supporting bamboo or timber structure. For reducing fire hazard the top and bottoms surface of the thatch are plastered with bitumen stabilised mud and a solution of bitumen is prepared by adding one per cent of hot melted bitumen into 2 per cent of kerosene oil and stirred. One coat of this emulsion is applied by brush on the top surface of the well-dried and plastered thatch. The treatment is allowed to dry for three to four hours and then the second coat of this emulsion is applied.

Other methods for imparting greater earthquake resistance to mud houses have also been suggested. These include bamboo reinforced mud construction, use of stabilised soil blocks for construction of walls, construction of walls with bamboo frame and mud-in-fill panels etc.

DEMONSTRATION HOUSING PROJECTS:

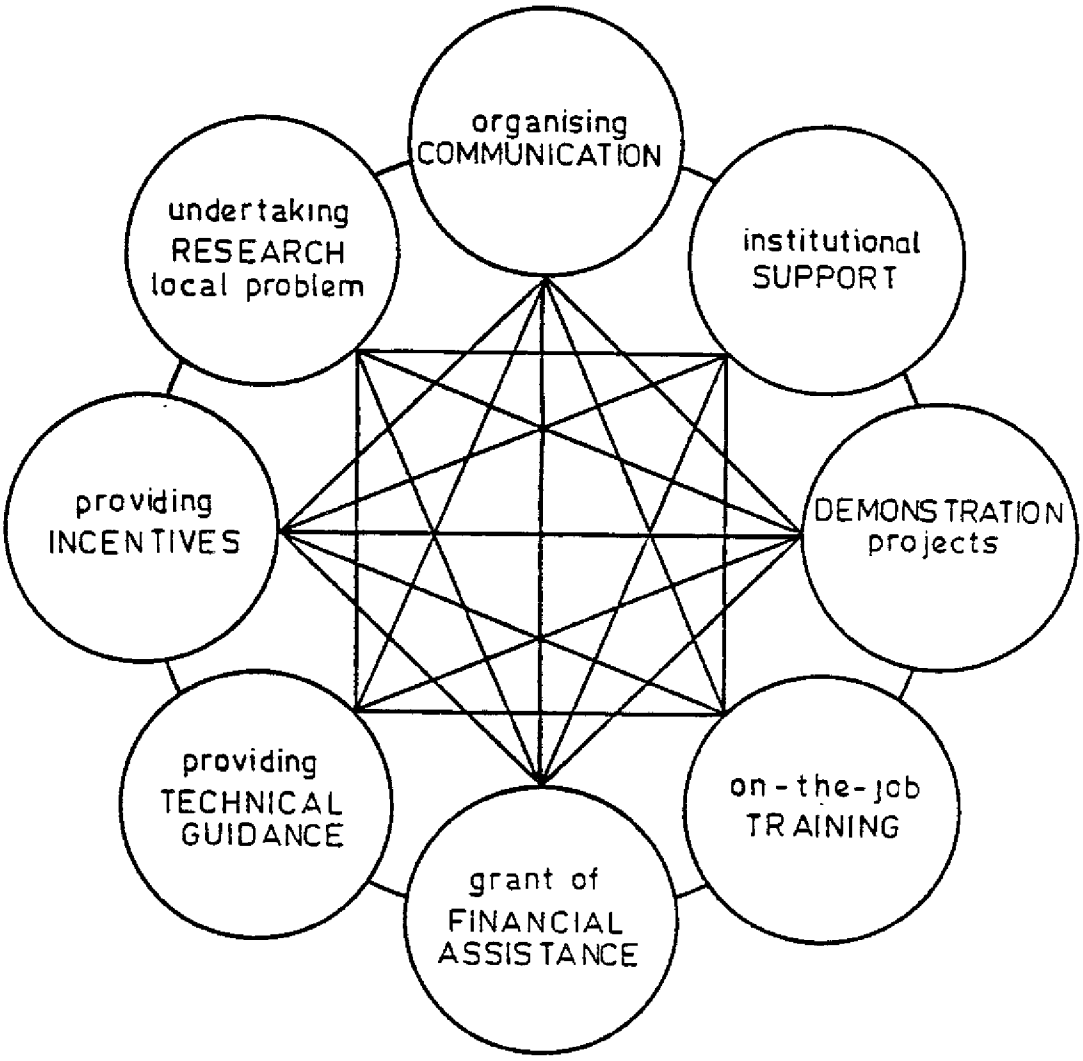
Several measures have been adopted for transfer of technology particularly in the rural areas by the National Buildings Organisation and its Nine Regional Rural Housing Wings which are engaged in promoting improvement in design and construction of rural houses. Clusters of 20 demonstration low cost houses have been put up so far in 36 villages in different regions in the country having varying climatic conditions with a view to motivating the rural people in adopting appropriate technology largely for building more durable and earthquake resistant low cost houses based on improved use of local materials such as mud, bamboo, timber, thatch, etc. and self-help building methods.

The basic principles of design and construction of earthquake resistant houses and buildings have been widely propagated through a movie film 'When the Earth Trembles' and 'For You a Cheap House', the production of which was sponsored by N.B.O. A number of T.V. and radio programmes, desmonstration and exhibitions have been put up to widely propagate appropriate techniques of construction of mud houses which may offer greater resistance to seismic forces.



SOCIAL & ECONOMIC CONSTRAINTS

FIG. 1



TRANSFER OF TECHNOLOGY

FIG. 2.

IMPROVED MUD HOUSE FOR THE RURAL POOR.

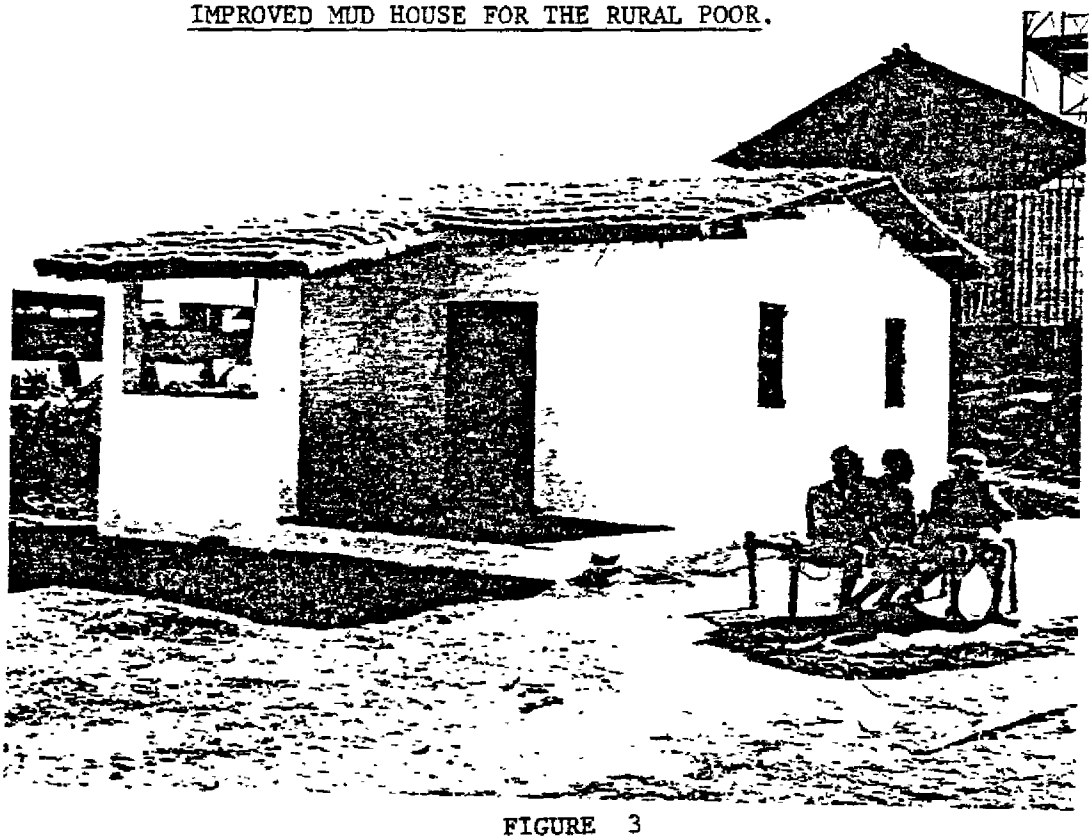
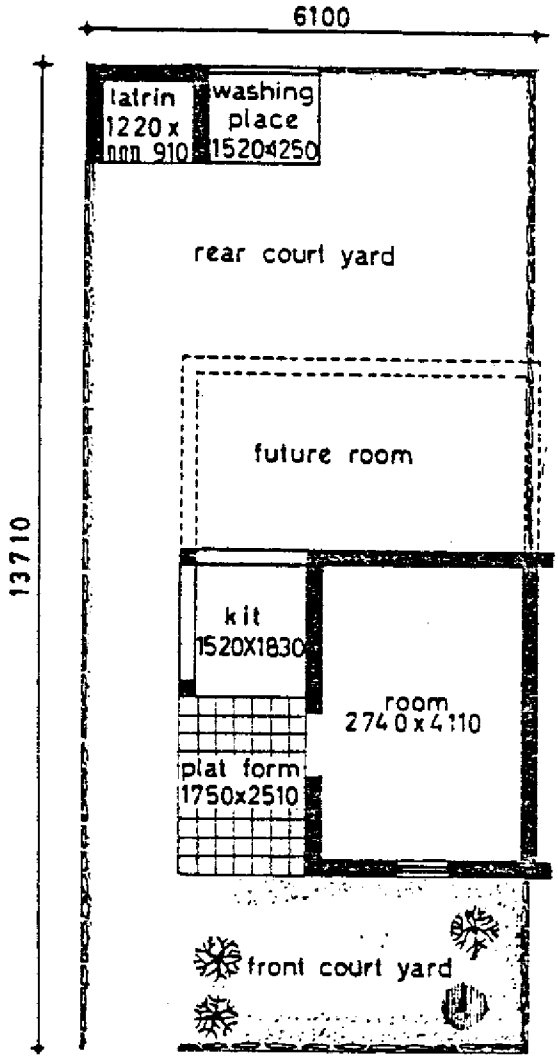


FIGURE 3

FIGURE 3-A



	Thatch Roof	Tile Roof
Plinth Area	.....20m²	20 m²
Cost	.....1500/-	Rs. 2000/-

IMPROVED MUD HOUSE FOR THE RURAL POOR.