



**ANNAMACHARYA INSTITUTE OF TECHNOLOGY & SCIENCES**

**(AUTONOMOUS)**

**UTUKUR (P), C. K. DINNE (V&M), KADAPA, YSR DIST.**

Approved by AICTE, New Delhi & Affiliated to JNTUA, Anantapuramu.

Accredited by NAAC with 'A' Grade, Bangalore.



# ***COST EFFECTIVE HOUSING TECHNIQUES***

**(23HPE013a)**

**Lecture Notes**

*By*

*K Chandrakala*

*Assistant Professor*

*Dept. Of Civil Engg.*

*AITS, Kadapa*

| CIVIL ENGINEERING   |                                                                |   |   |   |   |
|---------------------|----------------------------------------------------------------|---|---|---|---|
| III B.Tech – II SEM |                                                                |   |   |   |   |
| Course Code         | COST EFFECTIVE HOUSING TECHNIQUES<br>Professional Elective-III | L | T | P | C |
| 23HPE013a           |                                                                | 3 | 0 | 0 | 3 |

**Course Objectives (COs):**

**The objectives of this course are to make the student to:**

1. Analyze the housing scenario in urban and rural areas, including challenges in housing finance and urban planning.
2. Explore and evaluate innovative low-cost housing technologies for sustainable construction.
3. Investigate alternative building materials and infrastructure services for cost-effective housing solutions.
4. Assess rural housing techniques, including traditional mud housing, soil stabilization, and fire treatment for roofing.
5. Develop strategies for housing in disaster-prone areas, with a focus on earthquake, cyclone, and flood-resistant construction.

**Course Outcomes (COs):**

**After successful completion of this course, students will be able to:**

1. Examine the current status of urban and rural housing and analyze the role of finance and planning in housing development.
2. Evaluate and recommend cost-effective construction techniques, prefabrication and innovative roofing/flooring systems.
3. Assess the feasibility of alternative building materials and infrastructure solutions for low-cost housing.
4. Analyze traditional rural housing methods and propose modern techniques for improving rural housing quality.
5. Design housing solutions for disaster-prone areas by incorporating earthquake, cyclone, and flood-resistant strategies.

| CO – PO Articulation Matrix:- |      |      |      |      |      |      |      |      |      |       |       |       |       |       |
|-------------------------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|
| Course Outcomes               | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 |
| CO -1                         | 3    | 2    | 1    | 2    | -    | 2    | 2    | -    | -    | 1     | -     | 1     | 2     | 2     |
| CO -2                         | 3    | 3    | 2    | 3    | 2    | -    | 3    | -    | -    | -     | -     | 2     | 3     | 2     |
| CO -3                         | 3    | 2    | 3    | 3    | 2    | -    | 3    | -    | -    | -     | -     | 2     | 3     | 3     |
| CO -4                         | 2    | 3    | 3    | 3    | 2    | 2    | 2    | -    | -    | -     | -     | 2     | 3     | 3     |
| CO -5                         | 2    | 3    | 3    | 3    | 3    | 3    | 3    | -    | -    | -     | -     | 2     | 3     | 3     |

**UNIT – I**

**Housing Scenario :**Introducing - Status of Urban Housing - Status of Rural Housing

**Housing Finance:** Introducing - Existing Finance System in India - Government Role as Facilitator - Status At Rural Housing Finance – ImpedimentIn Housing Finance and Related Issues

**Land Use and Physical Planning for Housing :**Introduction - Planning of Urban Land - Urban Land Ceiling and Regulation Act - Efficiency of Building Bye Lass -Residential Densities

**Housing The Urban Poor :** Introduction - Living Conditions in Slums - Approaches and Strategies for Housing Urban Poor.

## **UNIT – II**

### **Development and adoption of low cost Resilient housing technology**

Introduction - Adoption of Innovative Cost-Effective Construction Techniques - Adoption of Precast Elements in Partial Prefabrication- Adopting of total Prefabrication of Mass Housing in India- General Remarks On Pre Cast Roofing/Flooring Systems -Economical Wall System - Single Brick Thick Load Bearing Wall - 19cm Thick Load Bearing Masonry Walls - Half Brick Thick Load Bearing Wall – Fly-Ash Gypsum Thick for Masonry - Stone Block Masonry - Adoption of Precast R.C. Plank and Join System for Roof/Floor in The Building

## **UNIT – III**

### **Alternative Building Materials for Low Cost Housing**

Introduction - Substitute for Scarce Materials – Ferro-Cement - Gypsum Boards - Timber Substitutions - Industrial Wastes - Agricultural Wastes - Alternative Building Maintenance

### **Low Cost Infrastructure Services:**

Introduction - Present Status - Technological Options - Low Cost Sanitation - Domestic Water Supply, Energy

## **UNIT – IV**

### **Rural Housing:**

Introduction Traditional Practice of Rural Housing Continuous - Mud Housing Technology Mud Roofs - Characteristics of Mud - Fire Treatment for Thatch Roof - Soil Stabilization - Rural Housing Program

## **UNIT – V**

### **Housing in Disaster prone areas:**

Introduction – Earthquake - Damages to Houses - Traditional Prone Areas - Type of Damages and Repairs of Non-Engineered Buildings - Repair and Restore Action of Earthquake Damaged Non-Engineered Buildings Recommendations for Future Constructions. Requirement's of Structural Safety of Thin Precast Roofing Units Against Earthquake forces Status of R&D in Earthquake Strengthening Measures - Floods, Cyclone, Future Safety

## **TEXT BOOKS:**

1. Building materials for low – income houses – International council for building research studies and documentation.
2. Hand book of low-cost housing by A.K.Lal – Newage international publishers.
3. Low-cost Housing – G.C. Mathur by South Asia Books



# Housing Sector

## Introduction

Housing is one of the basic human needs along with food and clothing. Mankind has been evolving different kinds of shelter over the years and time. Human ingenuity has led to construction of multi-storeys in recent times. High rise buildings dot the skyline of cities all over the world. Notwithstanding the rapid stride in construction, there is still a shortage of providing shelter to the teeming millions at affordable prices. A survey in most of the developing countries across the globe in 1975 showed that 55% of the households in Mexico City, 50% in Nairobi, 47% in Bogota, 64% in Ahmedabad, and 70% in Bombay could not afford the cheapest dwellings available in the open market. The situation in these cities has since further deteriorated.

Like any other developing country, India too is plagued with the problem of acute housing shortage. As per National Commission on Urbanization estimates, in 1991, there was a shortage of 31 million units, out of which shortage of 10.4 million units existed in the urban sector and remaining 20.6 million units in the rural sector. The



## COST EFFECTIVE HOUSING

---

overcrowding encroachment of available open environmental degradation and crime galore population, the number of slums and shanty towns in major Indian cities at an alarming rate. Over 46 squatter settlements in the cities. Most of these cheapest house available in the urban market. A building materials have further aggravated the problem between the demand and availability of housing.

During 1971 to 1991 there has been the century, in India both in terms of the number of urban as also the urban population. The number of metropolitan in 1981 to 23 in 1991. The cities like Ahmedabad, Delhi, Madras, Kanpur and Pune are experiencing alarming trend of migration to these cities from been observed. According to the 1991 census out of 844 million, 217 million lived in 3,768 urban agglomerations the total urban population of the country lived in Bombay, Delhi, Calcutta and Madras, and the proportion of class I (1 million or above) cities is as high as 65% share of the urban population in small towns has declined, some 13% urban population lived in class, V (50,000 to 99,999) towns, the figure came down to meagre 2.5% in 1991. Similarly in (10,000 to 19,999) towns, the figure has come down from 3.0% in 1971 to 1.5% in 1991. The concentration of settlements in the cities

## COST EFFECTIVE HOUSING

---

designated areas. In 1994, there were as many as 1000 colonies dotted all over Delhi U.T. Apart from mushroom colonies, unauthorised colonies are also now a part of the city. There are some 1,500 unauthorised colonies in Delhi, many of which have no electricity and water connections and no basic amenities. These colonies cover 12,000 hectares of land, 10 times the area of squatter settlements in the city. More than 2 million people live in these ineffective land policy and the excessive demand for housing are responsible for the growth of such unauthorised colonies. The growth of Delhi's housing stock is presently under control, but the unauthorised settlements.

According to a World Bank paper, many big cities in India are experiencing shanty town population growth in the last decade. The problem of a doubling of slums and shanty towns is a major concern.

A qualitative study of housing shortage makes the situation of housing more disquietening. At present, there is a shortage of 10 million kutcha unserviceable housing stock (units with thatched roofs) in the urban and rural areas in the country. According to the Census, the housing stock in urban areas is 'pucca' with walls of brick, stone, G.I sheets or other metal sheets, and roofs of corrugated iron/zinc sheets and reinforced brick/concrete. 24% of the housing stock does not belong to the classified categories namely (unserviceable kutcha) and the balance is unserviceable (units comprise of mud walls and thatch roofs). New



## COST EFFECTIVE HOUSING

---

about 73% of the total housing stock in the country. The one-room dwelling units had an average population of 2.84 of two-room units.

As per the study conducted by the Institute of Development, the rural houses are more than 50 years old requiring footing. It is disgusting to observe that the construction has fallen from 67% in 1961-71 to 32.4% in 1971-81. Simultaneously, construction has increased testifying the fact that the country is still poorer in the country.

# Housing First

## Introduction

The grim housing situation in the country warrants a concerted effort to combat the ever growing demand of housing in the housing sector. Non-availability of adequate funds is, however, a major stumbling block in providing housing in the country. Though in absolute terms, the investment has increased substantially over the years, from Rs. 1,150 crore in the housing sector in the First Five Year Plan (1951-56) to Rs. 1,150 crore (1985-90), the relative sharing of housing sector



## COST EFFECTIVE HOUSING

### Existing Housing Finance System in India

Compared to the Western scenario, the existing system presents an entirely different picture. According to a survey, 90% of houses purchased in India are financed through institutions. The formal housing finance system in India in the form of Housing Finance Companies (HFCs) is of relatively recent origin. Prior to the formation of Urban Development Corporation (UDCO) in 1973, the Housing Development Corporation (HDC) was a government company entrusted with the task of financing urban development projects with prime focus on Economically Weaker Sections (EWS) and Low Income groups (LIG), the organised institutions were not existent in the country.

The housing finance system, as it exists now, covers both the formal sector and the informal sector. The formal sector includes allocations of Central and State Governments, assistance from Life Insurance Corporation (LIC), General Insurance Corporation (GIC), India (UTI), National Housing Bank (NHB), Housing Development Corporation (HDFC), commercial banks, provident funds, institutions like housing finance companies and co-operative societies and employers in organised public and private sectors providing staff quarters facilities to their employees.

The informal sector, on the other hand, contributes to housing through various sources. These include sale of property, saving in cash and kind, sale of personal assets such as gold, property, and borrowings from friends, relatives and co-operative unions.

## COST EFFECTIVE HOUSING

shortly.

### ii) Life Insurance Corporation (LIC) and Corporation (GIC)

The LIC and GIC are playing a very important role, confining themselves largely to refinancing operations. In refinancing, both the LIC and GIC have channelised funds through the HUDCO, the Housing Development Finance Corporation, Governments, Housing Boards, Development Authorities, Housing Finance Societies which are the leading institutions in the housing finance set-up. The recipients of LIC's funds are local agencies which can cater to local requirements and carry out housing activities (With a major thrust on housing the JEWS way).

The LIC has emerged as an important contributor to the housing sector. Up to March 31 1991, it had contributed over Rs. 1000 crore and helped generate 30 lakh dwelling units. The flow of funds was of the order of only Rs. 146 crore in 1992-93 (including Rs. 100 crore under Government's quota). The GIC loans are now being used in schemes in the rural sector. Under the existing guidelines, GIC earmarks 36% of its annual accretion to invest in housing for government for rural housing schemes and also loans to the National Housing Bank, the LIC has jumped into the housing finance way. In June 1989, LIC Housing Finance Ltd. (LIC



## COST EFFECTIVE HOUSING

banks for lending 10 housing sector. These guidelines SCBs are now required to allocate 1.5% of the income year towards lending to the housing sector. The R utilisation pattern for the allocations made by SCBs allocation is for direct lending of which half should be further 30% by way of indirect lending and the government guaranteed bonds and debentures of I mobilise a major portion (over 39%) of the total for sector, there has been a perceptible shift in the pattern with investments in capital market instruments share scenario, the SCBs contribution to the housing sector crore in 1986-87 to Rs. 387 crore in 1990-91, is likely allocation of deposits is raised. It is also relevant to note opt out of housing finance since it represents a high poses more difficulties in servicing as compared to volume ventures.

### iv) Provident/Pension Funds

Provident and pension funds mobilise over 17% household sector. In terms of absolute volumes, they The contribution of provident/ pension funds to the housing by way of loans extended to members. In absolute terms the provident fund increased from IQs. 129 crore in 1991. Besides being a repository of huge investible resources are eminently suited to housing sector finance



## COST EFFECTIVE HOUSING

resources for housing. This is a loan-linked saving scheme known as 'Bausparkassen.' As per this scheme, any individual, anywhere in India, can open the HLA with any designated bank. The responsibility of dealing with him or her on its behalf is given to the branches of public sector banks, scheduled private banks, urban co-operative banks and recognised Housing Finance Companies. The minimum monthly deposit permissible under the scheme is Rs. 100 (for the NHB financial housing projects). This will be credited to the HLA account. After five years, the person can get a housing loan after five years. The person maintains a savings account and he/she receives the loan for housing in proportion to the savings he/she receives the loan for housing in proportion to the savings including interest at the interest rate varying from 10% to 12%. The loan amount ranges between 1.5 and 4 times the amount of savings and interest earned. Savings in this account interest is eligible for tax concession under section 80(c). Saving, thus mobilised, is to be used by the bank for advancing loans to the private sector, manufacturing building materials and to individuals.

*The NHB extends facility of refinancing to scheduled banks, urban co-operative banks, finance societies and housing finance companies in respect of the following:*

- (a) individuals (including co-operative societies) for the purchase of new housing units or for up gradation/repair of existing units.*
- Housing boards and Development Authorities, co-operative societies, professional developers for undertaking land development.*
- maximum amount of loan sanctioned by the HFCs is Rs. 10 lakhs.*



## COST EFFECTIVE HOUSING

---

*Societies, the current interest rates in respect of the NCHF are 10% to 13.5% on the loan amount ranging between Rs. 10,000 to Rs. 50,000. Under this scheme, loan is now also made available for under construction and existing buildings. The higher limit of the loan amount for under construction and restoration is Rs. 60,000 at the interest rate of 13.5%. The NCHF is an institution for directing its credit and other assistance to the State Land Development Banks (SLDBs) and Agricultural Rural Development Banks (ARDBs) in various States are extended assistance to the Rural Housing Debentures floated by them for the special housing in rural areas.*

### vi) Primary and Apex Co-operative Housing Finance Societies

The co-operative housing movement is a strong movement comprising some 70,000 primary societies, 25 State Co-operative Housing Societies, and the National Co-operative Housing Federation (NCHF). The co-operatives have a total membership of 45 lakhs, and have been constructed through housing co-operatives under construction. A part of funds for construction is provided to the societies. The state-level Apex societies had advanced Rs. 100 crore to the Primary Co-operative Societies for the construction of housing in March, 1993. The major source of funding of the societies is the NCHF, which accounts for 90% of the loans available to them. The NCHF provides assistance directly to both primary and Apex Societies. Other sources are State Governments, floating debentures, and also launched schemes to help co-operatives.

## COST EFFECTIVE HOUSING

lakh. The lower limit for the loan is Rs. 25,000. The rate of interest is 12% per annum. The loan amount which, in turn, is determined by the borrower's repayment capacity. In determining the repayment capacity, factors such as the borrower's age, number of dependents, spouse's income, assets, and the borrower's credit record are also taken into consideration. It, range from Rs. 10 lakh to Rs. 100 lakh per annum. The principle generally adopted is that the loan should not exceed 20% of the monthly income of the household. The borrowing period in the range of 5 to 20 years not exceed 20 years. The loan is given to the beneficiary. Of late the HDFC has also launched a scheme of Rs. 10 lakhs for undertaking repairs and renovation of the existing housing. Of late the HDFC has been actively involved in promoting housing finance, namely, the Gujarat Rural Housing Finance Corporation, established from the International Finance Corporation, Washington, D.C., the World Economic Development, Geneva, and the Government of India. Housing Promotion and Finance Corporation Ltd. (with the participation of the stock markets), Infrastructure Leasing and Financial Services Ltd. (with the participation of India and VTI) and the Can-Fin-Homes Ltd. (with the participation of Canada). In all last three institutions the HDFC holds 20% of their share.

### *Governmental Role as Facilitator*

Realising the exigency of enhancing the investment in housing, the Housing Policy (1992) has envisaged that 20% of the housing requirement would be met by specialised housing finance institutions.



assistance from banks.

### Status of Rural Housing Finance

Rural communities languish in a near total absence of financial support. Housing in rural areas has been mainly the subject of a study of National Sample Survey (NSS). The 44th round of the study revealed that only 5.18% of total finance for rural housing comes from the resources for rural housing comes from savings and relatives — 9.36% and other resources — 22.22%. The financing institution of the country to reach housing finance has provided a loan of Rs. 907 crore to enable construction of housing units during the past 22 years.

The LIC and GIC are the other two financing institutions for the rural housing needs. During 1993-94, the LIC has been providing loans for rural housing. The GIC loans are also now available for the rural sector. During 1993-94, a sum of Rs. 557.83 crore was provided. The National Co-operative Agriculture and Rural Development Bank has planned to earmark Rs 500 crore of lending for rural housing.

## COST EFFECTIVE HOUSING

savings to considerable extent by providing stimulus to housing and creating mass awareness through public information. The expensive and time-consuming procedural formalities and transfer of land are the results of complex laws governing estate transactions. Availability of land, though a prerequisite for housing, is full of legal formalities. This situation indirectly causes skyrocketing of land prices by creating impediments to the use of developed land. Positive steps are, therefore, being taken to simplify procedures and bring down the expenses to be incurred in the existing stumbling blocks in the shape of Rent Control Acts, Land Ceiling Act and Agricultural Land Ceiling Act. Municipal Bye-laws will go a long way in achieving the goal of housing activity in the country. Fortunately, modification of the Act is presently under of the Union Government. The steps to remove hurdles presently being experienced in the existing housing law introduced in the Parliament is also aimed at making housing a profitable proposition. It would encourage supply of housing and remove distortions in the rental housing market.

At the national seminar on Mass Housing Development, the larger participation of private builders in mass housing was emphasised. The National Housing Policy also encourages private developers in development, construction and provision of housing. Some of the major housing agencies, like the Delhi Development Corporation, have already announced their decision to involve private builders in their housing programmes. Some apprehensions, however,



# Land Use and Physical for Housing

### Introduction

Land is one of the important prerequisites for planning without land. In most of the countries in Asia, Africa, there has been increasing pressure on the urban population in these countries has increased as much where in the demand for housing is far in excess of population into urban agglomerations, and rapid increased the pressure on demand for housing in cities fourth of the country's population was concentrated area covering 3768 urban settlements, out of which accounted for 65% of the urban population. In metro, where density of population is as high as 1,000 to

## COST EFFECTIVE HOUSING

cities can be earmarked for housing the poor in especially for migrants, are raised by the increasing apart from its scarcity. This leaves them with little on vacant land, or to occupy sites on the urban periphery.

### Planning of Urban Land

Concern for planned development of urban land in 1894 When the British Government introduced the primarily for the purpose of housing its military and adjoining a few existing urban centres and establish the basis for legislation in several States in the post planning system, during the British period, however development, while public development was restricted and social amenities.

The inadequacy of serviced land in most of the density pockets along with chunks of vacant land, the congested 'chawls' in and around industrial and features drew the attention of planners to the independence period. In 1958, the Town and Country envisaged a scheme of land use classification to usage of terms and categories. Subsequently, in 19 pattern of 103 cities and towns belonging to different



## COST EFFECTIVE HOUSING

than an exception. This was often attributed to the way land was used. It was also argued that the land policies, in general, have discouraged high residential densities and growth in large cities. Some Critics even called the above in "anti-poor and pro-rich" bias in the structure of the cities.

In the absence of a clear-cut policy on land use, land prices have skyrocketed in large cities. An interesting feature of urban centres is, they have risen at steady but different rates in different localities in a city. The increase in land prices is due to inflation, population growth, lacunae in land legislation, weak enforcement organisations, and above all, the speculative factors.

There are two streams of thought about the issue. On the one hand, the planner's perception that the pressure of population growth is the explanation for the deterioration in living standards. On the other hand, the proponents of people's right to housing see land as conceived as business enterprise, land emerges as a commodity, both as a means of production and as a prime objective of production. Around land use and redevelopment there ensues a struggle among the rich, the middle class and the poor. According to them, so much the non-availability of land as the inability of the state to constitute to supply adequate land for housing the population. In the planning and land use regulations, the conflicting interests of the land of the poor and the speculative urge of the property owners are being allowed to perpetuate the housing scenario.

In the present context, land has lion's share in housing.



## COST EFFECTIVE HOUSING

(ULCRA), 1976-a very useful Act aiming to socialise land. It needs to be suitably amended so as to eliminate the existing loopholes in the positive Act so that the urge to circumvent it is minimised.

**Urban Land Ceiling and Regulation Act, 1976**

Faced with the problems of dearth of resources and high costs, the agencies have tried to acquire land through legislative means. On this subject, several States, have passed laws similar to the ULCRA, so that the compensation paid to the land owners could be reduced. The low rate of compensation in the initial years of the Act encouraged the farmers, apprehensive of their land being acquired by the government, to sell the same to private colonisers. Studies undertaken to review acquisition of land by public agencies have indicated that their performances have always been poor. With a view to augmenting availability of land for development, India enforced ULCRA, which was basically aimed at preventing urban land in a few hands, with a view to bringing it under the favour of the urban poor and to prevent speculative transactions in precious urban land. Under the Act, the owner had to surrender surplus meters to the government at pre-determined rates and the land was for housing the poor. The intention was, indeed, well-meaning, but boomeranged into becoming a major impediment in the way of hectares of the surplus land that the Government possessed. It was caught in the never-ending rigmarels of court litigation.



## COST EFFECTIVE HOUSING

all flat construction in the city. The enactment repercussions-imposition of restriction on buying skyrocketing of land values. The slow freezing of development and marketing of land has had the advantage the objective of urban land policy. Most of the attributed to the problems relating to the urban land the availability of urban land for housing due to the The act deserves amendment on rational lines so as of private builders in mass housing programmes for Of late the Government of India is contemplating an and Rent Control Act which might help augment supply programmes for masses in the country.

In recent years, emphasis is increasingly being laid sector in meeting the challenge of housing in the country evergrowing demand for housing coupled with the inability to meet the housing requirements of masses. What's through the necessary amendments in the ULCRA will private builders in mass housing programme for the people

### Effectiveness of Building Bye-laws

Despite formulation of town planning regulations and centres in the country, an effective control on building possible. Violation of the building bye-laws and the become order of the day in most of the metropolitan

## COST EFFECTIVE HOUSING

constructions through application Of which not only achieved but also it could be possible to make stru their performance. Due to pressure of modern urban bye-laws has became a common practice in urban lengthy procedures and restrictive nature of the bypassing and undertaking construction work in advantage of the inadequacy of urban administration. The inability of the authorities to control such develop pressure unauthorised housing colonies and squatter regularisation of such settlements at a future date violation of the building bye-laws.

By and large the municipal administration and urban given adequate attention to the work of control of urb way, has allowed the problem to grow to such an ex remedial measures are either not possible or very c dealing with such problem which is vital for the essential for the developing countries like India w identify the inadequacies in the building regulations. Some of the important remedial measures are given. Measures such as realistic review of Master Plans regulations, rationalisation of building bye-laws base the practical implications Of the existing bye-laws an the municipal administration/ local authorities backed



## COST EFFECTIVE HOUSING

|                             |                             |
|-----------------------------|-----------------------------|
| (iii) three-storeyed houses | 100-- 125 houses<br>hectare |
| (iv) four-storeyed houses   | 125 — 150 hous<br>hectar    |
| (v) five-storeyed houses    | 150 houses per g            |

If the above densities are adhered to and layouts planning agencies, it may be feasible to ensure ad parks and other sites for communal facilities consiste

### ***Concluding Remarks***

To conclude, inadequate availability of land and its h and administrative constraints is leaving vast n alternative but to illegal settlement on poorly-service serviced dilapidated structures. Moreover, the rising urbanisation and population growth make it difficult f land for social housing programmes. It is hoped, existing ULCRA and the Rent Control Act housing activity in the country.

## COST EFFECTIVE HOUSING

these in these countries have both quantitative and qualitative side, the problem of housing has been worsened by (i) exponential population growth; (ii) fast rate of urbanization; (iii) pressure on the existing housing stock; (iv) large-scale migration from rural areas to smaller towns, and (v) obsolescence of existing housing stock and proper maintenance.

The statistics of housing shortage in major cities is alarming. Mumbai had a backlog of houses in 1991. The present rate of construction in the city is, however, a meagre 5,000 units per year, while the co-operative efforts take care of another 20,000 units, leaving a huge short of demand. In effect, shortage increases by 15,000 units per year. Situation is equally horrifying in case of Delhi too. According to estimates, 10 lakh dwelling units will be required in Delhi by the year 2020. At present, the city is in a position to build at the most 10,000 dwelling units per year.

It is now well-established that the growth of slums is a direct result of the supply of houses at affordable cost being far too small. To meet the demand, increase the stock of low cost housing in urban areas, and provide land and building materials, and inadequate financial resources are engaged in the exasperating task of improving the living conditions of millions of the urban poor condemned to the sub-human conditions.

Gravity of the situation arising out of the proliferation of slums is gauged from the fact that in 1956 only 22% of Bombay population in 1986, about 52% lived in sub-standard conditions.



## COST EFFECTIVE HOUSING

mortar and plaster, clay roof tiles, thatch, etc. They are poorly ventilated and mostly single room units with inadequate lighting. Private toilets do not exist in a majority of slum areas; public toilets are available only in a few. Where there are no toilets, open defecation, which, besides being an environmental nuisance, is a health hazard for women. Community latrines, even where available, are often in insanitary conditions.

Most of the houses in slum areas do not have indoor plumbing. In some slum pockets, public taps do exist but the number of people using such taps is generally very high. Long rows of people waiting at public hydrants are a common feature in squatter settlements. The drainage system in slums is almost non-existent. During the monsoon season when storm water finds its way into the streets, the conditions in slum areas are extremely unhygienic. Streets are narrow and often unpaved. Road and street lighting is inadequate. This adversely affects the safety and security of residents, and is responsible for high rates of night-time crime.

There is a close relationship between environment and health. It has been shown that the unhygienic slum environment is highly susceptible to diseases like respiratory diseases, diarrhoeal diseases, malarial fever, tuberculosis, etc.

A majority of the slum dwellers are employed in the informal sector. A large proportion of them work on a daily wage basis,

## COST EFFECTIVE HOUSING

### a) Move to Decongest Large Cities

The Government of India has, through its successive development, always emphasised the need for rural development. It has also pushed through the policy of restricting the growth of metropolitan cities which alone account for national growth, simultaneously encouraging small and medium size cities. Land for housing is relatively cheaper within reasonable distances. With shorter commuting distances, the urban population can improve transportation, increasing their ability to channelise investment towards housing. The Integrated Development of Small and Medium Towns (IDSMT) is one of the government sponsored schemes. It is a recommendation of the Task Force on Planning of Small and Medium Towns and Cities constituted by the erstwhile Ministry of Housing (now Ministry of Urban Development), Government of India. The allocation of Rs. 96.00 crore. The scheme is aimed at providing housing where problems of slums and squatters are related to the urban areas. It is allocated under the Scheme by the Central Government. The scheme that would improve the living conditions in smaller towns and cities, making them attractive to a prospective migrant who may otherwise migrate to a large city. During the Eighth plan (1992-97), only towns with a population of 10,000 and above as per the 1991 Census, are eligible for financial assistance. The scheme towns are to be covered during the aforesaid plan-period. Rs. 155 crore.

Under the IDSMT Scheme, a 50% Central subsidy



## COST EFFECTIVE HOUSING

IDSMT Scheme as they aim to improve the lot of the rural poor rather than let them migrate to cities. But schemes for rural development are beset by severe resource constraints and funds. The schemes, therefore, have not been successful to the desired extent. Another notable government initiative has been the conception of the National Capital Region Plan to decongest Delhi and regulate its population within its metropolitan area.

### b) Government-Sponsored Programmes for Slum Dwellers

The main programmes undertaken by the government to tackle the housing problem of the urban poor include the following:

- 1) Slum Clearance and Relocation Schemes
- 2) Environmental Improvement of Urban Slums
- 3) Sites-and-Services Scheme (S&S)
- 4) Urban Basic Service Programme for the Slum Dwellers
- 5) Scheme for Housing and Shelter Upgradation

#### 1) Slum Clearance and Relocation Schemes

Under the Slum Clearance and Relocation Schemes, the government envisaged to get the existing slum areas cleared and relocate the slum dwellers to alternate sites. They were given highly subsidised housing. However, these schemes did not succeed in the sense that these schemes did not provide adequate housing for the slum dwellers. The government

## COST EFFECTIVE HOUSING

to the intended beneficiaries. The nonethless, improved the insanitary conditions like Delhi. But the formation of slums are unabated, posing enormous problem for the

### 2) Environmental improvement of Urban Slum Schemes

In the light of the experience of Slum Clearance Schemes, the approach was changed with the implementation of Environmental Improvement of Urban Slums (EIUS) Scheme in 1974. The scheme was launched by the Ministry of Planning (MNP) in the same year. The MNP is responsible for improvement in larger towns. The scheme is at an attempt to improve the living conditions of urban slum dwellers, and envisages provision of drinking water, public baths, community latrines, widening and paving of roads, and other community facilities. The approach of tackling the problem of environmental improvement was a significant improvement over the traditional slum clearance. The Bustee Improvement Programme (BIP) demonstrates the kind of result that can be achieved by this approach. The programme had benefitted some 1.6 million people in a period of about 9 years (1971-79).

The Central Government moves plan allocations for housing improvement under the EIUS Scheme. The said scheme is operating at State and city level with additional support from the Central Government for housing improvement and other socio-economic activities taken up by State Government agencies as a grant-in-aid. Physical infrastructures like widening and paving of roads, provision of drinking water, public baths, community latrines, etc. are included in the scheme. The scheme is



## COST EFFECTIVE HOUSING

only, to a limited extent, take into consideration the needs of the community.

In Delhi, presently two slum upgradation schemes are operational: EIUUS targetted at notified slums and the Environmental Improvement in Jhonpries (EIJJ) targetted at squatter settlements. The EIUUS aims at improving the living environment in notified slums through provision of water supply (one tap for 150 persons), sewerage and latrines (one lavatory seat for 20-50 persons), community halls (one for 100 persons), widening and paving of existing lanes for use by pedestrians, bicycles and handcarts and to avoid mud roads (one per metre), community halls baratghars) open air markets etc. The EIJJ Scheme, which is operational since 1987, provides street lights poles, water supply, dhalos/dust bins, etc. The scheme provided in jhuggi jhonpri clusters (under the parallel lanes) of about 7 lakh people has improved substantially with the EIUUS Scheme, a massive programme of constructing pucca houses (Suvidha) complex in the JJ clusters has been launched. The complex is open to the women and children free of charge. However, a nominal amount each time they use the complex. Under the EIUUS schemes, a massive crash programme for providing water supply, planned and laid out colonies to the slum dwellers is under way in near future. Moreover, the Slum Wing of DDA has launched a new Scheme for allotment of flats to the residents of slum colonies, unauthorised colonies and urban villages. The scheme is registered themselves under this scheme. So far, 3.0



## COST EFFECTIVE HOUSING

recovery records were, however, better in sites-and-services projects. As in the case of other social housing schemes, the Services Scheme also, the HUDCO has been designated as the agency for routing central allocations. The HUDCO has decided that all the composite housing schemes that it finances have to be spent by the receipt (State) housing agency for EWS. It could either be in the form of sites-and-services

Under Jhuggi-Jhonpuri (JJ) Resettlement Programme, from the inception of the Seventh Five-year Plan, about 2.20 lakh families were re-settled in 46 JJ Colonies, where these families were given a 21 sq.m minimum size from time to time with basic amenities. The size had been varying from time to time depending on the problem and physical/ financial constraints. The scheme, however, discontinued with the termination of the Seventh Plan and emphasis shifted from resettlement of jhuggi jhonpuri to slum/JJ Clusters on 'as is where is' basis.

Among other notable projects undertaken under the Services Scheme, names of Arumbakka Sites-and-Services Scheme, slum Rehabilitation Project of Ahmedabad are worth mentioning.

### 4) Urban Basic Service Programme for the Poor

One of the identified deficiencies both under the EWS and the Urban Basic Service Programme for the Poor is that the clients are not well-equipped to avail full benefits of the programme. In connection it is felt that there is a need to educate the clients about the programme and its benefits. On the other hand, the



## COST EFFECTIVE HOUSING

sector scheme of EIUS and the Centrally-sponsored

### 5) Scheme for Housing and Shelter Upgradation

The Scheme for Housing and Shelter Upgradation (SHS) was launched by the Government of India in 1985. The NRY was recast in March 1990. The entire expenditure is to be shared on a 60:40 basis between the Government with effect from the eighth plan. The SHS is for housing and shelter upgradation to economically weaker population as well as to provide opportunities for workers of construction skills. A loan up to a ceiling of Rs 10 lakh is provided under the scheme to the entitled beneficiaries for Upgradation. In case of enhanced financial requirement, an additional loan can be procured from HUDCO under the SHS. This scheme is applicable to urban settlements having a population up to twenty lakh. Requirements for institutional finance for SHS are as follows: The Central Government had made an allocation of Rs 1.61 crore for shelter upgradation, and Rs 2.61 crore for training for construction trades during 1993-94. HUDCO has sanctioned 4000 projects for Upgradation upto December 1993 since the inception of the SHS.

### c) National Housing Policy

The National Housing Policy announced in May 1997 aims at providing shelter to all from slum and squatter settlements in urban areas.

## COST EFFECTIVE HOUSING

- promote incremental construction and upgradation through access to land and services, through cost technology and materials, opportunities for housing finance on flexible terms
- provide night shelters and sanitary facilities for homeless.

### d) World Bank Aided Programmes for Urban Housing

The World Bank has played a significant role in promoting programmes for improving the plight of urban housing. Its support to deal with the problem of slums in Bombay and Madras in a noteworthy manner. It considers Madras as a showcase. The World Bank provided financial aid for the purpose of Urban Development in 1973. In contrast to the Slum Clearance Scheme, with its origin in a 'welfare state' approach, World Bank funded projects aim at recovery of costs to an extent, considering and maintaining the improvement work. The tenurial rights and enforcing recovery of service charges. In the case of the World Bank funded projects, cost recovery is more encouraging in sites-and-services than upgrading projects.

At present, the World Bank aided projects are operating in the States of Maharashtra, Gujarat, Uttar Pradesh, and



## COST EFFECTIVE HOUSING

Full coverage of 18 sq.m. plots is permitted to the squatters and subsequently, when the affordability of allottees is added by the beneficiaries, approachable by a ladder on the ground floor. Independent Water Closet (WC) and shelves are to be provided to make the residential unit

The squatter families are organised into multi-purpose association of NGOs/ voluntary organisations and to approved byelaws. For shelter construction, Delhi Housing Society (DCHFS) is designated as funding agency to provide per jhuggi households in three phases through HUDCO. The loan is to be recovered from slum dwellers as a part of the project before shifting of the jhuggi complexes, construction of foundation upto plinth level is to be undertaken at the sites of alternative plots by DDA or by Co-operative Societies, as the case may be.

### f) UCD Approach

The Slum upgrading programme successfully taken up in Hyderabad and Vishakhapatnam in 1983-84 and with financial assistance from Overseas Development Bank is widely known as 'UCD' approach. UCD stands for Urban Community Development. The programme is geared up to pursue the objective of improving life for the residents by making the community aware

## COST EFFECTIVE HOUSING

successful story of community participation settling the dwellers without their eviction from the site of the Bangalore, secure land tenure has been offered a rehousing project.

### g) CD Wings

The other approach attempted is integrating community organisations like the Slum Boards and Housing Development Board, Tamil Nadu Slum Clearance Board and the Maharashtra Housing and Urban Development Authority ((MHADA) have community wings to coordinate, structure, Community Development (CD) Wings for contacting and communicating with the community about infrastructure and housing improvement plans of the

### h) Role of Voluntary Organisations

Voluntary organisations have been playing an important role for the poor and the under-privileged. Main spheres of activity are restricted to education, (including adult education), health, planning and social forestry. In the field of housing, they have not been able to do much because of the enormous resources needed for such an effort.

The Subsidised, Aided, Self Help Housing Schemes



## COST EFFECTIVE HOUSING

originally intended for non residential purposes category includes the 'conventillos' of Santiago (mansions) and 'mohallas' of Old Delhi. The second types that were, from the beginning, intended for low cost housing. This category includes the 'chawls' (Three-to four-storey tenement house tenements and row tenements of South-east Asia).

The critical issues in planning for inner-city rehabilitation relate to competing sets of interests and the ways in which they are defended. Planning strategies always reflect the interests that are able to exert, since the interests are great and the stakes high in inner city, this applies to the central area perhaps more so. The position of the poor in the inner city is particularly vulnerable in that they stand to lose most from the changes that are being made. The changes that squeeze the space that is available for low cost commercialisation of inner cities is, in most cases, the displacement of dwellers. Such pressures may be accompanied and intensified by 'gentrification,' whereby areas and floor space traditionally occupied by low income groups are gradually taken over by higher-income groups. The poor are typically unable to resist commercialisation and gentrification. There have been isolated instances of organised industrial workers' movements that prevent 'take-over' of the relatively small areas in which they live.

## COST EFFECTIVE HOUSING

sharp decline over the past three decades in the proportion of the population in the low and middle income groups.

In Bombay, the typical rental housing solution for the low-income population has been provided by the private and public sector, which dominate the construction of new housing. In Bombay, the low-income population live in these 'chawls' which were built by the British in 1939 followed by a rent freeze and a system of protected tenancy that has ensured to this day the survival of these areas in the central areas. In 1969, the Maharashtra Government established the Building Repairs and Reconstruction Board, which was responsible for ensuring the timely repair and reconstruction of buildings not owned by co-operative societies or public bodies for social housing purposes. A repair levy was levied in all buildings requiring repair. In the case of buildings repaired, the owners were required to contribute. In 1977, the legislation was repealed and replaced by the Housing Development Act under which the State assured the repair and reconstruction of buildings. Most of the affected areas were on the priority list towards which, while accounting for only 26.8% of the total stock, were 'cessed' buildings. In 1981, the priority list contained 10% of the stock were considered beyond economic repair. Where repair was not proved manageable, reconstruction work has proved to be the only solution. Bombay experience lies in the efforts to preserve and improve the existing stock in central neighbourhoods, while ensuring that new housing can remain in the neighbourhoods. The experience also lies in the involvement of the poor in rehabilitation programmes.



## COST EFFECTIVE HOUSING

approach in countries where the urban land market schemes tackle one of the main constraints on inner city development, opposition to the upgrading of slum areas which they fear would lead to redevelopment. The schemes are based on a trade-off between landlords and owners versus residents—which allows the landlords to increase their profits while permitting the residents to retain possession of their homes in the inner city areas where growing demands on valuable land in the inner city force the low-income groups, land-sharing is able to break a cycle of poverty and allow the poor to remain where they are. The Bangkok experience suggests that it has to have considerable potential, not only for stabilising the urban environment in the inner city. It could be applied to the government's housing policy used by the public sector as an effective tool for slum upgrading programmes.

### j) Night Shelter/Sanitation Facility to Pavement Dwellers

People sleeping on footpaths or road berms present a major problem due to lack of housing shortage in urban centres, especially in the context of socio-economic disparity in the villages, these have become a more attractive option than to migrate to cities in search of livelihood. Such people are generally casual labourers, petty vendors, hawkers, pullers, hawkers, vendors and cart-drivers, etc. Having no other alternative, they are forced to pass their nights on pavements.

Realising the agony of pavement dwellers and the slum problem, the government had launched a scheme for construction of night shelter facilities for the pavement dwellers.

## COST EFFECTIVE HOUSING

---

urgency to check the uncontrolled migration from small urban centres to large cities. It is believed that the root of urban poverty lies in the rural poverty and the spill-over of the rural poverty. There should be an economic lot of the rural poor so as to arrest the migration of towns and cities in search of livelihood. There is a need of land reforms in the right earnest as the structure of agrarian, and the majority of rural population are engaged in agro-based industries. It is the landless labourer population. Economically, they are the most susceptible to migrate to towns or cities as the villages are not able to contain them due to unfavourable conditions in the countryside for their sustenance. Efficient urban housing means for encouraging community involvement, defining the role of private developers, and evolving realistic standards for housing urban poor which deserve special attention to resolve the conditions of the urban poor.

(ii) Squatter-settlement upgrading and sites-and-services programmes have displayed a tendency to serve the needs of the urban poor. This has led to a "creaming off" as well as polarising effect as the programmes are perceived as the prime instrument for improving the conditions of the urban poor.



## **Introduction:**

Most of the developing countries in Asia are suffering from poverty, large population growth and acute housing shortage. Providing housing to masses at affordable cost is a major challenge. These countries are hardly in a position to cope with Mass Housing by adopting appropriate building technology with low cost construction. Prefabrication is the obvious choice for these countries. However because of the prohibitive initial investment, it does not sound to be a pragmatic proposition in majority of these countries. For economy construction, the only practical solution for housing masses in the present context will be to go in for a building system of prefabricated building component of such size and quantity that can be made in industrial production units: economical walling system.

Premier R&D institutions engaged in the field of building research institute (CBRI), Roorkee: the Structural Engineering Research national council for cement for building materials research laboratories etc. Have played important role in the development of new techniques and materials. On the other hand org

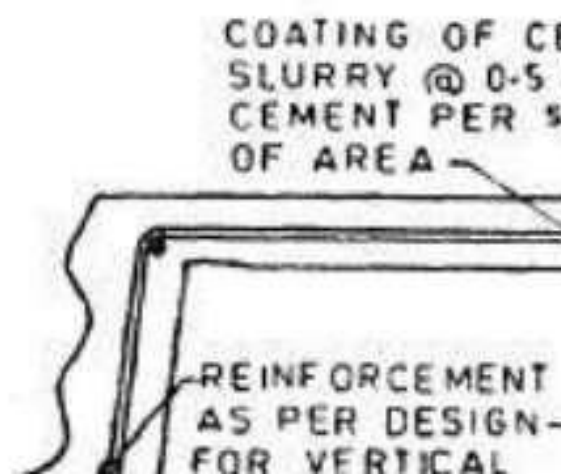
## COST EFFECTIVE

---

### **Precast Roof system:**

Roofing accounts for up to 25% cost of construction. To achieve a 30% economy in the cost of roofing/flooring techniques promoted by the NCST, the consumption of cement and steel and increase in erection time. Precast systems make use of components which are fabricated in a factory building. In-situ concreting work is minimised in the field. The necessity for putting up centring and formwork for concrete (RC – Slab completely) is eliminated and shuttering is a time consuming process and increases erection time.

### **Precast RC Channel Units:**





## COST EFFECTIVE

---

These units are cast in well-seasoned timber aggregate. The concrete is consolidated using pneumatic rammer and cured for 14 days keeping through filled with water in position. The units are then placed side by side which is compacted properly. Negative reinforcement is provided at joints between the units. Electrical conduits for cables are cast in concrete. The system provides an overall saving in cost. In this system of roofing there is as well saving in cost.

### **Precast RC Plank and joint System**

This system of roofing is based on the use of precast concrete planks 60 mm thick in the centre 30 mm edges. The size of the plank is restricted. However the maximum size of the plank is restricted by the length of the Bars as main reinforcement. The planks are placed side by side with 30 mm. Cast-in-situ concrete laid over the joints and over the planks in both directions to make a monolithic structure. This system is used for brick panel floor/ roof with tie beam.

## COST EFFECTIVE

---

This system in results in saving of the comparison to traditional RC roof. There is also such as roof as compared to the conventional

### **Precast brick panel system:**

In India, the technology to be adopted for housing erection technology be adjusted to suite the metropolitan, urban and rural conditions.

The reinforced brick panel is such an option for panels with reinforcement bars as fillers between. The roofing panels can be easily prefabricated the construction of thousands of affordable and over India. Not only itself it is a cost effective to form erection and rebar requirement may also

The construction of the slab is similar to other concrete laid over distribution reinforcement. E light and the slab exhibits similar live load carrying size 1150 x 530 x 75 mm weighs 75 kg and the



## **COST EFFECTIVE**

---

### **Partially precast RC joist**

- The joist shall be designed as a composite
- The width of the joist shall support two s
- Width: minimum 130 mm, which can be
- Depth: minimum 100 mm for a joist spa

### **Reinforcement bars**

- Precast Brick panel: Reinforcement conform to IS 456  
Conventionally for brick panels, 2 bars of 12 mm diameter are provided
- Precast RC joist: Reinforcement conform to IS 456
- Cover: minimum 15 mm for the brick pa

### **Moulds for precast elements**

- Mould to be made on site of seasoned
- For mass housing projects, it is recomme

## COST EFFECTIVE

---

### D. ADVANTAGES:

- By adopting this method of roof construction, the concrete cost. Also the centring and the s approx. 25-35% on the overall slab cost.
- Time is saved by the use of precast elements foundations being laid. The finishes and s in the conventional in-situ RCC slabs, du they are removed. Thus, saving of time.
- In conventional methods, the shuttering frequent cutting, nailing etc. On the other used for large number of repetitions the
- In the panel and joist system, similar type increased productivity and economy in c and economy.
- In panel and joist system, the work at site of work, reliability and cleanliness.



## COST EFFECTIVE

---



Image 2: Prefab brick panels. (picture taken from [unclear])

Image 3: Laying of panels over the joists. (picture taken from [unclear])



## COST EFFECTIVE

---

(a) Bond/friction at the interface of lintel and masonry:

The masonry above the lintel acts like an arch and the lintel acts like a tie for the arch. For the arch to develop, there must be friction between the masonry and lintel near supports, which is provided by the thrust of the arch.

(b) Crushing strength of masonry :

The arch action developed in the masonry above the lintel is compressive near supports. When this stress exceeds the crushing strength of masonry, failure sets in.

(c) Shear strength of masonry:

Once the shear stress developed in masonry exceeds the shear strength of masonry, failure sets in.

(d) Masonry bond:

For better composite action, the masonry should be built with stretchers.

(h) Height of masonry above lintel:

If the height of masonry above the lintel is too small, the arch action cannot be formed in the masonry and hence composite action is not developed.

(f) Whether the masonry is already stressed to its full capacity:

In case the masonry is already stressed to its full capacity, it cannot accommodate the peak vertical stresses developed in the masonry.

(g) Reinforcement in lintel:

Normally, this is not a controlling factor.



## COST EFFECTIVE

---

### **(d) Variation of vertical and horizontal stress**

The average vertical compressive stress to be 1.75 times the uniformly applied stress. In more than half the vertical stress intensity.

### **(e) Deflection:**

The maximum deflection recorded at the center to 1 in 381 of the span. This variation in deflection above lintel.

### **(f) Stress developed in reinforcement:**

The stress developed in the reinforcement is less than the permissible stress in steel. This indicates that a significant portion of the load is carried by arch action developed in the brickwork. The deflection is proportional to  $WL/344$  where  $W$  is the total load and  $L$  is the span. Masonry and more height showed lesser bending.

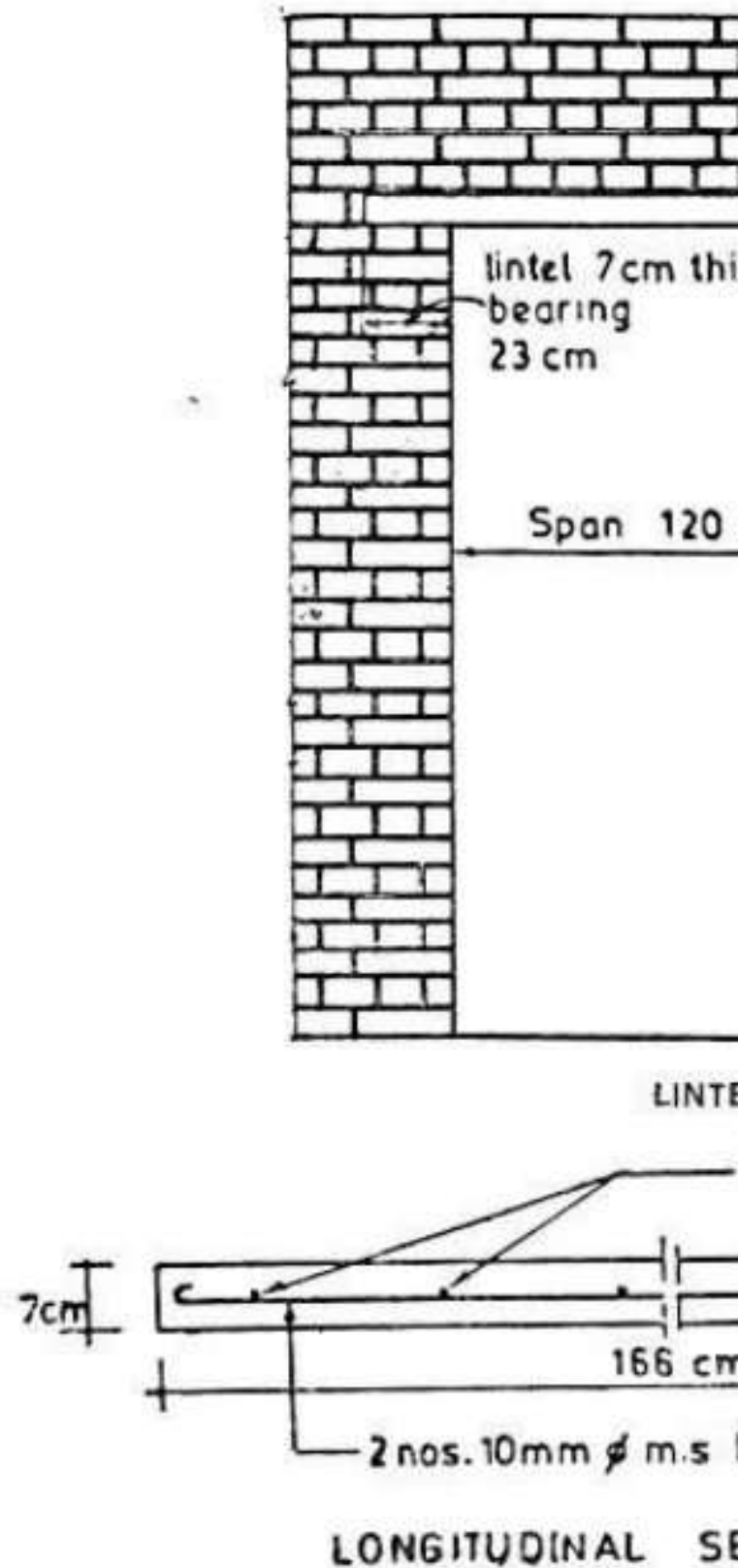
(a) There is composite action of lintel with brickwork, which increases the strength and the height of brickwork above lintel.

(b) For a given masonry, the load carrying capacity increases with height above lintel.

(c) For a given height of brickwork, the load carrying capacity increases with the strength of lintel.

(d) When the height of brickwork above lintel is less than the span, the load carrying capacity is less.

# COST EFFECTIVE





## COST EFFECTIVE

cm for a clear span of 120 cm and lintel-cum-chajja are given below. From this basic data, knowing and lintei-cum-chajja can be worked out for any added.

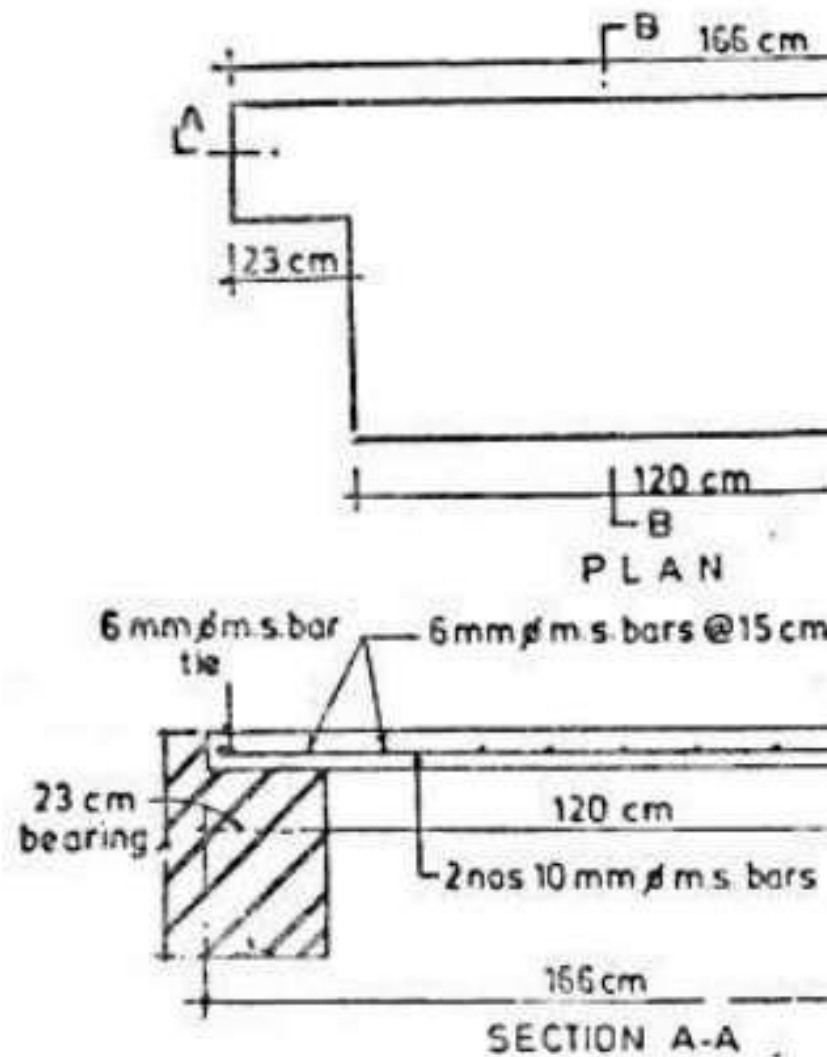


Fig. 2. Details of a

# COST EFFECTIVE

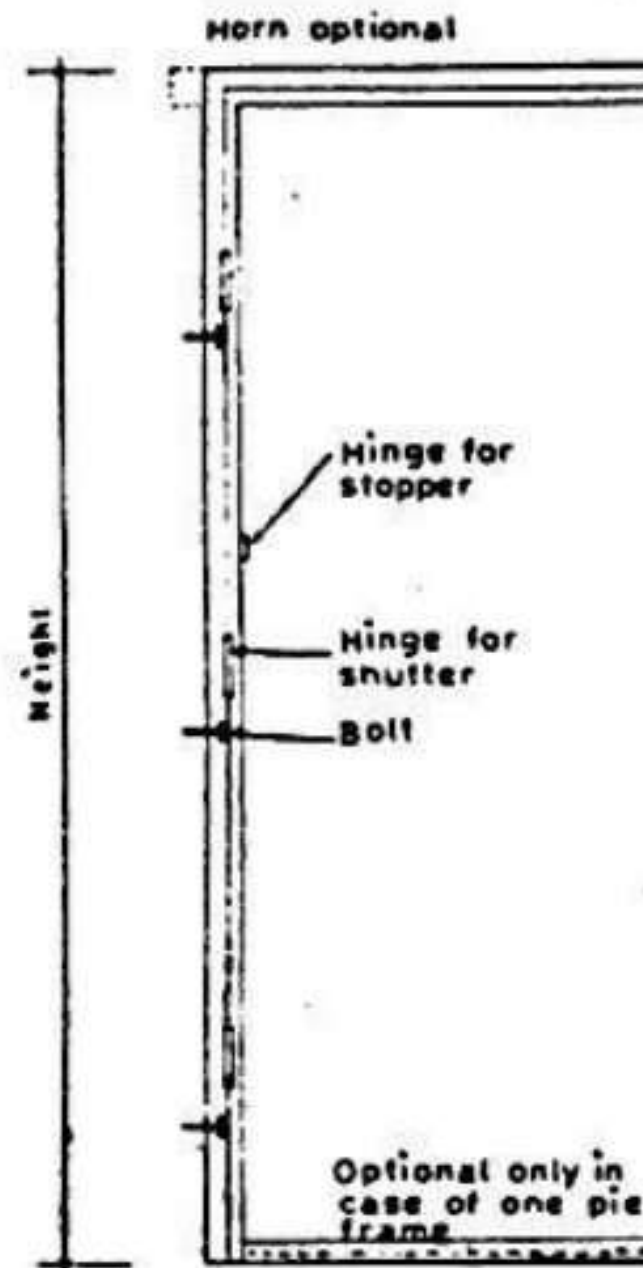


Fig. 5.12 Precast F

Adoption of total prefabrication for mass



## COST EFFECTIVE

---

since 2004 production of PRC railway sleeper components has been suspended, as manufacturing alternative, to remain a going concern, HPL focuses on civil construction projects which includes major educational, hospitals and other institutional buildings. Works entrusted to HPL are executed by ensuring and prefabricated technologies.

HPL is one of the "Turnaround CPSE" as per Guidelines for sick CPSE as "Turnaround CPSE". The financial restructuring through conversion of Govt. Loan and interest as financial restructuring without cash infusion and any budgetary support from the Government.

### **Shirke - Siporex consortium**

Siporex India Pvt Ltd was established in 1969 and manufactures weight, Autoclaved, Cellular reinforced floor and walls both for load bearing and partition walls. During the years abroad in all types of climatic conditions and extensively used in all types of buildings such as buildings, five star hotels, hospitals etc.

## COST EFFECTIVE

---

concrete construction. All components are easy to use, providing considerable flexibility and minimizing investment. L&T Formwork ensures speedy construction with a high finish with enhanced productivity in tandem. Systems include column formwork, flex systems for RC floors, self-climbing automatic climbing formwork system and modular wall panels and columns.

The services of the Business Unit encompass:

Specialist designs and preparation of formwork details.

On-site training for personnel for effective implementation.

Continuous research, product development and adoption of the advantage of emerging technologies and modern construction techniques.

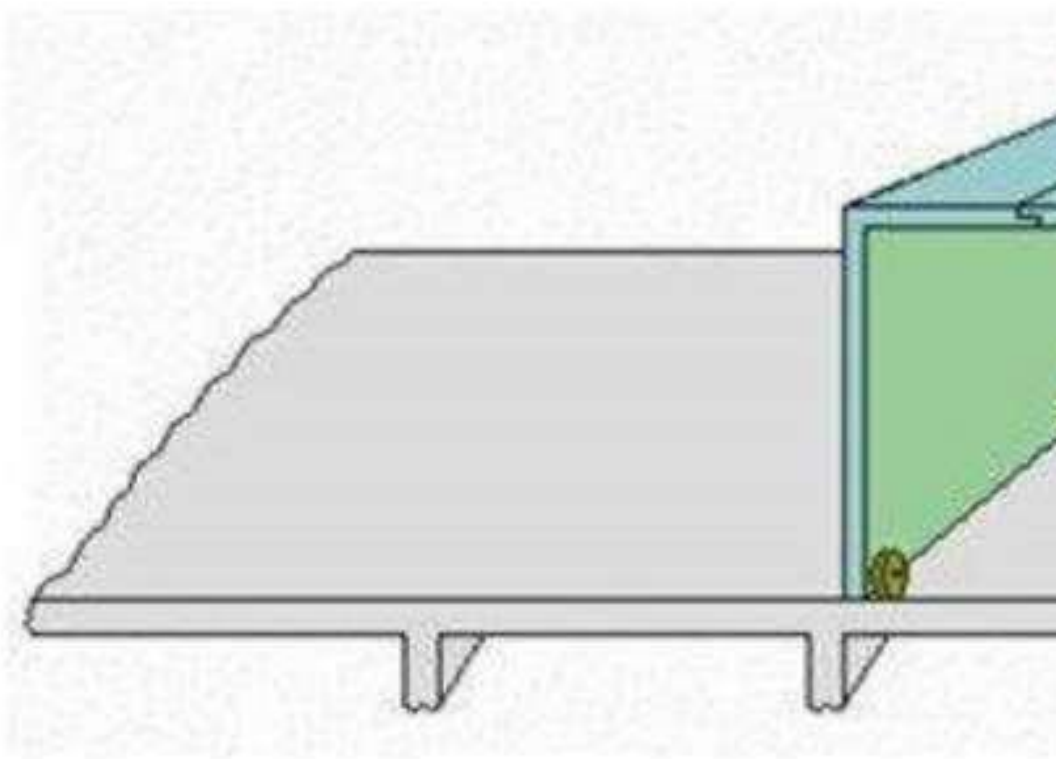
### **Tunnel Form System:**

**Tunnel Form Construction Technique** produces high quality monolithic structures. It is a continuous process (Blasting etc). It is basically an operation to construct a tunnel by using a tunnel form system.



## COST EFFECTIVE

---

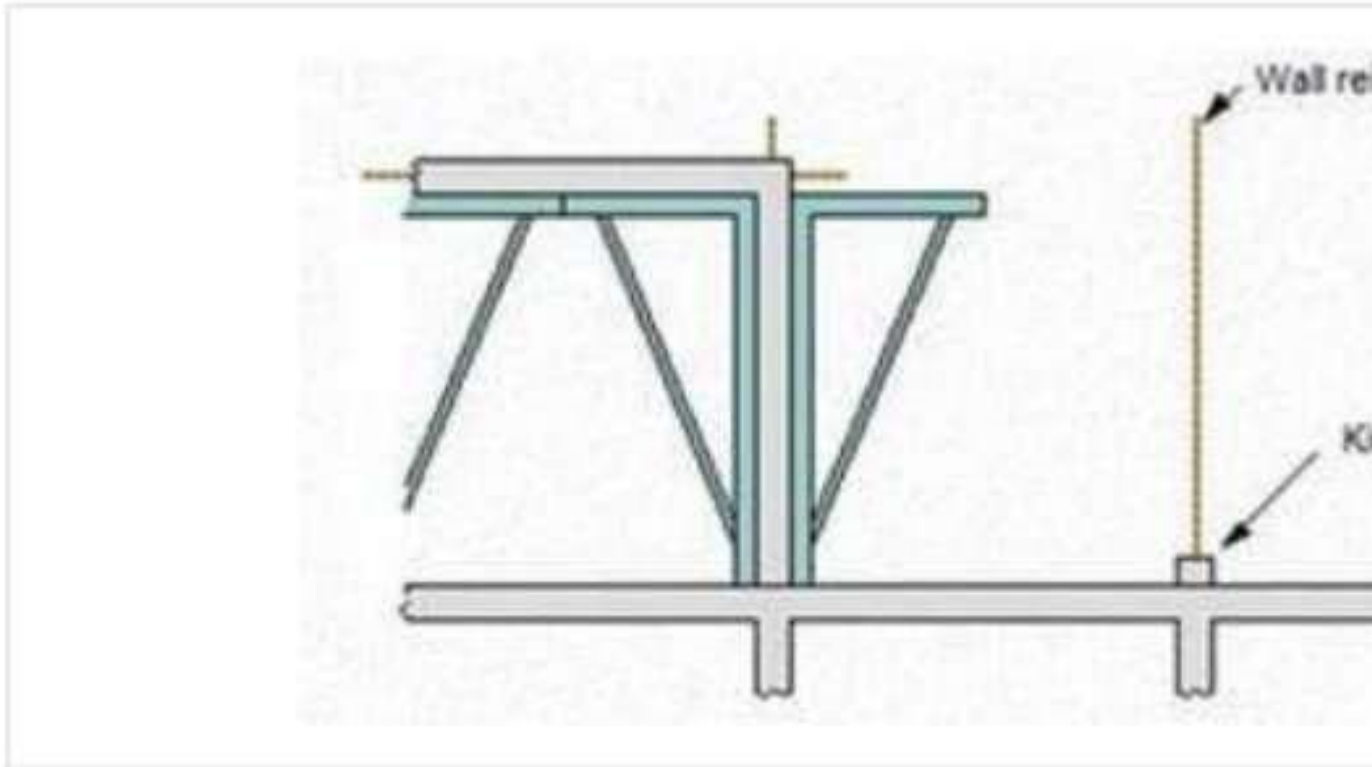


The factory-made steel formwork can be re-used in various sizes. This makes the method of construction very cost-effective.

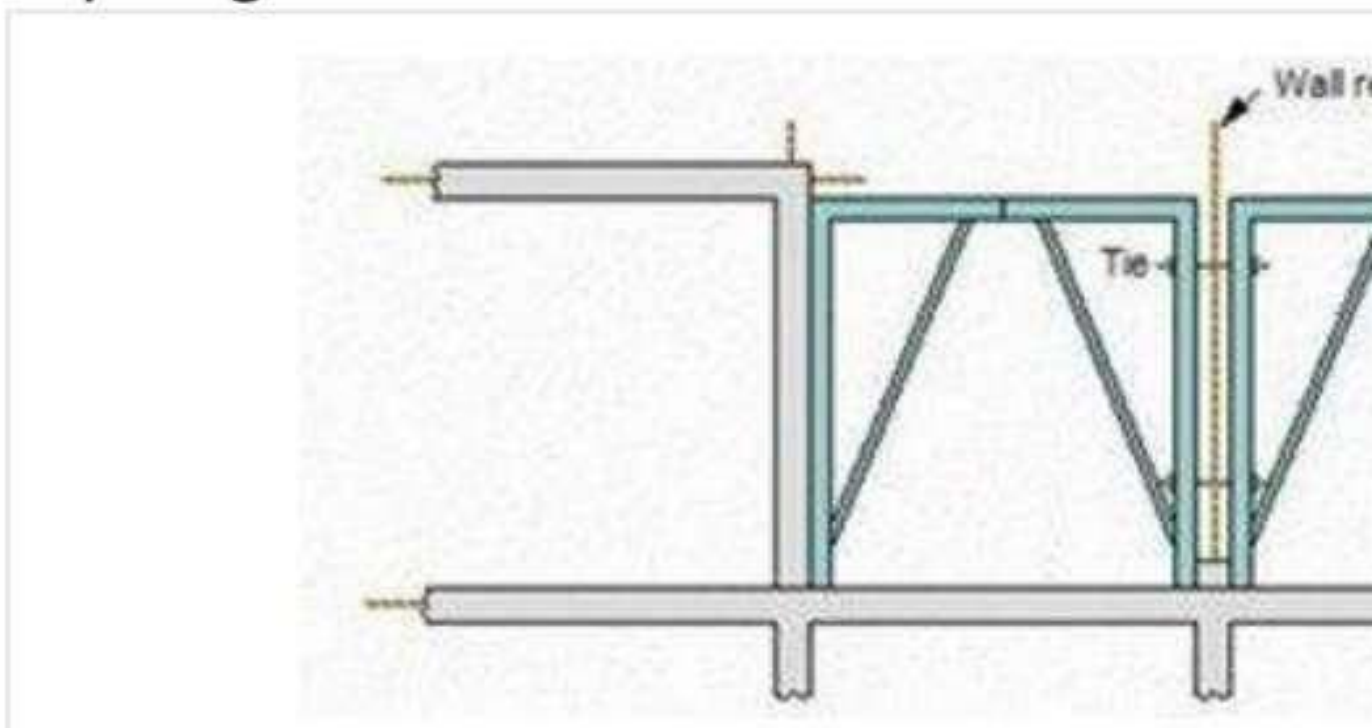
Tunnel-form work allows a 24-hour construction cycle. The quality of concrete is improved by choosing this type of formwork.

In practice, when the two halves are bolted together, they form a complete tunnel, as shown in the figure.

# COST EFFECTIVE

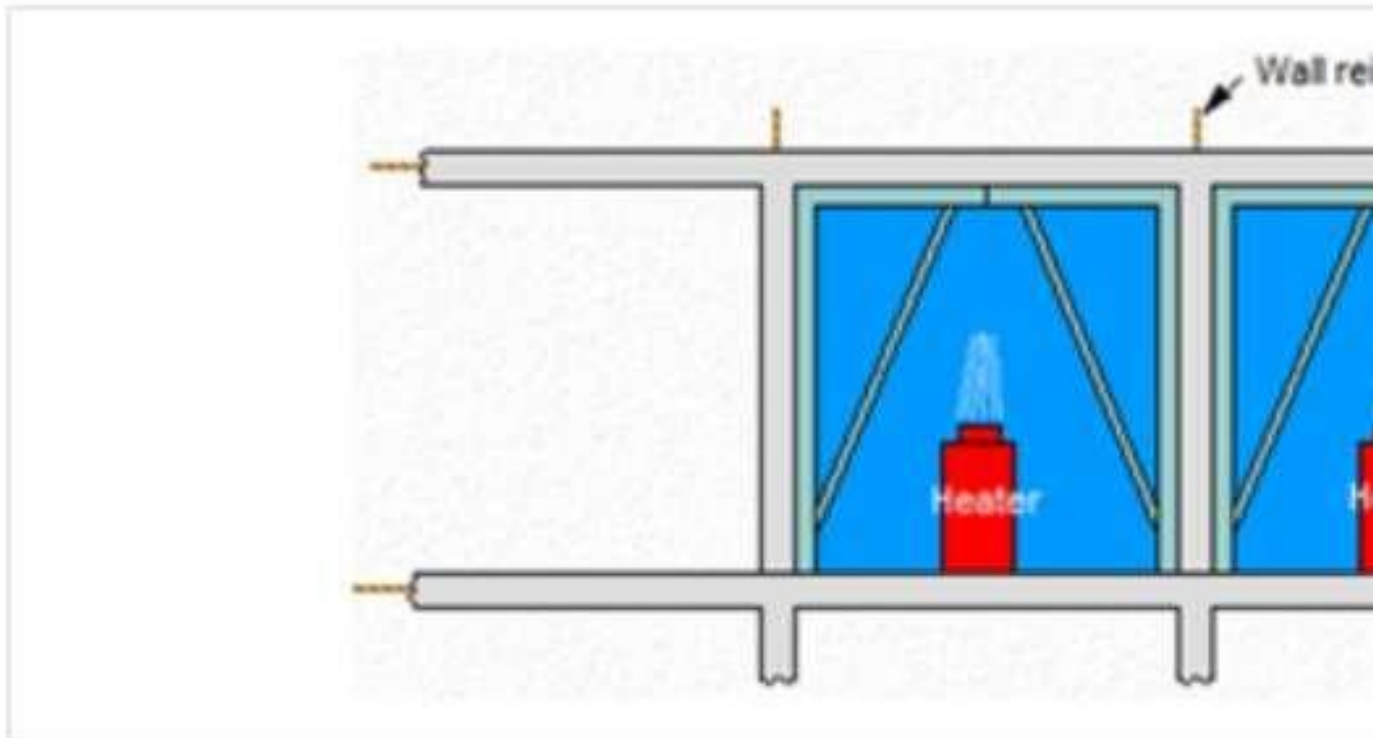


**2) Stage Two:** Two and a half tunnel is craned

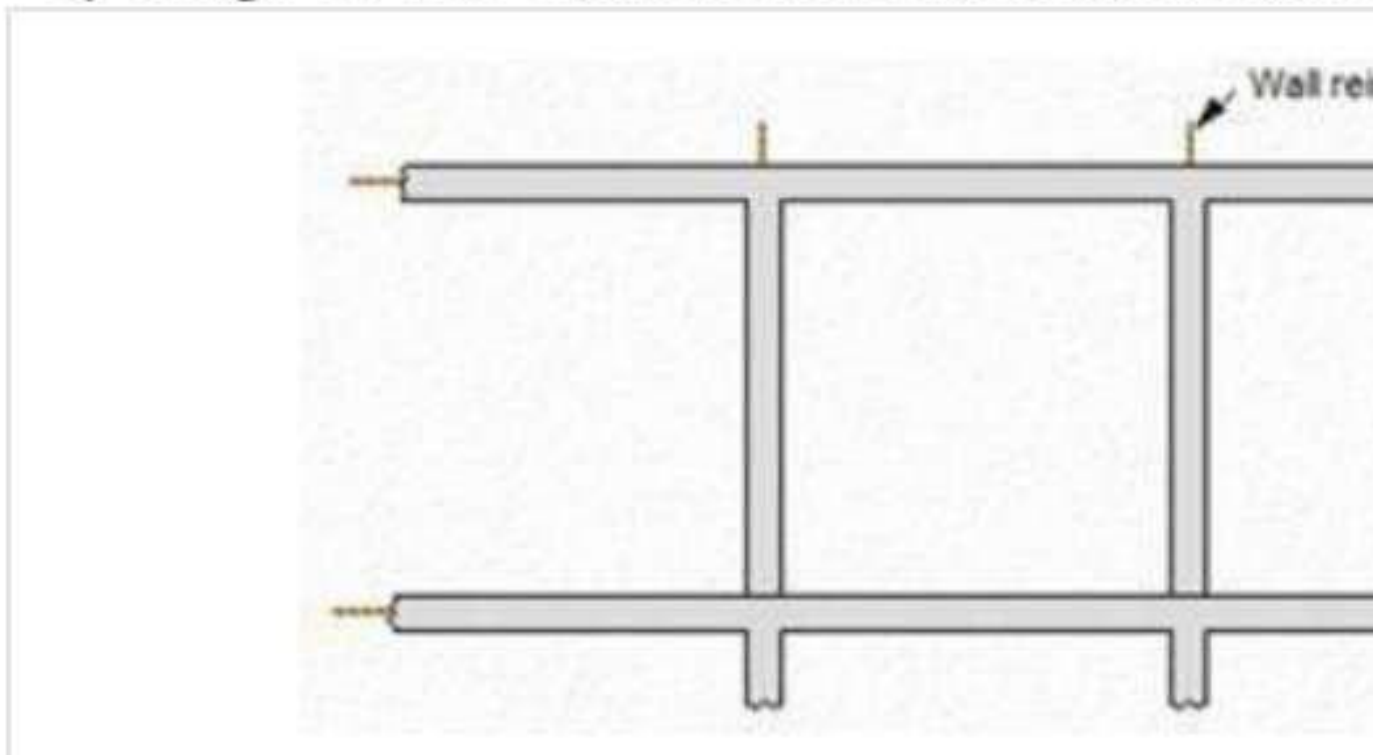




## COST EFFECTIVE



**6) Stage 6:** The tunnel-forms are removed ne



## COST EFFECTIVE

---

established business in these countries. In Europe, concrete masonry construction is popular in recent years. Such blocks can be used for 10 stories. Concrete masonry unit is a modular system. The advantages of concrete masonry in western countries are its various advantages like its strength, thermal and acoustical characteristics, attractive appearance and low cost construction.

There are at present, quite a number of masonry systems in use, the minasto shrike and Gospel to name of few.

The zip block system pre fabrication, precast concrete hollow blocks of 600X200X150 mm size and 530X250X140 mm as filler materials for roofing. In this system of construction, foundation is not precast. The integral part of the system the Zipbloc system uses for construction of houses upto three storeys.



# COST EFFECTIVE

---



## COST EFFECTIVE

---

- III. The precast units may be designed by ultimate load method of design or limit state design as per Indian standards both ordinary steel reinforcement.
- IV. Precast units should be adequately cured and attention should be given particular attention to avoid cracking.
- V. Joints are the most critical parts in the system and their failure of the system.
- VI. All opening should be pre planned and proper sealing of the precast units is completely is avoided.
- VII. Fan hooks, electrical conduits etc. should be avoided.
- VIII. The water proofing of the roof should be done in the precast roof assembly.
- IX. The American earth quake (December 1971) components to the forces of earth quake.

### **Economical Walling System:**

Wall is one of the important structural element and on an average accounts for 25 to 30 % of the cost of the building and stone masonry are the two most popular walling systems.

As a result research work undertaken by the Indian Institute of Technology, Kanpur on the construction of load bearing brick masonry



## COST EFFECTIVE

---

Generally half brick thick wall are common in planning, it is possible to put up half brick thick walls, over lapping of half brick walls at regular intervals, pilasters transfer the load of the roofing system.

Masonry work in brick of 10 N/mm<sup>2</sup> strength is required for constructing such walls. A ring beam of 23 cm depth is required to provide bearing for the roof saving the traditional 23 cm thick load bearing walls.

### **Fly ash Gypsum brick for masonry:**

Common burnt clay bricks can be manufactured with a certain percentage of clay, sand, etc. within variable limits. In southern India where good quality soil for manufacturing bricks is available.

Fly ash gypsum bricks are good substitutes for burnt clay bricks. They are readily available. These bricks can be manufactured with 10 % kankar lime and 3.5 % gypsum in volumetric ratio. The strength expected to be achieved from these bricks. They provide better thermal comfort to the occupants.

### **Stone Block masonry:**

The precast block masonry is an improved system which requires less excessive material and more skilled labour and can be produced at factory or at site with semi-skilled labour.

# COST EFFECTIVE

---

## Single stack system of plumbing

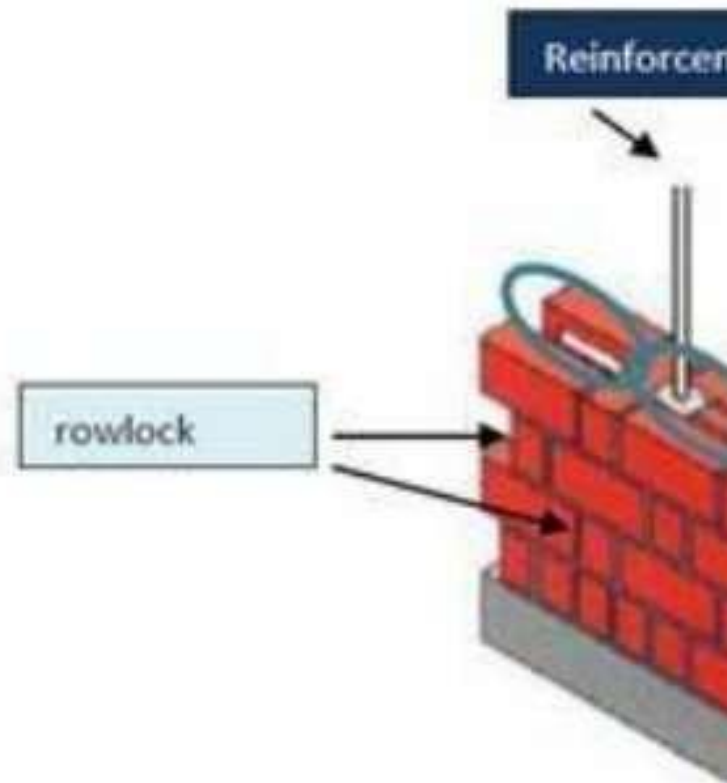
In the conventional system of drainage for building which takes discharge from the water closet, urinals, sinks and wash basins, etc. besides, a vent pipe is required to maintain the seal of the traps of different appliances. The single stack system, is essentially a one pipe system in which the discharge from toilets is carried out of the single stack.





## COST EFFECTIVE

---



This gives the wall with an internal cavity bridge materials like brick clay and cement can be con Green building technologies and sustainability brick wall masonry.

This cavity adds an added advantage as it adds thermal comfort and keep the interiors colder t

The Bat trap bond construction is a modular t

## COST EFFECTIVE

---

- Virgin materials such as bricks, cement, etc. are used in this technology. It will also help reduce the production of Green House Gases into the atmosphere.
- In case for more structural safety, reinforced concrete foundation.

### Filler slabs:

**Filler slabs** are one cost-effective roofing technology instead of placing **filler** material there.

Filler slab technology is a simple and a very effective

The reason why, concrete and steel are used together is their properties as separate building materials and their combination in compression and steel is good in tension. Thus Filler slab is well as tensile.



## COST EFFECTIVE

---



*Fig 2: showing u*

If we refer Figure 2, which indicates the neutral the slab which is in tension but the top fibers w understand the filler slab technology. Tension top fiber. That means if we want to optimise th zone where it is not much needed. That's the k

This is a very cost effective roofing technology

## COST EFFECTIVE

---

economy of high energy material's, consumption of the slab.



### **Brick arches:**

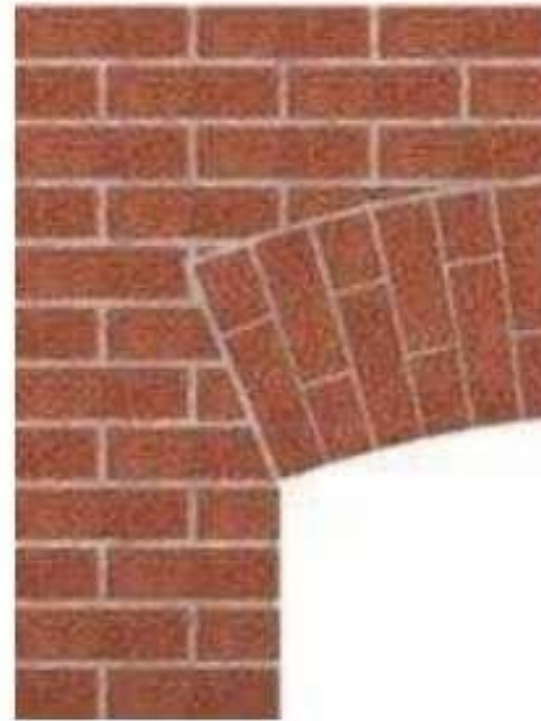
Types of arches based on shape, material are discussed here. An arch is constructed in curve to supports (pier or abutment).

- ☐ **Flat Arch**
- ☐ For flat arch, the intrados is apparently flat.



## COST EFFECTIVE

---



### **Semi-Circular Arch:**

The shape of arch curve looks like semi perfectly vertical direction since skewback is horizontal the springing line.



## COST EFFECTIVE

---

### **Ashlar Arches**

In this type, the stones are cut to proper shape to construct an arch) and fully dressed, joined with flat arches.



### **Case study: Adoption of precast RC planks**

The national buildings Organization with the help of the All India Institute of Medical Science (AIIMS) to suggested ways and means



## COST EFFECTIVE

---

- VII. Secondary species of timber for joinery work and costly.
- VIII. Common stair case to serve eight dwellings for vertical travel, and
- IX. Ferro cement overhead tanks for water supply.



**BED ROOM**  
**12' X 12'**

B.

## Alternative Building Materials for

### Introduction

Building materials account for 70-75% (Table 1) of the total cost of construction programmes in the country, the demand for materials like cement, steel, bricks and timber has outstripped their supply. Rapid population growth and the existing housing shortage have made the situation worse. There is a general shortage of conventional building materials, especially timber in different parts of the country. In 1993, there was an estimated demand of 17 million tonnes of cement, 285 million tonnes of steel, 13 million cu.m. of timber. It is thus quite obvious that the conventional building materials in the country is not in a position to meet the ever increasing demand. In the present situation, the country has very little option but to resort to the use of cost-effective building materials and components. The R&D efforts of various research organisations like CRBI, Roorkee; SERC, Madras; National Institute of Building Materials (NCB), Ballabgarh; Central Fuel Research Institute (CFRI), Durgam Cheruvu; NBO and BMTPC have led to development of various low cost building materials using several industrial and agricultural wastes. The use of agro-exploitation of the agro-industrial wastes for their commercial application in construction programmes.

Table 1

Average cost break-up of building c

| Materials (73%) | Labour (27%) |
|-----------------|--------------|
|-----------------|--------------|



### Hydrated Lime

It is normally assumed that 70% of the cement produced is consumed, of which 40% is used for masonry mortars and plasters. Out of this, 30% can be profitably replaced by lime •alone or in conjunction with cement. In recent times, the use of lime in building construction has declined due to the material available in the market and its inherent defect in the preparation of mortars.

An innovative process of hydration of lime has been developed to produce lime in dry form, standard quality and ready to use form as in the form of bags for 6 months without any deterioration. NBO had set-up a unit for demonstrating the production of standard quality hydrated lime in 1976. Consequently, over 50 hydrated lime plants of total capacity of 1 million tonnes have been established in various parts of the country over the past few years. The plants set up by public sector construction agencies, one each in the states, have estimated that 1 million tonnes of cement in building construction can be replaced by materials produced in the aforesaid units with anticipated savings of 10%.

### Lime Pozzolana Mix

The clay pozzolana, available in the market, is known as surkhi and is used in brickbats and is of variable quality. A new process of production of pozzolana has been developed in which clays of suitable specifications are calcined and then ground to a fine powder as per the IS specifications. The reactivity is 5 to 10 times that of ordinary surkhi made by powdering.

The lime pozzolana mix conforming to LP-20 as per IS 1172-1977

5,000 litres, 7,500 litres and 10,000 litres capacity. These tanks are a substitute for traditional brick-walled water tanks up to the extent of 30%. They are being used at many locations in India. It is estimated that about 5,000 ferro cement tanks are produced every year in Madras alone both in public and private sectors. The use of ferro cement is also being experimented for the production of other building units.

### Gypsum Boards

Gypsum board is ideal substitute for conventional building material. It can be used in several applications like panelling, wall-covering, etc. It can give the effect of brickwork or a smooth finishing like Plaster of Paris. It is fire proof. It weighs one-tenth of the normal brick, the actual weight depending upon the thickness. It is easy to use as it can be nailed with ordinary tools. Such boards are available in thickness of 9.5, 12.5 and 15 mm, width 1200 mm, and length to 3600 mm.

### Timber Substitution

There is presently an acute shortage of good quality timber due to over-exploitation, skyrocketing. This is mainly because usually only half a dozen species of timber such as teak, deodar, sal, shishum and rosewood, etc., are used, mainly on account of their durability, decorative appearance and high strength. The stock of primary species of timber is rapidly dwindling due to fast depletion in the country and the phenomenal rise in population over the past few decades. The rate replenishment of the felled timber, and the increasing awareness of the importance of maintaining ecological balance. A survey of



### ii) Plywood

Plywood utilises the secondary species of timber. Shelvings of secondary species of timber and plywood are the two basic materials. It is universally available in various sizes and thicknesses. It is used for furniture making, wall panelling, door panels, shelving, etc. Plywood allows easy and quick working as compared to timber.

### iii) Metals

Hollow, pressed metal doors and windows have been used by various departments/ agencies such as the CPWD and DDA, etc., over the years. These doors and windows possess the advantages of longer life, fire resistance, freedom from warping and swelling. Hinges, holdfasts, bolts and nuts are easily available for installation. However, maintenance of such doors poses some problems for house owners to arrange a welding set at later stage of the life of the doors and windows made of mild steel.

Another improvement over mild steel doors and windows are the doors and windows made of mild steel. Welding has been totally eliminated by using zamac alloy and weather resistant rubbers. These doors and windows can withstand cyclone wind velocity upto 190 km/ hr.

Aluminium is yet another metal tried out for doors and windows. In conjunction with aluminium door shutters are being increasingly used in various projects. Such doors and windows have, however, not been widely used in the construction of residential buildings due to their higher cost.

### iv) Poly Vinyl Chloride (PVC)

Another important wood-substitute that has made inroad at least

major construction departments in the country.

### vii) Fibre Boards

The most promising wood substitute that possess all the good qualities of a fibre board. These boards are manufactured by converting raw materials like bagasse, cotton stalks, rice husk, jute and corn, etc., into mats, pressed to give uniform distribution of fibres and then bonded with a resin. The density that is achieved is very high, in the range between 2400 to 2600 kg/m<sup>3</sup>. They are claimed to possess excellent mechanical, moisture-resistant and fire-resistant properties. Some of the major Indian companies have taken significant steps to produce high quality fibre-board. The Birla Group has set up a big plant. Nuwood has set up a big plant with the Swedish know-how at Tohana (Haryana) with a production capacity of 13 million sq.m. tonnes) (39,000 tonnes) of fibre board. Nuwood as 'Nuwood MDF' is a Medium Density Fibre (MDF) board made from wood chips (phenol formaldehyde) and paraffin wax. In this process, the wood chips of different graded sizes made into fibres, added with resin binder to form a mat. These boards. Fibre board is manufactured in varying densities-soft, medium and hard. It is used for thermal insulation and as a resilient material for floors, doors, and windows for panelling, wall-linings, ceilings, doors and windows. Hard fibre board is used for windows as these are claimed to be water and abrasion resistant. It can be cut into any size like natural wood. The Bureau of Indian Standards (BIS) IS 12406 for specifications of fibre boards.

Fibre board has been widely used as a viable timber substitute in many countries in Europe.

### viii) Other Substitutes

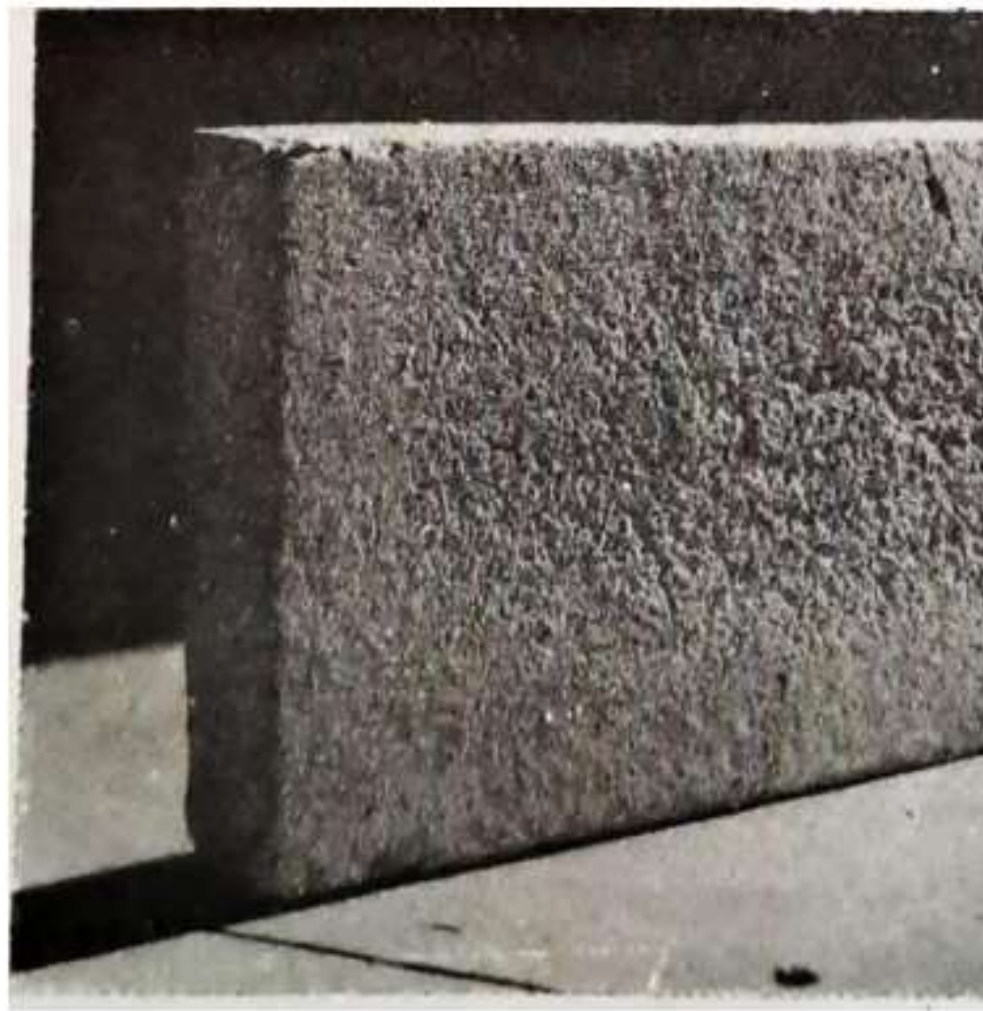
Besides the other suitable timber substitutes for doors and windows are



## COST EFFECTIVE HOUSING T

---

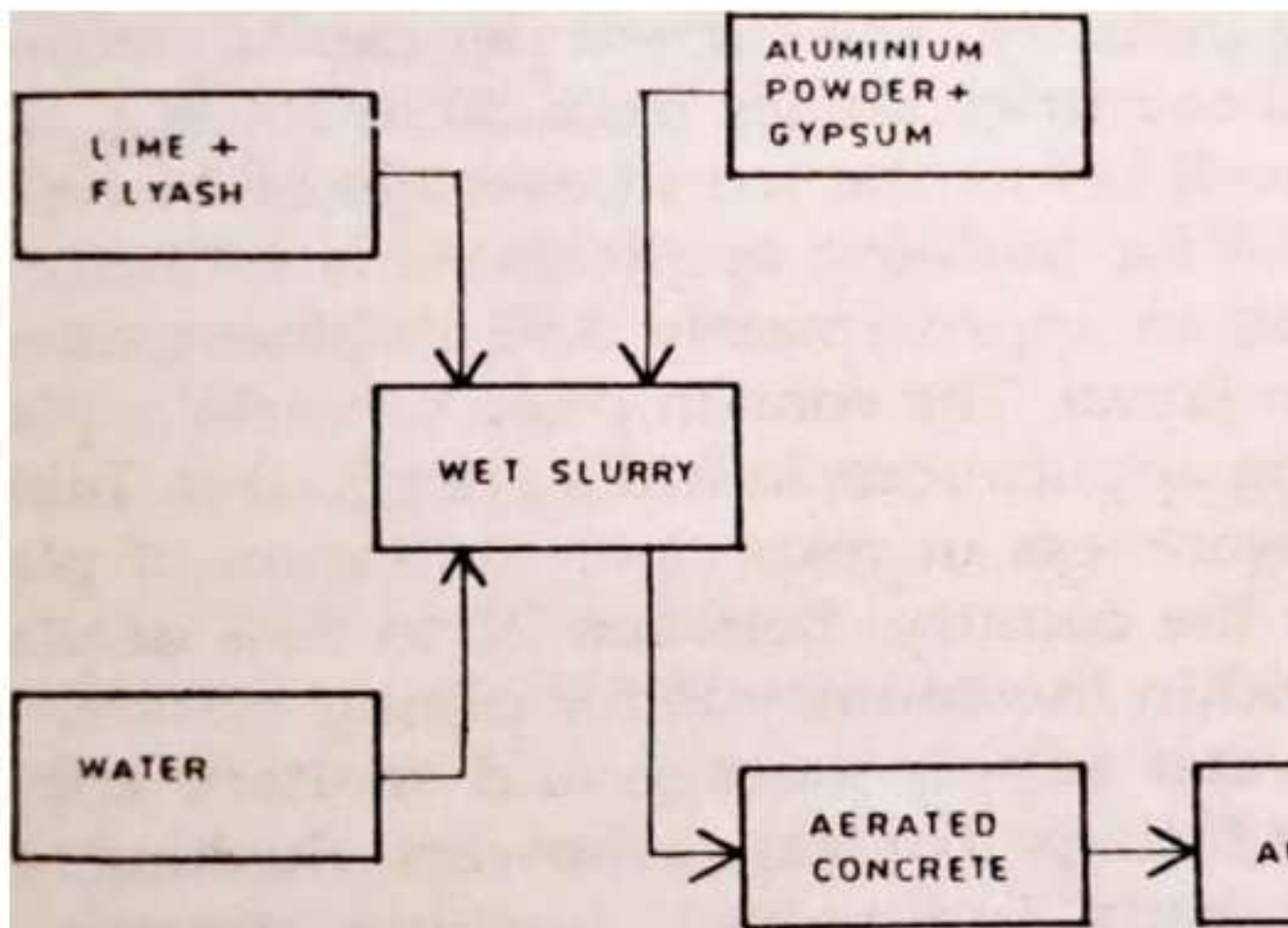
blocks in fig can be sawn, cut, drilled and nailed. Because of this, it is suitable for the construction of multistoreyed buildings as it reduces the cost of construction due to lightweight and high strength to weight ratio of cellular concrete. There is an appreciable saving in consumption of scarce materials like cement.



A view of cellular concrete block

Cellular concrete is produced by autoclaving a set slurry consisting of cement, sand, and water, with the addition of foaming/ air entraining agent, Base on this, it is divided into two groups namely i) cement based and ii) lime based. Generally, the foaming agents are either organic foaming agents based on resin soap, glue, etc.

## COST EFFECTIVE HOUSING T



Schematic diagram for production of lime-fly

The lightweight cellular concrete products manufactured by (Madras) is known as 'Celcrete.' The plant was set up under produced with lime and sand as raw materials. The Celcrete pr their housing programmes. Blocks of dimension 600 x 200 x 125 bearing as well as non-load bearing blocks. Experience of the T cellular concrete for roofing and there is saving of '10 to 50% shuttering and 80% in water requirement at construction site v 10% compated to RC roof slab -



## COST EFFECTIVE HOUSING T

flush water fully or partially, as required with exceptional efficiency. The consumption of plastics for cistern in 1994-95 was around 1

Toilet seats and covers made of polypropylene and appearance, hygienic, heat and chemical resistant, and are easy to use. The weight of such toilet seats is about 1.5 kg. Their production was of the order

PVC and high density polyethylene (HDPE) are the two main materials used in the manufacture of piping system for water supply and related applications. Water supply in India commenced in the year 1962 with the establishment of Delhi. There has since been appreciable rise in its application in the country. It has risen from the level of 82,000 tonnes per annum.

Table 2

Application-wise consumption of plastics in building and construction  
reproduced with permission from Civil Engineering Construction  
Review, New Delhi)

| S.No | Component                   | Material  | C |
|------|-----------------------------|-----------|---|
| 1    | Pipes Fittings and Conduits | PVC       | 2 |
| 2    | Overhead water tanks        | HDPE      | 3 |
| 3    | Floor Tiles & Skirting      | LDPE/HDPE | 4 |
| 4    | Walling materials           |           |   |
|      | (a) Wall Paper              | PVC       | 7 |

## COST EFFECTIVE HOUSING T

---

in 1979 to 4,00,000 tonnes per annum in 1993. During the previous years, plastic pipes were laid in the country. Rigid PVC (unplasticised) pipes and low density polyethylene pipes upto 400 mm diameter are produced in India. Fittings conforming to relevant Indian Standards Specifications. Unplasticised PVC pipes for water mains in diameters ranging from 90mm above have been used by the Government of Delhi, DDA, above Tamil Nadu Housing Board, by MES, PHED, etc., in U.P. Jal Nigam, etc., both in their rural and urban water supply schemes. Pipes form the second largest application of plastics in buildings after plastic. PVC flooring and skirting tiles in India was about 11,900 MT during 1993.

There are two kinds of PVC floorings-one is flexible which is available in sheet form and the other is rigid which is available in tile form. Vinyl tiles are made of pigments bonded together with PVC binder. Asbestos-PVC tiles are also available with lasting appearance. These tiles and semi-flexible are quite strong and rigid surface. They are anti-skid and quiet under foot. They are used instead of portland cement paste as a binder for marble chips.

The plastic floor tiles and coverings have been in use in India for many years. They are quiet, resilient, non-combustible and damp proof wearing and durable. They are generally expensive but preferred by users over other floorings materials for their value.

Low density polyethylene overhead storage tanks upto 10,000 litres are successfully produced and marketed in India. Plastic tanks are light in weight (a 10,000 litre polyethylene water tank would weigh about 15 kg) and installation are much easier. The present consumption of plastic tanks is about 10,000 MT with the annual growth rate of about 15-20%.

A suitable replacement of timber could be found in composite materials using plastics foam as core and surfacing of conventional materials like Reinforced Plastic (GRP), concrete, and gypsum, etc. These materials are stable, possess high strength to weight ratio, possess excellent sound insulation, low transportation and maintenance cost.

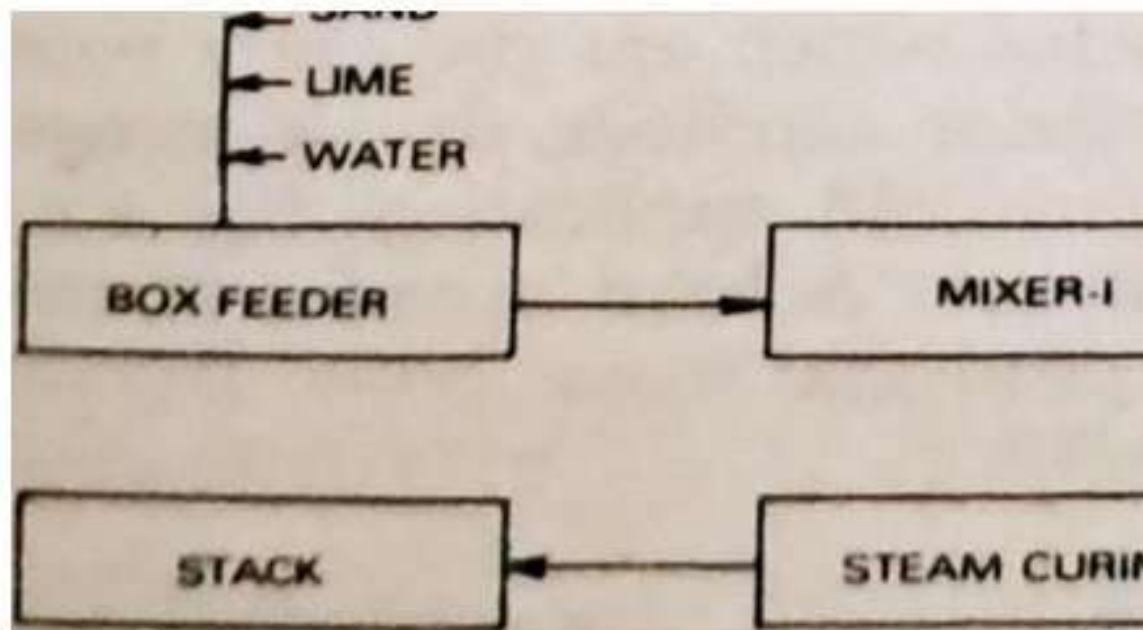


## COST EFFECTIVE HOUSING T

bricks per year using completely imported plant and machinery about three decades ago. Another factory near Calcutta is producing using indigenous technical know-how and machinery. Largescale material has not been possible in India due to the non-availability of

Sand-lime brick is an alternative walling material which may replace clay bricks in the country. Particularly in those areas where sand is manufactured and sand or siliceous wastes like flyash or ore-tailings can solve the problem of good quality bricks as well the disposal of waste. The diagram for production of sand-lime bricks.

Calcium silicate brick consists of a uniform mixture of sand or a mixture of lime, mechanically pressed and autoclaved, so that the materials are cured by steam under pressure. Such bricks are quite strong (compressive strength) and compare well in cost with the conventional bricks in the aforesaid areas.



Schematic diagram for production

## COST EFFECTIVE HOUSING T

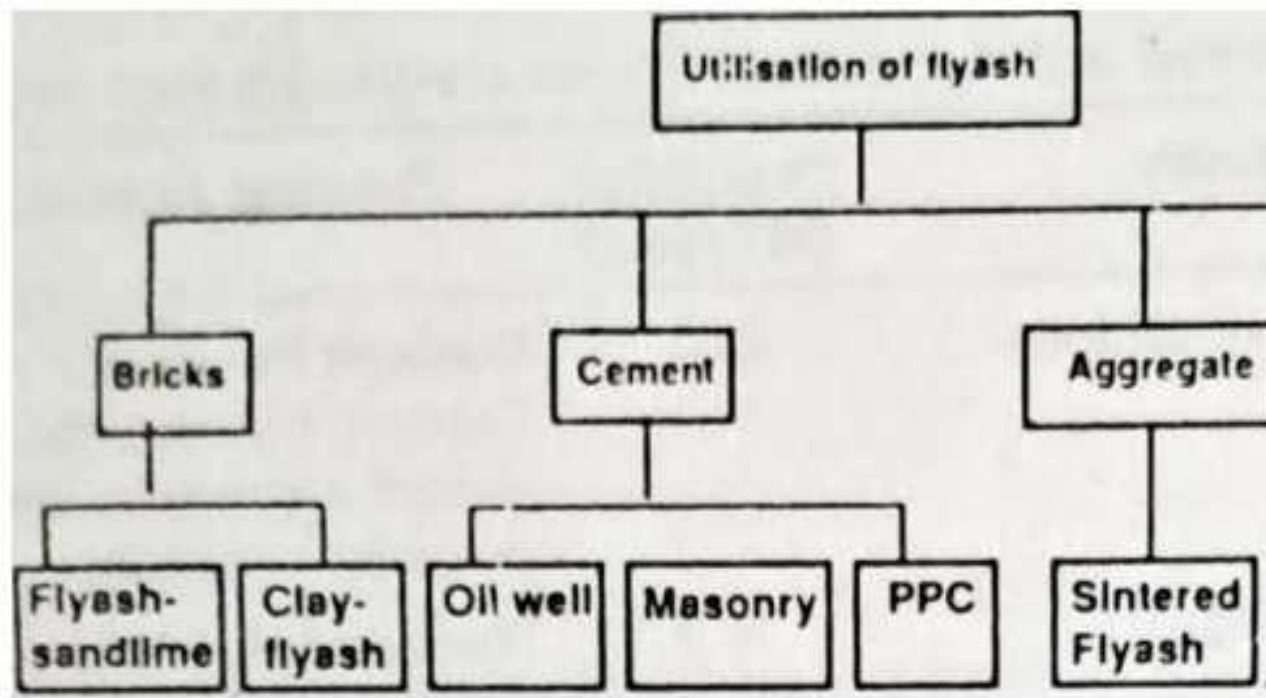


Fig. Various utilisations of flyash

### a) As Pozzolana

Most of the flyash varieties available from the Indian thermal power stations have the chemical and physical properties required in pozzolana.

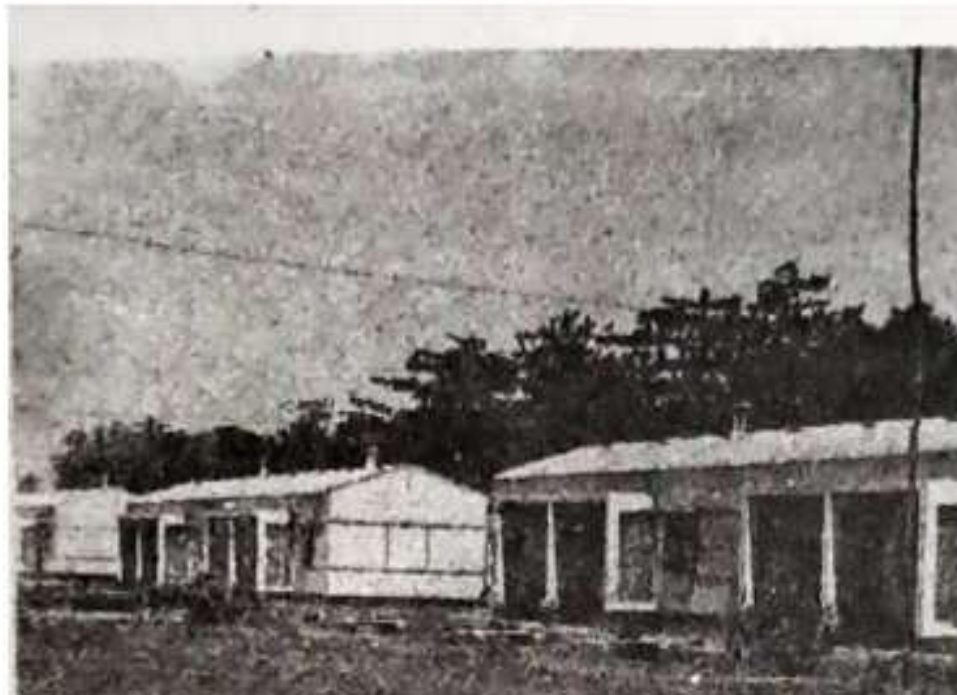
Table 3  
Annual Production of Industrial and Agricultural Wastes

| Waste   | Industry               | Production (MT/Year) |
|---------|------------------------|----------------------|
| Fly ash | Thermal power stations | 40.0                 |



## COST EFFECTIVE HOUSING T

|                        |                                      |       |
|------------------------|--------------------------------------|-------|
| Coal washery reject    | Coal washeries                       | 3.0   |
| Rice husk              | Rice mills                           | 25-30 |
| Coconut husk           | Coir-fibre industry                  | 2.0   |
| Bagasse                | Sugar mills                          | 5.3   |
| Ground nut hulls       | Oil mills                            | 5.75  |
| Rice straw wheat straw | Agricultural farms                   | Large |
| Straw mill waste       | Straw mils and wood based industries | 2.0   |



## COST EFFECTIVE HOUSING T

---

Portland Pozzolana cement is suitable for use wherever Ordinary Portland Cement is usable under normal conditions. It produces less heat of hydration, improves impermeability, reduces alkali-aggregate reaction and offers better resistance to aggressive waters than OPC. It is, therefore, particularly suitable for durable structures and other mass concrete constructions.

### c) Ready Mixed Flyash Concrete

Portland Cement concrete in which a part of the cement has been replaced by flyash is called flyash concrete. When it is prepared and supplied to consumers in ready-to-use state, it is called ready mixed flyash concrete. The process of producing ready mixed concrete consists of two operations namely (i) proportioning of ingredients and (ii) batching and mixing of different ingredients. The flyash concrete should have a 28-day compressive strength equal to that of the corresponding plain concrete. The mixing of different ingredients is generally done at a central batching plant. Sometimes, different ingredients are taken in a truck mixer at the site and mixed either during the journey or on arrival at the site of delivery.

The ready mixed concrete has the advantage of better quality control, less wastage and pilferage of materials, labour and supervision, which are not required when concrete is prepared at site.

### d) Precast Flyash Concrete Building units

Flyash concrete has been used in the production of various types of precast concrete building blocks (solid or hollow), columns, beams, hollow core slabs, frames, etc. It has also been tried out in the production of large precast units, such as cored units, channel units and cellular units by using flyash in place of cement. The strength and other structural properties were found to be comparable to those produced using plain cement concrete. In the NBO experimental



## COST EFFECTIVE HOUSING T

---

Fal-G bricks have recently been used in the construction of 200 h

Fal-G could also be used as a substitute of OPC mortar and units of Fal-G cement is to be used against one unit of OPC.

The Government of India has recently finalised plan for setting up plants at Dadri, Delhi and Ahmedabad.

### f) Lime-Flyash Cellular Concrete

Lightweight aerated concrete or cellular concrete can be manufactured by mixing of flyash, quick lime and gypsum in a high speed mixer. A small amount of foaming agent such as aluminium powder is added and hydrogen gas. The aerated slurry is poured into steel moulds and then removed after initial set and autoclaved at steam pressure. It is then allowed to cool and stacked for use. These are considered excellent for prefabricated floor slabs. The bulk density of product ranges from 500 to 700 kg/cu.m. suitable for load bearing walls in buildings upto 2-3 storeys and for non-load bearing buildings. They can be sawn, Chiselled, planed, screwed and nailed. The high strength to weight ratio of cellular concrete products results in economy in consumption of cement and steel. Flyash-based aerated concrete are manufactured by the Ballarpur Industries Ltd. at Palwal (Haryana). Flyash has of late also been used in production of reinforced concrete. The problem of corrosion of reinforced cement in these units has also been solved. It is suitable for flooring, roofing and walling in common dwellings and

### f) Sintered Flyash Lightweight Aggregate

Conversion of flyash into lightweight aggregate is one of the possible uses of flyash in an economical manner. Sintered Flyash Lightweight Aggregate of density of 640-750 kg/cu.m. has been produced in a pilot plant at Ballarpur. The process from the Indian flyashes which was successfully carried out in

### h) Flyash-Sand-Lime Bricks

Another way to supplement the present shortfall of the traditional clay bricks for production of flyash-sand-lime bricks commonly known as flybricks. The production of such bricks is a technically sound proposition and is viable in areas where good quality brickmaking clay is not available. Costwise, flybricks are found to be costlier than common burnt clay bricks. This type of bricks is widely used in many developed countries like Germany, Russia and the Netherlands. There are 200 factories producing Calcium silicate bricks whereas in India only a few are producing this building material. One is situated near Cochin producing flyash-sand-lime bricks using imported know how and machinery. The second plant is located near Bangalore producing bricks on small scale with indigenous know-how and machinery. Calcium silicate bricks contain about 60-70% flyash in their manufacturing process.

The production of flyash-sand-lime bricks consists of four main operations: (a) preparation of new materials; (b) mixing; (c) shaping or pressing, and (d) curing. The curing of bricks depends upon various factors. And the notable among them are: (i) materials; (ii) moulding pressure, and (iii) steam curing in autoclaves. The duration of curing. Initially, flyash and sand are mixed dry and then lime is added in the proportion of 80:10:10 to 60:30:10 by weight, respectively. Water is added to the mixture. The slurry so formed is next transferred to the moulds. A moulding pressure of 20-30 N/mm<sup>2</sup> is applied. The green bricks are then loaded on trolleys for onward transmission to the autoclaves (steam pressure of 1.0-1.4 N/mm<sup>2</sup> of steam pressure for 4-6 hours. The cured bricks are then removed from the autoclave and sent for use.

In April 1994, a flyash-sand-lime brick plant with an installed capacity of 1000000 bricks annum has been set-up at Tribeni West Bengal).

The plant is to utilise 200 tonnes/day of flyash produced at the Band



## COST EFFECTIVE HOUSING T

---

- iv) Non-availability of adequate data regarding quality of
- v) High initial investment in setting-up flyash based build
- vi) Non-incorporation of flyash based building materials and specifications of the construction departments/ ag impediment in its large-scale utilisation.

vii) Wide spread reluctance to use of flyash in civil engin the fact that thermal power plants have not yet accorded re as two distinctly different resource materials for other in accorded, their disposal would acquire a dignified status flyash collected from different locations would not be inc would be suitably collected in the manner as would not d viz, their pozzolanic characteristics and reactivity with lim

### **Blast Furnace Slag**

Blast Furnace slag is the only industrial waste which so far has four is a waste product from steel plants. Presently, India produces mor out of which 3.5 MT are being granulated for the manufacture of whose present production stands at around 3.15 MT. Small quantit manufacture slag wool. It is also used in the road construction in ste In addition to the manufacture of blast furnace slag cement, gran manufacture of super sulphated cement which possesses high sulph

## COST EFFECTIVE HOUSING T

---

aluminium oxide. The Red Mud waste and PVC are combined in the material. Possessing a better heat stability, the material is claimed to possess better fire resistance. The inorganic oxides present in RMP add to the flame retarding nature of the material. The material is claimed to be weather proof with a long exposure life. RMP sheets are being used in Japan, China and tropical countries.

RMP's characteristics make it a suitable material for roofing and construction in the Indian market only recently. Half a dozen organisations in the country have developed technology for its manufacture. However, only two or three companies have started actual production of RMP corrugated roofing sheets since 1986. Its weight is 2 kg/cu.m. These sheets are light in weight (2 kg/cu.m.) and available in 1 m width and length a little over 1 metre.

### Lime Sludge

Lime sludge, which essentially contains Calcium Carbonate with some impurities, is a waste product from sugar, paper, fertiliser and Calcium Carbide industries. The quantity of lime sludge is approximately 4.8 MT. The utilities of lime sludge in various fields have been investigated for commercial exploitation.

Besides, lime sludge mixed with rice husk may be used as a cement substitute. Further studies and field trials are required for proper burning of lime sludge in the vertical shaft kiln. Based on the CBRI technology developed for processing of lime sludge, three entrepreneurs have been licensed to set-up lime-sl



## **COST EFFECTIVE HOUSING T**

---

The Union Ministries of Chemicals and Petrochemical, Environment and Employment have joined hands to promote the use of phosphogypsum big way. The first such project is being set up at Visakhapatnam with the phosphogypsum-based products are to find their application in other. Apart from reducing environmental pollution, the gainful application of building material as envisaged in the aforesaid project will go a long way among the entrepreneurs and users in respect of larger application of phosphogypsum in building construction.

Cements produced from phosphogypsum have delayed setting and strength but strengths at later ages (28 days and beyond) are comparable to Ordinary Cement (OPC).

### **Agricultural Wastes**

In the rural areas 370 MT of agro-waste is available of which 50 MT are maize stalks and other such crop wastes. Another 50 MT comprise groundnut shells and such small wastes. These could be gainfully utilised.

#### **i) Rice Husk**

About 25-30 MT of rice husk is produced annually in the country. Bricks produced from rice husk and clay may be used for making masonry of lower grades. Rice husk is obtained as a waste material from rice mill.

Investigations have been undertaken with a view to utilising the waste. Technical know-how has been developed and pilot plant trials are being conducted in institutions in the country like RRL, Jorhat; NCB, Bailabhar, and

## **COST EFFECTIVE HOUSING T**

---

for production of insulation boards and building wall panels with binder. Field trials have been carried out for making insulation boards and indigenous technology is available for production of bagasse-based insulation board in the country. However, the economy of manufacturing insulation board on a large scale is yet to be worked out. There is great potential for utilisation of bagasse-based insulation board in view of the large scale availability of the main raw materials and prerequisites for establishment of the waste based industry.

### **Other Agricultural Wastes**

Furthermore, about 10 MT of cotton stalks, 4 MT of jute stalks, 5.7 MT of sawdust (saw mill waste) and 1 million of coconut pith are available for exploitation as viable building materials. The R&D efforts have been directed towards the development of building materials, especially for production of insulation boards by utilising these wastes. However, no indigenous technology is available in the country for commercial production of building components based on these wastes.

### **Future Strategy for Promotion of Alternative Building Materials**

Industrial and agricultural wastes like flyash, phosphogypsum, bagasse, husk and coir waste, etc., hold great promise as building materials. Various measures have been undertaken in recent years in the country to popularise use of these wastes. Measures initiated in this regard are listed as below:

- i) The National Housing Policy (NHP) announced by the Government in 1992 has emphasised on economising the use of scarce building materials, promoting cost-effective and environmentally appropriate technology and innovation, and for providing an impetus to larger use of materials based on indigenous resources.



## COST EFFECTIVE HOUSING T

---

power stations in Delhi U.T. The Government of India has recently set up three flyash brick units at Dadri, Delhi and Ahmedabad under the programme.

v) With a view to promoting use of flyash based products, the Government has decided that no new licence for burnt clay kilns should be given within a radius of 50 km. of an existing brick manufacturer start using flyash to replace natural soil, which will help the conversion over to flyash-based brick will help save at least 30 to 35% of the cost.

vi) The HUDCO and NHB are promoting new building materials made from agricultural and industrial wastes by participating in the equity of the venture, by extending term-loan support to entrepreneurs for setting-up in the rural areas and components based on agro-industrial wastes.

vii) While technologies for making clay bonded sand-lime bricks and other building products have been developed at the CSIR laboratories, the Government is in the process of developing national standards on such bricks and components made of phosphogypsum in construction works.

viii) The Building Material and Technology and Promotion Council, under the Ministry of Urban Development (MUD), has undertaken identification of technologies which could help larger utilisation of industrial wastes like flyash in the brick industry. The Council has prepared technical profiles in respect of sand-lime bricks, cellular concrete components, cement fibre roof tiles and phosphogypsum based buildings components for their larger utilisation. The Council also incorporates proposals for foreign assistance in the form of grants and also taken initiative in respect of encouraging larger entrepreneurs and institutions.

## LOW COST INFRASTRUCTURE

The position in villages is still worse. In 1988, drinking water supply 15% of the households. Inadequacy of services in the countryside is according to the 44<sup>th</sup> Round of NSS (1988-89), around 89% of the rural latrines.

### Technological Options

Over past three decades many cost-effective technological options in developing countries in respect of supply of potable water, provision of drainage of waste water, sewerage system, collection and disposal of environment in housing and human settlements. Brief description of technological options which could lead to environmental upgradation is given below.

#### **Low Cost Sanitation**

The modern technological solutions offered for improving sanitation in new settlements in metropolitan cities, small and medium towns, of magnitude. A study published in 1980 by the World Bank identified varying from simple on-site latrines to water-borne sewerage. Out of found appropriate for adoption on mass scale in India. Water-borne user convenience but it is extremely costly, and demands large quantities. Sanitation, more than any other infrastructure services, offers prospect of alternatives to conventional sewerage.

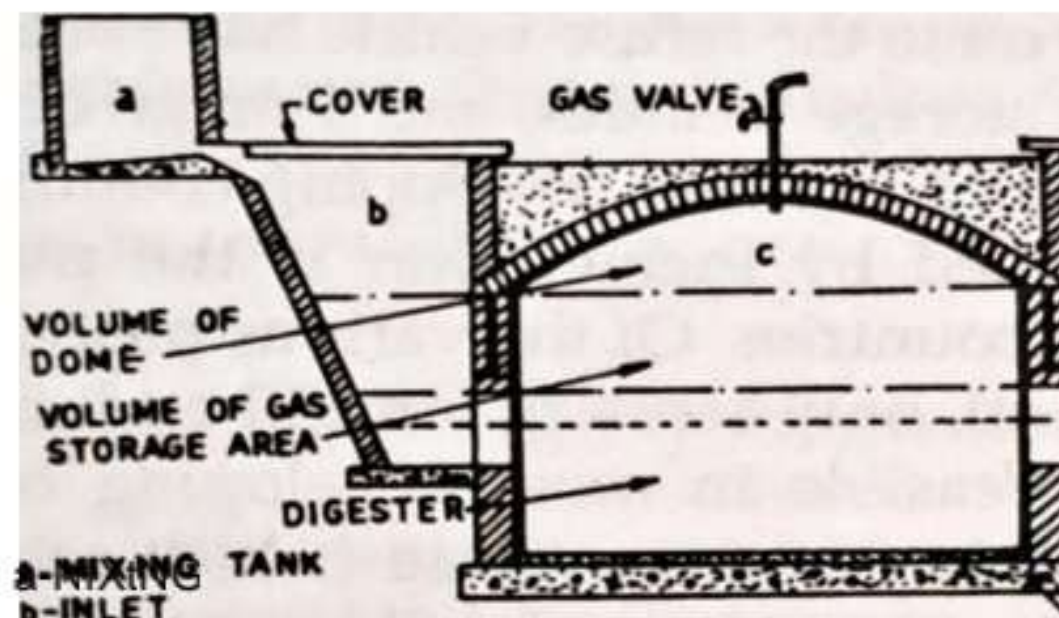
As a result of the sustained research undertaken in the field of low cost country, different types of low cost sanitary latrines have been identified depending upon their appropriateness to local situation. Criteria for



## COST EFFECTIVE HOUSING T

Septic tanks, despite their high costs, have been widely used in developing countries, and the use of a single tank to serve many households has considerably reduced the cost of this form of sanitation.

Community toilets have been tried in many developing countries, and education programmes are often necessary to ensure the success of such schemes. The International has put up more than 3,000 community toilet-cum-bathrooms all over the country. The 'pay-and-use' concept of community toilets has been recommended by the World Bank for adoption in Asia, Africa and Latin America. 'Sulabh' (Fig) is an ordinary portable toilet especially designed slopy pan which requires no more than two litres of water, compared to 12.5 litres required in case of a normal flush toilet. The two covers are used so that only one is used at a time. This twin-pit combination is claimed to



## COST EFFECTIVE HOUSING T

---

developing countries. Large capacity (5-10 cu.m.) roll-off containers directly on to the refuse vehicle have been successfully used as facilities, and a range of such vehicles and containers has been countries.

Open dumping accompanied by incineration is the most developing countries. Of the various processes available for waste sanitary landfill and, in some cases, composting are economical countries.

The high organic content of developing country refuse (which weight) makes composting a feasible option. In Bangalore and D out of organic wastes through their decomposition by earthworms. rich manure for better agricultural yield.

In India, pellets made out of organic wastes have been tried fuel. Plants producing such pellets have been set-up in Madras, Bon

## Water Supply

Provision of safe and adequate drinking water is not only essential healthy living. Pressure of over urbanisation in our urban centres es



## COST EFFECTIVE HOUSING T

---

rata basis is estimated at Rs. 2,000 crore approximately. As against assistance earmarked for this scheme during the Eighth Plan is Rs. 50

### Rural Water Supply

As regards rural water supply position, only 41 per cent of the rural population has convenient access to safe drinking water supplies. In most of the rural areas, the percentage of rural Population covered with provision of safe water is very low. Open wells, ponds, streams and rivers still continue to be the traditional sources of water for the majority of the Indian villages.

According to the IMRB study in India, the traditional open dugwells are the main source of water for all purposes including drinking water. The handpump with overhead tank is generally the order of preference. Nearly 10 per cent of the rural population gets water from exposed sources such as ponds, lakes and canals.

### Accelerated Rural Water Supply Programme (ARWSP)

With a view to meeting the requirement of water supply in the villages, the Central Government introduced the Accelerated Rural Water Supply Programme in 1973 to assist States and Union Territories with 100% grant-in-aid for drinking water supply in villages.

This programme continued till 1973-74, and when in 1974-75, it was introduced under the Minimum Needs Programme (MNP).



Fig. "Stand-alone" street light for rural area (Sou

### i) Biogas Plant

The normal method of disposing of animal dung is to dry it into cakes, which only leads to insanitary conditions in the house and the neighbourhood.



## COST EFFECTIVE HOUSING T

---

Energy Sources (MNES), the target for village street lighting system exceeded by 900 upto December 1992, while that for villages power met by setting up plants at 87 kilowatt capacity.

Solar photovoltaic lanterns are gradually becoming a more popular. According to an estimate, there are at present (1995) 700 solar lanterns. The price of a solar lantern is around Rs 950, which considering that maintenance charges, and the life of a lantern, if properly handled, is not unreasonable. Even the poorest household incurs more expenditure on them. Beside this solar heaters and cookers are also being used for domestic purposes. Heaters result in saving of conventional sources of energy such as wood. Solar cookers are pollution free. Under a government-sponsored programme to solve the rural energy problems and commissioned by the MNES, the solar cookers are being distributed in different parts of the country. Till date as many as 3 lakh solar cookers have been distributed in different parts of the country.

### Smokeless Chulha (Hearth)

Cow dung, charcoal and firewood which are most commonly used as fuel for cooking produce a lot of smoke which is very injurious to health. To avoid this nuisance, exhaustive investigations on efficacy of the existing chulhas were undertaken by the National Bureau of Action Institute, Lucknow in 1964. The study had identified some designs which could work without causing any smoke hazard. Such chulhas are found to be much convenient for cooking. The NBO has promoted such chulhas through its incorporation in cluster demonstration rural houses put up in 81 villages in different regions of the country. Each improved chulha saves 700 kg. of fuel annually. MNES has been actively implementing the scheme for installing smokeless chulhas. Over 1 million rural households in the country have already been covered under the scheme. Additional households are proposed to be covered during

# Rural Housing

## Introduction

Housing scenario in the rural India is more appalling than the urban agglomerations. As per NBO estimates, there was a shortage of 20.4 million dwelling units in 1991 in the country. The quality of housing observed in the rural areas is an indicator of the abject poverty, tremendous socio-economic disparity and extreme backwardness prevalent in the countryside. Inadequacy of infrastructure facilities in villages is very obvious from the fact that protected drinking water supply through tap was available only to 15% of the households in villages, and about 89% households in rural areas did not have sanitary latrines in 1988. Slush, dirt and unhygienic environment are generally synonymous with the human settlements in rural areas.

## Traditional Practice of Rural House Construction

A majority of rural houses in the country are constructed with mud wall and thatch roof (Fig). In places where stone is locally available, as in Rajasthan, Gujarat and hilly areas like Himachal Pradesh, houses are constructed with stone wall and roof comprising of Stone slab and slate etc. Timber and bamboo are used in north-eastern States of Assam, Meghalaya, Tripura, Nagaland, Mizoram, Arunachal Pradesh and Manipur. Bricks and tiles are used as building materials in the rural areas of Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar, Punjab, Karnataka, Kerala, and Tamil Nadu, etc. In construction of traditional rural houses age-old conventional methods are normally employed.



Fig. Traditional rural housing in a Rajasthan village



## COST EFFECTIVE HOUSING TECHNIQUES

---

### **Appropriate Rural Housing Technology**

In the present context, the appropriate technology for meeting the requirements of rural housing in the country will be the one which emphasises on judicious blending of the technological advancements in the field of building technology, living habits and financial capabilities of the rural people with due importance being accorded to optimisation of the locally available building materials.

The NBO Regional Housing Development Centres (RHDCs), the Central Ministry of Rural Areas and Employment, HUDCO, various state Rural Housing Co-operatives, and Government of Kerala etc. have been instrumental in promotion of cost-effective and appropriate rural housing technology in the country. Improved designs of village houses were evolved by the RHDCs to make them more hygienic and liveable. The centres have put up clusters of demonstration low-cost rural houses in selected villages across the country. Over 81 such clusters (Fig) comprising of 10-20 houses along with measures for environmental improvement have been put up in different geo-climate regions of the country with the objective of educating the rural people about the innovations in low-cost housing technology. This has been done with emphasis on optimisation of locally available building materials, which could help bring down the cost of construction as well as make rural houses more durable and liveable. The list of the cost-effective construction techniques and indigenous materials, which have been extensively tried out under the cluster demonstration rural housing projects, is provided at Annexure I. Items of environmental improvement provided in the aforesaid projects included sanitary latrines, paved streets, smokeless chulhas, bathing platforms, supply of potable water and provision of streets and open space etc.



Fig. NBO cluster demonstration rural houses in a Gujarat village constructed in stone masonry





## COST EFFECTIVE HOUSING TECHNIQUES

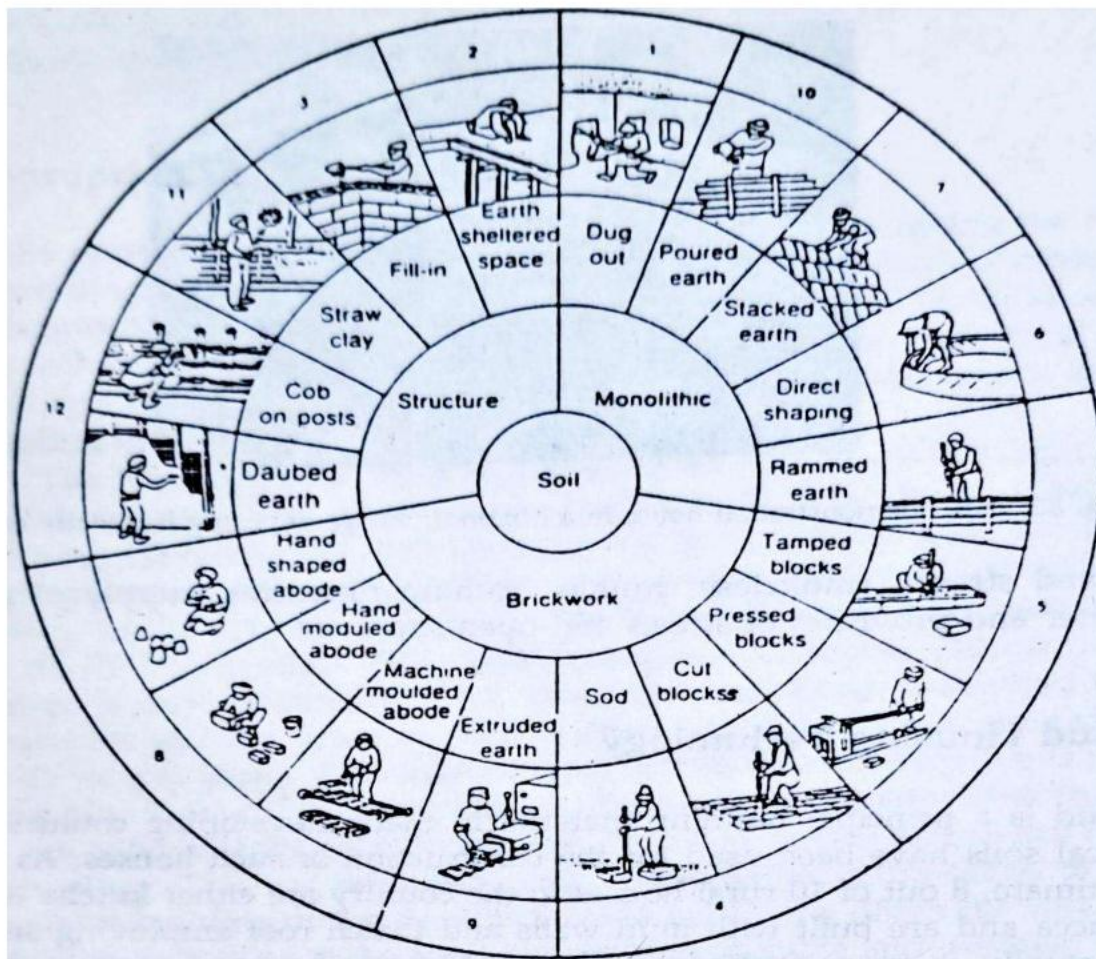
either kutcha or semi pucca and are built with mud walls and thatch roof employing self-help. Virtually, in every continent of the world-from the dry deserts of the Middle East to the rain forests of South America, from impoverished Asia to the affluent Europe, examples of mud buildings are abundant, and apart from their regional variations, mud is the predominant building material all over the world, especially in the countryside. Versatility of earth as a building material is illustrated Fig.

In Asia and Africa, as well as in parts of Europe and Latin America, where most people still live in villages, there is an age-old relationship with the earth. In Nigeria's hot and humid climate, the mud-bamboo and mat house is the only viable choice, its latticed walls open to the breeze and deep overhangs keep the interior cool and dry. Similarly, in the hot arid Dra Valley in Morocco, where earth is the only material available, mud house huddle closely together to keep out the desert dust and heat. The arch and dome, which have now become established symbols of Islamic architecture, have their origin in the mud brick structures of the Middle East.

There are at least 20 different techniques in use the world over. Though they vary enormously, six of them are commonly used.

### a) Mud Lump (Cobwall)

This is the simplest method of construction of mud walls. In this technique, local soil which is neither too clayey nor too sandy is mixed with requisite amount of water to form lumps of good consistency. Lumps are placed one over another manually. Each layer is placed on alternate days to make allowance for sufficient time for drying. Wall so constructed is then plastered with a coat of mud-mixed with some organic material such as cowdung. Generally, height of such wall is low, not exceeding 2.4 m and thickness about 30 cm.





## COST EFFECTIVE HOUSING TECHNIQUES

The roof for such construction normally comprises of bamboo or wooden trusses placed at regular intervals on the mud wall which support the wooden purlins and rafters. Thatch or country

tiles is used for covering the roof. The roof overhang of such houses is generally kept between 30 to 45 cm. Such houses are built at very low cost through self-help, though they are not very durable and strong.

### b) Wattle and Daub

This is one of the simplest and cheapest forms of wall construction. For many people in Africa (e.g., Swaziland) and Asia it is the only way they can afford to build their houses. Wattle and daub basically refers to a framework of vertical poles, tied together with horizontal branches and plastered inside and outside with mud.

### b) Sun Dried Mud Brick (Adobe)

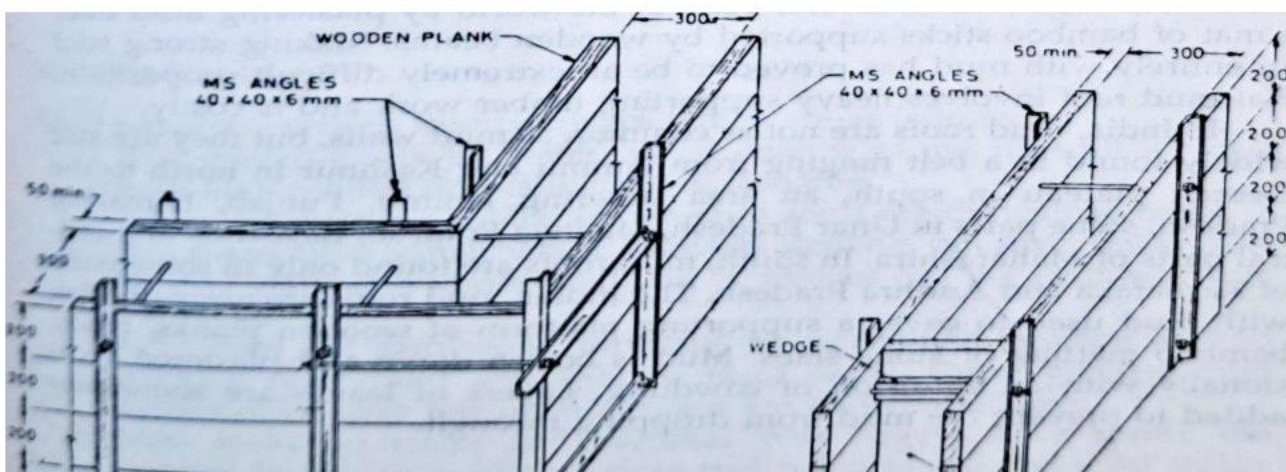
Under this method, walls are prepared from sun dried bricks. For preparation of sun dried bricks, any soil which is found to contain 80% clay and 20% sand, or 40% clay and 60% sand may be used. Water is added to the soil in the requisite quantity and then the prepared mud is moulded into the shape of bricks/ blocks of suitable size with the help of wooden mould. The green dried mud bricks are used for construction of walls. The bricks are laid in courses in mud mortar. The wall is raised in stages, about 1 metre high every day. The mud wall so prepared is well formed and strong.

Sun dried mud bricks are known as 'adobe' in Mexico and the USA. Such bricks are very popular in south India, Egypt, Peru, New Mexico, Southern Africa and West Tunisia. The State of New Mexico in South Western USA has developed a regulatory code for mud buildings which covers mainly adobe (sun dried mud bricks).

Manually prepared sun-dried mud bricks are now becoming common in rural India. Though they are normally larger than kiln-fired bricks, they do not conform to any standard size. Such bricks usually make stronger walls than mud.

### c) Rammed Earth (Pise de terre)

Rammed earth (pise-de-terre) (Fig) is a technique where mud is rammed manually between two moveable timber shutterings (vertical frames) which are erected where the finished wall will be. The preferred type of soil for such construction is 'sandy loam.' The soil prepared for ramming is just moist enough to form a compact ball when it is pressed between cupped hands.



## **COST EFFECTIVE HOUSING TECHNIQUES**

---

Rammed earth technique of wall construction has been used for centuries in Venezuela and Colombia.

In India, rammed earth was first tried out in 1948 in the construction of 4,000 houses at Karnal (Haryana). These houses have been in use for more than four decades now. The Bureau of Indian standards has also brought out a code of practice (IS: 2110-1980) for the construction of rammed cement soil walls for rural houses.

### **e) Compacted Soil Block**

The technique of production of compacted soil block is relatively young in comparison with others. Compacting the soil in a small form produces a block, which by virtue of the increased density, is both stronger and more water resistant than an ordinary mud brick. Such blocks can be produced by compressing earth into a solid block in machine called the 'Cinva Ram'.

## **Mud Roofs**

Mud roofs are made in several parts of the world by plastering mud over a mat of bamboo sticks supported by wooden beams. Making strong roof entirely with mud has proved to be an extremely difficult proposition. Flat mud roof involves heavy supporting timber work and is costly. In India, mud roofs are not as common as mud walls, but they are still widely found in a belt ranging from Jammu and Kashmir in north to the Deccan plateau in south, an area covering Jammu, Punjab; Himachal Pradesh, some parts in Uttar Pradesh, Madhya Pradesh, Rajasthan and central parts of Maharashtra. In south, mud roofs are found only in some parts of Karnataka and Andhra Pradesh. The Indian mud roofs are normally flat, with mud used to cover a supporting platform of wooden planks, reeds, bamboo matting or stone slabs. Mud is beaten down and plastered occasionally with an emulsion of cowdung. Layers of leaves are sometimes added to prevent the mud from dropping through.

### **Mud Brick Vault and Dome**

Making strong roof 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 6,000 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.

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

Domed or vaulted roofs are extremely used in Iran and Turkey. In Europe, vaulting involves laying masonry over a wooden form work, which is later removed when the vault became dry. But in the West Asian construction, no supporting formwork is required for fired or sun-dried brick. If sun-dried bricks are used with mud mortar, the bricks fuse together on drying, since they are of the same material. This gives the vault additional strength.



## COST EFFECTIVE HOUSING TECHNIQUES

---

- i) It is a truly natural, cheap and local material—available in most parts of the world.
- ii) It provides excellent heat insulation, so the internal part of a mud building is cooler in summer and hotter in winter than a building made with steel and concrete. Due to this property, mud houses are most suited in tropical and sub-tropical climatic conditions.
- iii) It is strong in compression and so makes good walls. It can also be made strong in sheer and tension through additives and reinforcement.

### Disadvantages

Mud has some serious disadvantages which are as follows:

- i) It is eroded easily by water, which makes its use difficult in areas with high rainfall or possibilities of flooding.
- ii) It has low strength, which means mud roofs are difficult to make.
- iii) It is susceptible to mechanical damage. Rodents can easily make hole in mud walls and under the floor, or thieves can dig their way into the house.
- iv) 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.
- v) Mud soaks up water and becomes very heavy. As a result, the wooden beams supporting a mud roof begin to sag, the mud cracks and the roof starts leaking.
- vi) Mud houses behave very poorly in the event of earthquakes.

### Overcoming Disadvantages of Mud

Centuries of trial and error have generally produced designs appropriate for local conditions. There is, however, always scope for improvement. A Cornish proverb has it that "All a mud house needs is a good head and a good pair of boots," meaning thereby that all a raw-earth building needs to survive is a 'pucca' (stone or concrete) foundation, and overhanging roofs to save walls from water.

Most of the disadvantages associated with mud houses can be overcome by suitable improvements in design and technology, such as soil stabilisation, appropriate architecture, and improved structural techniques. As the majority of the people in the developing countries will, out of necessity, continue to live in mud houses, ways of improving on the traditionally built mud houses have been evolved out of sustained research in the direction.

The Central Building Research Institute (CBRI), Roorkee, has developed non-erodable mud plaster for making mud houses more durable. The water-repellent treatment for mud walls consists of mixing cut-back bitumen with ordinary mud plaster prepared with bhusa (paddy/wheat chipping) and cowdung. The water-repellent mud plaster is prepared by mixing upto 5% (by weight) cut-back with ordinary mud plaster comprising of mud and bhusa (paddy/ wheat chipping) in the proportion of 70 Kg bhusa to one cubic metre of soil. The cut-back, an emulsion of bitumen (90/100 grade), is prepared by hot mixing 50 Kg bitumen, 10 litres of kerosene oil and 0.5 Kg of wax. For every cu.m. of soil 70 Kg of cut-back is added. The mix of soil, bhusa and cutback is thoroughly mixed by turning over and kneading to get a homogeneous mix. The mortar so prepared is applied in the usual way. When the plaster has dried, a coat of gobi-leaping (cowdung mixture)-1 part gobi and 1 part soil and cutback in the same proportion as for plaster is applied over the dried surface of plaster. The plaster thus rendered can withstand the rains for 3 to 5 years without major maintenance.



## COST EFFECTIVE HOUSING TECHNIQUES

---

Furthermore, this is left to dry to receive spray of bitumen solution. Bitumen solution is prepared by mixing hot molten bitumen and kerosene oil in the proportion of 1:2. One coat of this emulsion is either sprayed or applied by brush on the top surface of the plastered thatch. The second coat follows after three to four hours. Two coats of lime are then applied over the bitumen-sprayed surface

### Soil Stabilisation

Researches have identified around 130 different stabilising agents including cement, lime and bitumen. Before deciding the correct type of stabiliser to be added to the soil, thorough testing of the soil is essential. The best type of soil for stabilisation with cement is one which has a proper grading of particles of different sizes, from the sand range to fine day. Very clayey soil, particularly black Cotton soil, is best stabilised with lime, and bitumen is suitable for sandy soils. In some cases, a combination stabilisers should be used. Highly plastic soils, and soils containing organic matter are not suitable for stabilisation.

The following percentages of additives are found most suited to achieve the desired strength to manufacture stabilised bricks/blocks, resistance to weathering and to effect economy. The exact quantity of stabiliser to be added depends on the type of soil. As a rough guide, the following could be adopted under normal situations:

Sandy soils: 5% cement stabilisation

Clayey soils: 5 to 6% hydrated lime and 2% cement

Normal red soils with upto 25% clay: 2 1/2 % hydrated lime.

lime combined with flyash makes a cement almost as good as Portland cement. ms is used as a stabiliser for both sandy and clayey soils.

Of all the stabilisers, cement has been the most extensively used. Soils which are teated with lime are not as strong nor as water tesiTant. Soil stabilised with cement or lime can also be compacted in a Cinva Ram. In hdia, apart from the Cinva Ram, some of the popular soil-block making machines in vogue are 'Ellson block master,' 'Balram' and 'Astram.' On average, about five hundred 23 x 19 x 8 cm. pressed-soil blocks can be made with the 'Astram' machine per day, and about a thousand 23 x 11 x 7.5 cm. blocks with the 'Balram'.

The Stabilised bricks are usually sun-dried, and laid in ordinary mud mortar, although stabilised mud mortar would be better. They are protected with a covering of non-erodable mud plaster from the outside, and with ordinary mud plaster from the inside.

The stabilisation of soil with the addition of Portland cement, lime, bituminous binder, industrial wastes like flyash and bagasse, etc., can improve the bearing strength of bricks and render it increasingly water and moisture repellent. Of the various additives, cement bricks (with 5% cement) though better in strength (about 4 N/mm<sup>2</sup>)\* are poor in water and moisture resistance, whereas bitumen-stabilised bricks (with 1% bitumen), though poor in strength (about 3 N/mm<sup>2</sup>), are good in water and moisture resistance. Stabilised bricks can be laid in ordinary mud mortar or stabilised mud mortar; the latter one, of course, is preferred from strength and durability considerations. Experiments have been carried out at the CBRI, roorkee to reduce the amount of bitumen from 1.0 to 0.5% through the use Of industrial wastes like flyash and bagasse as additives. The use of rice husk cement has also been tried for the stabilisation of soil with promising results. Application of Science and Technology for Rural Areas (ASTRA) at the Indian Institute of Science (IISC) Bangalore, and the NBO RHDC, Bangalore have played an important role in the promotion of soil cement blocks as useful building component for house construction in Karnataka. As a result Of promotional work undertaken by the ASTRA and the NBO RHDC, five stabilised mud housing programmes involving construction of about 7.000 houses have been undertaken in different parts of the State. The major advantage of the stabilised soil block vis-a-vis the burnt brick is the significant saving in energy (about 70%). Such blocks are cheaper by 20 to 40% compared to burnt bricks. A study of the performance of the soil blocks used in the construction of houses undertaken by the Karnataka Housing Board has revealed that the compressive strength obtained from Such blocks



## COST EFFECTIVE HOUSING TECHNIQUES

---

Various traditional- materials ranging from plant juices to cowdung are mixed with mud for rendering mud walls. Such treatment renders mud walls more water repellent. In northern Ghana, an extract of boiled banana (or plantain) stems is mixed with lateritic soils. In Upper Volta, a plant extract locally known as 'am' is used as varnish. In Northern Nigeria, 'laso' (an extract from the vine 'vitis pallida,' locally known as 'dafara') and 'makuba' (made from fruit pod of the lowest bean tree) are used for waterproofing of mud walls. Cowdung mixed with clay has been widely used in Ghana and India. In Sudan, 'jaloos' (mud) houses are treated with 'Zibla,' a local water proof material made from cow or horse dung. 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.

### Rural Housing Programmes

In a country like India where about 75% of the population lives in 5.83 lakh villages, a rural housing programme is necessarily an aided self-help programme. Such aided self-help is the technical systemisation of the wellknown traditional principles which have a bearing on co-operative efforts. Over the past two decades, number of rural housing programmes have been undertaken in the Government and co-operative sectors. Some of the prominent rural housing programmes undertaken in the country are described below.

In order to ameliorate the living conditions of the landless rural poor, the Government of India had introduced a scheme envisaging provision of house-sites to the landless agricultural families in rural areas free of cost in 1971 in the Central Sector as a component of the Fourth Five-year Plan (1969-74). Under the said scheme, the State Governments and the Govt. of Union Territories provided house-sites measuring minimum of 82 sq.m, (100 sq.yds.) free of cost to 14.5 million landless rural families who did not own house sites nor built-up houses. The beneficiaries were expected to build modest houses through self-help. The scheme was transferred to the state sector with effect from April 1, 1974, and was also included in the Minimum Needs Programme (MNP). The scheme had been continued in the Fifth Five-year Plan (1974-79) wherein its scope was extended to other landless workers who were bonafide artisans such as potters, carpenters, fishermen, blacksmiths, etc., who had no house-sites of other land of their own. The scheme was accorded high priority through its inclusion in the 20 Point Programme announced by the Prime Minister in July 1975. The scope of the said scheme was further broadened in the revised New 20-point Programme announced in 1980, according to which construction assistance was to be provided to some 3.6 million households during the Sixth Five-year Plan (1980-85). So far 194.23 lakh rural landless workers have been provided house-sites, and 60.25 lakh families have been given construction assistance on allotted house-sites.

(i) Rural Housing Co-operatives can play an important role in the integrated rural development by mobilising saving and channelising community action not only for the construction of houses but also for the management of community facilities. This is being taken advantage of in some developing countries notably India, Pakistan, Malaysia, Thailand and Sri Lanka.

In India, with a view to encourage housing in rural areas; the Maharashtra Co-operative Housing Finance Society provides long-term credit on priority basis. Similarly, in Andhra Pradesh, the Scheduled Castes and Scheduled Tribes Co-operative Housing Federation has provided a large number of houses to the rural poor through utilisation of loans received from the Life Insurance Corporation of India. Besides, the Tamil Nadu Cooperative Housing Society, the Karnataka State Co-operative Housing Federation and the Rajasthan State Co-operative Housing Finance Society have played a significant role in providing affordable houses to the rural people.

(ii) In 1973, the Government of Kerala had launched a scheme popularly known as 'One Lakh Housing Programme.' Under this programme, 100 houses were to be constructed in each of the existing 1,000 Panchayats in the State at that time. The houses were to be provided to one lakh landless poor families whose poor affordability prevented them from having their own houses. The construction of houses under the scheme was undertaken by the Panchayats. The State Government



## COST EFFECTIVE HOUSING TECHNIQUES

---

programme, though conceived in 1982, was implemented in full swing during 1984-85, The entire loan assistance for this programme Was provided by HUDCO. Over 800 voluntary organisations have since participated in the implementation of the aforesaid housing scheme in Kerala

iv) Over the past one decade, the Ministry of Rural Areas and Employment (MRAE) under the Government of India, has undertaken number of schemes catering to the housing needs of the rural poor. The Indira Awas Yojana (IAY), launched during 1985-86 is fully subsidised by the Central Government. This is a scheme of the construction of low cost houses for the poorest of the poor belonging to the SCs/STs and freed bonded labour in the rural areas. The overall target during the Seventh plan (1985-90) was for construction of one million houses. The scheme is now also extended to non-SC/ST families, with ceiling of expenditure on such families being 4% of the total allocation. The IAY has since became part of the Jawahar Rozgar Yojana (JRY). The latter was initiated in 1989 by merging the National Rural Employment Programme (NREP) and the Rural Landless Employment Guarantee Programme (RLEGP). Over 18.43 lakh houses have been constructed with a financial involvement of Rs. 2,197.49 crore since its inception till November, 1994.

(v) The HUDCO is actively engaged in evolving designs and financing of low-cost rural housing programmes in the country. It started financing of rural housing schemes in 1977. It has since financed 1,496 projects envisaging construction of more than 27.3 lakh housing with a loan commitment of Rs. 1043.32 crore.

(vi) The Government of India has recently approved a scheme to supplement the efforts of the States and Union Territories to give an impetus to housing for the weaker sections and people in the rural areas during the Eighth plan-period (1992-97). This is to involve allocation for capital subsidies for rural housing as well as allocation of resources for internal subsidy and setting-up 300 rural centres to popularise low cost building materials.

Under the new scheme, the States and Union Territories will receive matching allocation for rural housing schemes meant for the weaker sections. It covers sites and services; shelter upgradation and construction of new houses. Funds are to be provided to States on equal proportion to the expenditure incurred by them on housing programmes for the poor under the ND-CP. This support will be available to the States in a flexible manner to help them continue with their existing programmes which are suffering for want of adequate resources.

The allocation for rural housing during the Eighth plan is Rs 350 aores. A sum of Rs 12,000 is to be given to those below the poverty line for this purpose. The subsidy will be shared equally by the Centre and the States. For borrowers, who have to pay loans over a period of 15 years, there will be an interest subsidy upto 4.5 per cent. Housing subsidies are presently provided through the Indira Awas Yojana for Scheduled Castes and Scheduled Tribes, allotment of house sites-cum-construction assistance under the MFJP. The HUDCO supported loan schemes for economically weaker sections, whereas the LIC/GIC funded loan schemes for the State Governments.

### Typical Specifications for Low Cost Rural Housing

For the guidance of prospective builders and construction agencies entrusted with the task of providing houses to masses at affordable cost, the typical specifications for low cost housing to be adopted are provided at Annexure II. Selection of a particular specification is generally influenced by the builder's choice for the specific alternative specification and the availability of the locally available building materials.



## COST EFFECTIVE HOUSING TECHNIQUES

---

5. Sundried brick masonry with mud/ water proof mud plaster.
6. Brick masonry in mud mortar.
7. Bitumen-soil stabilised bricks for masonry.
8. Stone masonry in mud mortar.
9. Laterite stone masonry.
10. Lime mortars and composite mortars for masonry.
11. Clay block masonry in mud mortar.

### Roofing

12. AC/CGI Sheet Roofing over local wood rafters and purlins.
13. Asphaltic sheet roofing.
14. Country tile roofing over precast RC battens.
15. Country tile roofing over wooden battens (Secondary-Species).
16. Mangalore tile roofing/country tile roofing over split bamboos/secondary species of timber.
17. Stone Slab Roofing over wooden joists.
18. Brick tile roofing over wooden battens.
19. Thatch roofs treated with fire retardant.
20. Brick Panel roofing over RC/Wooden joists.
21. Jack arch-terrace (Madras Terrace).

### floorings

22. Mud flooring.
23. Mud Gobri flooring,
24. Stabilised Mud flooring,
25. Moulded Blocks from the block making machine.
26. Stone Slabs locally available such as cuddapah slabs.
27. Cement flooring over Jhama Brick Bats.

### Finishing

28. Lime Surkhi Cement Pointing and plasters.
29. Water Proof Mud Plaster.
30. Secondary Species of Timber.

### Structural Members (Beams, columns, etc.)

31. Precast RC columns and beams.
32. Precast concrete staircase elements.

### New Materials

33. Use of deformed bars.
34. Partial replacement of cement by flyash.
35. Use of hydrated lime.
36. Plastic stays.

# COST EFFECTIVE HOUSING TECHNIQUES

---

## Architectural Planning and Structural Designs

42. Lower ceiling height.
43. Precast lintels.
44. Jalis for ventilation,
45. Design for solar energy utilisation.

## Annexure II

### Typical Alternative Specifications for Low Cost Housing in

#### Rural Areas

##### t. Foundation

Boulders, gravel, kankar, local burnt bricks, bricks, stones or laterite in lime or mud mortar, Stabilised soil using cement, lime or bitumen. Rammed earth (Please see note 1 below).

##### 2. Damp Proof Course

2 course Of burnt clay bricks soaked in 2% soap solution laid in cement mortar containing 1% soap solution.

2 course of burnt bricks dipped in tar laid in tar-sand mortar consisting of 15 kg. of tar in 100 kg. of sand.

##### 3. Walls

Burnt clay bricks, stone, laterite, laid in lime or mud mortar/unburnt clay bricks or blocks; stabilised mud bricks or blocks with cement, lime or bitumen as stabiliser and laid in stabilised mud mortar containing 2% lime. Pise construction i.e., in-situ rammed earth at optimum moisture content

Timber or bamboo post with panels of split bamboos, reeds or palmyrah matting with or without plaster. (Please see note 2 below).

##### 4. Structural floor/roof

###### Flat roofs

Local wood joists and planks, bamboos, reeds covered with a layer of 8 to 12 cms. thick compacted soil.

Stone slabs.

###### Sloping roofs

Trusses of local timber, ballies and purlins of local timber, ballies and bamboos covered with thatch, reeds, palmyrah leaves, country tiles, slates, Mangalore tiles (Thatch and palmyrah leaves to be made fire-proof).

Asbestos cement sheets, GI sheets.

Asphaltic roofing sheets (Please see note 3 below).

##### 5. Flooring



# Housing in Disaster

### Introduction

Natural disasters like floods, earthquakes, cyclones, landslides, volcanic eruptions and tsunamis, etc., cause great loss of human lives and property. In India, too, are often subject to the vagaries of nature. Floods are more frequent natural calamities to hit the country. The nature and extent of damage caused to structures by such disasters and measures to be adopted in the event of their occurrence have been discussed at length. In view of the large number of non-engineered buildings more resistant to the devastation caused by earthquakes have been discussed at length. In view of the large number of buildings and houses belonging to the low strength category, the earthquakes of recent past occurring in North Bihar (September 1991) and Killari, Maharashtra (September 1993), a study of earthquake damaged non-engineered buildings is also

### Earthquake

Earthquake is nature's one of the most catastrophic natural disasters since time immemorial. On an average, nearly 10,000

# COST EFFECTIVE HOUSING

Table 1  
Deaths in natural hazards (in millions)  
(reproduced with permission from The India Yearbook of International Law)

| Natural hazard     | Deaths, per cent | Region              |
|--------------------|------------------|---------------------|
| Earthquakes        | 50.9             | Asia, South America |
| Floods             | 29.7             | Europe, Asia        |
| Cyclonic storms    | 16.8             | America, Europe     |
| Volcanic eruptions | 1.9              | Africa, Asia        |
| Tsunamis           | 0.5              | Asia, Europe        |
| Landslides         | 0.1              | Asia, Europe        |

## Earthquake Forecast

Despite tremendous advancements in the field of seismology, seismologists the world over to make any prediction of a future earthquake, unlike the cyclones. In recent years, the Very Long Baseline Interferometry (VLBI) equipment has been used to measure the movement of the Earth's crust. This has helped to predict the location of the next earthquake, but it is still not possible to predict the time of the next earthquake.



## COST EFFECTIVE HOUSING

---

ground and formation of 'horst', a block of the earth's surface which is reckoned as the probable reason for the poverty of the region and its surrounding villages on September 30, 1993 led to the above, the recent forecast of a catastrophic earthquake cannot be taken lightly.

Lack of sensitive earthquake monitoring system, stations which are capable of recording even minute movements with accuracy, and poor history of earthquake recording (the earliest recorded earthquakes dating back to 1500 BC, the earliest reliable record goes back by 350 years only) have been inhibitory factors in the realistic forecast of Indian earthquakes in the past.

### **Validity of Plate Tectonics**

The occurrence of earthquakes in zones designed by plate tectonic considerations questions the validity of the well-established theory according to which the potential earthquake belts global boundaries of lithosphere plates which constitute earth's crust. The Indian Subcontinent, Circum-Pacific belt, around the perimeter of the Pacific Ocean, extends across Central Asia to the Mediterranean Sea. In the Himalayan mountainous region, forms a part of the Alpine belt which extends from Spain through Myanmar, India, Middle East and South

## COST EFFECTIVE HOUSING

---

large number of unreinforced masonry houses in the p  
Armenia (December 1988), Kangra (April 1986), No  
(October 1991) and Killari, Maharashtra (September 19  
Guatemala earthquake, more than 25,000 people had  
2,50,000 adobe houses. The Armenian earthquake ha  
precast constructions too. Massive death toll (about  
attributed to collapse of hundreds of precast concrete an  
the contrary, the experience of Loma Prieta earthqua  
properly-designed earthquake resistant structures very  
earthquake leading to much less casualty in terms of los  
to Armenia's 25,000) and damage to buildings. Ironically  
Scale in the two earthquakes were nearly similar. Likev  
Killari earthquake measuring 6.4 m on Richter scale had  
of almost similar intensity (magnitude 6.6) in the Nort  
California claimed only 57 lives.

Table 2

Building types for housing in India  
(reproduced with permission from The Indian

| Category<br>(vide MSK) | Type of wall material | Rural,<br>percent |
|------------------------|-----------------------|-------------------|
|                        |                       |                   |



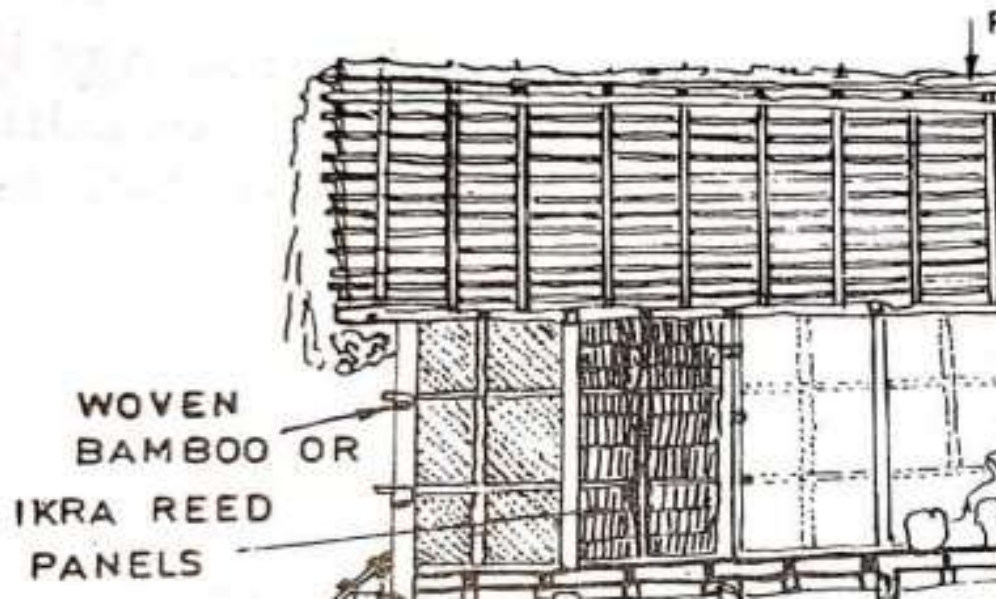
## COST EFFECTIVE HOUSING

---

### Traditional Housing in Disaster Prone Areas

In Jammu and Kashmir, which lies in a zone of severe earthquakes, the 'diwari' technique is adopted to minimise the destructive forces of construction uses a timber frame construction with mud walls, which makes the structure more rigid and helps to withstand earthquakes. In Assam, also in a severe-intensity earthquake zone, the 'kakra' technique of walling (Fig. 1) is adopted which comprises of timber-frame or split bamboo with mud plaster on either side. Mud walls and thatched roof on account of their flexibility withstood the earthquake forces without any damage in the earthquake.

The colossal destruction of houses in the modern earthquake zones (e.g. 1993) and Uttarkashi (October 1991) was due to poor



quality and weakness of the stone masonry construction with plastic soil mortar. The tragedy of the present time is the resistant constructions like 'dhaji-diwari' in Jammu and the 'ikra'-wall construction in most seismic region of India disuse in favour of the more damage-prone stone and brick masonry.

### **Types of Damages and Failures of Non-Engineered Buildings**

#### **Masonry Buildings**

Induction of tensile and shear stresses in walls of masonry buildings leads to different types of damage suffered by such building in earthquakes. The damages and modes of failure are briefly described below.

#### **Typical Damages**

##### ***Non-Structural Damage***

The non-structural damage is the one due to which the structural integrity of the building is not affected. Such damage occurs very frequently in earthquakes. Cracking and overturning of masonry partitions; falling of balconies; failing of plaster from walls and ceiling; cracking of walls; cracking and falling of ceilings; and cracking of floors are some of the non-structural damages.

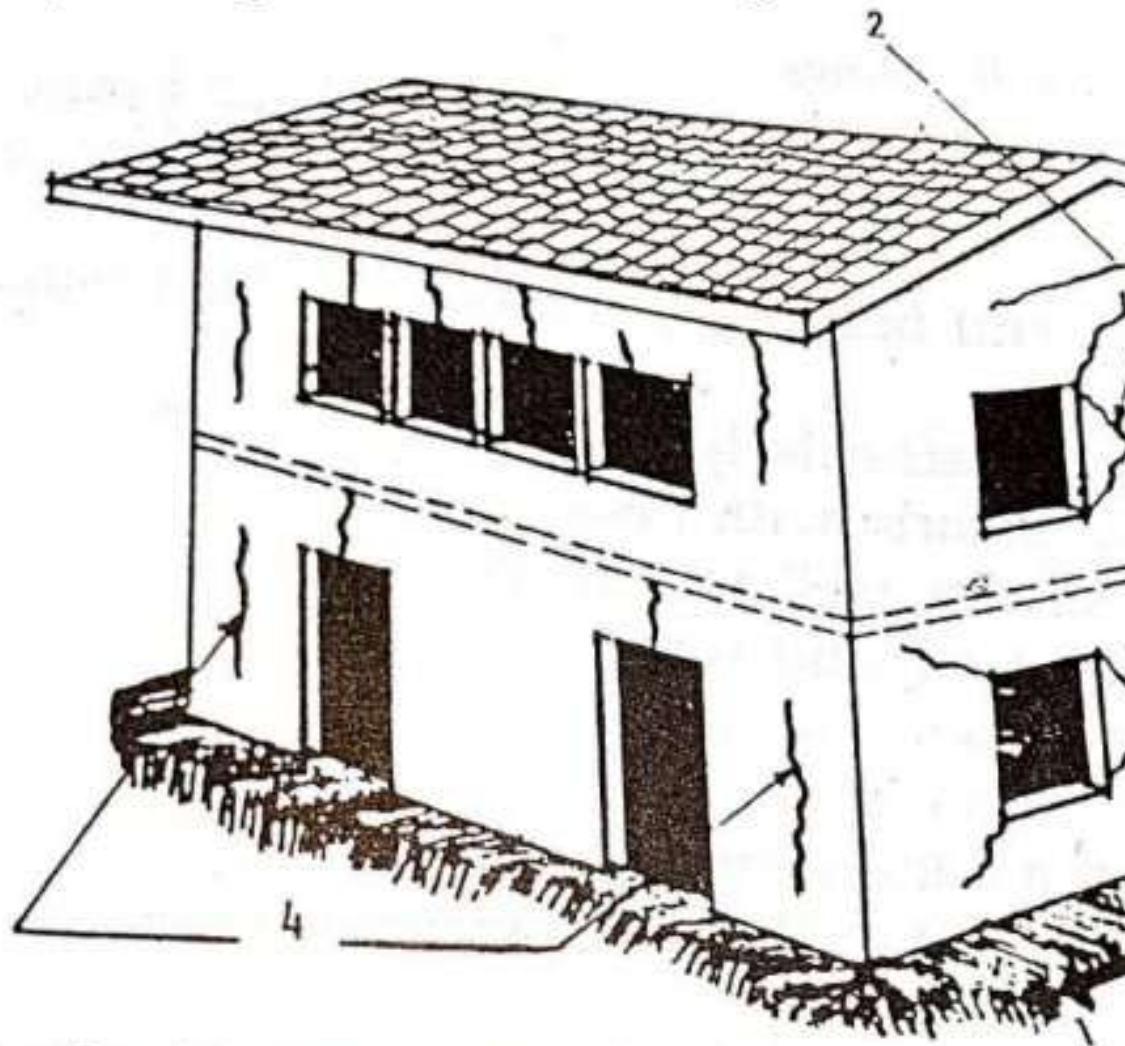


# COST EFFECTIVE HOUSING

## Damage and Failure of Bearing Walls

i) Failure due to racking shear is characterized by diagonal compression or diagonal tension.

ii) Crack patterns in load bearing walls due to be



1-1 Earthquake motion, 2-Horizontal  
3-Diagonal cracks due to shear,  
4-Cracks due to bending of wall.

**Fig. 3 Cracking in bearing wall building**

iii) Unreinforced gable end masonry walls

## **Failure of Roofs and Floors**

Improperly tied roofing material is dislodged due to wind. This mode of failure is typical of sloping roofs, particularly those with corrugated roofing material. Brittle material like asbestos cement sheets and purlins are not properly braced together.

## **Causes of Damages in Masonry Buildings**

The following are the main weaknesses in the existing constructions and other reasons for the extensive damage:

- Heavy weight and very stiff buildings, attracting high wind pressure
- Very low tensile strength, particularly with poor mortar
- Low shear strength, particularly with poor mortar
- Brittle behaviour in tension as well as compression
- Weak connection between wall and wall
- Weak connection between roof and wall
- Stress concentration at corners of windows and doors
- Overall unsymmetry in plan and elevation of buildings
- Unsymmetry due to imbalance in the sizes and positions of windows and doors
- Defects in construction such as use of substandard materials, poor workmanship, etc.



## **Repair and Restoration of Earthquake Damage**

### **Concepts of Repair and Restoration**

The methods of repair and restoration depend largely on the materials used in construction of building, feasible technology, and availability of funds. Some methods like 'Splints and grout injection/ etc., have been tried out for repair and strengthening in some countries.

The underlying concepts in repair and restoration are described as below:

#### **Repairs**

The main purpose of carrying out repairs of damaged building is to restore the architectural shape of the building dealing with the damage. After repairs, the services could start working and the functional use of the building could be resumed. Repair does not improve the structural strength of the building for meeting the strength requirements of the future earthquake. Repairs include the following:

- a) Patching up of defects such as cracks and fall of plaster
- b) Repairing doors, windows, replacement of glass
- c) Checking and repairing electric wiring
- d) Checking and repairing gas pipes, water pipes

### **Restoration**

This activity envisages restoration of the original structure by appropriate treatment of the damaged structural components such as walls, beams, columns, etc. It may involve cutting portions of damaged material or simply adding more structural material so that the original strength is restored. The process may involve inserting temporary supports, underpinning, etc. The relative cost of retrofitting to reconstruction cost determines whether any restoration work. As a thumb rule, if the cost of repair, including temporary supports, is less than about 50% of the reconstruction cost, retrofitting is the preferred option.

Some of the techniques of restoration are stated as below:

- a) Removal of portions of cracked masonry walls and piecing them with new mortar. Use of non-shrinking mortar will be preferred.
- b) Addition of reinforcing mesh on both faces of the cracked concrete through spikes or bolts and then covering it suitably. Several layers may be used.
- c) Injecting epoxy like material, which is, strong in tension, into the cracks in columns, beams etc.

### **Repair Materials**

The most common materials for damage repair works of various situations are non-shrinking cement or an admixture like aluminium powder, etc. will be suitable. Such materials are available in the form of



## COST EFFECTIVE HOUSING

---

### **Epoxy resins**

Epoxy resins are excellent binding agents with various preparations the compositions of which can be varied. The components are mixed just prior to application, and they can be injected in small cracks too.

The higher viscosity epoxy resin can be used to fill large cracks or holes. The epoxy mixture strength is high at room temperature (lower strength for higher temp.) and method of application is simple.

### **Epoxy Mortar**

For larger void spaces, it is possible to combine epoxy resin with higher viscosity, with sand aggregate to form a mortar. This has higher compressive strength, higher tensile strength than Portland cement concrete. Thus the mortar is stronger than concrete. It is also reported that epoxy is a combination of epoxy resin and sand.

Therefore, it is not used alone. The sand aggregate provides a heat sink for heat generated and provides a rigid matrix.

### **Gypsum Cement Mortar**

It has got rather limited use for structural applications. It is not as strong as concrete among these three materials.

### **Quick-setting Cement Mortar**

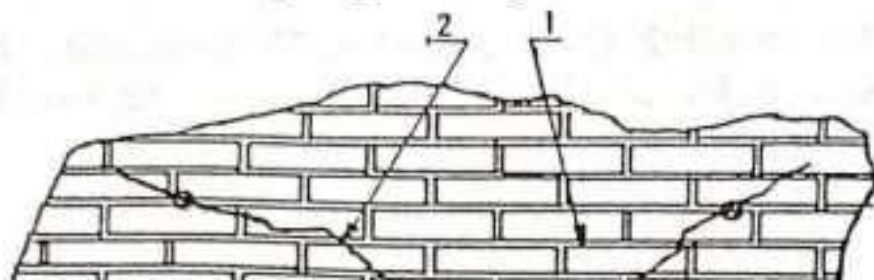
This material is patented and was originally developed for use in the construction of

## Restoration Techniques

While considering restoration work, it is important to consider the load bearing members, which are unreinforced, like masonry. The strength of these members is reduced very largely. Therefore, all cracks must be located and the most critical ones fully repaired either by injecting strong grout or by providing external bandage. The techniques are described in the following measures.

### Small Cracks

If the cracks are reasonably small (opening width less than 0.5 mm), the original tensile strength of the cracked element is not significantly reduced. The procedure is as follows -(Fig. 9.5 and 9.6).





The external surfaces are cleaned of non-structural material and ports are placed along the surface of the cracks on both sides of the crack and filled with an epoxy sealant. The centre-to-centre spacing of the ports is related to the thickness of the element. After the sealant has cured, the epoxy is injected into one port at a time beginning at the lowest port and moving upwards at one end of the crack in case it is horizontal.

The resin is injected till it is seen flowing from the top port or the corresponding port or from the next higher port on the other side. The port should be closed at this stage and injection equipment removed.

The smaller the crack, higher is the pressure or more closely spaced should be the ports. Higher is the pressure or more closely spaced should be the ports for better penetration of the epoxy material throughout the depth of the crack. This will permit larger port spacing, depending upon width of the crack. This is appropriate for all types of structural elements-beams, columns, walls, masonry as well as concrete structures. Two items should be noted for this type of repair.

- a) In the case of loss of bond between reinforcement and concrete adjacent to the bar has been pulverised to a very fine state, the epoxy from saturating the region. So it should be done under pressure prior to injection of epoxy.

## COST EFFECTIVE HOUSING

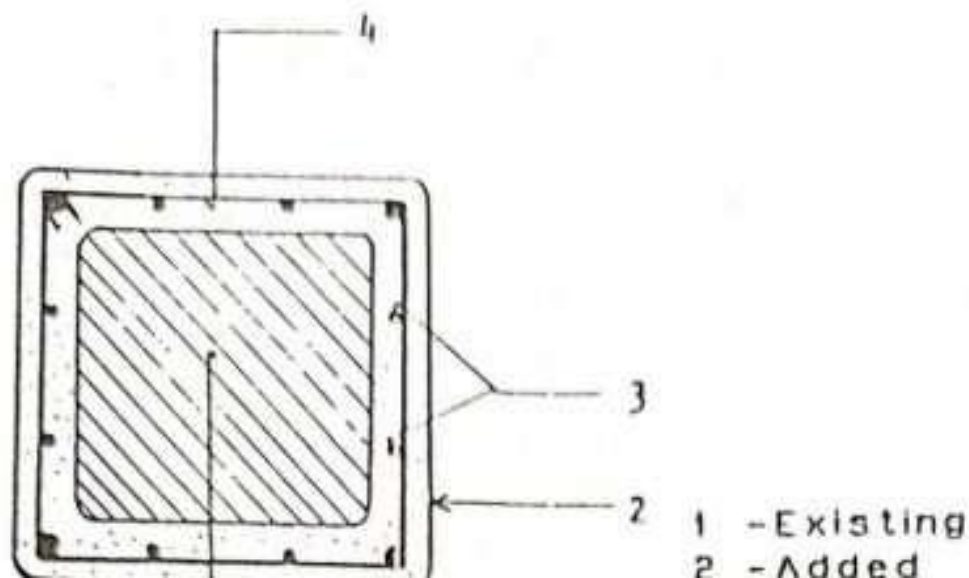
In some cases it may be necessary to anchor additional reinforcement. A common technique for providing the anchorage uses the following steps:

A hole larger than the bar is drilled. the hole is filled with a high strength grouting material. The bar is pushed into the hole. The grout has set.

### Strengthening RC Members

The strengthening of the RC members is a task that should be undertaken by a structural engineer. Here a few suggestions are briefly described. The strengthening could be undertaken.

i) The RC columns can best be straightened by jacketing. This involves adding an additional cage of longitudinal and lateral tie reinforcement around the existing concrete ring (Fig. 9. 7 & 8). The RC beams and shear walls can be strengthened in a similar way.





## COST EFFECTIVE HOUSING

---

ii) Inadequate sections of the RC columns and beams can also be

strengthened by removing the cover to the old steel reinforcement, cleaning the surface, and replacing the cover. In all cases of adding new concrete to old concrete, the old concrete should be roughened, grooves made in the appropriate direction for proper bonding. Any additional steel are to be anchored in adjacent beams or columns.

### Recommendations for Future Construction

#### **Low Strength Masonry (LSM)**

##### **a) Burnt Brick Buildings**

For earthquake resistance the following measures have been suggested:

1. To prevent the occurrence of collapses but also in controlling the propagation and widening of cracks.

(i) Restriction of height of load bearing wall is necessary. The guidelines in respect of suggestive height for various types of buildings are provided in Table 3.

Table 3

Suggested height restrictions on buildings in masonry

## COST EFFECTIVE HOUSING

---

(iv) The most important concept in strengthening of horizontal seismic bands. A seismic band is a continuous runner running into all external and internal walls with proper connection to the wall. The seismic bands are generally provided at the plinth level.

Plinth band should be provided in these situations wherein the seismic risk is high, it usually happens in the hilly tract.

Lintel band is the most important band and incorporates in the reinforcement of which should be extra to the

required lintel band steel. From earthquake stability considerations, it is required in all the storeys in the building.

Roof band should be provided at the eave level of trussed roof if precast roofing units are used. Such band may not be provided if timber bearing on all four walls is used for roof or floor.

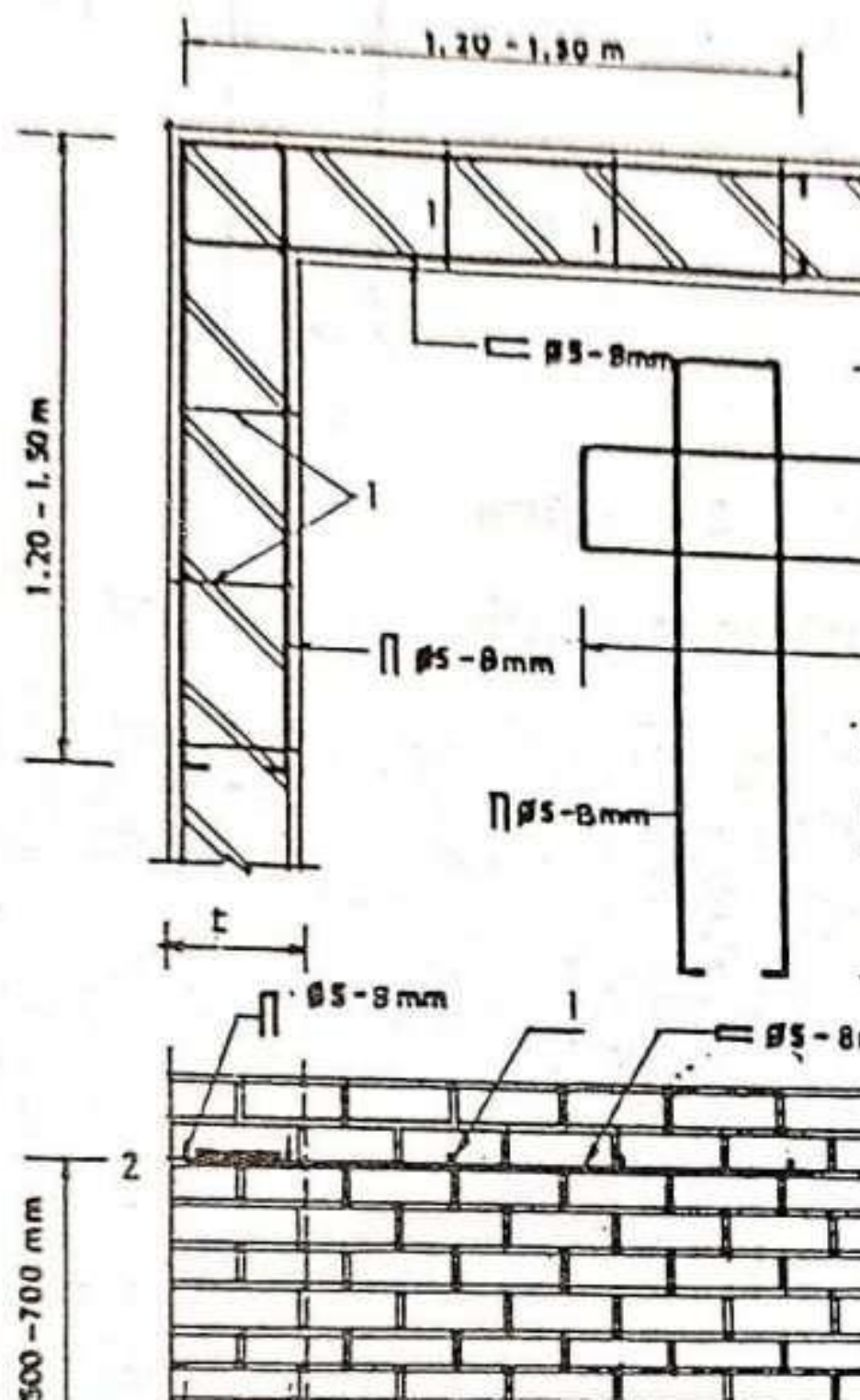
(v) Vertical reinforcement should be provided in the walls of brick or bamboo/cane at the critical sections of the walls. The critical sections are the corner walls and jambs of window and door openings.

(vi) Steel or wooden dowels should be provided at the corners to ensure effective bonding between them, say every fourth course (Fig. 10.10).

(vii) Use of stronger mortar in masonry, say cement-sand mortar, in construction of walls.



# COST EFFECTIVE HOUSING



## COST EFFECTIVE HOUSING

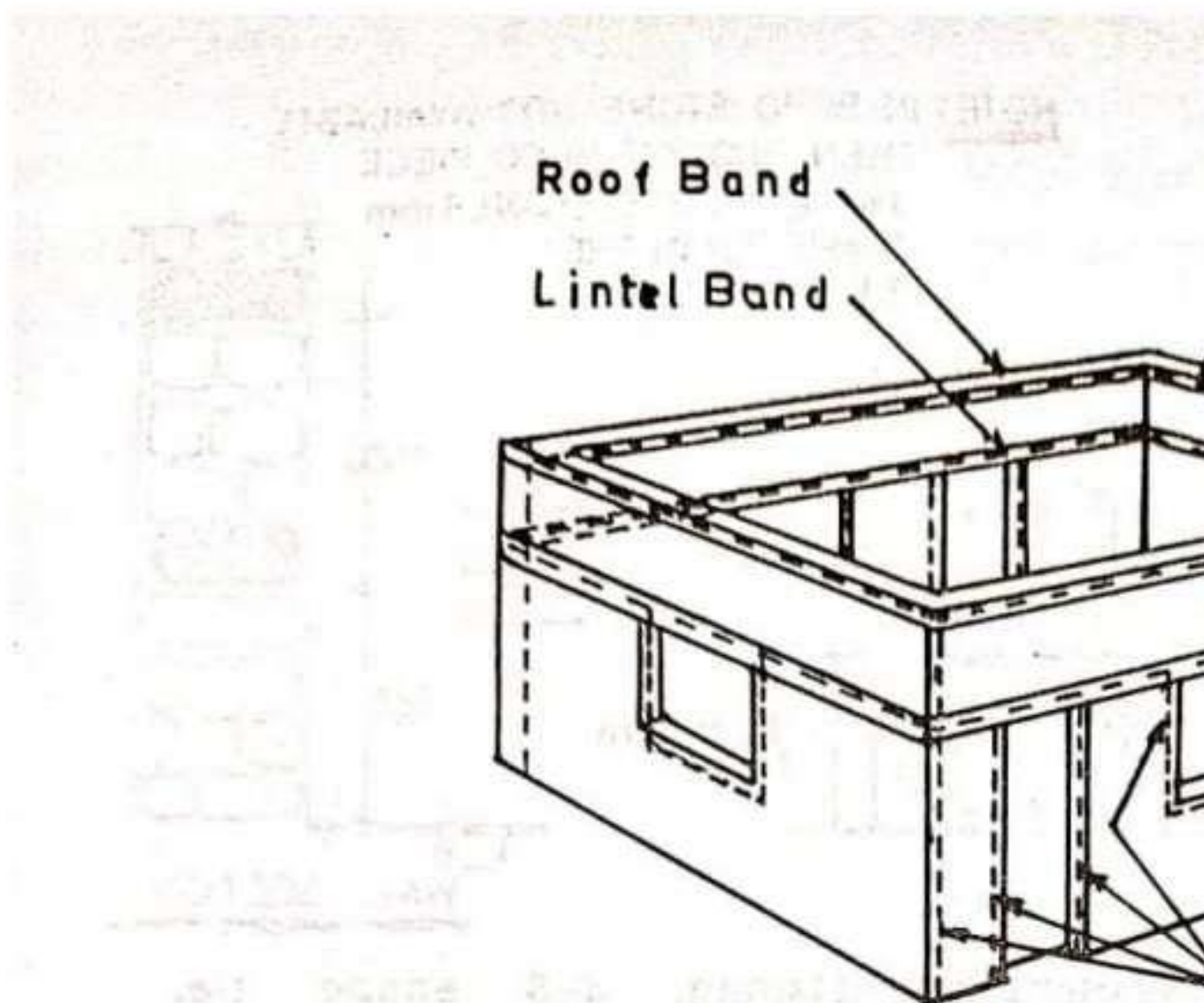
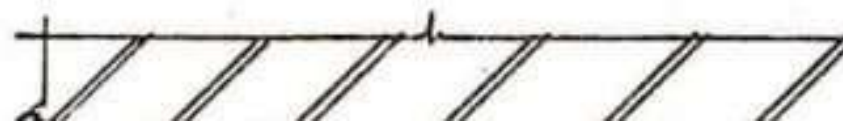


Fig. 9.13(a) Overall arrangement of r





# COST EFFECTIVE HOUSING

## *b) Stone Masonry Buildings*

For Stone masonry buildings, all the protective measures as for random rubble masonry. For random rubble and half dressed masonry, the following are necessary, i) Provision of 'through stones or bonding' elements of thickness in every 60 cm lift at not more than 1.2 m apart horizontally.

ii) Restriction of the thickness to not more than 45 cm since undesirable filling material, inside, adding to mass but reducing

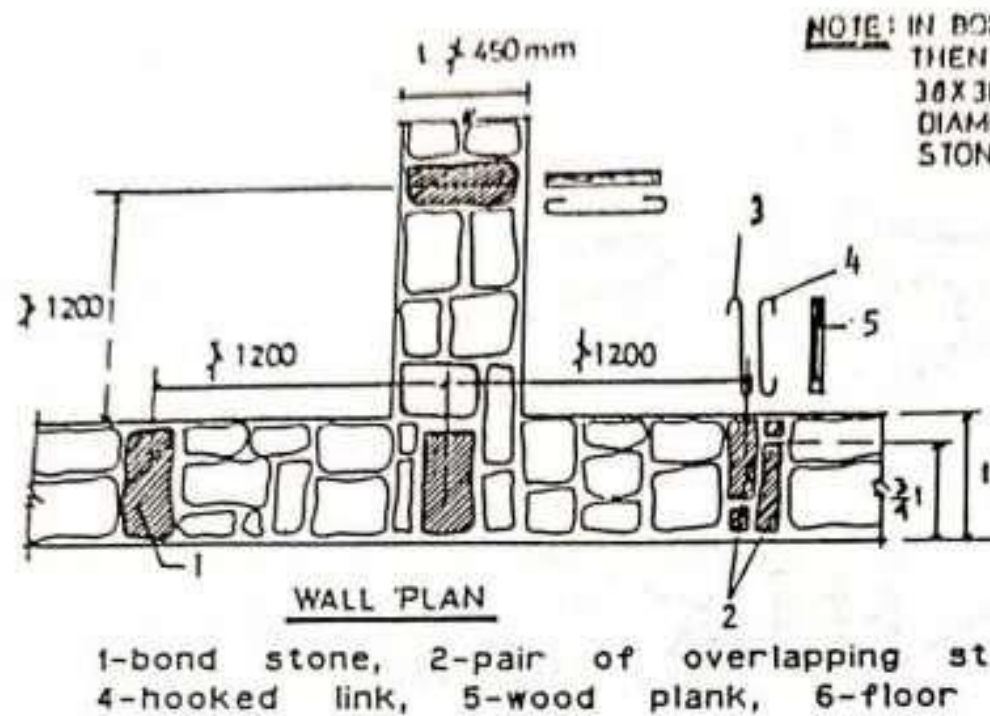


Fig. 9.14 "Through" stones or "Band" elements

## COST EFFECTIVE HOUSING

---

### c) Earthen Houses

i) In view of poor performance of earthen houses during earthquakes, such houses should be restricted to one storey only or one storey plus a roof.

ii) Length of rooms should be restricted to 4m maximum and room height to about 2.8 m.

iii) As a thumb rule, openings' width should be less than their length, and these should be away from the corners by about 1/3 of the length. Soil should be adequately stabilised using suitable stabilisers to improve the structural performance of earthen houses in the form of bricks, units and mortar, clayey soil with about 20% clay content should be used.

v) Earthen (adobe) houses should be strengthened by using lashing or wood. The roof rafters should be held to the roof band through the walls.

vi) Mud walls are made stronger for better performance by using buttresses or pillasters at the corners and wall junctions.

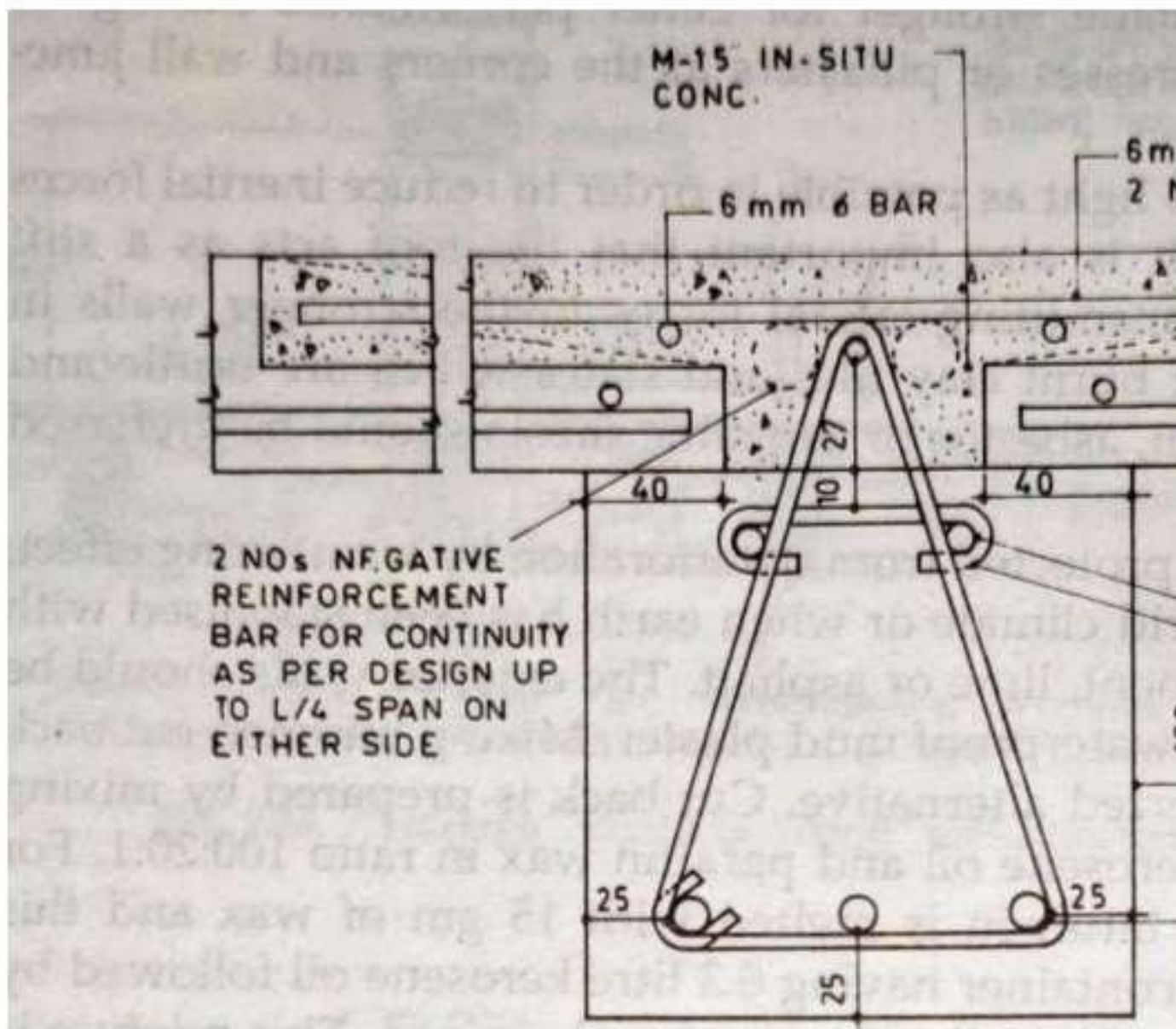
vii) Roof should be as light as possible in order to avoid failure by its mass. It is also important that the roof acts as a stiff diaphragm to resist lateral forces to the 'stronger wall' in each direction. Instead of tiles which are brittle and dislodged, corrugated iron, asbestos sheets are preferred for roofing.

viii) Earth should be protected from deterioration by painting in zones of very arid climate or when earth has been stabilised with cement, lime or asphalt. The exterior walls should be adequately plastered with mud plaster. Mixing bitumen cut back in mud mortar is a



## COST EFFECTIVE HOUSING

c) Use of such units may be avoided in wet areas, for e.g., with reinforced topping concrete.



**Fig. 9.16 Joint at beam support near wall**





### Floods

Among several natural disasters, floods are more recurrent. Recurring floods in the developing countries like India cause damage to crops, livestock, communication, irrigation and mention loss of a large number of human lives every year.

Data available from the United Nations Disaster Relief Fund indicates that the major impact of natural disaster is concentrated mainly located in Asia, where agriculture is the principal occupation. It is also mentioned that over 90% of disaster losses in these countries are agricultural. The importance of flood hazard Assessment and mitigation programme is highlighted by the impact on agricultural economy.

### **Magnitude of Losses in India**

Among several natural disasters that India experiences, floods are the most common in terms of losses it causes to housing/building and other infrastructure.

Flood is a perennial problem in India. It is an annual occurrence in the country. A large number of States like Punjab, Haryana, Uttar Pradesh, Orissa, Assam, Tripura, Kerala, Karnataka, Andhra Pradesh are flood prone. Off and on floods also occur in other States due to heavy rain, burst and unusual rains. Cloud burst caused untold miseries in the otherwise dry and arid Rajasthan 1986, 1987 and in Himachal Pradesh. As per the estimates of the National Commission on Disaster Management, India, the annual loss due to floods in India is estimated to be Rs. 1000 crore.

### b) **Tidal Flood**

Cyclonic winds cause high tidal waves which spill into the interior.

### c) **Flash Floods**

Flood flow develops gradually in many large rivers but suggests is a sudden phenomena. In this type the time of discharge is much smaller in comparison. It is caused as from a thunderstorm (cloudburst) and by steep catchment off. They are particularly dangerous because of the damage they occur.

## **Damage to Houses by Floods**

Floods constitute a hazard to houses and buildings. The natural function of carrying away excess water and with some awareness of the hazard, more and more people are flood prone areas due to pressure of population and economic development.

Depending on their location the houses can suffer different types of damage.

The type and extent of damage to houses depends on the type of flood they are exposed to. Flash floods, riverine floods, local floods have different dynamic characteristics and leave distinct marks of their passage. Damage of different degrees takes place is described below.



## COST EFFECTIVE HOUSING

---

- a) The soil gets softened leading to sinking of the sagging of roof with consequent damages to roof cracks in the wall and sinking of floors. Scouring flow of flood water can further aggravate the problem done with considerable expense depending on the
- b) The standing water causes deterioration of distempering, plastering, etc, Timber works and pelmets are soaked leading to their decay.

Flooding of low lying areas by local heavy rain described above.

### **Other Effects**

Floods can also have a devastating effect on land behind a rugged surface which is unsuitable for construction common phenomenon when the flood water brings with other materials and deposits them on an existing settlement floods which have the requisite momentum to carry case the clearing operations and restoration become difficult

### **Vulnerability of Mud Houses**

By and large damages to houses and buildings depend

## COST EFFECTIVE HOUSING

---

Changes in the land use can have an effect on the hydrology and the flood potential of catchments. In urban areas can cause less surface absorption causing higher volumes of runoff. In rural areas concentration giving higher volume of runoff. This is also considered.

In rural areas, vegetation and afforestation have a significant effect on flood response. Studies in the USA have demonstrated that on a small watershed, equivalent peak discharges are reduced by approximately of 25 years by an average value of about 10%. Induced floods have not been clearly understood. Different land management cause differing effects in soil water infiltration and runoff.

### **Settlements of Flood Plain**

The height of land surface gradually increases above the flood plain away. Consequently, the flood hazard gets reduced as the distance increases. However, for socio-economic reasons, the flood plain is avoided. It is, therefore, advisable to exercise some control over the flood plain by confining the constructions to zones involving flood plain. Zoning incorporates this idea.

By taking into account the variability of flood hazard, the flood plain is demarcated depending on the degree of risk and potential damage. The type and density of occupation could be controlled. This is discussed below.



# COST EFFECTIVE HOUSING

---

## **Building Regulations**

Damage to individual buildings and structures may be minimized by incorporating in their design, the ability to withstand high wind velocity. It is desirable to enforce some building regulations which protect the welfare of the individual as well as the community. If such regulations exercised at regional and national levels, it would contribute to the reduction of disasters and save life and property in a large measure.

## **Flood Resistant House Construction**

Floods affect the whole community and the related problems are not satisfactorily only at the community level. Nevertheless, flood mitigation warrants its own special consideration and a special approach to meet the situation. The strengthening and protection of individual houses should be given due priority and importance. Total flood resistance necessitate incorporation of strong reinforcing measures in the construction. Such a type of construction is generally not within the means of the poor who are vulnerable to flood disaster. However, the following are some protective measures to the houses which may at the least reduce the damage.

- a) Good siting of houses should be aimed at to minimize damage. Houses should be constructed on the best bearing soil on the flood plain.
- b) Ground drainage and escape lanes should be incorporated in the design.
- c) The houses may be raised on individual mounds with the mounds made by thoroughly compacting soil. The mound should be at least 1.5 m high.

## COST EFFECTIVE HOUSING

---

- h) Houses constructed with mud are highly vulnerable and require special treatment.
- i) Parapet pillars in cement mortar 1:6 should be replaced by bamboo/poles in order to enable the victims to climb over the flood water level rises to about 3.5 to 4.0 m.
- j) In areas subjected to heavy rains and floods, the foundation height of 1 metre should be of burnt bricks.

### Cyclone

Cyclone is a devastating natural disaster the onslaught of which has been felt in the littoral States of the country since time immemorial. It causes loss of human life and property. In India, tropical cyclones develop in the Bay of Bengal and Arabian Sea. From the point of view of the frequency of occurrence, the Bay of Bengal is more vulnerable than the Arabian Sea. In India, the states of Tamil Nadu, Andhra Pradesh and Orissa are more susceptible to cyclones. The months of May, June, October and November are the months when cyclones are most frequent. During the monsoon period, the peak storm activity is reached in the first half of November. Compared to the pre-monsoon period, the months of October and November are known for severe storms. The most severe cyclones which have hit the Indian coast in the past hundred years have wind speeds of 220-240 km/ hr. According to one survey of the past century, the eastern coast has experienced cyclones almost every year. During this period, more than 100 cyclonic storms are reported to have hit the coast.



## COST EFFECTIVE HOUSING

---

### a) Location

Natural windbreaks such as trees or hedges should be used to protect a site for building. Such a location can reduce the impact of wind.



Fig. 9.17 Protection to house

### b) Shape of Building

Based on the research done on the effect of geometric shapes on wind forces, the following ratios are recommended (Fig. 9.18):

- (i) Length : Width = 1.5
- (ii) Height : Width = 1

Square houses are safer against winds. Pyramid-shaped houses are the most dangerous. The following shapes should be avoided:

## COST EFFECTIVE HOUSING

---

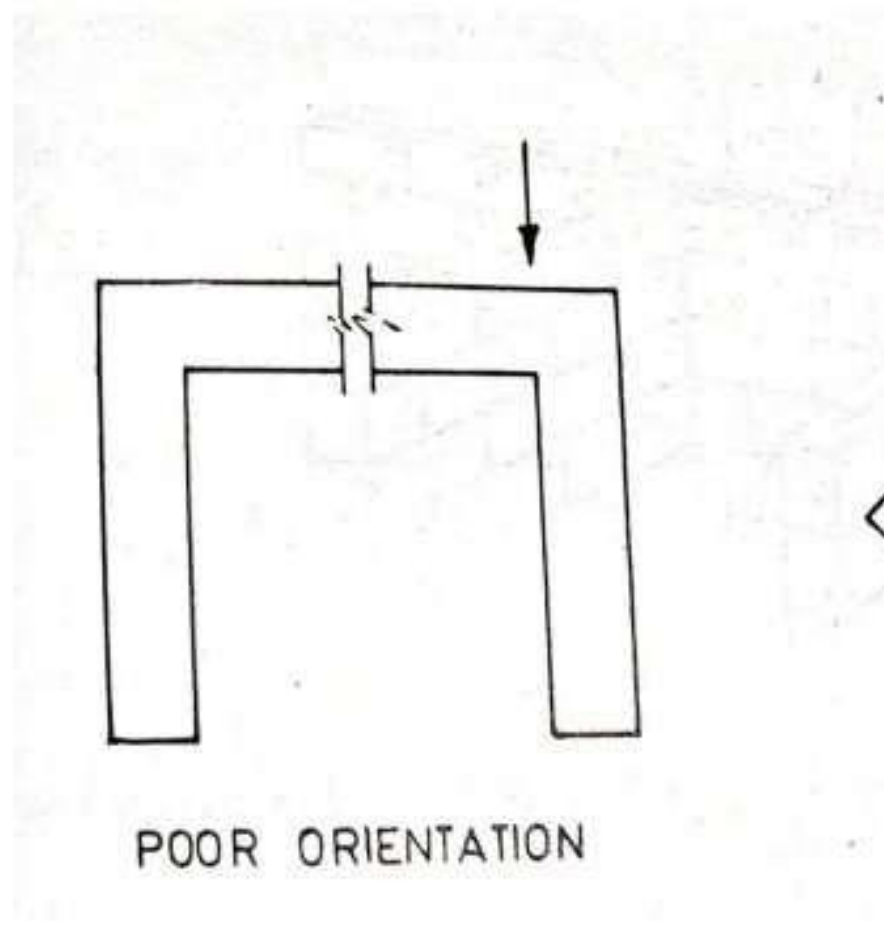


Fig. 9.19 Effect or orientation of building



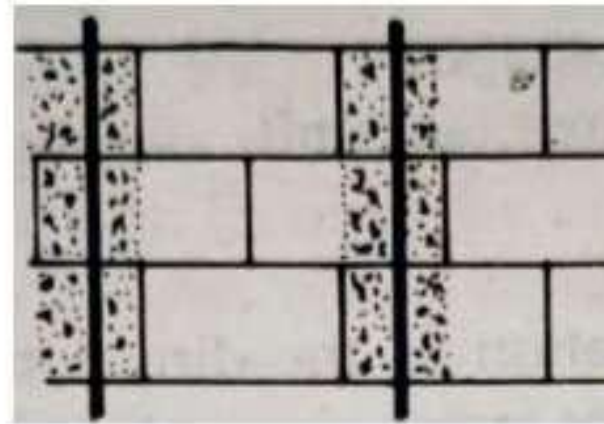


Fig. 9.21 Reinforcing masonry wall

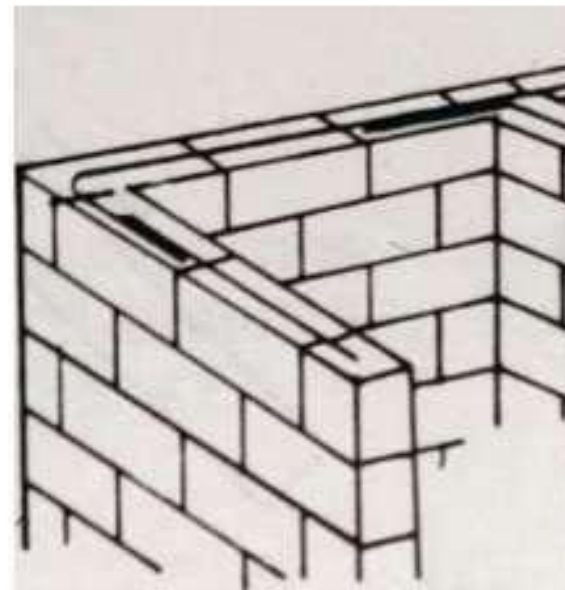


Fig. 9.22 Proving horizontal reinforcement around corner

internal load bearing walls) will greatly improve the integral box like action and increase the stability of the walls.

## COST EFFECTIVE HOUSING

vii) Bracing provides lateral stability to masonry wall

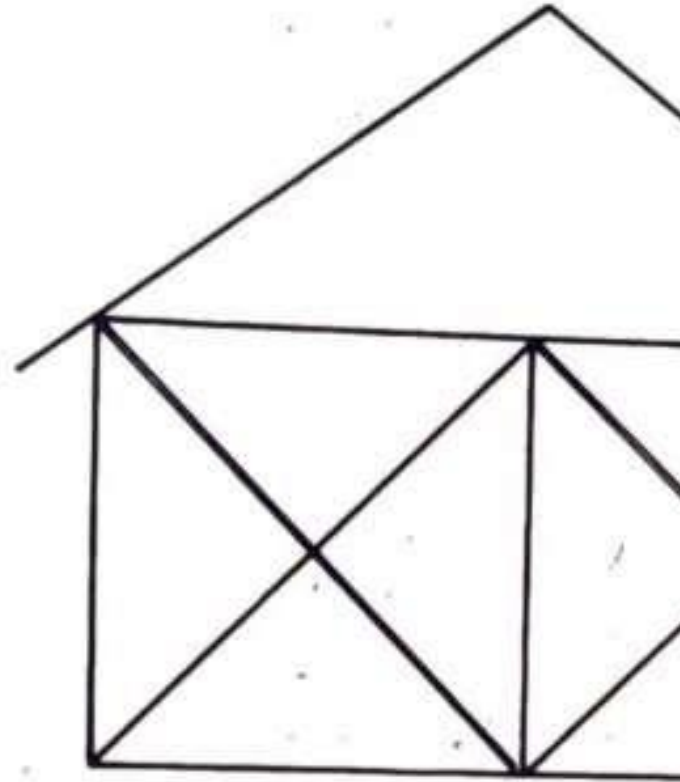
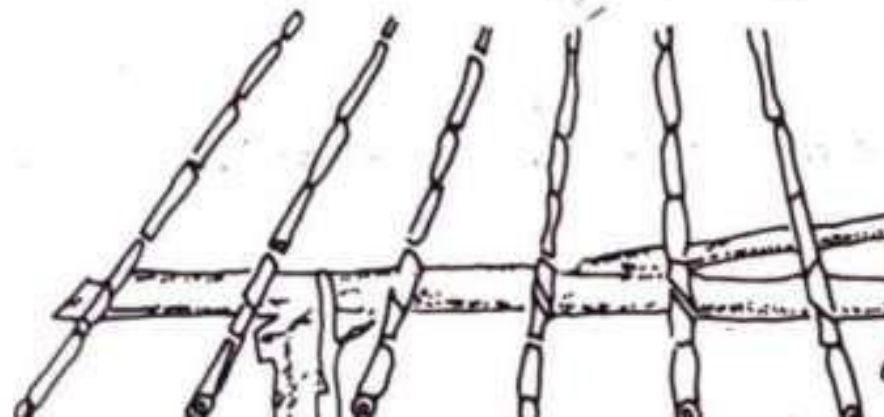


Fig. 9.25 Bracing of

z) Roof Construction

- i) Whatever the form of construction it should be supported by walls or posts (Fig. 9.26). Ignoring the cause of damage due to hurricane winds.





# COST EFFECTIVE HOUSING

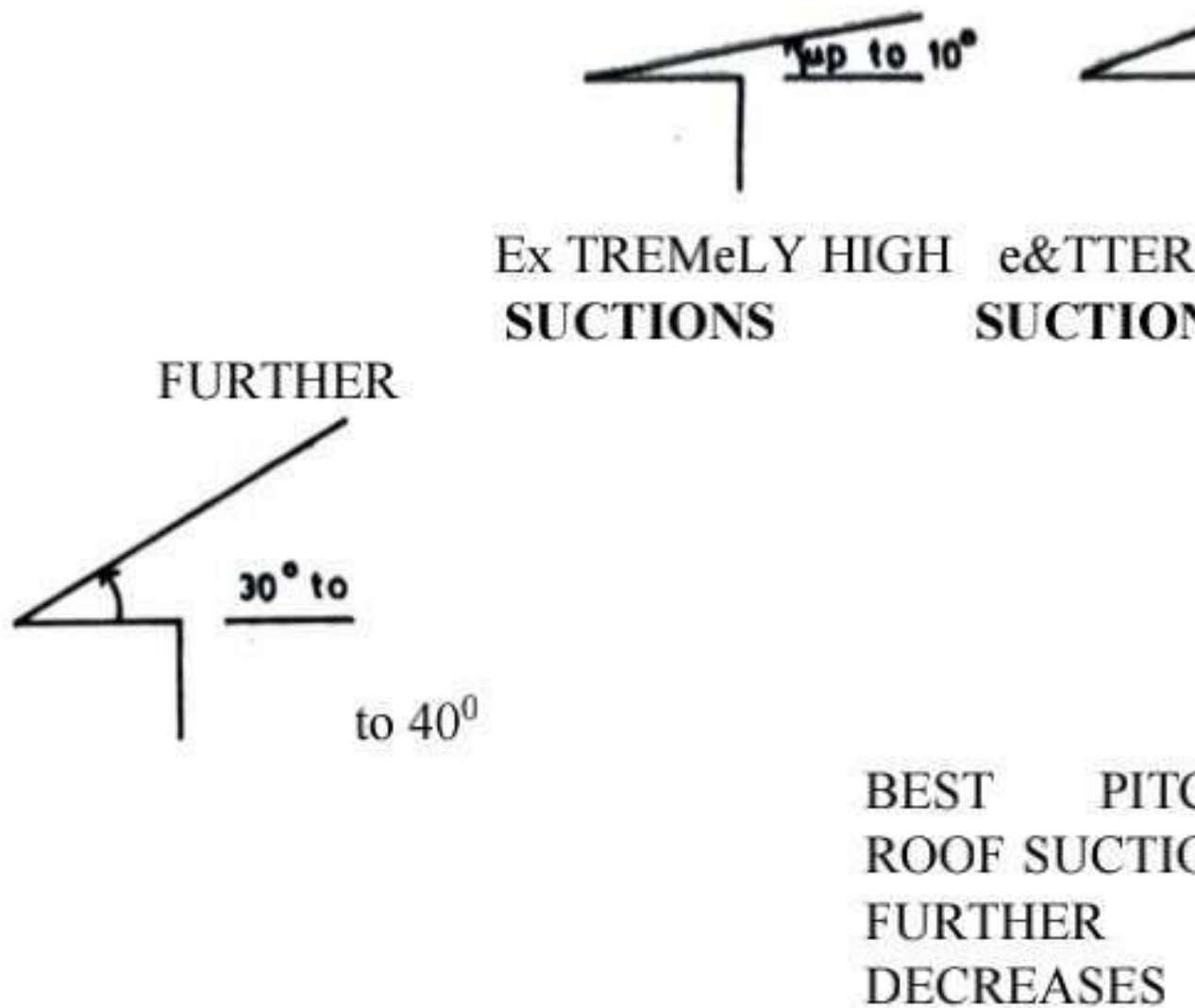
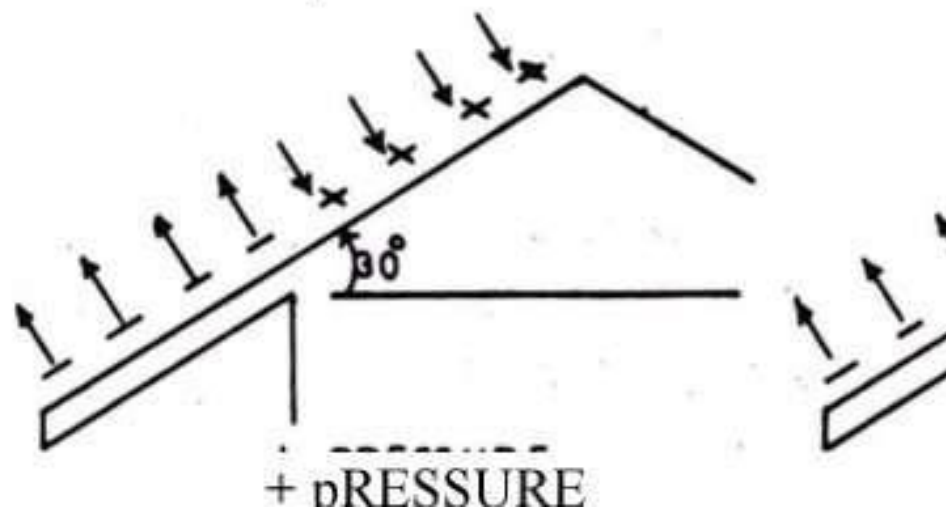
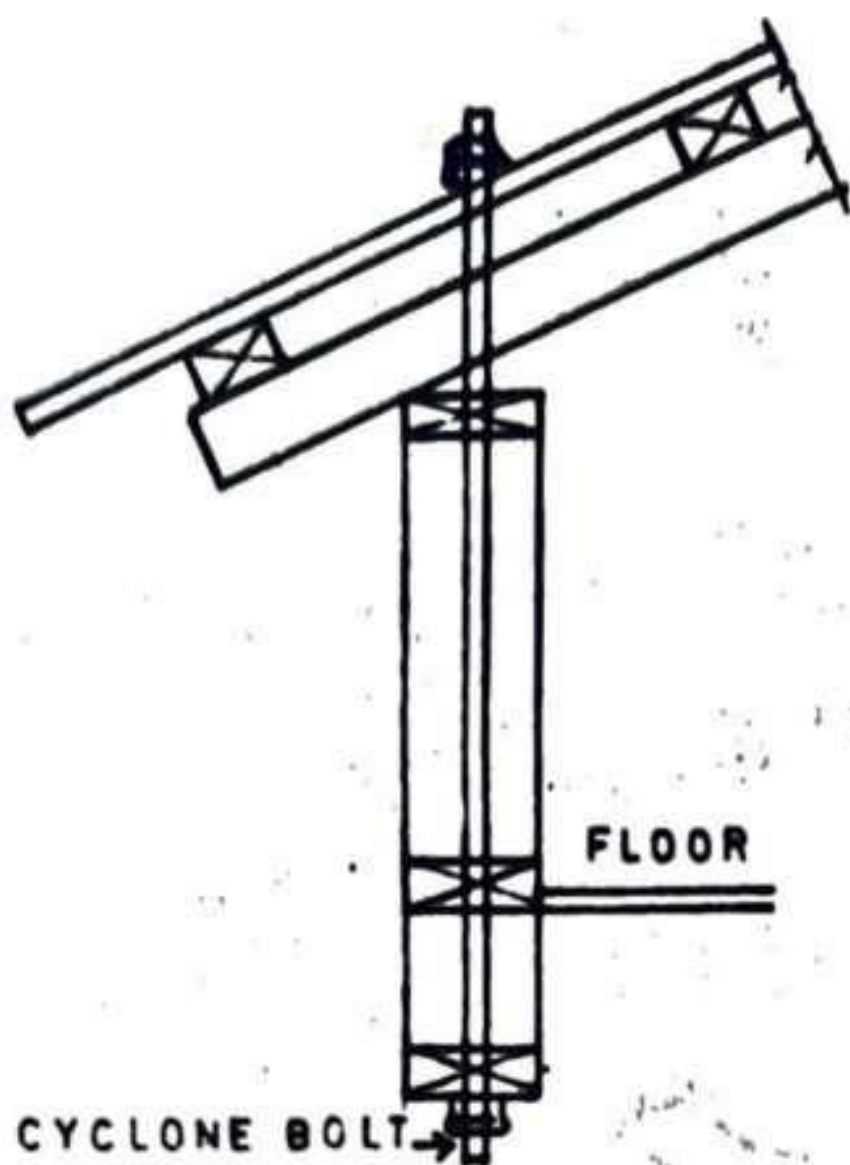


Fig. 9.27 Preferred roof slopers





**Fig. 9.31 Cyclone bolting**

**Fig. 9.32**

then to the foundation. Cyclone bolts (Fig. 9.31) provide continuity from the roof to the foundation.

- vi) All purlins should be tied to rafters by at least one nail. It should be ensured that nails are driven laterally, as shown in Fig. 9.33). Various cyclone resistant joints and Connections



## COST EFFECTIVE HOUSING

ctions ar shown in Fig. 9.33 to

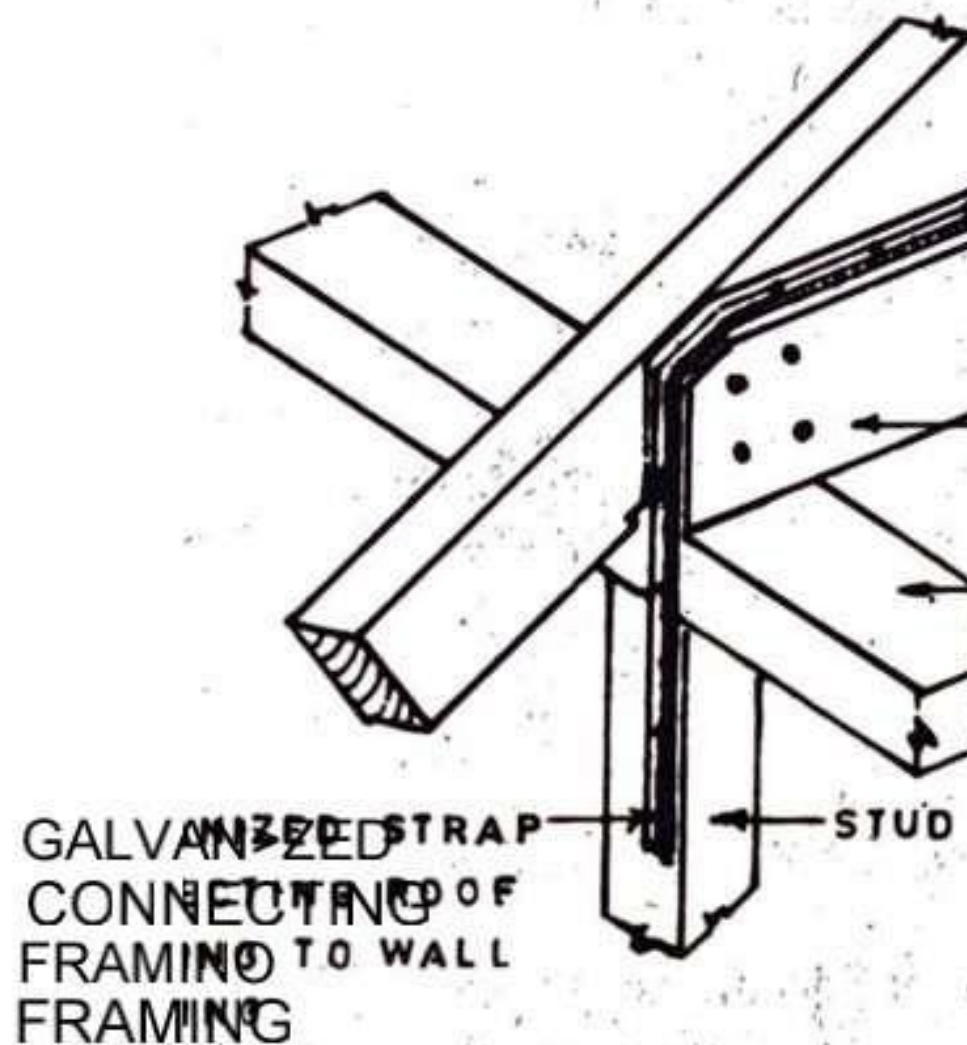


Fig. 9.33 Connection of roof

9.36.

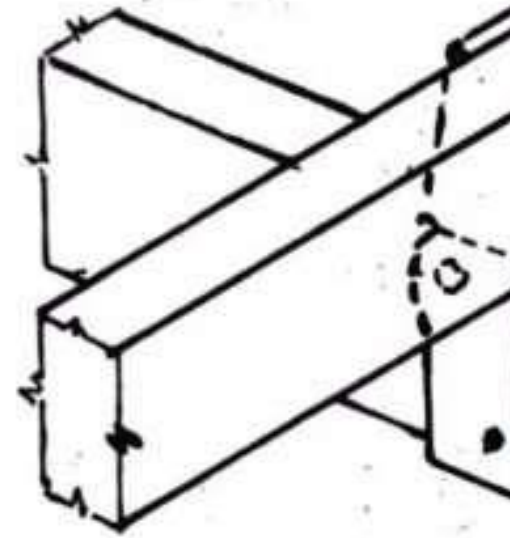
- vii) When nailing corrugated roof sheetings to purlins, use a large washer at the peak of corrugations and a washer at least  $3/4"$  (18 mm) wide at the eaves.
- viii) Every corrugation should be nailed to the purlin.

LARGE WASHER



## COST EFFECTIVE HOUSING

---



**Fig. 9.36** Metal batten

nailed, and it should be nailed along the top edge. Ignoring these nailing recommendations could lead to sheeting in the hurricane winds.

- ix) The probability of bamboo roofs covered with sheeting could be greatly reduced by covering them with local materials such as coconut fibre rope.
- x) A roof of clay tiles could be considerably strengthened.





## COST EFFECTIVE HOUSING

---

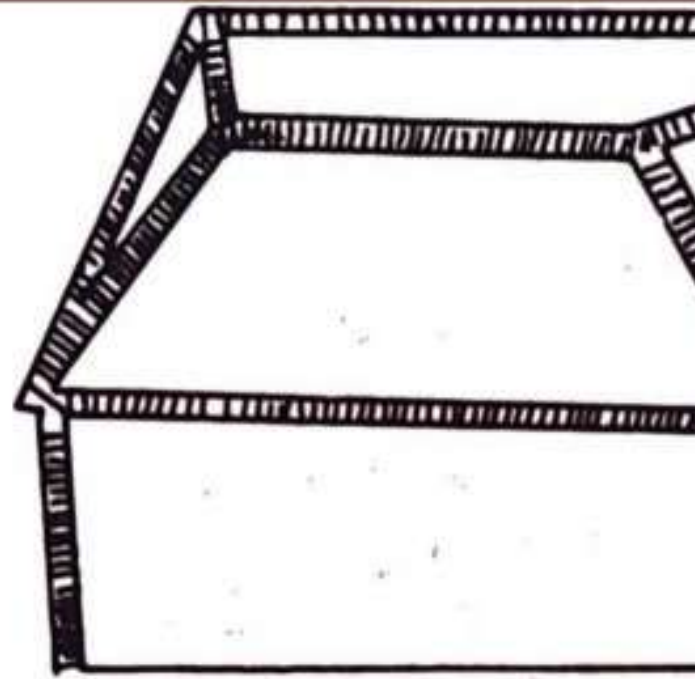


Fig. 9.39 Provision of mortar bands on roof top

prevented from blowing away by weighing it down.  
The above measures could go a long way in making a

### Future Strategy

(1) The Municipal Bye-laws and Building Regulations should provide provisions for strengthening of houses and buildings in areas prone to natural disasters. Strict enforcement of Existing Building By-laws and Regulations should address shortcomings in the provisions for adequate and safe construction, taking into account the type and the intensity of disaster.

(2) North India faces a serious threat of a de

## COST EFFECTIVE HOUSING

---

(8) Much attention is required to be paid to escape lanes should be incorporated in the lay-out.

(9) The importance of flood plain zoning should be free from undue hazards. Survey should be undertaken prohibited restricted and warning zones and the in zones with proper demarcation. The concerned zoning maps which should be implemented in established

(10) Well-designed and maintained towns to avoid local flooding.



## COST EFFECTIVE HOUSING

---

(11) Growing of regular plantation in the catchment areas as well as coastal areas, should be encouraged to retard runoff.

(12) Plants and shrubs should be grown as a natural measure of protection by breaking the force of gushing waves.

(13) People should be educated about the impact of cyclones in order to avoid choking.

(14) With a view to creating awareness among the people on natural calamities should be prepared on the lines of earthquake, and shown on the national network of Doordarshan as part of the syllabi of school and college level education. Mock exercises should be carried out as is regularly done in the case of earthquakes.